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HERE COME THE CLAM: SOUTHERNMOST RECORD WORLDWIDE OF THE ASIAN CLAM *CORBICULA FLUMINEA* (PATAGONIA, ARGENTINA)

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The invasive Asiatic clam, *Corbicula fluminea* (Müller, 1778), is reported in new localities from the Negro River, from Conesa until Viedma. Fourteen years since its first record in this area, the species has established in the entire Negro River basin, upstream until Cipolletti and downstream until Viedma, where it reached densities up to 525 ind/m^2. The most probable dispersal vector of clams is passive upstream and downstream transport which is probably facilitated by some human activities, such as fishing, fish stocking, recreational activities, sand and gravel extraction. This work state the southernmost record worldwide of *C. fluminea*.

Key words: *rivers*; dispersal; introductions; Negro River; invertebrates; alien species.

INTRODUCTION

Invasive species are considered a huge environmental problem worldwide, with known impacts in biodiversity [*e.g.* Kaufman, 1992], ecosystem functioning [Sousa *et al.* 2011] as well as economic and human health [*e.g.* Pyšek & Richardson, 2010].

The human - assisted spread of non - indigenous fishes and aquatic invertebrates, microbes and plants has had strong ecological impacts in lakes and rivers worldwide [Ricciardi & McIssac, 2011]. One of the most “efficient” worldwide freshwater invaders, listed among the 100 worst invasive alien species [DAISIE 2009] is the Asian clam or so called basket clam, *Corbicula fluminea* [O.F. Müller, 1774]. *C. fluminea* has many traits that let it become a successful invasive species: rapid growth, early sexual maturity, and high fecundity among others [reviewed in Sousa *et. al.*, 2008].

The Asian clam has been reported as indigenous from Southern and eastern Asia (eastern Russia, Thailand, Philippines, China, Taiwan, and Korea). However, *Corbicula fluminea* has been widely distributed worldwide [Sousa *et. al.*, 2008]. It can be founded as an introduced species in North and South America [Darrigran, 2002; Strayer, 1999], Europe [Araujo *et. al.*, 1993] and Japan [Magara *et al.*, 2001].

In South America, *C. fluminea* was first reported in del Plata basin in 1979 [Ituarte, 1981]. *C. fluminea* has been also reported in Uruguay [Darrigran, 2002], Brazil [Mansur *et al.*, 2003; Maroneze *et al.*, 2011] and Colombia [de la Hoz Aristizábal, 2008].

Since Ituarte's report [Ituarte, 1981] in Argentina its distribution has continuously increased and now *C. fluminea* can be found in several rivers and streams in the Buenos Aires province (Argentina) [Martín & Estebenet, 2002; Martín & Tiecher, 2009] and also has reached some Patagonian’s rivers [Colorado River, Cazzaniga, 1997; Negro River, Cazzaniga

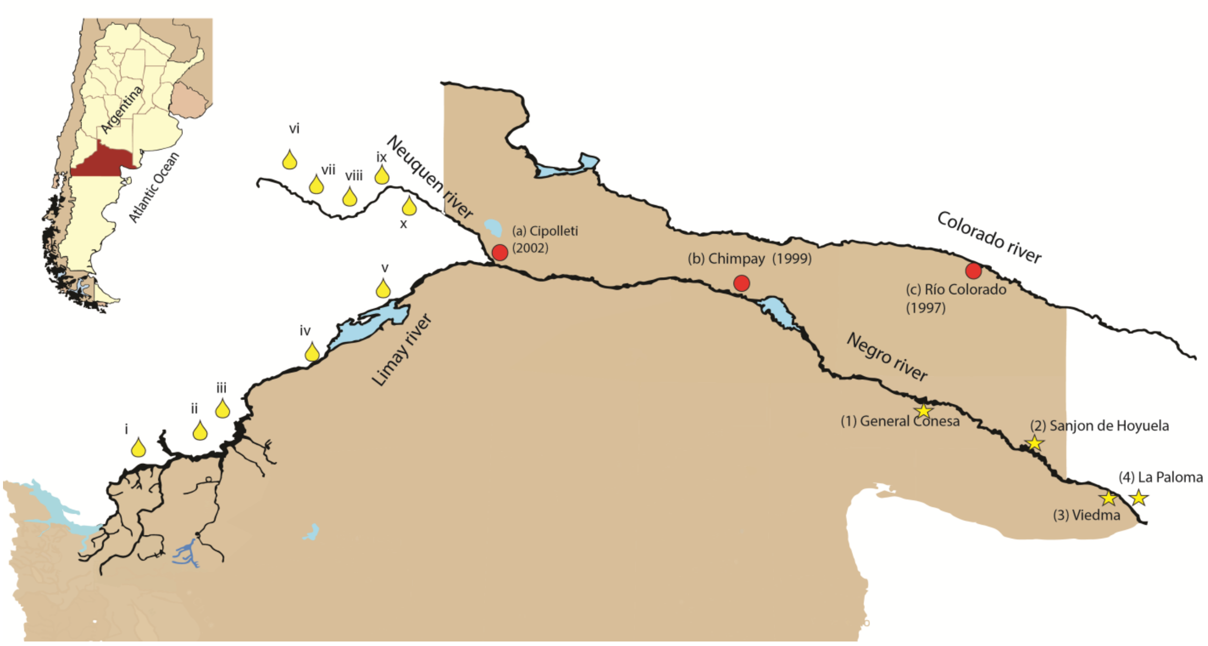

Figure 1. Map of Río Negro province showing the location of sites referred in the text and inset map of Argentina showing the study area. *Circles*: previous records (a= Cipolleti (Semenas & Flores, 2005); b= Chimpay (Cazzaniga & Perez, 1999); c=Río Colorado City (Cazzaniga, 1997). *Stars*: spatial distribution of sampling sites (1= Conesa; 2= Zanjon de Hoyuela; 3=Viedma; 4= La Paloma). *Drops*: Dams on Limay River (i- Alicura, ii- Piedra del Aguila, iii- Pichi Picún Leufú, iv- El Chocón, v-Arroyito) and Neuquén River (vi- Portezuelo Grande, vii- Loma de la Lata, viii- Marí Menuco, ix- Planicie Banderita, x- El Chañar)

& Peréz, 1999; Limay and Neuquen rivers, Semenas & Flores, 2005].

In this paper we report *C. fluminea* downstream spread along one of the most important rivers of Patagonia, the Negro River, since the last southernmost invasion report [Cazzaniga & Perez, 1999] until the river end, being this record the latest southernmost record worldwide of this invasive species.

MATERIALS AND METHODS

Study area

The Rio Negro basin is located to the north of Patagonia, where the river flows approximately 869 km from the mountains up to the Atlantic Ocean (Figure 1). Its current outflow is muffled by the presence of reservoirs damming and hydroelectric dams that regulate it placed in its tributaries rivers, Limay River (Dams: Alicura, Piedra del Aguila, Pichi Picún Leufú, El Chocón and Arroyito; Figure 1) and Neuquén River (Dams: Portezuelo Grande, Loma de la Lata, Marí Menuco, Planicie Banderita and El Chañar; Figure 1) The Negro River has three principal sections: high, middle and low valley.

The river's water have been characterized as slightly alkaline [Abrameto, 2004], low organic carbon content (1.2 mg * L^{-1}) and suspended particulate matter (16 mg * L^{-1}) [Gaiero *et al.*, 2002]. It receives the contribution of drainage channels, transporting salty water derived from fruit activity and from its associated industry, introducing to the river organic matter, nutrients and xenobiotic substances, products of the anthropic activities that are developed in the region.

The specific sites where *C. fluminea* was searched corresponds to the last section of the river, covering a river distance of 250 km between Conesa city (40°6' S 64°27' W) and the river end (40°58' S 62°49' W, Figure 1). The substrate is composed of a mixture of sand, mud. and gravel. Vegetation was absent.

Figure 2. Individuals of *Corbicula fluminea* collected in the Negro River.

Field sampling

In December 2011 we found a few isolated clams (Figure 2) in sediment samples at Conesa city, during a field survey intended to determine heavy metals concentrations at river's sediment.

After that, we carried out a systematic sampling downriver to test the presence and abundance of this species. The samplings were made between the last southernmost record (Chimpay - 39°9'55.75" S 66°8'55.32" O' - figure 1)

[Cazzaniga, 1997] and the Negro's River end, with five sampling stations: Conesa, Guardia Mitre, Sanjon de Hoyuela, Viedma y La Paloma, covering 250 km long, from summer 2011 to spring 2013 (Conesa, Sanjon de Hoyuela y La Paloma once in summer 2011; Viedma, once in summer 2011, 2012 and once in spring 2013).

At each station 20 PVC cores of sediment (20 cm in diameter and 10 cm in depth) were taken from the sediment in each sampling date. Sediment was washed and sieved through a 500 µm mesh screen. Specimens of clams retained were preserved in fridge, and then were counted and measured (height) using an electronic caliper. Although this was a descriptive investigation, we performed descriptive statistic for morphometric characters, and one way ANOVA to test differences in density between localities. Also in Viedma station, we tested between years variation using a student t test [Zar, 1999].

RESULTS AND DISCUSSION

We found the Asian clam in all the sampling stations along the Negro River. Number and length of specimens of *Corbicula fluminea* collected at different stations are shown in table 1. The specimens collected were larger at the Viedma y La Paloma sampling sites, being the smallest ones registered at Hoyuela sampling site (Figure 3). There were significant differences in density between sampling sites (ANOVA, $F_{(3;422)} = 436{,}24$; $p < 0.001$). The highest densities were found at Viedma city, and the lowest ones at Conesa (Table I).

It is worth noting that one of us (LM) has found the clam since 1997 at Viedma city, but it was not reported because he did not know that it was an invasive species [Molina, personal communication].

The first records of the Asian clam *Corbicula fluminea* in Patagonia were from the Colorado River at Río Colorado city in 1997 [Cazzaniga, 1997] (figure 1) and two years later in Negro River at Chimpay [Cazzaniga & Perez, 1999] (figure 1). In 14 years the species has established in the

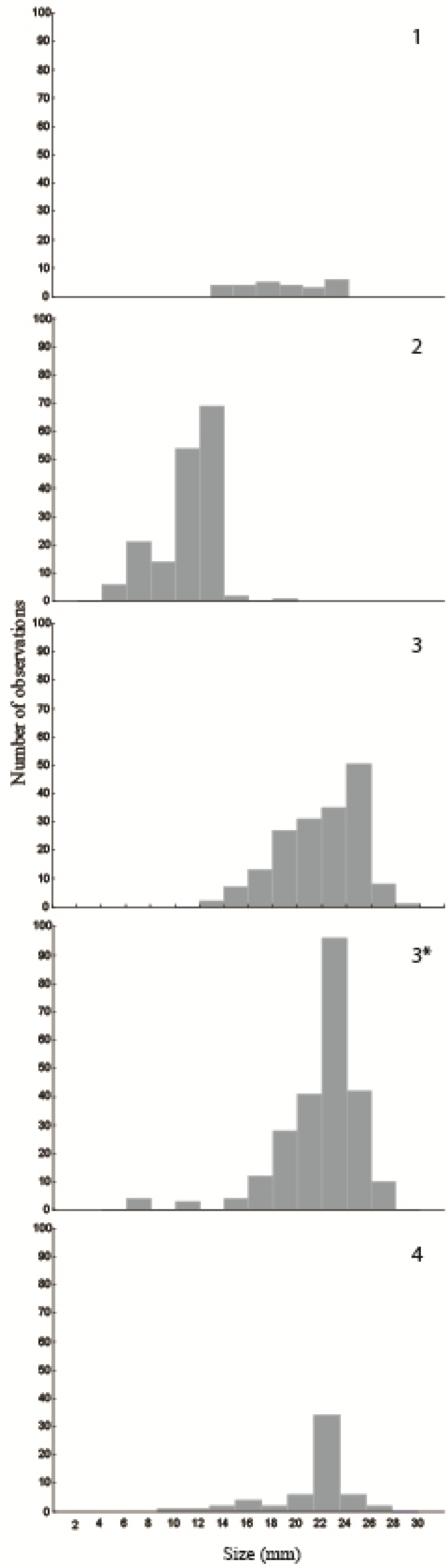

Figure 3. Histogram of measurements of the collected specimens of *Corbicula fluminea* from: 1 - Conesa (2011); 2 - Zanjon de Hoyuela (2011); 3 - Viedma (2011); 3* - Viedma (2013); 4 - La Paloma (2011).

Table 1. Abundance and length of *Corbicula fluminea* collected at different sites. The first column shows shells length measurements; last columns shows the average density and its standard deviation in each place

	Size						Density			
	N	Mean	Median	Min	Max	Std.Dev.	Mean	Min	Max	Std.Dev.
Conesa	26	18,62	18,37	12,94	24,15	3,45	40,28	0,00	162,50	65,78
Hoyuela	167	10,97	11,64	4,76	18,25	2,34	117,36	0,00	356,25	126,51
Viedma	175	21,93	22,40	12,58	28,42	3,17	166,67	25,00	525,00	170,82
La Paloma	58	19,97	21,12	9,68	25,43	3,12	60,42	0,00	93,75	33,23

entire Negro River basin, upstream until Cipolletti [Semenas & Flores, 2005] and downstream to Viedma (this work), where it reached densities up to 525 ind./m^2. The most probable dispersal vector of *C. fluminea* is passive upstream and downstream transport, which is probably facilitated by some human activities, such as fishing, fish stocking, recreational activities, sand and gravel extraction [Sousa *et al.*, 2008]. This work states the southernmost record worldwide of *C. fluminea*.

Conclusions

Several factors favour for the presence of *C. fluminea* in most locations, such as their ability to reproduce asexually and to survive in a wide range of environmental conditions, plus the absence of predators [Sousa *et al.*, 2008].

The ecological impact of *C. fluminea* in the study area needs determination, especially its effect on community structure. Further work is required to determine the clam effects on other bivalve species like *Diplodon chilensis*. This species is an important component of the fauna of lotic and lentic water bodies, living in muddy substrate, sandy loam, unusually on hard substrate, filter feeding, with an important role as recyclers of organic matter [Soto and Mena, 1999; Semenas and Brugni 2002], and sensible to ambient contamination [Bogan, 1993; Darrigran, 1999; Bogan, 2008; Clavijo, 2009], and to interspecific competition with invaders who change the native composition of molluscs [Mansur *et al.*, 2003; Scarabino, 2004; Cherry *et al.*, 2005; Darrigran and Damborenea, 2005; Scarabino and Mansur 2008; Clavijo, 2009].

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