Reef of *Ficopomatus enigmaticus* (Polychaeta; Serpulidae) in the Mar Chiquita Coastal Lagoon, Argentina

Evangelina SCHWINDT & Oscar Osvaldo IRIBARNE

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Ficopomatus enigmaticus (Polychaeta, Serpulidae) is a reef-building polychaete that since the sixties has colonized the SW Atlantic Mar Chiquita coastal lagoon (Argentina, 37° 32' to 37° 45' S and 57° 19' to 57° 26' W; a UNESCO MAB site). The reefs have an approximately circular shape reaching up to 4 m in diameter and 0.5 m in height. Living individuals are at the edges where larval settlement occurs. Settlement has also been observed on shells, bottles, rocks, pillars and bones. The habitat created by their tubes provide shelter for numerous organisms that have largely increased the amount of organisms that inhabit in structured habitats. All evidence accumulated to the present suggests that the introduction of this reef building species has provoked a significant environmental change, affecting the sediment dynamics and the ecological structure of the lagoon.

Keywords: Ficopomatus enigmaticus, *reef, polychaete, coastal lagoon.*

ESCULLS DE *FICOPOMATUS ENIGMATICUS* (POLYCHAETA; SERPULIDAE) EN LA LLACUNA COSTERA DE MAR CHIQUITA, ARGENTINA. *Ficopomatus enigmaticus* (Polychaeta, Serpulidae), és un poliquet formador d'esculls que des dels anys 60 ha colonitzat la llacuna costera Mar Chiquita del sud-oest atlàntic (Argentina, 37° 32' a 37° 45' S y 57° 19' a 57° 26' O; un lloc MAB de l'UNESCO). Els esculls tenen una forma aproximadament circular, podent arribar fins els 4 m de diàmetre i 0,5 m d'alçària. Els individus vius es troben en les vores, on també esdevé l'assentament larval. L'assentament també ha estat observat sobre les valves, ampolles, roques, pilars de ponts i ossos. L'hàbitat creat pels seus tubs dóna refugi a nombrosos organismes i ha augmentat en gran manera l'abundància d'organismes que viuen en hàbitats estructurats. Totes les evidències acumulades fins ara suggereixen que la introducció d'aquesta espècie ha provocat un canvi ambiental significatiu, afectant la dinàmica sedimentària i l'estructura ecològica de la llacuna.

Paraules clau: Ficopomatus enigmaticus, *escull, poliquets, llacuna costera.*

Evangelina SCHWINDT and Oscar Osvaldo IRIBARNE Laboratorio de Ecología, Departamento de Biología (FCEyN), Universidad Nacional de Mar del Plata, Argentina. Dirección Postal: Casilla de Correo 573. Correo Central Mar del Plata, (7600) Mar del Plata, Argentina. Correo Electrónico: schwindt@mdp.edu.ar

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Human beings have radically altered the world wide species distribution pattern by transporting species throughout the world deliberately and accidentally, and introducing them into areas where they are not native (e.g. by shipping; Primack, 1993; Cohen & Carlton 1998). These exotic species may displace native species through competition for limited resources, predation to the point of extinction or, change the habitat to such extent that natives are no longer able to persist (Primack, 1993). Several exotic species are easily able to invade and dominate new habitats for many reasons. One of these being the absence of their natural predators to control their population growth. Exotic species may also have better adaptive qualities than native species to the disturbances generated by the activity of modern humans (e.g. dredging, contamination, resource overexploitation; Adam, 1990). Moreover, exotic species may be very difficult to remove from the colonized environments (Coblentz, 1990).

Most accidental introductions are from fouling organisms growing on the undersides of ships (e.g. barnacles; Raffaelli & Hawkins, 1997) favoring their dispersion. Serpulid worms are one of the most important groups of fouling organisms (Allen, 1953). *Ficopomatus enigmaticus* (Polychaeta, Serpulidae) is a calcareous reef-building species distributed in brackish waters in temperate zones throughout the world (Ten Hove & Weerdenburg, 1978). This species originated in Australia (Allen, 1953) and was observed in Argentina in 1943 (Rioja, 1943 in Orensanz & Estivariz, 1971). This species was already present in the Mar Chiquita coastal lagoon (Argentina, 37° 32' to 37° 45' S, and 57° 19' to 57° 26' W; Fig. 1) in the early seventies (Orensanz & Estivariz, 1971). However, there is no evidence of their presence in Holocene sediments (Orensanz & Estivariz, 1971) which suggest that it is a new invader.

Mar Chiquita is one of the few coastal lagoons of Argentina which has evolved following the relative oscillations of sea level that occurred during the Holocene period (Fasano *et al.*, 1982). Today the lagoon covers a surface of approximately 46 km^2 and has a drainage basin of about 10.000 km^2. The shape is elongated with an NE-SW orientation, and is characterized by mudflats and large surrounding areas dominated by the cordgrass *Spartina densiflora* (Olivier *et al.*, 1972a; Fasano *et al.*, 1982). The mean depth is 0.6 m, but depths of up to 2 m occur along the discharges channel (Isla, 1997). The mouth of the lagoon is affected by low amplitude ($\leq$ 1.5 m) tides, and the lagoon receives sediment and water charges from creeks and artificial channels (Fasano *et al.*, 1982). Wind is the principal force controlling the variations in water level (Reta *et al.*, 1997). Salinity changes are particularly important oscillating from a salt content higher than the sea during the summer (up to 40, pers. obs.) mainly due to marine input and evaporation, and to freshwater during the rainy autumn (Fasano *et al.*, 1982). The mean annual precipitation in the area is 790 mm (in 30 years, Fasano *et al.*, 1982).

The lagoon mudflats are important stopover sites for several migratory shorebirds that breeds in the northern parts of North America wintering in South America (e.g., *Charadrius falklandicus*, two-banded plover; *Calidris canutus*, red knot; *C. alba*, sanderling; *C. fuscicollis*, white-rumped sandpiper; *Limosa haemastica*, hudsonian godwit; *Tringa melanoleuca*, greater yellowlegs; *T. flavipes*, lesser yellowlegs; *Pluvialis dominica*, American golden plover; *P. squatarola*, black-bellied plover; *Numenius phaeopus*, whimbrel; Botto *et al.*, 1998). Several bird species are residents of this site (Martínez, 1993; Bortolus *et al.*, 1998) including swans (*Cygnus melancoryphus* and *Coscoroba coscoroba*), roseate spoonbills (*Platalea ajaja*), flamingos (*Phoenicopterus chilensis*), white-faced ibis (*Plegadis chihi*) and oystercatchers (*Haematopus palliatus*). Due in part to their importance as a stopover site for shorebirds the lagoon is now a "Man and the Biosphere" (MAB) site and is being

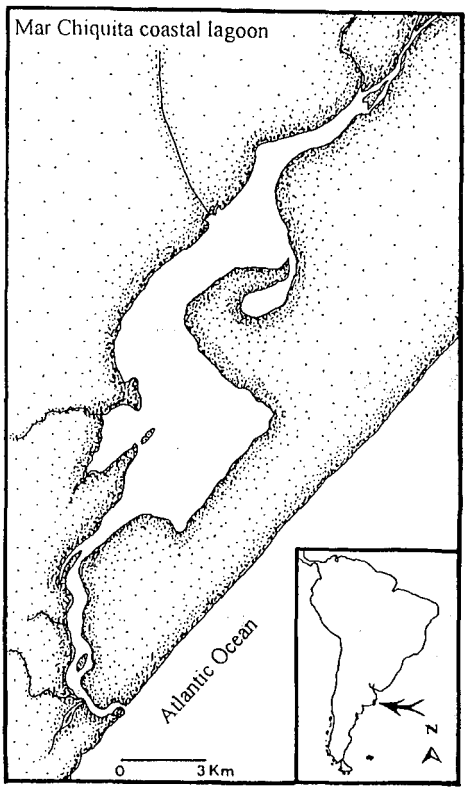

Fig. 1. Map showing the location of the Mar Chiquita Coastal Lagoon (Buenos Aires, Argentina). Inset in the lower right corner shows the location of the lagoon in South America.
Fig. 1. Localització de la llacuna costera de Mar Chiquita (Buenos Aires, Argentina). El requadre de la part inferior dreta mostra la localització de la llacuna costanera a Sudamèrica.

proposed as a "Ramsar" site. However, this is the only SW Atlantic estuarine environment notoriously invaded by the reef-building serpulid *Ficopomatus enigmaticus,* and today the reefs occur in almost all sites of the lagoon (Pezzani & Obenat, 1994).

The size of *Ficopomatus enigmaticus* reefs depends on their location. The areas most covered by reefs are the embayments where the water flow is multidirectional dominated by wind (pers. obs.). In these areas mean depth is 0.4 m depending of rainfall and reefs have an approximately circular shape (Fig. 2). The size is variable (up to 4 m in diameter and 0.5 m in height) and the maximum height depends on the water level (Obenat & Pezzani, 1994). It is also common to find pairs of reefs that are fused (Obenat & Pezzani, 1989; Schwindt, 1997a). When water flow is unidirectional (i.e. in channels and creeks), the shapes of reefs are generally elongated, mainly parallel to current direction. The accumulation of sediment inside the reef produces the mortality of the oldest organisms (Keene, 1980; Pezzani & Obenat, 1988). The abundance of reefs decreases towards the mouth of the lagoon (where salinity increases), and their distribution is restricted to only a few sites (mainly pillars; pers. obs.).

Areas covered by reefs, lead to retention of sediments that would otherwise be transported out of the lagoon (pers. obs.). As a result sediment input to the lagoon during heavy rainfall, river drainage or human activities is accumulating, decreasing the lagoons mean depth (Fasano *et al.*, 1982). *Ficopomatus enigmaticus* is an annual iteroparous whose females may produce 1 to 2 batches of small eggs per reproductive period that are freely released into the water. The eggs develop into planktonic planktothrophic larvae that act as a dispersal phase (Obenat & Pezzani, 1994). There are two larval settlement periods, the first occurs between March and April and the second between November and December (Obenat & Pezzani, 1994), and individuals reach up to 55 mm in length (Obenat, 1984). Individuals are suspension feeders mainly capturing detritus (Olivier *et al.*, 1972b). The only predator described is a reef inhabitant fish (*Austrogobius parri,* Olivier *et al.*, 1972b), a species found at very low density in the lagoon (pers. obs.).

The living polychaetes are at the reef edges and larval settlement occurs between their calcareous tubes (Obenat & Pezzani,

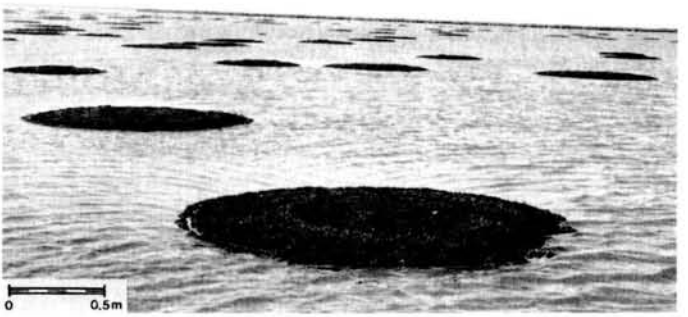

Fig. 2. Photograph showing the size and shape of the *Ficopomatus enigmaticus* reefs.
Fig. 2. Fotografia que mostra la mida i forma dels esculls de Ficopomatus enigmaticus.

1994). Recruitment also may occur on shells, principally on the gastropod *Adelomelon brasiliana*, and secondarily on the bivalves *Mactra isabelleana* and *Tagelus plebeius* (Schwindt & Iribarne 1998). The three species are represented in Holocene fossil shell assemblages (Fasano *et al.*, 1982). However, today only *T. plebeius* lives in the lagoon while *A. brasiliana* and *M. isabelleana* are exclusively marine species. Occasionally the larval settlement occurs on bottles, rocks, pillars bones and dislodged parts of the reefs (pers. obs.), but which always need a hard fixed substratum on the sediment (Obenat & Pezzani, 1994).

Similarly to other reefs, the one's generated by *Ficopomatus enigmaticus* increase the habitat's structural complexity, affecting abundance, diversity and distribution of its associated fauna. In this case there is a significant increase of adults and juveniles of the crab *Cyrtograpsus altimanus* (E. Spivak pers. com.) and recently molted juveniles of the crab *C. angulatus* (4 to 7 mm size) with an abundance of up to 4,800 individuals·m^{-2} (Spivak *et al.*, 1994). The *F. enigmaticus* tubes also provide refuge to numerous organisms (Orensanz & Estivariz, 1971; Schwindt, 1997a) including the mollusk: *Littoridina parchappi*, polychaetes (adults and juveniles): *Laeonereis acuta, Heteromastus similis, Nephtys fluviatilis, Neanthes succinea, Polydora ligni* and *Boccardia hamata*, amphipods: *Corophium insidiosus* and *Melita palmata*. Several aquatic birds (e.g., swans, ducks) use the reefs as resting sites increasing the concentration of guano (pers. obs.). The tubes, which are white when initially secreted, are steadily covered by briozoa (*Conopeum* cf. *seurati*), green algae (*Cladophora* sp. and *Enteromorpha* sp.) and diatoms (Obenat, 1984) as they age. Large grapsid crabs (*C. angulatus* and *Chasmagnathus granulata)* shelter underneath the reefs *C.* (Schwindt, 1997a). *C. angulatus* is the most common crab and their abundance is positively related to the reef size (Schwindt, 1997b).

The soft bottom areas surrounding the reefs are inhabited by four infaunal polychaetes: *Laeonereis acuta, Heteromastus similis, Nephtys fluviatilis* and *Neanthes succinea* (the latter found in low abundance). The abundance of infaunal polychaetes is affected by the reefs, *H. similis* and *L. acuta* decrease in density while *N. fluviatilis*

increase as the result of distance (0.2 m, 2 m and 6 m) to the reefs (Schwindt, 1997a). The meiofaunal organisms that inhabit the upper sediment (approximately 3 cm) are dominated by: ostracods, juvenile polychaetes, copepods harpacticoideos, nematodes, the gastropod *Littoridina parchappi* and the amphipods *Melita palmata* and *Corophium insidiosus*. The most abundant meiofaunal organisms are ostracods and juvenile polychaetes (93% of the total abundance), and their abundance is not affected by the reefs (Schwindt, 1997a). After rainfall periods, and fresh water drainage from the creeks, there are also observed, ciliates, cladocerans, hydroids, gnathostomulids, the shrimp *Palaeomonetes argentinus* and hirudineans (Schwindt, 1997a).

In conclusion the introduction of *Ficopomatus enigmaticus* in the Mar Chiquita coastal lagoon has provoked a significant change in the lagoons ecological and sedimentological dynamics, affecting recreational and sport navigation given the changes in depth. This pattern is similar to changes reported for serpulid in other coastal lagoons (Fornós *et al.*, 1997). Furthermore, all evidence suggests that the reefs have produced a large change in the ecology of this environment, mainly by transforming a soft bottom habitat into a structured hard bottom environment (Schwindt, 1997a; 1997b).

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