INVASION OF *CYPRIDEIS SALEBROSA* (OSTRACODS, CRUSTACEANS) IN BAHIA BLANCA ESTUARY, BUENOS AIRES, ARGENTINA

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ABSTRACT: Large populations of the living benthic ostracoda *Cyprideis salebrosa* Van den Bold, 1963 are reported for the first time from marsh and intertidal mud flat sediments of the Bahía Blanca estuary (Argentina). *C. salebrosa* has been found in current sediments of the inner zone of the estuary of Bahia Blanca in lower densities than 15%. The highest abundance values were recorded in the Villarino Viejo place (VV1-VV4) where 200 individuals of *C. salebrosa* were found in 6 g of dry-sediment, and the B4 samples from the Club Almirante Brown. At this site *C. salebrosa* represents from 96 to 100 % of all benthic ostracoda. Towards the mouth and the outer zone of the estuary (site V and VV) *C. salebrosa* represents approximately from 70 of 100% of the total ostracoda assemblage. The prolific distribution of *C. salebrosa* the levels of eutrophication in the Bahía Blanca estuary is very important in some places and directly affecting the diversity of ostracod assamblages present; It is *C. salebrosa* the only species present on the sites with the highest degree of eutrophication. If these conditions continue throughout the benthic community will be affected.

KEY WORDS: Ostracoda, opportunistic species, Bahía Blanca estuary, eutrophication

Aquatic invasions have become a matter of growing concern for their potential to significantly alter the structure of host ecosystems (Hallegraeff, 1998; Williamson, 1996). Invasive species may rapidly adapt to new environments and act as consumers, prey, competitors or disturbers (Huey et al., 2000; Mooney & Cleland, 2001). Some of them are reported to cause local extinctions, spread diseases or lead to profound ecological change (Colwell, 1996; Mooney & Cleland, 2001). Microcrustaceans ostracods are extensively used for the characterization of the different environments of the past; they have a calcareous shell composed of two valves, are fundamentally benthic with a wide ecological range; inhabit freshwater environments, brackish, marine and hypersaline. They are important paleoecological and paleostratigraphic indicators, since they are very sensitive to ecological changes and have a wide stratigraphic range, because they are recorded from the upper Cambrian to present (Laprida, 2006, 2007). In terms of high pollution the ostracods disappeared and in conditions of enrichment with high levels of nutrients the opportunistic species rapidly increased the number of individuals (Ruiz et al., 2012). We have examined recent and fossil ostracoda assemblages from shallow-water habitats of the Bahía Blanca estuary (Argentina) to assess their potential as indicators of sea-level change. The Bahía Blanca estuary is a large bay inlet system that is home to one of the largest overseas harbors of Argentina. While comparing recent and fossil ostracoda assemblages, we have discovered abundant individuals and dominance of *Cyprideis salebrosa* Van den Bold, 1963 in the recent samples studied. Here, we report the first invasions of the one opportunistic species in the Bahía Blanca estuary and explore possible causes and consequences of this invasions.

MATERIALS AND METHODS

Recent and fossil sediment samples were collected between 2009 and 2011, from cross-transects and outcrops at six locations of the Bahía Blanca estuary (Fig. 1, Table 1). The Bahía Blanca estuary is a complex sedimentary and ecological system in the southern part of the Buenos Aires province. It has a total surface of about 2,300 km^2 and includes marshes (410 km^2), islands and mudflats (1,150 km^2).

Salinities are vertically homogeneous except in the sectors associated with the mouth of streams where the water presents a marked stratification (Piccolo et al., 1987). The Bahía Blanca estuary houses the largest deepwater harbor of Argentina and contains commercial, petrochemical and naval bases. The harbor receives large commercial vessels and ships from Europe, Asia, Oceania, Africa and South America (Puerto de Bahía Blanca), but mostly from the tropical regions of Brazil. In relation to organic pollution, the estuary of Bahia Blanca, in the last decades, It has been heavily affected by intense human activity, associated especially to urban development, by the constant and increasing sewage effluents dump raw or inadequately treated. These are the second contribution of freshwater estuary receives, after the addition of the river Sauce Chico and Arroyo Napostá Grande (Streitenberger & Baldini, 2010). Human activities in the last century have caused significant alterations in the structure and functioning of natural environments (Nowicki & Oviatt, 1990; Vitousek et al., 1997; Smith et al., 1999). Both temperature and dissolved oxygen (very interrelated parameters, because the solubility of oxygen in water decreases with increasing temperature) they have soft seasonal variation, registering the highest values of temperature in summer coinciding with the minimum values of dissolved oxygen, in all cases the values of dissolved oxygen are appropriate for biological growth (Freije & Marcovecchio, 2004).

Recent material was collected at stations off Villa del Mar (V) is in the outer area of the main channel (Canal Principal), located transitional between estuarine environments that are dominated by fine and sandy sediments., the Club Almirante Brown (B) is located in the inner area of the estuary, situated in the intertidal zone next to salt marshes., in the Canal Maldonado (M) is located within a typical salt marsh environment in the inner portions of the estuary and the Villarino Viejo ; this area is characterised by silt and clay muddy tidal flats and salt marshes, habitats of burrowing crabs (*Chasmagnatus granulata*) and halophytic plants (*Salicornia ambigua*). All samples (# =28) were collected by hand and include material from the top 2 cm (Fig. 1). The internal sector of Canal Principal has been recognized as naturally eutrophic system, due to high levels of inorganic nutrients that occur in the water column, along almost all year (Freije & Marcovecchio, 2004). The proximity of cities, an important industrial area and agricultural activities in the area provide the estuary of Bahia Blanca a large discharge of organic waste, which it has increased significantly in the last decade (Marcovecchio et al., 2008). The fossil material was recovered from two outcrop core (TB and PD24) (for detailed locations see Fig. 1 and Table 1). The core (TB) It was obtained by vibrocore in the Bahía del Palo channel, Tierra Firme channel tributary, which in turn it is a tributary of Tres Brazas channel, which flows into the Principal channel of the estuary of Bahia Blanca. For reasons of greater simplicity, henceforth it is assigned the acronym TB this core. Core the ceiling is 1.25 m above mean sea level, being the tidal range syzygy this place the order of 3.5 m. This core has four radiocarbon date: the first one is the 488.89 cm deep and yielded an age conventional of 5,090±40 B.P. (BETA 282197) (calibrated

5,662-5,907 years B.P.), the second at 280 cm with a conv. age of 4,760 ± 40 B.P. (BETA 282198) (cal. 5,322- 5,583 years B.P.), the third located to 231.11 cm deep threw a conventional age of 4,040 ± 70 A.P. (BETA KIA 42949) (cal. 4,240-4,808 years B.P.) and the fourth radiocarbon date, obtained the 71.11 cm deep, gave a conventional age of 3,188 ± 64 A.P. (ARIZONA x28022) (cal. 3,176-3,553 years B.P.). The material from the core and from the outcrops were radiocarbon dated (Gómez et al., 2011; Kihn unpublished data).The core PD24 comes from the foreign sector to the islands that make up the estuarine environment, approximately 20 km offshore from the mouth of the main channel, with greater than 16,3 m deep which currently dominates the high energy given by the action of tidal currents and ocean waves. The material from the core and from the outcrops were radiocarbon dated (Carbonella et al., 2012, 2014; Kihn unpublished data).

All samples studied in this work were dissolved in hydrogen peroxide (H_2O_2) in a concentration of 10%. They were then screened with a sieve of 63 microns mesh. Once the process was completed the residue is collected in a petri dish. Then the material was a heater a 50°C, after drying proceeded to recover by picking technique total valves ostracod present. For taxonomic identification followed the generic classification proposed by Moore (1961). Local literature was used for specific determination (Bertels et al., 1990, 1997, 1999; Ferrero, 2006, 2009; Laprida, 2006, 2007, 2009; Whatley et al., 1975, 1987, 1988, 1995). The photographs were taken with a scanning electron microscope Leo EVO 40, the Regional Center for applied and basic research Bahia Blanca (CRIBABB).

RESULTS

Quantitative faunal analysis and specific identification of recent and fossil material revealed that *Cyprideis salebrosa* is particularly abundant at almost all sample sites where recent material was collected (Fig. 2). All fossil sample material recovered from TB and PD24 cores contained abundant benthic ostracoda but *Cyprideis salebrosa* presents few specimens and is among the less numerous species (Table 3). Live specimens were recovered in all current sediment samples. Quantitative analysis of ostracoda assemblages from the Bahía Blanca estuary shows that *C. salebrosa* makes up between 10 and 100 % of the total ostracoda assemblages. The highest abundance values were recorded in the Villarino Viejo place (VV1-VV4) where 200 individuals of *C. salebrosa* were found in 6 g of dry-sediment, and the B4 samples from the Club Almirante Brown. At this site *C. salebrosa* represents from 96 to 100 % of all benthic ostracoda. Lower abundances were recorded in sample M1, M3 and M4 (Table 2). Towards the mouth and the outer zone of the estuary (site V and VV) *C. salebrosa* represents approximately from 70 of 100% of the total ostracoda assemblage (Table 2).

DISCUSSION AND CONCLUSION

The diversity of ostracods drastically decreases under high pollution, the ostracod faunas are represented by opportunistic species tolerant to hypoxic conditions (Ruiz et al., 2012).The benthic ostracoda *C. salebrosa* live in a wide range of salinities of hypohalite environments (0 %.-29%.), in a temperature range from 15° C to 25° C and sandy-silty sediments, rich in organic detritus and coastal vegetation (Ornellas & Würdig, 1983; Ramírez, 1967). Our analysis of modern ostracods assemblages shows that *Cyprideis salebrosa* is widely distributed and abundant throughout the modern habitats of the Bahía Blanca estuary. The abundant occurrences of *C. salebrosa* and its apparently rapid proliferation show that the increase in anthropic action on these sites favors the development of this opportunistic species. A survey of the available literature on recent ostracoda shows that to date *C. salebrosa* has been found in current sediments of the inner zone of the estuary of Bahia Blanca in lower densities than 15% (Martínez, 2005). Literature records and analysis of core assemblages thus suggest that the invasion of *C. salebrosa* in the Bahía Blanca estuary is a comparatively recent event. The large increase in the populations of *C. salebrosa* in recent years in the estuary of Bahia Blanca demonstrates that human activity produces changes in the environment that favors the development of this species.

Nixon (1995a) defines eutrophication as an increase in the rate of contribution of organic matter, definition that is practical because the term relates to the amount of material available to support metabolic demands of the system. In marine environments, eutrophication involves a complex set of phenomena which are triggered by the increase in limiting nutrients. Coastal systems in the complex set of direct and indirect responses enrichment with excess nutrients include changes in the distribution and biomass of plant species, biochemistry sediment, nutrient dynamics and environmental quality (McKee et al., 2002; Pennings et al., 2005). Excess nutrients in addition to directly increase primary productivity of the system, they can also alter benthic communities, trophic relationships and other types of interactions indirectly (Robertson et al., 1992). The stress response of an estuary may be influenced by the composition of species present in the system (Silliman et al., 2005). When we consider the benthos, once the eutrophication is a developing process can be generated unfavorable conditions for biota. Some of the indirect effects of increased production of organic matter are oxygen depletion (generating hypoxia or anoxia conditions), changes in the composition and species interactions. Is known the importance of eutrophication in an environment and many of its consequences, but little is known about the possible response of benthic communities to this new state of the system and the consequences for the dynamics of nutrient flows. Pearson & Rosenberg (1978) developed a qualitative model, which it is based on changes that occur in abundance, biomass and the number of species in a given environment, with increasing organic matter enrichment. According to this model, changes in these variables follow a typical pattern which can be described as follows: in the early stages of eutrophication, as organic contribution increases, the number of species and also increase the total biomass. This trend continues until it reaches a relative maximum from which, if the organic enrichment increases, both biomass and species richness decreases. If the eutrophication process progresses, the reducing conditions in the sediments are intensified and is usually seen a secondary peak of biomass and abundance of individuals associated with small and opportunistic species, if the continuous enrichment, at the end of all fauna gradient disappears. The prolific distribution of *C. salebrosa* the levels of eutrofhication in the Bahía Blanca estuary is very important in some places and directly affecting the diversity of ostracod assamblages present; It is *C. salebrosa* the only species present on the sites with the highest degree of eutrophication. If these conditions continue throughout the benthic community will be affected.

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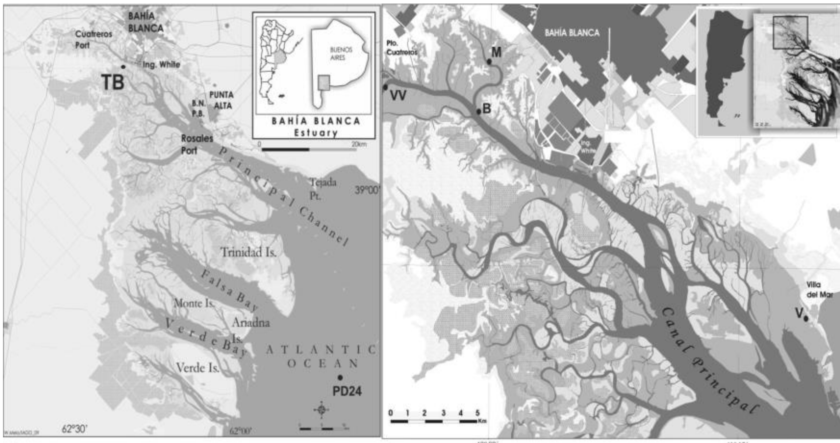

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Figure 1. Map showing the sites studied: 1. cores; 2. current sites.

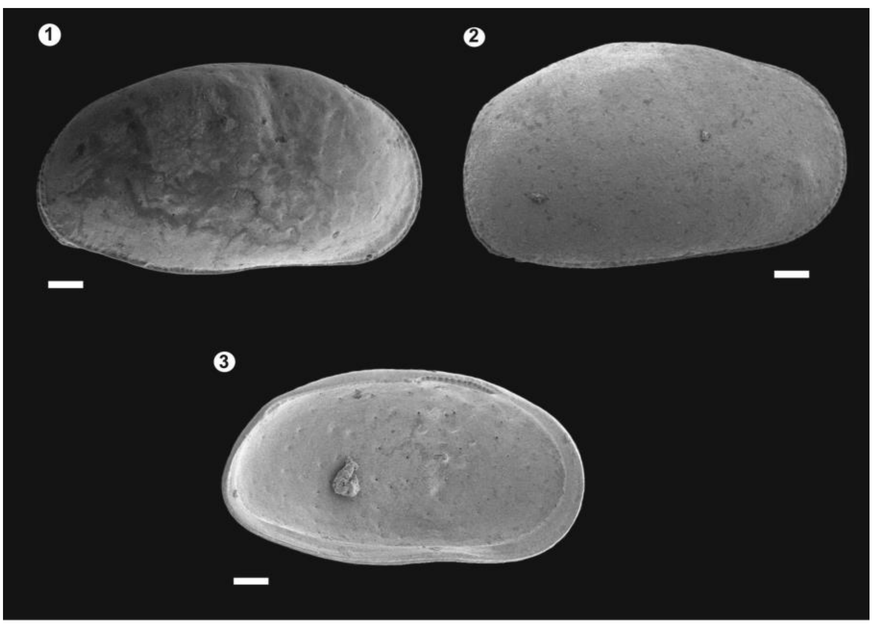

Figure 2. Recent specimens of *Cyprideis salebrosa* from intertidal environments of the Bahia Blanca estuary (Argentina): 1. Right valve male external view, 2. Right valve female external view, 3. Male left valve internal view. Scale bar= 30 μm.