

Rapid Communication

Updated distribution and range expansion of the gastropod invader *Melanoides tuberculata* (Müller, 1774) in Brazilian waters

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Received: 6 October 2017 / Accepted: 10 June 2018 / Published online: 1 October 2018

Handling editor: Kenneth Hayes

Abstract

Melanoides tuberculata (Müller, 1774), a mollusc native to the Afrotropical and Palearctic regions, has established populations in a number of localities in the Neotropical region. This non-native species was introduced to Brazil prior to 1970, but this record was only reported in the literature in 1986, and its invaded range has continued to expand. In this work, based on scientific literature and specimens deposited in biological collections, we provide an update on the distribution of *M. tuberculata* in Brazilian waters. Our results show that *M. tuberculata* currently occurs in 351 municipalities, 20 Brazilian States and the Federal District. We also provide a brief discussion about its potential as a vector for zoonotic diseases, and possible pathways for its introduction in Brazilian waters.

Key words: nonnative mollusc, invasive species, Neotropical region, aquaculture, fishkeeping, zoonotic potential

Introduction

Melanoides tuberculata (Müller, 1774) (Figure 1) is a freshwater snail native to the Afrotropical and Palearctic regions (Facon et al. 2003); with a fossil record in Indonesia as far back as the Pliocene (Oostingh 1935; van Benthem Jutting 1937). However, currently this species is found in numerous aquatic habitats around the World as a result of anthropogenic introductions (Duggan 2002; Karatayev et al. 2009; Peso et al. 2011; Gashtarov and Georgiev 2016). Establishment and invasion success in non-native habitats may be attributed to aspects of this species' biology, such as parthenogenetic reproduction (Dudgeon 1986).

In Brazil, *M. tuberculata* was introduced prior to 1970, probably via the plant and pet trade, yet the invasion of this species went unreported until 1986 (Vaz et al. 1986). Subsequently, this species has been reported from many other Brazilian regions (Fernandez

et al. 2003; Silva and Barros 2011; Souto et al. 2011; Lima et al. 2013).

The first systematic survey for *M. tuberculata* in Brazil recorded populations in 17 States and the Federal District (Fernandez et al. 2003). Since this time, its distribution has been verified for 201 Brazilian municipalities (Santos et al. 2012). However, no recent comprehensive update on the distribution of this species in Brazil has been published. Here we provide an update and new records for the distribution of *M. tuberculata* in Brazil, and discuss possible pathways for its introduction and its potential as a vector of zoonotic diseases.

Material and methods

We used peer-reviewed publications published starting in 1986 with the first record of *Melanoides tuberculata* in Brazil (Vaz et al. 1986) through 2017

(Table S1). In addition, we used data from biological collections housed at museums in Brazil, including MZUSP (Museu de Zoologia da Universidade de São Paulo, SP, Brazil), MNRJ (Museu Nacional Rio de Janeiro, Rio de Janeiro, Brazil), and CMIOC (Coleção de Moluscos do Instituto Oswaldo Cruz, Fundação Oswaldo Cruz, Rio de Janeiro, Brazil). In cases where coordinates were not available for a record they were geo-referenced from the biotope or municipality name. All distributions were mapped using Quantum GIS 1.8 (QGIS Development Team 2012).

Results

Melanooides tuberculata was reported from 20 Brazilian States and the Federal District, totaling 351 municipalities (Table S1). The northeastern region presented the highest number of occurrences, followed by the southeast, north, midwest and south of the country (Figure 2).

Discussion

This study extends the previous geographical distribution of *Melanooides tuberculata* (Santos et al. 2012) to an additional 150 municipalities, to encompass 351 locations spread across 20 Brazilian States and the Federal District. It is probable that the range of *M. tuberculata* in Brazil is much greater than that reported here, as these records only reflect targeted surveys biased by the specific research interests of those sampling and collecting (Santos et al. 2012). For example, there are more records in states with greatest numbers of malacological surveys (e.g., Bahia and Rio de Janeiro). In contrast, the absence of records in the Northern region (except for the State Tocantins) may reflect the scarcity of surveys in the States of Acre, Amapá, Amazonas, Rondônia and Roraima (Santos et al. 2012). As such, we recommend further surveys in this region.

According to Santos et al. (2012), among the states of the southern region of the country, no records have been made in Rio Grande do Sul. However, we can verify the first record of the species in the state was reported in the Uruguay River by Peso et al. (2010). Further, *M. tuberculata* was found in Teresina, Piauí State (Table S1), near to Maranhão State. This suggests that this species perhaps has already become established in the latter state. However, to confirm this hypothesis, further malacological surveys are needed in the region.

The expanding distribution of *M. tuberculata* in Brazil is worrisome, as this species is a vector for several larval forms of trematodes of medical and veterinary importance (Boaventura et al. 2002). Based

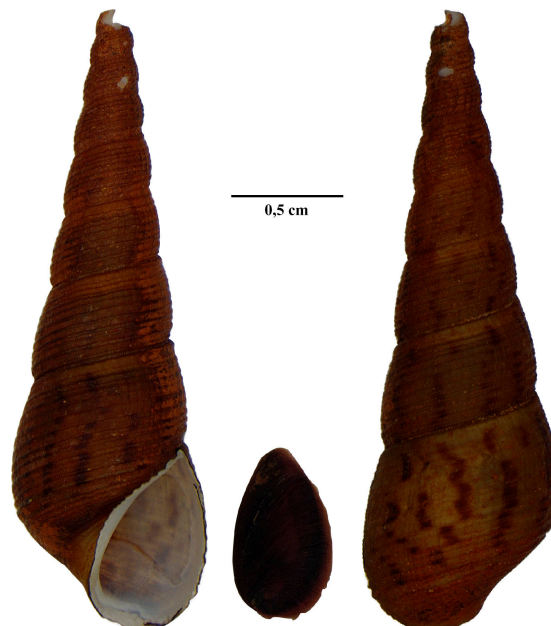


Figure 1. Individual *Melanooides tuberculata* (Müller, 1774) collected in the Tocantins River, municipality of Uruaçu, Goiás, Brazil. Photo credit: Eduardo da Silva Cinilha.

on a review of studies published between 1896 and 2010, Pinto and Melo (2011) listed 17 families, 25 genera and 37 species of trematodes transmitted by *M. tuberculata*, with 11 species recorded to infect humans, mainly in Asia. Although no human parasite has been associated with transmission from *M. tuberculata* in Brazil, authors report the finding of mollusc parasitized by larval forms of *Centrocestus formosanus* (Nishigori, 1924) and *Philophthalmus gralli* Mathis and Leger, 1910 (Pinto and Melo 2010a, b). In Venezuela, the interaction between *M. tuberculata* and *Haplorchis pumilio* (Looss, 1896), associated with haplorchiasis, has been documented (Díaz et al. 2008). Human cases of clonorchiasis (Leite et al. 1989), and paragonimiasis (Lemos et al. 2007), have been documented in Brazil, whose etiological agents *Clonorchis sinensis* (Cobbold, 1875) and *Paragonimus westermani* (Kerbert, 1878) use *M. tuberculata* as an intermediate host (Vaz et al. 1986; Souza and Lima 1990 *apud* Guimarães et al. 2001), although to date the participation of this mollusc in these infections has not been confirmed.

Recently, Ximenes et al. (2017) recorded *C. formosanus* in *M. tuberculata* collected in Ilha Grande, in the municipality of Angra dos Reis, Rio de Janeiro, only two years after its introduction, highlighting the short time necessary for establishment of this species and its potential for the transmission of parasites.

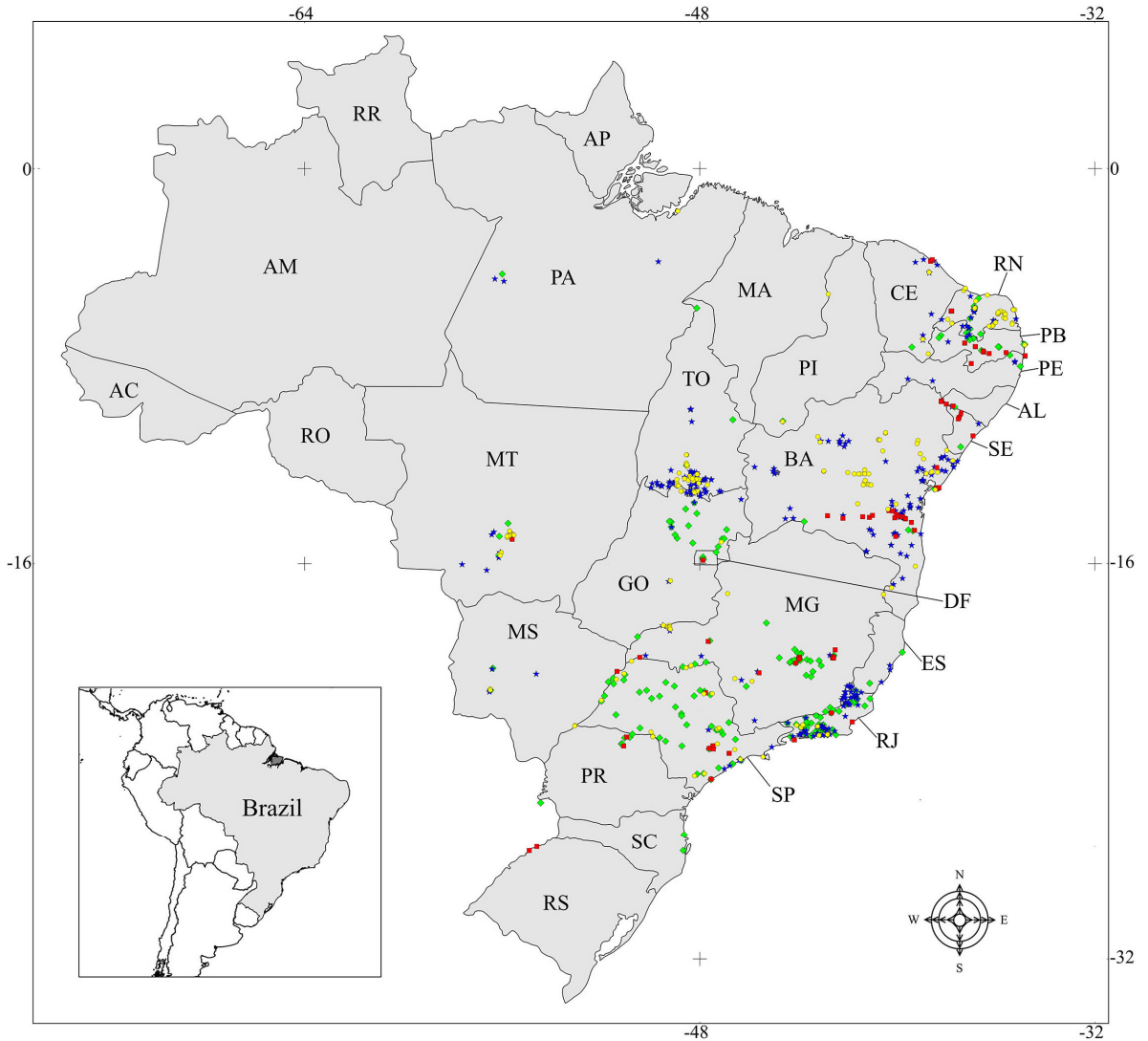


Figure 2. Geographic distribution of *Melanoides tuberculata* in Brazil: biotopes with the precision of local information (yellow circle = biological collections, red square = scientific publications) and locality records without geographical coordinates (blue star = biological collections, green diamond = scientific publications). Map constructed from Table S1. States acronyms: AC = Acre, AL = Alagoas, AP = Amapá, AM = Amazonas, BA = Bahia, CE = Ceará, DF = Federal District, ES = Espírito Santo, GO = Goiás, MA = Maranhão, MT = Mato Grosso, MS = Mato Grosso do Sul, MG = Minas Gerais, PA = Pará, PB = Paraíba, PR = Paraná, PE = Pernambuco, PI = Piauí, RN = Rio Grande do Norte, RS = Rio Grande do Sul, RJ = Rio de Janeiro, RO = Rondônia, RR = Roraima, SC = Santa Catarina, SP = São Paulo, SE = Sergipe, TO = Tocantins.

This report becomes even more relevant because it is an island with several areas dedicated to environmental preservation (Ximenes et al. 2017). Similarly, current records include the occurrence of *M. tuberculata* in other protected areas; for example, at the “Monumento Natural Grota do Angico” and in the “Área de Proteção Ambiental do Litoral Sul”, in the Sergipe State (Souto et al. 2011). It is important to highlight the ecological impacts of *M. tuberculata* populations on native mollusc species, as this snail may result in population reductions and the displacement

of some species due to the population growth of the invasive species (Santos and Eskinazi-Sant’Anna 2010; Santos et al. 2012). Although *M. tuberculata* has the ability to displace other mollusc species transmitting diseases (Guimarães et al. 2001), which has often been touted as a benefit, this does not negate the serious ecological impacts caused by this species.

It is possible that the dispersion of *M. tuberculata* in Brazilian waters has occurred through a variety of pathways. Fish stocking, as suggested by Carvalho

(1986) and Coelho et al. (2017), may be one of them. In fact, there are reports that stocking programs are a potential disperser of non-native invertebrates in Brazilian waters (Magalhães et al. 2005; Coelho and Henry 2017). In this context, juvenile forms of fish species, coming from environments containing *M. tuberculata*, may be marketed to different parts of the country. Fish stocking spreads *M. tuberculata* to adjacent rivers or streams, because several tanks (or aquaculture ponds) flow into nearby bodies of water. However, other pathways should still be considered, including the aquarium trade (Duggan 2010; Assis et al. 2014), water diversions (Azevêdo et al. 2014), boats, and sand transport that may also contribute to the dispersal of this species. The rapid spread and ease of establishment of this species reinforces the need for preventive actions, including new malacological surveys and rigorous inspection of lots containing fish to be stocked.

Acknowledgements

We thank the curators of the Scientific Collections for sending part of the data of this work; Eduardo da Silva Cinilha for the preparation of figure; Douglas D. Kane of Defiance College, U.S.A. and Ian C. Duggan of The University of Waikato, both for the English review; the anonymous reviewers for insightful comments and suggestions to ours manuscript. We are grateful to Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for financial support and scholarship to P.N.C, D.A.S.C and A.M.C.R.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Geo-referenced data of *Melanoides tuberculata* occurrence across Brazilian environments.

Appendix 1. References for Table S1.

This material is available as part of online article from:

http://www.reabic.net/journals/bir/2018/Supplements/BIR_2018_Coelho_et_al_SupplementaryMaterial.xlsx