Abundance and Distribution of the Golden Mussel (*Limnoperna fortunei*) Larvae in a Hydroelectric Power Plant in South America

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Abstract

The impact of the golden mussel (*Limnoperna fortunei*) in South America involves both the human and the natural environments. Larvae and/or juveniles go inside the water systems of the drinking water plants, refrigeration systems of industries and power plants in the human environment, then they settle and maturate producing macrofouling problems. Life cycle studies are undertaken in a hydroelectric power plants in order to gather basic information to develop promising strategies for prevention and control of *L. fortunei*. The aim of this contribution is to describe the temporal dynamics and variations of golden mussel larvae in the power plant water system. Veligers and postveligers were collected between April 1999 and May 2001. The samples were taken from the dam, from the water intake system (WIS) and from the cooling system (CS). Veligers were found between September and May. Veligers first appeared in September, when the temperature was about 20°C. They increased to peak densities in December to March and declined during May. Differences in larval densities between the dam and the water intake ducts and cooling pipes were found. Due to structural characteristics of the plant, larvae were recorded for a longer period, and with greater densities, in the interior of the power plant.

Key Words

Golden mussel, *Limnoperna fortunei*, larvae, South America, Neotropical Region, invader bivalve, macrofouling.

Introduction

Following the introduction of the golden mussel, *Limnoperna fortunei* (Dunker 1857), into Río de la Plata estuary in 1991 (Pastorino et al. 1993; Darrigran and Pastorino 1995), this species spread along the Plata Basin upstream at 240km/year (Darrigran and Ezcurra de Drago 2000).

The impact of the golden mussel in South America involves both the natural (Darrigran et al. 1998; Darrigran 2000) and the human environments (water distribution systems) (Darrigran et al. 2000) similar to the impact caused by the invasive species *Dreissena polymorpha* in the Northern Hemisphere (Nalepa and Schoelesser 1993; Ricciardi 1998). Larvae and/or juveniles go inside the water systems of the drinking water plants, refrigeration systems of industries and power plants in the human environment, then they settle and maturate producing macrofouling problems. This is a new problem for South American freshwater systems (Darrigran 1998; Darrigran and Ezcurra de Drago 2000).

To date the life cycle of *L. fortunei* in the neotropical region has been studied only in a template area (Darrigran et al. 1998; Darrigran et al. 1999; Cataldo and Boltovskoy 2000). No studies exist on this topic for a subtropical area, in either of the environments, natural or human.

Between 1999 and 2001 life cycle studies were undertaken in a hydroelectric power plant, on the upper Paraná River in order to gather basic information to develop promising strategies for prevention and control of *L. fortunei*. The first record of *L. fortunei* in this area was at the end of 1997.

The aim of this manuscript is to describe the temporal dynamics and density variations of the golden mussel larvae in the power plant water system in a subtropical area.

Material And Methods

The present study was undertaken in the Yacyretá Hydroelectric Power Plant. This is a binational Hydroelectric Central (Argentina-Paraguay) located on the upper Paraná river (27°29´S - 56°44´W). The mean caudal is 12 000 cubic meters per second. This plant has 20 turbines. Each turbine has a caudal of 380 m^3/sec. The Yacyretá Dam has an area of 1600 km^2 and a length of 342 km.

Veliger and postveliger larvae of *Limnoperna fortunei* were quantitatively sampled every two weeks, between April 1999 and May 2001. Samples were collected by plankton net (40µm), sieving known volumes of water (at least 30 L). The samples were taken at different points:

- Three samples from the water intake structure (from Turbine number 1, 9 and 18) (WIS)
- Six samples from different points of the cooling system (CS)
    - one before and one after the raw water auto-cleaner filter;
    - one after the auto-cleaner filter of turbine number 9;
    - one from the return water of turbine number 9;
    - one before and one after the seal water system (from turbine number 9); and
    - one sample from Yacyretá Dam (YD) (27°28´S - 56°42´W).

After collection, samples were preserved in 40% alcohol. In the laboratory a representative aliquot was taken, larvae were counted and the developmental stage identified under binocular microscope. Conductivity, total solid dissolved, pH, and temperature at each sample point were measured.

Results

Superficial water temperature registered during this study varied between 15.3 to 32.6 °C in the dam (mean value 24°C), between 16.3 to 31.8°C in the water intake structure (mean value = 24°C) and between 15.7 to 31.9°C in the cooling system (mean value = 23.6).

Veliger and postveliger larvae were only absent 2-4 months of the year. The temporal presence of the larvae varied between the samples considered. Larvae from the interior of the system were absent between June-July 1999 and July-August 2000; from the WIS between May-July 1999 and May-August 2000; and from the dam between June-September 1999 and May-August 2000.

The highest densities of larvae (both veliger and postveliger) were found in the samples from the WIS (Table 1) (maximum density observed = 259.3 larvae/L on November 26, 1999, in the WIS of turbine number 1). The mean density in this station was 24.01 larvae/L (SD = 43.99, n = 123). Larvae were first observed in August, when water temperature was about 19°C, veliger densities then increased during the summer to reach the maximum values for the year.

Table 1. Statistic summary of the samples.

	Yacyretá Dam	Water Intake Structure	Cooling System	Machine Return	Cooling System (without machines return)
Mean	5.91	24.01	8.08	16.27	6.36
Standard Deviation	17.0420	43.9852	23.6288	42.7727	17.1855
Minimum	0	0	0	0	0
Maximum	74.07	259.26	222.22	222.22	110.12
N° of Samples	41	123	246	41	205

High densities were maintained between October-March 1999 and November-January 2000 (Figure 1). After this, and beginning before the water temperature began to decline, veliger densities declined rapidly during March 1999 and February 2000.

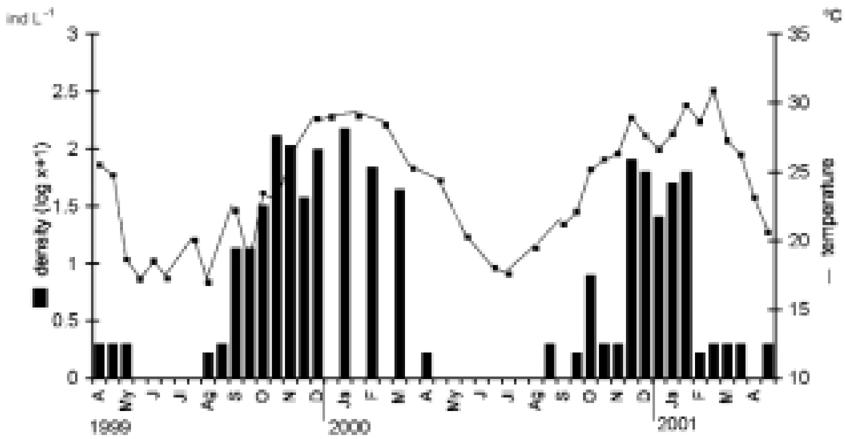

Figure 1. Larvae density (individuals per liter) and water temperature (°C) in the water intake structure during the sampling period.

In the samples from the CS the mean density (x = 8.01 larvae/L; SD = 23.63; n =246) was lower than the one observed in the WIS and the maximum value was 222.22 larvae/L observed on December 28, 1999, in the return water. Larvae were only not observed during one month in 1999 and during three months in 2000, when the water temperature was less then 19°C (Figure 2).

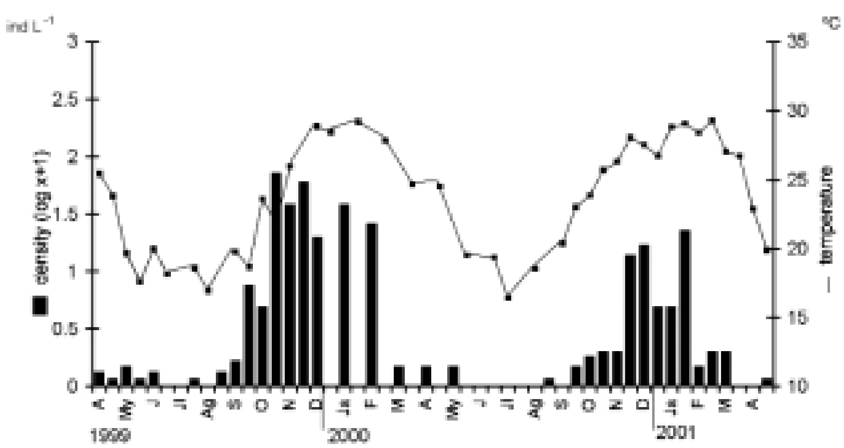

Figure 2. Larvae density (individuals per liter) and water temperature (°C) in Yacyretá dam during the sampling period.

In the dam, larvae mean density was the lowest observed (x = 5.91 larvae/L; SD = 17.04; n = 41). The maximum values were registered on November 26, 1999 and on December 29, 2000 (density = 74.07 larvae/L). Veligers and postveliger larvae were observed in spring (September) when water temperature was about 20°C. High densities were observed only during short periods between November and December, when water temperatures began to increase to reach maximum summer values. Then densities declined before water temperatures began to decrease.

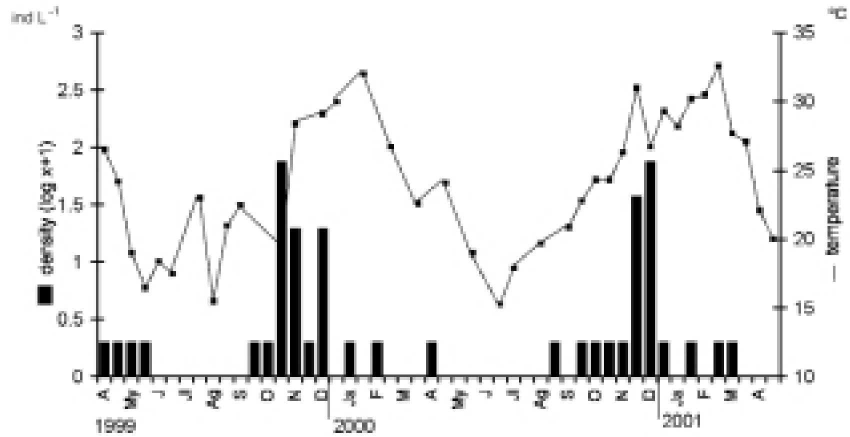

Figure 3. Larvae density (individuals per liter) and water temperature (°C) in the cooling system during the sampling period.

Four sample points were compared with t Student test (Table 2). The samples from the WIS showed significant differences ($P < 0.05$) with those from the cooling system, (not including the samples from machine return) and with the samples from the Yacyretá Dam.

Table 2. Result of t student analysis (t value and in brackets the probability)

	Yacyretá Dam	Water Intake Structure	Cooling System (Without Machines Return)
Water Intake Structure	-2.697 (0.0085**)		
Cooling System (Without Machines Return)	-0.134 (0.8933)	2.724 (0.0079**)	
Machine Return	-1.441 (0.1534)	0.852 (0.3969)	1.421 (0.1593)

Discussion and Conclusion

Veliger and postveliger larvae are present when the water temperature reaches approximately 20°C and were absent between June-July 1999 and July-August 2000 in the interior of the system; from the water intake structure between May-July 1999 and May-August 2000 and from the dam between June-September 1999 and May-August 2000.

Cataldo and Boltovskoy (2000) studied the golden mussel larvae occurrence in the plankton of the lower Paraná River. They described that the interruption of the reproductive activity of *L. fortunei* occurred when the water temperature dropped 16-17°C. Darrigran et al. (1999) found that the gonadal proliferation were almost continuous during the year, but spawning periods could be recognized. All these studies were undertaken in a template area.

Cataldo and Boltovskoy (2000) studied the densities of larvae in a natural template environment and in the outlet of a nuclear power plant of the same area. They found that the mean number of larvae was 7.48 larvae/L in the human environment and 4.83 in a natural environment. In the present study, the mean density in a similar human environment (machine return), was 16.27 larvae/L and in a natural environment was 5.91. These higher values could be due to the differences in the climate.

The highest larvae density was registered in the water intake structures. Therefore, before applying a control treatment, the first part of the system must be cleaned and protected in order to eliminate these "breeder chambers". This part of the system not only has the highest registered larvae densities, but also very high young and adult densities. The latter attach to the walls and generate a large number of larvae during the breeding period. These larvae added to those that entered in the system from the dam andcontaminated the interior of the system.

In the cooling system, larvae density is higher in the water return than in the samples taken before the filters (the filters are situated in the beginning of the cooling system). This means that in the interior of the system, adults are attached and they can contaminate the system again.

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