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The gastropod *Vitta zebra* (Bruguière, 1792) (Neritidae): a possible amphidromous species threatened by human impact in Brazilian rivers

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Abstract

The gastropod Vitta zebra *(Bruguière, 1792): a possible amphidromous species threatened by human impact in Brazilian rivers*. Amphidromous organisms grow, feed and reproduce in rivers but the newly hatched larvae migrate to the marine environment where they develop. The juveniles then migrate to fresh water. The present study aims to record the occurrence of the gastropod *Vitta zebra* in the São Francisco River, northeastern Brazil, and to warn of the risks the species faces due to the possible effects of human impact on its life cycle. Studies on the presence of the species in this river are required in order to develop conservation strategies.

Key words: Hydrographic basin, Conservation, Neritimorpha, Animal behavior

Resumen

El gasterópodo Vitta zebra *(Bruguière, 1792): una posible especie anfídroma amenazada por impactos humanos en ríos brasileños.* Los organismos anfídromos son aquellos que crecen, se alimentan y se reproducen en ríos, cuyas larvas recién nacidas migran al medio marino, donde se desarrollan, y los juveniles regresan al agua dulce migrando río arriba. El objetivo de este estudio es registrar la presencia del gasterópodo *Vitta zebra* en el río São Francisco, en el nordeste de Brasil, así como advertir sobre los riesgos a los que se enfrenta la especie habida cuenta de los impactos que sufre el río y que pueden interferir en el ciclo de vida de la misma. La presencia de *Vitta zebra* en este río requiere prestar atención a los estudios sobre su biología a fin de desarrollar estrategias para su conservación.

Palabras clave: Cuenca hidrográfica, Conservación, Neritimorfos, Comportamiento animal

Resum

El gasteròpode Vitta zebra *(Bruguière, 1792): una possible espècie anfídroma amenaçada per impactes humans en rius brasilers.* Els organismes anfídroms són aquells que creixen, s'alimenten i es reprodueixen en rius, les larves dels quals tot just néixer migren al medi marí, on es desenvolupen, i les juvenils retornen a l'aigua dolça migrant riu amunt. L'objectiu

d›aquest estudi és registrar la presència del gastròpode *Vitta zebra* al riu São Francisco, al nord–est del Brasil, com també advertir sobre els riscos que ha d'afrontar l'espècie atesos els impactes que pateix el riu i que poden interferir en el seu cicle de vida. La presència de *Vitta zebra* en aquest riu requereix prestar atenció als estudis sobre la seva biologia per tal de desenvolupar estratègies destinades a conservar–lo.

Paraules clau: Conca hidrogràfica, Conservació, Neritimorfs, Comportament animal

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Introduction

Amphidromy is a type of diadromy that can occur in fish (Thuesen et al., 2011), decapod crustaceans (Bauer, 2013), and gastropod mollusks (Pyron and Covich, 2003; Cook et al., 2010). In amphidromy, individuals grow, feed and reproduce in rivers. The newly hatched larvae migrate to the sea, where they feed and grow. Once developed, the juveniles return to freshwater (Bauer, 2013; Abdou et al., 2015).

Among the Mollusca, Gastropoda stand out as the most diversified group. This diversity is paralleled by variations in modes of life, with species occurring on land, in freshwater and in marine environments. Some neritid snails have an amphidromous life cycle (Kano and Kase, 2003; Blanco and Scatena, 2005); they are initially confined to fresh or brackish waters as adults, after completing their larval development in marine environments (Schneider and Lyons, 1993). Although data have been reported for some species, little is known concerning the practical details on how long the larvae survive in the ocean and how they migrate upstream (Blanco and Scatena, 2005, 2006; Barroso and Matthews–Cascon, 2009a). In a study by Tate (1870) (ap. Andrews, 1935), individuals of *Neritina listeri* (Bruguière, 1792) (amphidromous species) from rivers in Martinique were kept in an aquarium for three years, but the veligers that were released from their capsules after three weeks never metamorphosed, suggesting that they would need to be carried out to sea to complete their development. Eichhorst (2016) considered *N. listeri* (partly) a synonym of *V. virginea* (Bruguière, 1792). These factors have important implications, since in order to develop strategies for their preservation, it is crucial to understand their life cycle (Abdou et al., 2015).

The neritid *Vitta zebra* (Bruguière, 1792) measures up to 23 mm in shell length and is distributed from French Guiana to Southeastern Brazil (São Paulo State) (Barroso et al., 2012) where it is found in fresh or brackish waters, on intertidal rocks, mangrove roots, and muddy bottoms (Barroso et al., 2012; Eichhorst, 2016). Studies on this species to date have described its taxonomy (Baker, 1924; Russel, 1941; Matthews–Cascon et al., 1990; Mienes, 1991), anatomy (Calvo, 1987; Barroso et al., 2012), intracapsular development (Barroso and Matthews–Cascon 2009a), and ecology (Barroso and Matthews–Cascon, 2009b).

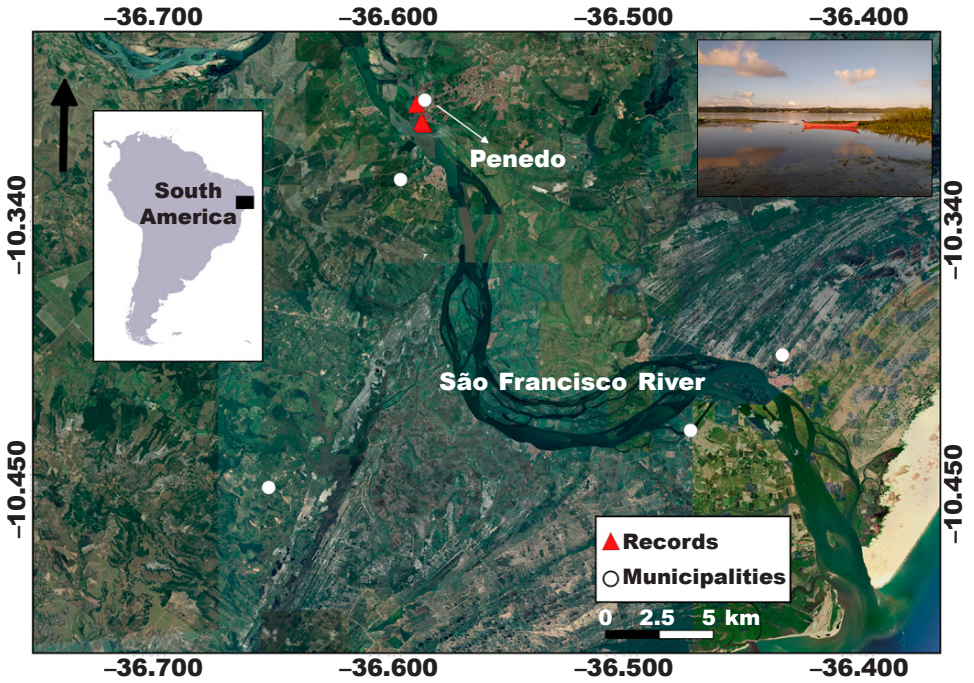

Fig. 1. Location of the municipality where *Vitta zebra* was recorded.

Fig. 1. Localización del municipio donde se registró Vitta zebra.

The present work aims to record for the first time the occurrence of the gastropod *V. zebra* in the São Francisco River, northeastern Brazil, highlighting the importance of its amphidromy, which makes the species particularly vulnerable. The need for migration to complete its life cycle could be interrupted by human impact and the constant changes in the São Francisco River, a major river in Latin America. It has a hydrographic basin of approximately 640,000 km^2, corresponding to about 7.5 % of the Brazilian territory. Among the rivers which are entirely Brazilian, it is also the largest: it is born in the State of Minas Gerais, crossing this and the State of Bahia in a south–to–north direction, then running from west–to–east between this and the State of Pernambuco, and finally flowing into the Atlantic Ocean on the border between Alagoas and Sergipe States.

Specimen collection

Live adult specimens of *V. zebra* were collected from two locations in the municipality of Penedo: Prainha (10º 17' 51" S, 36º 34' 59" W) and Rocheira (10º 17' 21" S 36º 35' 10" W). These two locations are situated in the south of the State of Alagoas, northeast Brazil, and are about 1 km apart (fig. 1). Both locations are about 40 km from the mouth of the São Francisco River.

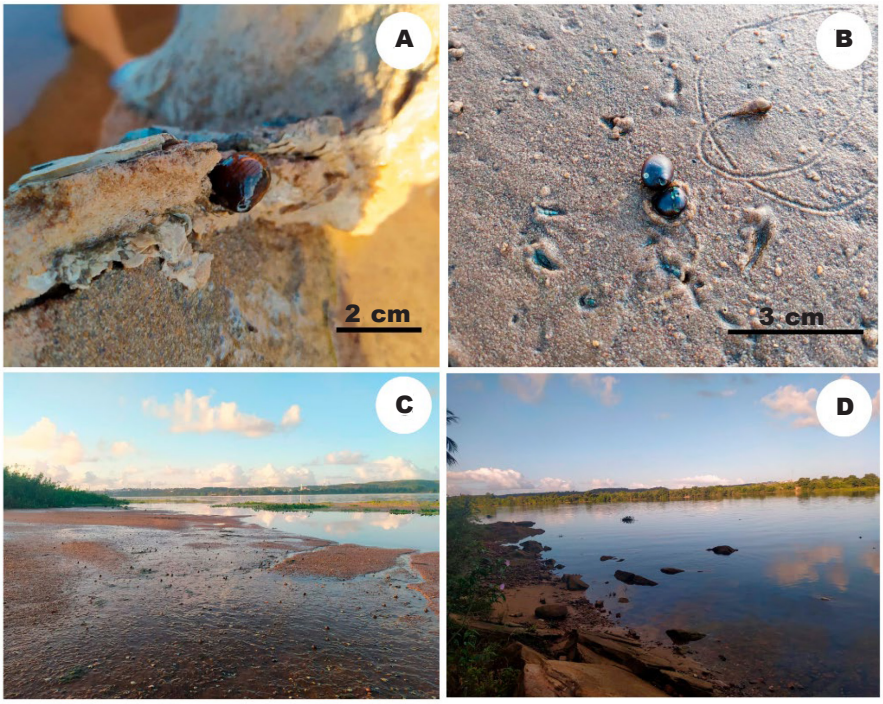

Fig. 2. View of the fresh water gastropod *Vitta zebra* in its habitat: A, an individual of *V. zebra* on the consolidated substrate (rock); B, two individuals of *V. zebra* on the unconsolidated substrate (sand); C, overview of the first collection site; D, overview of the second collection site.

Fig. 2. Vista del gasterópodo de agua dulce Vitta zebra *en su hábitat: A, un individuo de* V. zebra *en sustrato consolidado (roca); B, dos individuos de* V. zebra *en sustrato no consolidado (arena); C, vista general del primer punto de recolección; D, vista general del segundo punto de recolección.*

Both populations were found on the left bank of the São Francisco River, in clean, clear water, on rocks and boulders or on sand (fig. 2). The collected animals were fixed in ethanol and deposited in the molluscan collection of the Zoology Museum of the University of Campinas, Campinas, São Paulo (ZUEC–GAS 7927 to 7929), and in the Malacological Collection 'Prof. Henry Ramos Matthews'–Series B (CMPHRM 6710B) of Universidade Federal do Ceará, Fortaleza, Ceará, both in Brazil. Identification follows Barroso et al. (2012).

Implications for its conservation

In the development of amphidromous gastropods, following metamorphosis and distribution of larvae, juveniles spend a few weeks at the mouth of the rivers, near the sea, and then migrate upstream for a distance that may exceed 10 km (Abdou et al., 2015). The distance that amphidromous species need to migrate before reaching the ocean has a great impact

on the survival of populations (Pyron and Covich, 2003; Blanco and Scatena, 2005); the greater the distance, the more obstacles they will have to face. The locations where the populations of *V. zebra* were found are about 40 km from the sea; from there, the São Francisco River flows smoothly, without natural interventions by barriers such as waterfalls, or interruptions by dams, ending at the river mouth that is geomorphologically marked by the coastal plain, with nearby altitudes less than 100 meters, quaternary sediments (dunes and alluvium) and some patches of cretaceous sediment.

Barroso and Matthews–Cascon (2009a) studied the spawning of *V. zebra* and its intra–capsular development under laboratory conditions and observed that when the salinity was reduced from 15 to 10 ppt, the capsules opened after 26 or 27 days, releasing the veliger larva. Thus, amphidromy was suggested for this species, although direct evidence of this behavior was not observed. From the population record of *V. zebra* in the São Francisco River, some questions arise, such as how this species manages to migrate 40 km upstream against water currents and whether this migration seasonal. Blanco and Scatena (2005) observed 44 migratory aggregations of *N. virginea* in northeastern Puerto Rico. These occurred at least once a month and were strongly related to recurrent floods after periods of great river discharge. These aggregations were mainly composed of young individuals (5–7 mm) that would trigger the spatiotemporal distribution of predators and food as a trigger to initiate migration, in correlation with variations in water discharge and speed. According to the authors, these migrations are strongly influenced by the search for stable habitats, which are preferred both as areas of residence and of passage during 'upstream' migrations. These habitats must therefore be protected in order to conserve these populations. Blanco and Scatena (2006) continued to study the upstream migrations of *N. virginea* and the effects of different abiotic variables on these migrations. They observed, for example, that populations of *N. virginea* were not found in rivers that were disconnected from the ocean for most of the year, due to changes in the average monthly flow and sediment accumulation at the mouth. They concluded that neritids can be used as biological indicators of the physical and chemical integrity of rivers and highlighted the importance of the correct management of tropical coastal rivers for the maintenance of populations. As far as we know, migrations of *V. virginea* and *V. zebra* have not been observed in Brazil.

According to the secondary databases SpeciesLink (https://splink.cria.org.br/) and GBIF (Global Biodiversity Information Facility, https://www.gbif.org/), *V. zebra* occurs in almost all Brazilian hydrographic basins, with no records so far for the São Francisco River; this being the first one (fig. 3). Geographic distribution data of the species deposited in the collection of the Zoology Museum of the University of São Paulo, and data from the Malacological Collection 'Professor Henry Ramos Matthews' of the Federal University of Ceará (UFC), were also gathered. Studies on the development of *V. zebra* are needed to understand how and when the larvae are produced, to determine their swimming and settlement behavior, and to investigate how changes in rivers influence these aspects.

It is especially important to highlight the recurring impact that the São Francisco River has undergone in recent years. Considered the river of national integration as it is the link between the southeast and midwest with the northeast of Brazil, this important river has undergone pressure from human activities developed in areas of drainage, intense human occupation, and commercial exploitation, impacting on the local fauna (Alves and Leal, 2010). Another major threat can be highlighted if we consider that physiological changes related to ontogeny in amphidromous species are influenced by physical characteristics, such as salinity. Salinity at the mouth of the São Francisco River has increased due to the reduction of floods that manage to push the saline wedge back into the sea. When this flooding does not occur, the saline wedge is established in the river channel. Flood reduction is a result of the installation of hydroelectric plants. Baker (1924) cited *V. zebra* as a native species of Dutch Leeward Islands (Netherlands Antilles) and pointed out that this species has not been collected as there has possibly been a local extinction due to the conversion of estuarine habitats into saltpans.

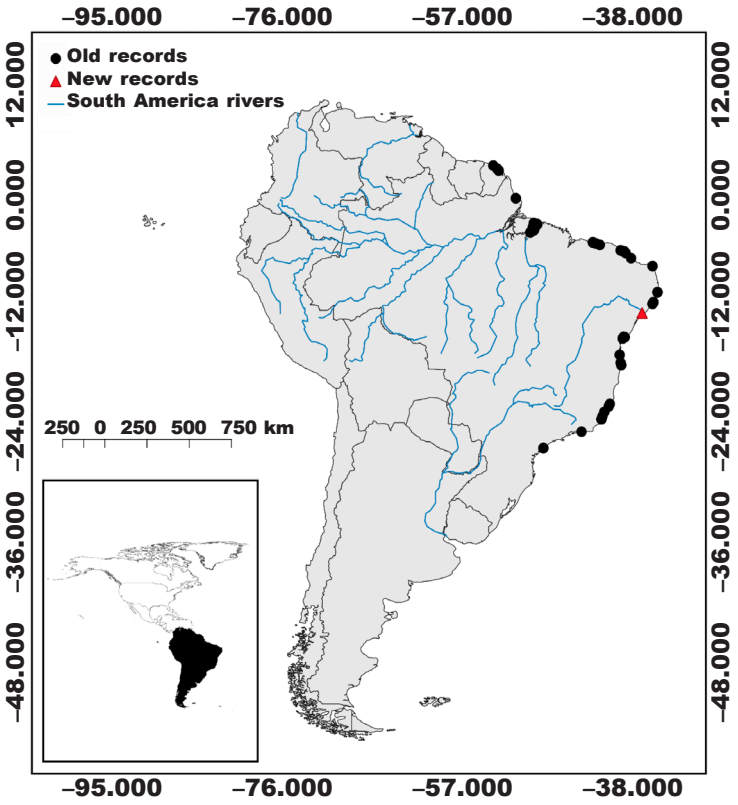

Fig. 3. Distribution of *Vitta zebra* in South America taken from secondary databases, including its new records in the São Francisco River.

Fig. 3. Distribución de Vitta zebra *en América del Sur a partir de bases de datos secundarias, incluidos los nuevos registros en el río São Francisco.*

Final remarks

Degradation has a strong impact on these marine environments, mainly in relation to migratory pathways, making it unfeasible for several species to complete their life cycle, as seen with the amphidromous gastropod *Neritona granosa* (GB Sowerby I, 1825), in the Hawaiian streams (Gorbach et al., 2012). In the places where *V. zebra* was found in the São Francisco River, the anthropic action was intense; the presence of numerous bathers, kiosks and bars all contributed to the generation of pollution. The study of *V. zebra* in the São Francisco River calls our attention to the need for research about its life cycle in relation to environmental conditions, larval migration, and factors that influence its distribution. Research into the biodiversity of the São Francisco River, taking the biology of each species into account, is also needed to determine appropriate conservation actions.

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