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doi:10.1016/j.marpolbul.2005.06.051

Benthic invasive pests in Uruguay: A new problem or an old one recently perceived?

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Aquatic ecosystems have always been subjected to changes in species composition, but natural migration of organisms due to climatic and geographic variations is becoming superimposed by anthropogenic vectors facilitating a much faster and wider distribution into new habitats. The introduction of species into a new ecosystem is an economic and environmental serious risk. Under favourable environmental conditions, without predators, parasites and/or natural competitors these new species can reach high densities and are difficult to eliminate once established (Carlton, 1989). Once introduced in the aquatic environment the invasive species may promote several changes. They can, for example, alter the local hydrological regime, produce loss of biodiversity with the elimination of native species, produce changes in the trophic web, habitat modification and can also cause negative economic impacts to human populations (Tundisi, 1999; Darrigran, 2002; Mansur et al., 2003). In the last two centuries, introduced species have caused a change in the biogeography of coastal zones, with an important decline in the local biodiversity (Raffaelli and Hawkins, 1997). Globally, the number of exotic aquatic species has increased exponentially over time (Ruiz et al., 2000). Important vectors are intercontinental shipping and the commercial transport of aquaculture and aquarium products (Carlton, 1996; Ruiz et al., 2000; Naylor et al., 2001; Semmens et al., 2004). Shipping ballast water is known as the highest risk vector for international introductions, causing a coastal community homogenization. At any given moment it is estimated that 10,000 different species are being transported between biogeographic regions in ballast tanks alone (Carlton, 1999).

Exotic species are aloctone organisms that can be considered as biological contamination. As in other areas of the world, the South-Western Atlantic contains many exotic aquatic species (Schwindt, 2001; Orensanz et al., 2002; Silva and Souza, 2004) and Uruguayan ecosystems are not an exception of this pattern (Brugnoli et al., 2005 and Brugnoli et al., in press). This recently discovered problem provides a new challenge for scientists and decision makers, since Uruguay has neither the scientific knowledge nor a legal system suitable to resolve the problem. However, some initiatives have been made in the last three years. In an attempt to face up to this problem, the scientific community together with environmental agencies, and public and private institutions have recently developed two workshops (Comisión Administradora del Río Uruguay, September 2002; FREPLATA, November 2004). The mains objectives of these workshops were to study the magnitude of

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the invasion processes in Uruguay and the Argentine, and to detect those ecosystems that are being directly or indirectly impacted.

In Uruguay, more than ten benthic invasive species have been reported (Brugnoli et al., in press). Two of them, recently recorded, are of special interest because of their potential to cause negative ecological and economical impacts, both in coastal and continental ecosystems (Clemente and Brugnoli, 2002; Borthagaray et al., in press). They are the golden mussel *Limnoperna fortunei* and the reef-building polychaete *Ficopomatus enigmaticus*. In this contribution we briefly summarized the state of the ecological/biological knowledge concerning these two benthic pests.

Mollusca, Bivalvia, Mytlillidae: *Limnoperna fortunei* (Dunker 1857), popularly known as the golden mussel is a mytilid invasive species of the Plata Basin, native to freshwater systems of China and South-East Asia. It was introduced accidentally in the region in 1991 via ballast water (Darrigran and Pastorino, 1995). It has an epifaunal and aggregate behaviour (Cataldo and Boltovskoy, 2000; Darrigran and Ezcurra de Drago, 2000) and occurs in fresh and brackish water ecosystems (Darrigran, 2002). It is a dioecious species with external fecundity and a swimming larval phase (Darrigran and Pastorino, 1993; Cataldo and Boltovskoy, 2000). Attached to hard substrata by means of a byssus, it reaches high densities. In Uruguay it has been recorded in four of the six main hydrographical basins: Río de la Plata, Santa Lucía, Negro and Uruguay Rivers (Fig. 1, Scarabino and Verde, 1995; Darrigran and Ezcurra de Drago, 2000; Brugnoli et al., 2005). In the Merín Lagoon and Atlantic Basins there are no records of this mussel, although Brugnoli et al. (2005) suggests that its access to both basins could had been possible throughout the San Gonzalo channel which connects Los Patos and Merín Lagoon systems.

Previous studies have demonstrated that the infaunal bivalves of the region, composed of Etherioidea and Corbiculidae, may be dramatically affected by *Limnoperna fortunei* (Orensanz et al., 2002; Mansur et al., 2003; Scarabino, 2004). The species richness and abundance of Hirudinea and Oligochaeta increased while Gastropoda decreased in communities inhabiting the benthic fauna of the Argentinean coast of the Río de la Plata estuary (Darrigran et al., 1998). Brugnoli et al. (2005) found changes in the relative abundances of the main groups of the zooplankton (Crustacea and Rotifera) caused by the presence of the *Limnoperna fortunei* larvae, with potential modifications in the trophic web at the Palmar reservoir (Negro River). Recently, Sylvester et al. (2005) reported that the high filtration rates associated with high densities of the golden mussel in the Paraná watershed may swiftly change the ecological conditions in the colonised areas.

Due to its high densities, *Limnoperna fortunei* has rapidly become a major nuisance for industrial and power plants along the Paraná-Paraguay, Uruguay and Río de la Plata that use raw river water (Darrigran, 2002; Cataldo et al., 2003). *Limnoperna* is a fouling bivalve causing filter obstructions, damage in the cooling systems and/or obstruction of the system pipes. In Uruguay, some problems associated with high densities of *L. fortunei* has been recorded, especially those related to water supply systems and hydroelectric power plants (Fig. 2) (Clemente and Brugnoli, 2002), and in several other industrial activities, which use water for refrigeration (Irurueta et al., 2003). Reservoirs, navigation locks,

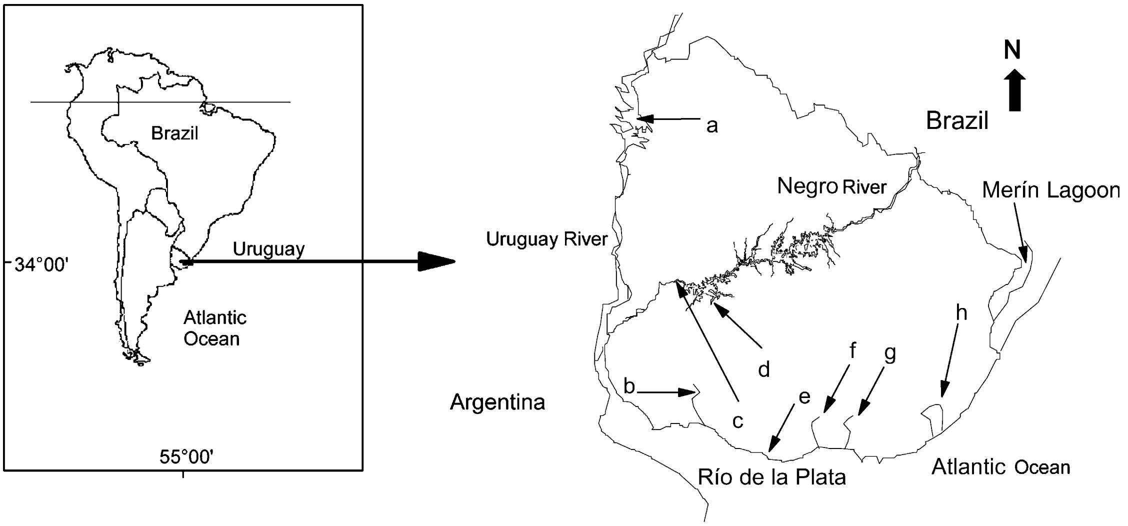

Fig. 1. Map of Uruguay showing the locations were *Limnoperna fortunei* (a, b, c and d) and *Ficopomatus enigmaticus* (e, f, g and h) have been recorded. a = Salto Grande reservoir at Uruguay River; b = Santa Lucia River; c = Palmar hydroelectric power plant at Negro River (UTE); d = Yí River; e = Oil petroleum refinery in Montevideo (ANCAP); f = Pando River; g = Solís Grande Stream estuary and h = Rocha coastal lagoon.

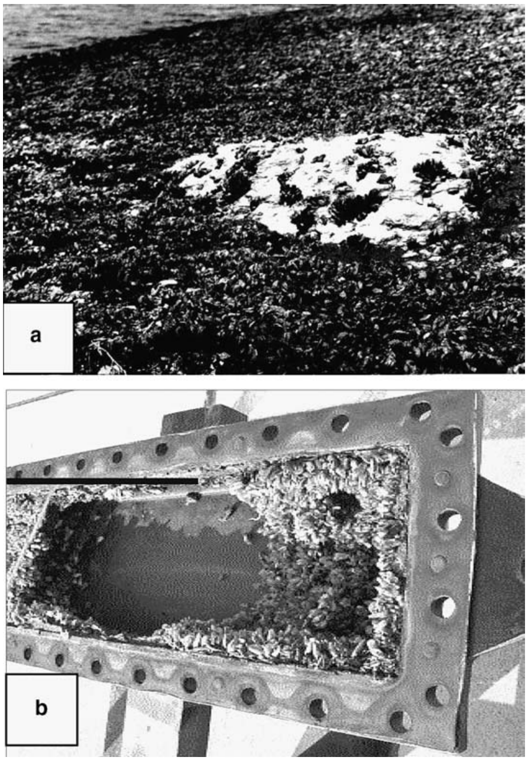

Fig. 2. *Limnoperna fortunei* (a) attached to hard substrata in the littoral zone of the Palmar reservoir during low water level; and (b) macro-fouling into the water distribution systems of Palmar hydroelectric power plant. Photograph credits: E. Brugnoli. Scale: 1 cm = 25 cm.

and other artificial structures can also become intensely fouled. These problems generate indirect costs due to an increase in the frequency of clean-up, equipment repair and for pest removal. Although this problem was recently discovered, it has been estimated that around US$ 70,000 has been spent in the last three years in Uruguay (Brugnoli et al., in press).

Annelida, Polychaeta, Serpulidae: *Ficopomatus enigmaticus* (Fauvel 1923) is an exotic reef-building polychaete distributed in most brackish waters in temperate zones throughout the world (Ten Hove and Weerdenburg, 1978). As a species producing habitat creation and modification, is it known as an "ecosystem engineer" (Schwindt et al., 2004a). Their calcareous reefs can produce large extensions in shallow water and low energy environments. These reefs can act as efficient traps for sediments, generating topographic heterogeneity that promote changes in the abundance and distribution of the benthic associated communities (Schwindt and Iribarne, 2000). The trochophore larvae, once settled in hard substrata, form a calcareous tube that is secreted by the collar glands (Obenat and Pezzani, 1994). This species originates in Australia (Allen, 1953), and in 1970 colonised Mar Chiquita lagoon in Argentina (Orensanz and Estivariz, 1971). Tube size and shape varies according to environmental variables, but in general the reefs are circular structures that can reach 2.5 m in diameter and grow a rate estimated to be 1.6 cm/month (Schwindt et al., 2004b). In Mar Chiquita lagoon, where the species has been well studied for 20 years, reef cover is presently much higher than in the past and reefs of similar size coalesce to form platforms several metres long (Schwindt et al., 2004b).

In Uruguay, *Ficopomatus* has been recorded in the Pando Stream and Castillos coastal lagoon (Nión, 1979), in the most inner region of the Solís Grande Stream estuary (Muniz and Venturini, 2001; Fig. 3) and more recently in the Rocha coastal lagoon (Fig. 1) (Borthagaray et al., in press). In the Solís Grande Stream estuary the reefs are of small size (approx. 20 cm) and are generally attached to dead and live valves of the native mollusc *Tagelus plebeius* (Muniz and Venturini, 2001). The species has a negative effect, making the benthic community health classified as heavily perturbed (Muniz et al., 2005). In the Rocha lagoon, the species is present only in the shallow innermost region, where the concentration of suspended matter is high and the current speed low (Conde et al., 1999; Borthagaray et al., in press).

Ficopomatus enigmaticus also causes negative economic impacts in Uruguay (Brugnoli et al., in press). Recently, large tubes (twice in size to those found in natural environments) were recorded obstructing the cooling system of the Uruguayan oil refinery (ANCAP, Fig. 3). The species has not been recorded in the waters of Montevideo Bay (Muniz et al., 2000; Venturini et al., 2004), but were found several years ago in the mouth of Pantanoso stream (Scarabino et al., 1975) near where the oil refinery is installed. How the species reached the ANCAP installation is a question that can not be answered with the present knowledge.

Invader species are often one of the main factors in ecological degradation (Ricciardi and Atkinson, 2004). Therefore, is necessary to establish national and international research programmes to minimise the impacts of the exotic species, and to develop models to predict the introduction of new invaders. It is clear that once established in a new environment, the eradication of exotic species is very difficult. Thus, in an attempt to solve this problem, which was recently discovered in Uruguay, we propose a simple assessment of potential recipient regions, which could be generated according to three simple steps: (i) identification of all possible exotic species whose introduction and dispersion should be avoided, as well as the assessment of the ecological and economic costs of their possible introduction; (ii) identification of the dispersion vectors (using for example patterns of recent invasions in other parts of the world); and (iii) assessment of the main environmental parameters of the recipient ecosystems and of those that present risk of invasion.

Finally, with knowledge of the distribution, ecology, life history and impacts of alien species, both in a

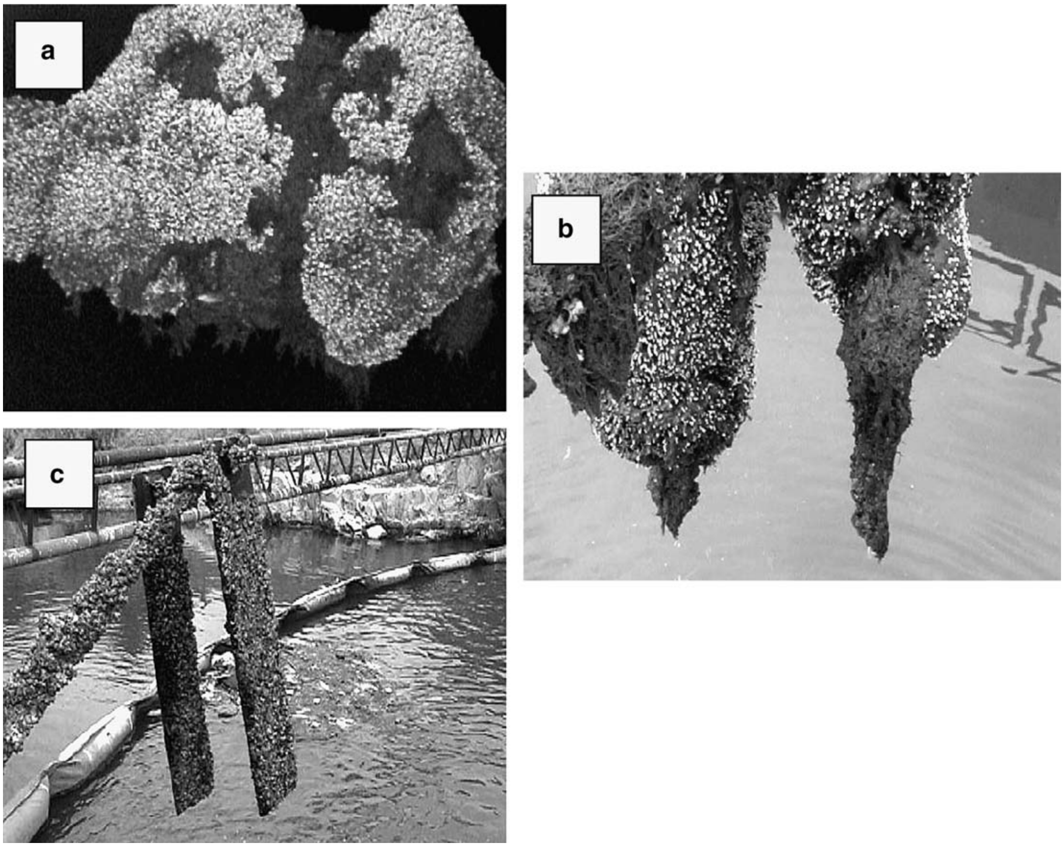

Fig. 3. *Ficopomatus enigmaticus* collected (a) in the northern portion of Solís Grande stream estuary and (b) and (c) in the cooling system of the ANCAP petroleum refinery (Montevideo, Uruguay) Photograph credits: J. Clemente for (a) and R. Russo for (b) and (c). Scale: in (a) 1 cm = 5 cm; (b) 1 cm = 15 cm and (c) 1 cm = 20 cm.

national and in a regional scale, it would be possible to improve management and control. Since shipping traffic appears to be the most important introduction vector, we emphasize the need for effective controls on ballast-water discharge in harbours of the region. The prevention of such a problem is always easier, less expensive and more effective than eradication.

Acknowledgements

Special thanks to the Institute for Global Change (IAI) through the SACC-CRN Project, for partial support for the first author. Thanks to L.Boccardi for the collaboration, R.Russo (Oil refinery ANCAP), and several colleagues of electric company (UTE) are also acknowledged for their contribution in different stages of the work and for some photos of *Limnoperna*. Finally, we wish to thank N. Venturini for kindly reviewing the English version of this paper and to the reviewers for their critical comments that improve the manuscript.

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doi:10.1016/j.marpolbul.2005.06.049