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Review

# The invasive snail *Melanoides tuberculata* in Argentina and Paraguay

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ABSTRACT

This article reviews the spread and current distribution of the invasive snail *Melanoides tuberculata* in Argentina and Paraguay based on data from specimens deposited in museums, published reports and field collections. Field collections were made between April 1999 and May 2010. Snails were searched for using different collecting methods in a variety of habitats. Specimens were identified according to a categorical scoring system based on shell traits and anatomy was compared with published descriptions. Only five records for Argentina and none for Paraguay were found in published reports. The first report of *M. tuberculata* in Argentina was in 1999. Neither specimens from Argentina nor Paraguay were found in the Argentine Museum of Natural Sciences (MACN). In La Plata Museum (MLP) the only material from these countries was that associated with the published reports. During the course of surveys undertaken since 1999, *M. tuberculata* was recorded at 19 sampling locations. The presence of this species in Paraguay is reported here for the first time. Since its discovery in Argentina and Paraguay, the snail has colonized both lotic and lentic habitats with a variety of substrata. The records suggest that the species is established and that its introduction resulted from passive dispersal. Actually, spreading is believed to occur by active dispersal (i.e. active migration) from established populations and impact in native communities is expected.



**Contents**



## 1. Introduction

*Melanoides tuberculata* (Müller, 1774) is a benthic freshwater snail native to Africa and Asia in the family Thiaridae. The main aspects of its biology have been summarized in Ben-Ami and Heller (2008), Escobar et al. (2009), Facon et al. (2003), Simone (2001) and references therein. As for many freshwater snails, *M. tuberculata* serves as the first intermediate host of a variety of trematodes in both its native and introduced ranges causing infections in people and animals (Escobar et al. 2009).

The extensive list of parasites (Derraik 2008) includes *Paragonimus westermani* (Kerbert, 1878), *Clonorchis sinensis* (Cobbold, 1875) and *Centrocestus formosanus* (Nishigori, 1924), helminthes responsible for paragonimiasis, clonorchiasis and centrocestiasis transmission, respectively (Fernandez et al. 2003).

*M. tuberculata* has become widely invasive in the tropics outside its native range (Facon et al. 2003). In the Neotropical region, it occurs in most countries between the southern states of the U.S.A. and Argentina. It was first reported in Argentina in 1999, at the Yacyretá Reservoir in the north of the country (Fernandez et al. 2003; Peso and Quintana 1999). Concern regarding *M. tuberculata* in Argentina and Paraguay relates to its potential impact on native snails, many of which are endemic to these coun-

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**Table 1**
Records of *M. tuberculata* in Argentina and Paraguay and habitat information (Env., environment; St., stream; Rv., river; Rs., reservoir; Is., Island; Irv., Island in river; Irs., Island in reservoir; PR., Paraná River; UR., Uruguay River; IR., Iguazú River).

| Country | ID N° | Year | Location | Env. | Substrata | Depth (m) | Coordinates** | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Latitude | Longitude | |
| Argentina | 1 | 1999 | Ituzaingó (PR) | Rv.* | Organic matter and sand | 0.30 | −27.5557 | −56.6746 | Peso and Quintana (1999) |
| | 2 | 2005 | San Martín Is. (IR) | Irv. | Stone and vegetation | 0.80 | −25.6833 | −54.4333 | Gutiérrez Gregoric et al. (2007) |
| | 3 | 2010 | Santa Rosa (UR) | Rv. | Sand | 1.70 | −27.4881 | −54.5997 | Peso et al. (in press) |
| | 4 | 2010 | Roncador (UR) | Rv. | Organic matter | 3.10 | −27.7662 | −54.9377 | Peso et al. (in press) |
| | 5 | 2010 | Panambí (UR) | Rv. | Organic matter | 7.50 | −27.6508 | −54.9076 | Peso et al. (in press) |
| | 6 | 2001 | Mártires St. | St.* | Organic matter and sand | 3 | −27.3648 | −55.9611 | New data |
| | 7 | 2002 | Pirá Pyta (PR) | Rv.* | Organic matter, sand and stone | 1 | −27.3517 | −55.9144 | New data |
| | 8 | 2008 | Ituzaingó Beach (PR) | Rv.* | Sand | 0.30 | −27.5992 | −56.7181 | New data |
| | 9 | 2009 | San Ignacio (PR) | Rv.* | Sand | 1.5 | −27.2754 | −55.5816 | New data |
| | 10 | 2009 | Exclusa Navegación | Rs.* | Sand and stone | 5 | −27.4961 | −56.7160 | New data |
| | 11 | 2010 | Posadas (PR) | Rv.* | Vegetation | 0.20 | −27.3511 | −55.9000 | New data |
| Paraguay | 12 | 2000 | Monte Santo Tomás (PR) | Irs.* | Sand | 0.50 | −27.4149 | −56.5723 | New data |
| | 13 | 2000 | Ibicuí Is. (PR) | Irs.* | Sand | 4 | −27.2991 | −56.0579 | New data |
| | 14 | 2004 | Mboi Cae St. | St.* | Organic matter | 3 | −27.3300 | −55.8842 | New data |
| | 15 | 2004 | Aguapey St. | St.* | Vegetation | 6 | −27.2865 | −56.3433 | New data |
| | 16 | 2004 | Quiteria St. | St.* | Organic matter and sand | 5 | −27.3128 | −55.9200 | New data |
| | 17 | 2006 | E4–MD | Rs.* | Organic matter and sand | 9 | −27.3406 | −56.3251 | New data |
| | 18 | 2007 | E10 | Rs.* | Sand | 22 | −27.4012 | −56.6126 | New data |
| | 19 | 2007 | Río Beach (PR) | Rv.* | Sand | 2 | −27.3729 | −55.8573 | New data |

*Yacyretá Reservoir and environs; **Decimal degrees

tries, and its role as intermediate host and transmission vector for trematode parasites dangerous to humans, livestock and wild animals.

This article reviews the spread and current distribution of *M. tuberculata* in Argentina, with special focus in the Yacyretá Reservoir and other impacted areas, and reports the presence of this species in Paraguay for the first time. A revised list of its known distribution and new location records in the two countries is included.

## 2. Methods

The main source of data was geopositioned field collections from the Yacyretá Reservoir as part of a monitoring program of the National University of Misiones (UNaM), Argentina, and the Yacyretá Binational Entity (EBY), Argentina–Paraguay. Specimens deposited in the Argentine Museum of Natural Sciences (MACN) and La Plata Museum (MLP), and published reports were also examined.

### 2.1. Yacyretá Reservoir–Paraná River collections

Yacyretá Reservoir is located in the Paraná River on the Argentina–Paraguay border (latitude, −27.4666; longitude, −56.7333). The reservoir at 76 masl (meters above sea level) has an area of 1140 $km^2$, a capacity of 7000 $hm^3$ and average depth of 6–7 m (maximum 23 m). The surveys were conducted between April 1999 and May 2010 in the Yacyretá Reservoir and areas both upstream and downstream of it. Surveys for *M. tuberculata* used various collecting methods in a variety of substrata: at the bottoms of the reservoir, river and streams by scuba diving, surber sampler, or with a long handled metallic scoop and by eye in other possible habitats in riparian areas.

Live snails were transported to aquariums at UNaM and kept in the laboratory biological observations and identification. Identification was based on a categorical scoring system of 14 shell traits (Facon et al. 2003). Five specimens per sampling point were relaxed by immersion in nembutal solution (0.05%) for approximately 6 h, and the visceral mass was extracted from the shells after immersion in water at 70 °C for 30 s. The visceral mass was dissected using standard techniques under a stereoscopic microscope and the anatomy was compared with published information (Simone 2001). Specimens were deposited in MLP and in the Reference Collection of the Zoobenthos Laboratory (LZ) at UNaM.

## 3. Results

Reports of the introduction of *M. tuberculata* in the Neotropical region and other parts of Latin America began in the 1960s (Escobar et al. 2009; Fernandez et al. 2003; Quintana et al. 2001–2002). The first record of *M. tuberculata* in Argentina was in April 1999 when it was found in the Paraná River (MLP N° 12824) near the Yacyretá Reservoir (Peso and Quintana 1999). Subsequently, it was recorded in June 2005 in the rapids of the Iguazú River at San Martín Island (MLP N° 12576) on the border with Brazil (Gutiérrez Gregoric et al. 2007) and in May 2010 it was recorded in the Uruguay River, at 3 sampling locations (LZ N°s 103070, 103078, 103089 and 103493) on the Argentina–Brazil border (Peso et al. in press). No other records for Argentina and none for Paraguay were found in published reports. Also, no specimens of *M. tuberculata* from Argentina or Paraguay were found in the MACN, and the only specimens in the MLP from these countries were those associated with the published reports above.

During the course of surveys undertaken since 1999 in Yacyretá Reservoir and its environs *M. tuberculata* was found at 14 locations both up and downstream of the dam inhabiting different substrata and environments, including the first record for Paraguay, in 2000, when it was recorded in Monte Santo Tomás, a little island in the middle of the Yacyretá Reservoir (Table 1; Figs. 1 and 2).

## 4. Discussion

The origin of *M. tuberculata* in Argentina and Paraguay remains unknown. The record of *M. tuberculata* in the Iguazú River near the border with Brazil (Gutiérrez Gregoric et al. 2007) and records from the upper section of the Paraná River in Brazil (Fernandez et al. 2003) suggest that the introduction into Argentina and Paraguay could have occurred passively down the Paraná River, perhaps on floating vegetation such as macrophytes, which provide a vehicle for rapid downstream dispersal (Appleton et al. 2009). Passive introduction may also be responsible for its presence in the Uruguay River, as it flows from Brazil.

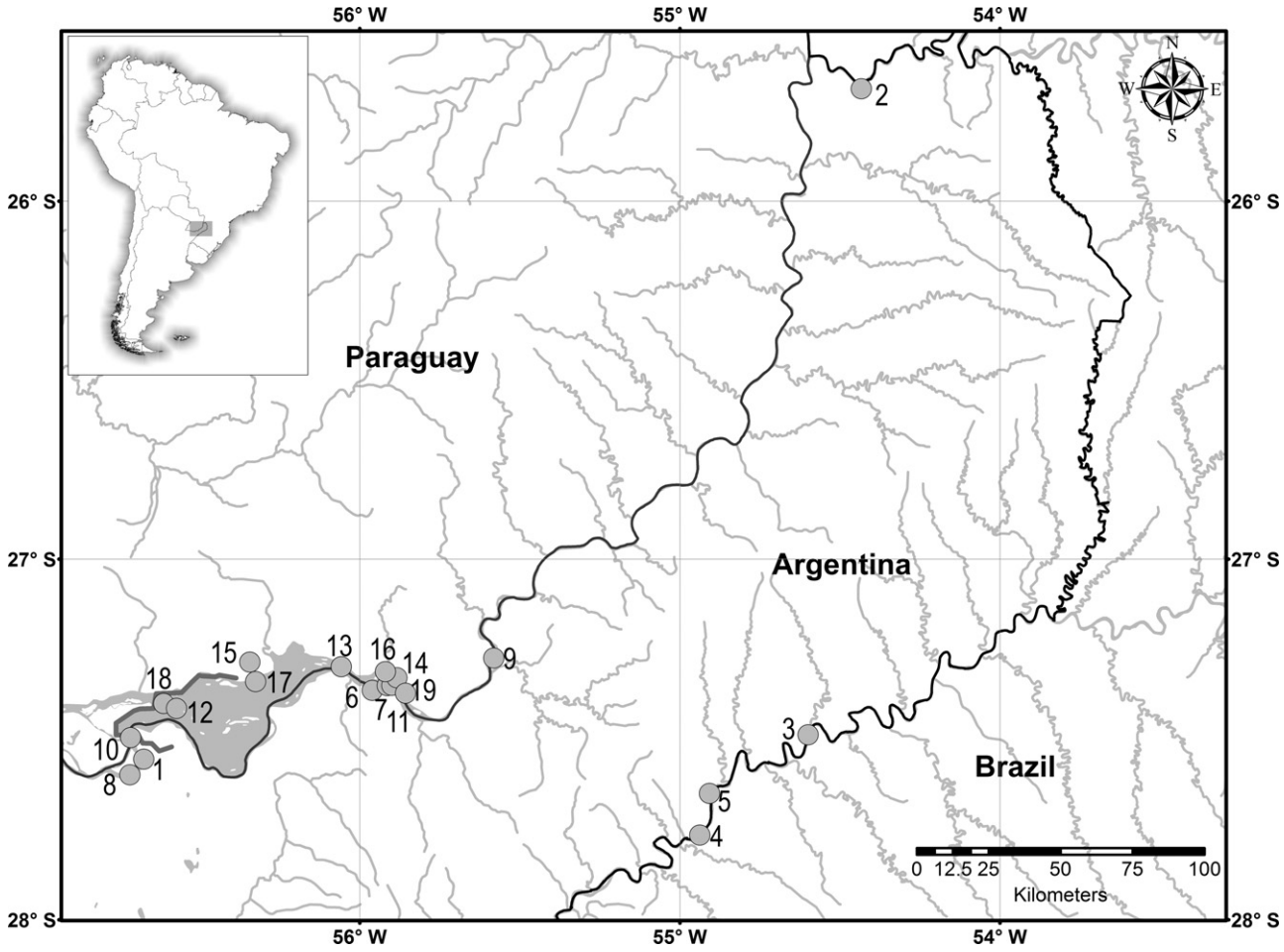


**Fig. 1.** Current distribution of *Melanoides tuberculata* in Argentina and Paraguay (location numbers correspond to the ID N° in Table 1).

Although literature records of *M. tuberculata* in Argentina are few compared to Brazil, for which there are more than 15 publications and over 60 location records throughout the country (Fernandez et al. 2003), the 14 new records for Argentina and Paraguay suggest this species has become established in these countries. Its spread in the northeast of Argentina over approximately two degrees of latitude (−25 to −27) since 1999 indicates that it is becoming widespread. Although the lack of data on actual area invaded per year, this spread in <11 years seems to be slower compared to Brazil, where in the course of three decades the snail spread from a few points in São Paulo to all Brazilian regions (Fernandez et al. 2003).

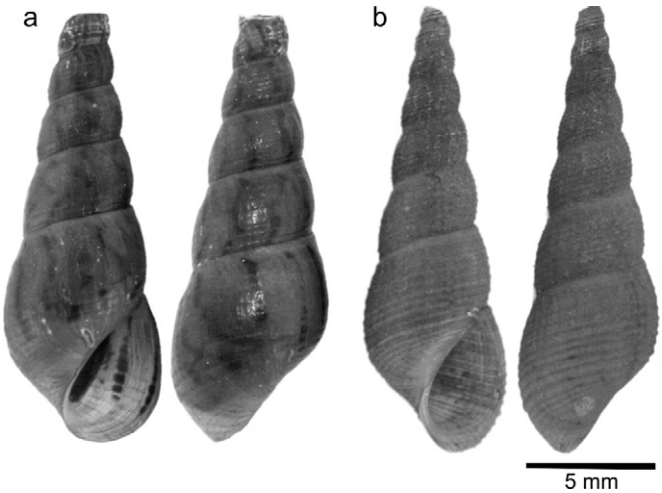


**Fig. 2.** *Melanoides tuberculata* from (a) Ituzaingó, Argentina and (b) Ibicuí Island, Paraguay.

Recent temperature tolerance studies predicting the species' potential distribution in North America, suggesting that waters with temperatures <18 °C or greater than 32 °C will probably not support *M. tuberculata*, indicate that temperature may be an important determinant of its distribution (Mitchell and Brandt 2005). In this context, mean annual temperatures of the Paraná River (ranging from 14 to 32 °C) would facilitate spreading of *M. tuberculata* by active dispersal (i.e. active migration) from established populations in Yacyretá Reservoir and several tributaries to both, up and downstream in the flowing systems, as reported in México (Contreras-Arquieta 1998).

The habitats in which the species was collected in Argentina and Paraguay include lotic and lentic environments (ranging from rapids in the Iguazú River and diverse basaltic streams to quiet waters in Yacyretá Reservoir) and a variety of substrata (e.g. sand, stone, marginal vegetation) that are similar to the habitats described in the literature for both artificial and natural habitats of *M. tuberculata* (Bogéa et al. 2005; Pointier and Augustin 1999).

The role of *M. tuberculata* as a competitor of native mollusks is widely documented in the French West Indies (Pointier and Augustin 1999). In Brazil, preliminary data indicate that native populations of the thiarid *Aylacostoma tenuilabris* (Reeve, 1860) in the Tocantins River were replaced by populations of *M. tuberculata* (Fernandez et al. 2003). No studies have been conducted in

Argentina and Paraguay on the impact of *M. tuberculata* in native communities. Replacement of other thiarid species was predicted after *M. tuberculata* was reported for the first time (Quintana et al. 2001–2002), but no experimental study has been performed. However, it is possible that native communities in the invaded aquatic systems may actually being impacted.

In 2009, introduction of *M. tuberculata* to Argentina via the plant and freshwater ornamental fish trade was reported (Gutiérrez Gregoric and Vogler 2010), a route often mentioned for the introduction and spread of freshwater snails (Cowie and Robinson 2003; Fernandez et al. 2003). *M. tuberculata* is widely available in pet shops (Gutiérrez Gregoric and Vogler 2010) and is now being sold in Argentina on the Internet. Dispersal facilitated by humans combined with the species adaptability to a wide range of environmental conditions could have serious consequences if specimens are accidentally released into the environment. This could rapidly increase the distribution of the species in new watercourses and probably new records in several states of the country will be reported in future if the commerce of the species continues.

Further studies (e.g. ecological, parasitological) should be made in order to understand the invasive behavior and impacts of this species in South America.

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