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Inventory

Freshwater mollusks and environmental assessment of Guandu River, Rio de Janeiro, Brazil

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Abstract: The Guandu River Basin is extremely important to state of Rio de Janeiro, as a water supplier of several municipalities. However, the malacological knowledge and environmental status is not well known to this basin. The aim of this paper is to present an inventory of freshwater mollusks, as well as an environmental assessment through a Rapid Assessment Protocol, of ten sampling sites at Guandu River basin in six municipalities (Piraí, Paracambi, Japeri, Seropédica, Queimados and Nova Iguaçu). Thirteen species of molusks were found, eight native (*Pomacea maculata*, *Biomphalaria tenagophila*, *Gundlachia ticaga*, *Gundlachia radiata*, *Omalonyx matheroni*, *Diplodon ellipticus*, *Anodontites trapesialis* and *Eupera bahiensis*) and five exotics (*Melanoides tuberculata, Ferrissia fragilis*, *Physa acuta, Corbicula fluminea* and *Corbicula largillierti*). The environmental analysis ranked most sites as "modified". The expansion of exotic species with their associated negative effects, as well the gap in knowledge of native species calls attention to the need of future studies of biology and ecology of the species found.

Keywords: *Gastropoda, Bivalvia, Mollusca, exotic species, RAP.*

Moluscos de água doce e avaliação ambiental do rio Guandu, Rio de Janeiro, Brasil

Resumo: A bacia do rio Guandu é de extrema importância para o estado do Rio de Janeiro, pois abastece grande parte da região metropolitana. Contudo, aspectos malacológicos e ambientais desta bacia são pouco conhecidos. O presente trabalho teve por objetivo realizar um inventário das espécies de moluscos de água doce ocorrentes na região, assim como uma avaliação ambiental através de um Protocolo de Avaliação Rápida, de dez estações de coleta na bacia do rio Guandu em seis municípios (Piraí, Paracambi, Japeri, Seropédica, Queimados e Nova Iguaçu). Foram encontradas 13 espécies, sendo oito nativas (*Pomacea maculata*, *Biomphalaria tenagophila*, *Gundlachia ticaga*, *Gundlachia radiata*, *Omalonyx matheroni*, *Diplodon ellipticus*, *Anodontites trapesialis* e *Eupera bahiensis*) e cinco exóticas (*Melanoides tuberculata, Ferrissia fragilis*, *Physa acuta*, *Corbicula fluminea* e *Corbicula largillierti*). A avaliação ambiental caracterizou a maior parte das estações de coleta como "modificado". A dispersão das espécies exóticas e os efeitos negativos a elas associados, além da nossa falta de conhecimento sobre as espécies nativas chama a atenção para a necessidade de futuros estudos biológicos e ecológicos das espécies encontradas.

Palavras-chave: *Gastropoda, Bivalvia, Mollusca, espécies exóticas, RAP.*

Introduction

Few molluscan studies were conducted in Guandu River Basin. Tubbs-Filho & Vettorazzi (2012) recorded the occurrence of the exotic bivalve *Corbicula fluminea* (Müller, 1774) in the tributaries of Ribeirão das Lajes which is an affluent of Guandu River. Lacerda et al. (2013) reported the first occurrence of *Gundlachia radiata* (Guilding, 1828) from southeast Brazil in this area. Thiengo et al. (2001) reported sixteen species of limnic gastropods in the municipalities of Itaguaí, Seropédica, Queimados, Japeri, Paracambi and Nova Iguaçu, but without the information of the water body surveyed.

The concern with the conservation of natural resources is growing due to constant alteration of habitats, overuse of natural resources and introduction of exotic species, which causes loss or reduction of the diversity at all scales (Lydeard et al. 2004, Amaral et al. 2008, Santos et al. 2012, Miyahira et al. 2012). An important step for conservation is making the information of occurrence and distribution of different taxa available (Metzger & Casatti 2006). Therefore it is necessary to inventory native

flora and fauna, in order to support conservation plans (Moulton et al. 2000). Molluscan fauna were not considered in most surveys, although it is the most diverse group after arthropods, occurring in different freshwater habitats such as streams, rivers, lakes, wetlands, swamps, dams, ponds and drainage ditches, with different degrees of eutrophication. Moreover, freshwater molluscs are among the most threatened faunal group in the world (Lydeard et al. 2004, Bogan 2008, Strong et al. 2008, Pereira et al. 2014).

Thus, the goals of this work were to: 1) study the freshwater mollusks diversity and distribution at the Guandu River Basin and, 2) evaluate the degree of preservation of the studied area through the application of a Rapid Assessment Protocol (RAP).

Material and methods

1. Study area and sampling

The Guandu River is formed mainly by the Ribeirão das Lajes River and the waters transposed of the Paraiba do Sul River (Tubbs-Filho & Vettorazzi 2012, Costa et al. 2013). The total length of the Guandu River is 108.5 km (Costa et al. 2013), flowing through the municipalities of Piraí, Paracambi, Japeri, Seropédica, Queimados, Nova Iguaçu and Rio de Janeiro, all in the state of Rio de Janeiro. In Guandu River Basin there are crops, pastures, sand extraction areas, cities, industries, hydroelectric plants and a reservoir at the responsibility of CEDAE (Companhia Estadual de Águas e Esgotos), that provide water to approximately eight million people in the metropolitan area of Rio de Janeiro (Tubbs-Filho & Vettorazzi 2012).

It were performed 10 sampling sites in six municipalities: Piraí (PR1; -43.81638, -22.68165 and PR2; -43.81779, -22.68307), Paracambi (PA1; -43.80007, -22.69054 and PA2; -43.71366, -22.64109), Itaguaí (ITA; -43.78791, -22.69493), Japeri (JAP; -43.66498, -22.65561), Seropédica (SE1; -43.64508, -22.73790 and SE2; -43.63964, -22.71110), and Nova Iguaçu (NI1; -43.62473, -22.80675 and NI2; -43.62626, -22.80764) (Figure 1). The sampling sites were done at confluence of Floresta River and Ribeirão das Lajes River (PR1), Ribeirão das Lajes River (PR2 and PA1), Guandu River (PA2, ITA, JAP, SE1 and SE2) and at Guandu Reservoir (NI1 and NI2). The sampling sites have different degrees of anthropic impacts (Figure 2). PR1 and PR2, as also NI1 and NI2 are sites close together (Figure 1).

1.1. Collection and analysis

The mollusks were searched in all suitable habitats, including marginal and floating vegetation, using a handled metallic scoop as described by Fernandez et al. (2008). Large freshwater mussels (Unionida) were searched in sand and muddy substrates using bare hands and feet. The search was made by three collectors during 20 minutes, totalizing one hour per sampling site. The abundance values presented are the sum of the specimens obtained in each site. The field work was done at May/2013 and January/2014.

After field work the gastropods were submitted to a parasitological test, light/dark cycle exposures test (Fernandez et al. 2008). The cercariae were identified following Schell (1970) and preserved in AFA. Thereafter, the mollusks were anesthetized with menthol ($C_{10}H_{20}O$), sacrificed in hot water (only gastropods), soft parts were preserved in 70% ethanol and shells were preserved dry.

Mollusks were identified under a stereomicroscope according to specialized literature (e.g., Santos 2003, 2012, Simone 2006, Arruda et al. 2006, Lacerda et al. 2011, 2013, Miyahira et al. 2013) and with the assistance of specialists. The classification above genus level followed Bouchet & Rocroi (2005), Simone (2006) and Albrecht et al. (2007) for the gastropods and Graf & Cummings (2006) and Bieler et al. (2010) for bivalves. The mollusks collected were housed at Mollusk Collection of Universidade do Estado do Rio de Janeiro (UERJ).

We used the RAP developed by Callisto et al. (2002) to evaluate the conservation status in each sampling site at the Guandu River Basin. This protocol evaluates 22 characteristics of the water body, margins and surroundings. The final score reflects the conservation level of the site:

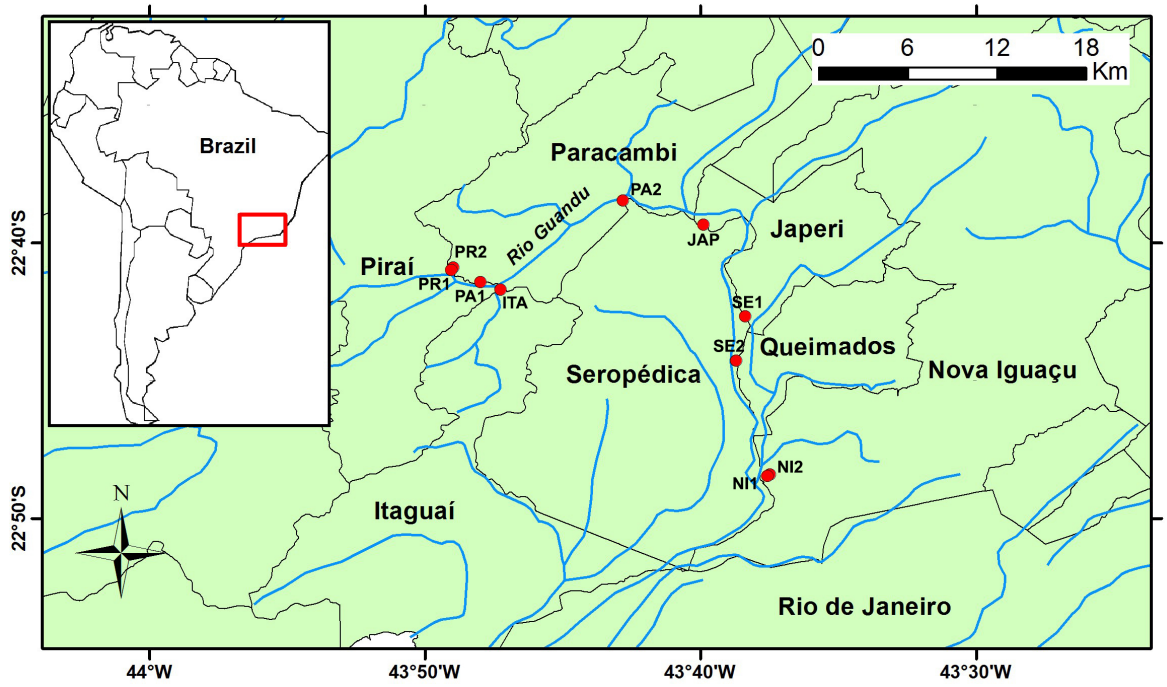

Figure 1. Studied area and the ten sampling sites at Guandu River Basin in six municipalities of the state of Rio de Janeiro.

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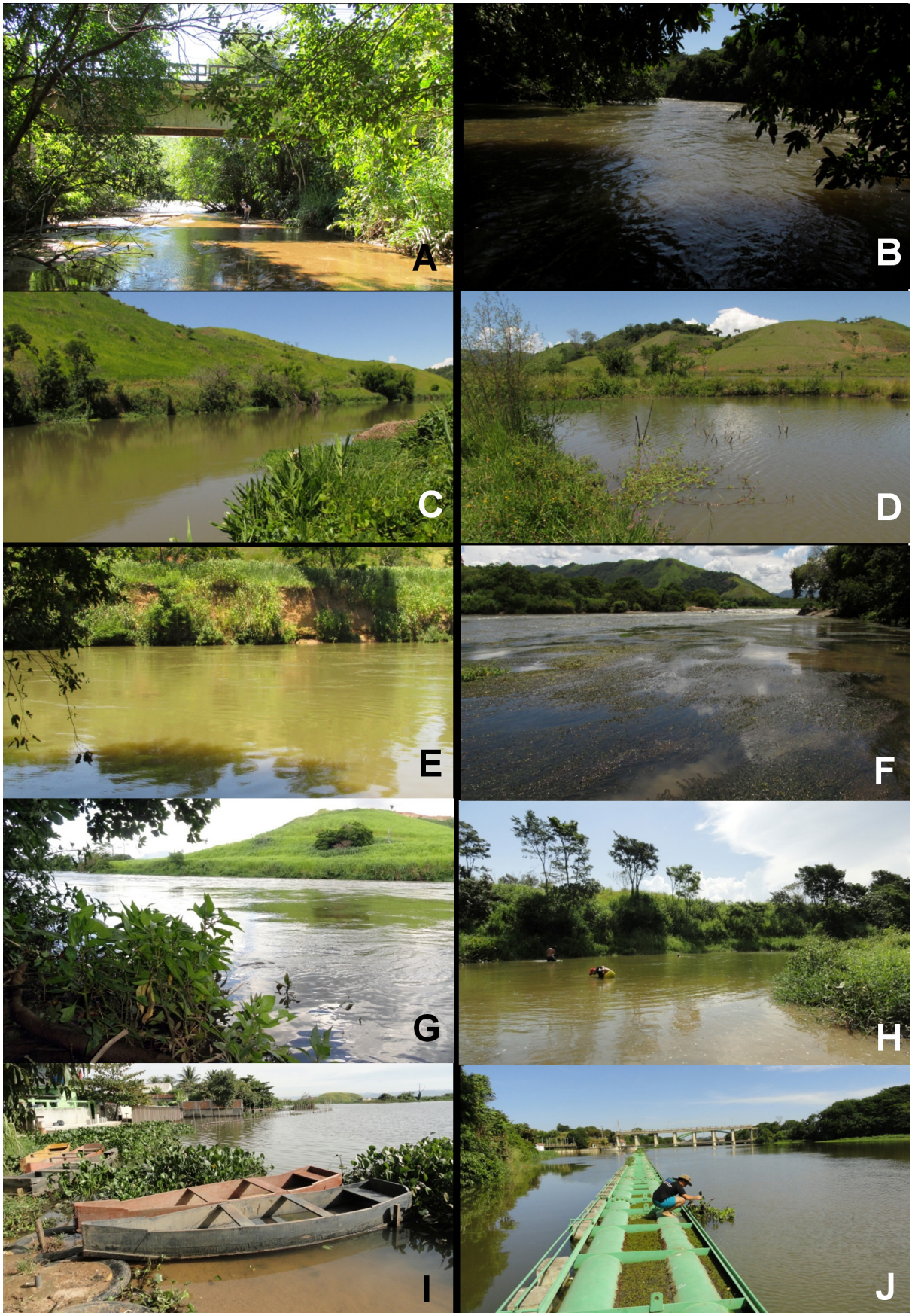

Figure 2. Overview of the sampled sites at Guandu River Basin. A - Piraí (PR1), B - Piraí (PR2), C – Paracambi (PA1), D - Paracambi (PA2), E - Itaguaí (ITA), F - Japeri (JAP), G - Seropédica (SE1), H - Seropédica (SE2), I - Nova Iguaçu (NI1) and J - Nova Iguaçu (NI2).

zero to 40 points is "impacted", 41 to 60 points is "modified" and above 61 points is "natural".

Results

1. Species diversity, distribution and parasitological test

Thirteen species of freshwater mollusks were found: eight gastropods and five bivalves (Table 1, Figure 3). Only two genera were represented by more than one species: *Gundlachia* Pfeiffer, 1849 and *Corbicula* Megerle von Mühlfeld, 1811. Five species were exotic: *C. fluminea, Corbicula largillierti* (Philippi, 1844), *Melanoides tuberculata* (Müller, 1774), *Physa acuta* Draparnaud, 1805 and *Ferrissia fragilis* (Tyron, 1863).

Only the exotic species *C. fluminea* was found in all sampling sites. Another widespread exotic species in Guandu River Basin was *M. tuberculata*, missing in only one sampling site. The native species with widest distribution was *Pomacea maculata* Perry, 1810 found in seven sites. However, most species presented smaller distributions, restricted to three, *Diplodon ellipticus* Spix in Wagner, 1827*, G. radiata*, *Gundlachia ticaga* (Marcus & Marcus, 1962) and *Omalonyx matheroni* (Potiez & Michaud, 1835); two, *F. fragilis* and *Anodontites trapesialis* (Lamarck, 1819), or even only one sampling site, *Eupera bahiensis* (Spix in Wagner, 1827) (Table 2).

Gundlachia ticaga is found at upstream-intermediate sites (PR1, PA1 and ITA); *F. fragilis* is found at intermediate sites (ITA and SE2); and *G. radiata*, *D. ellipticus*, *A. trapesialis* and *E. bahiensis* at intermediate-downstream

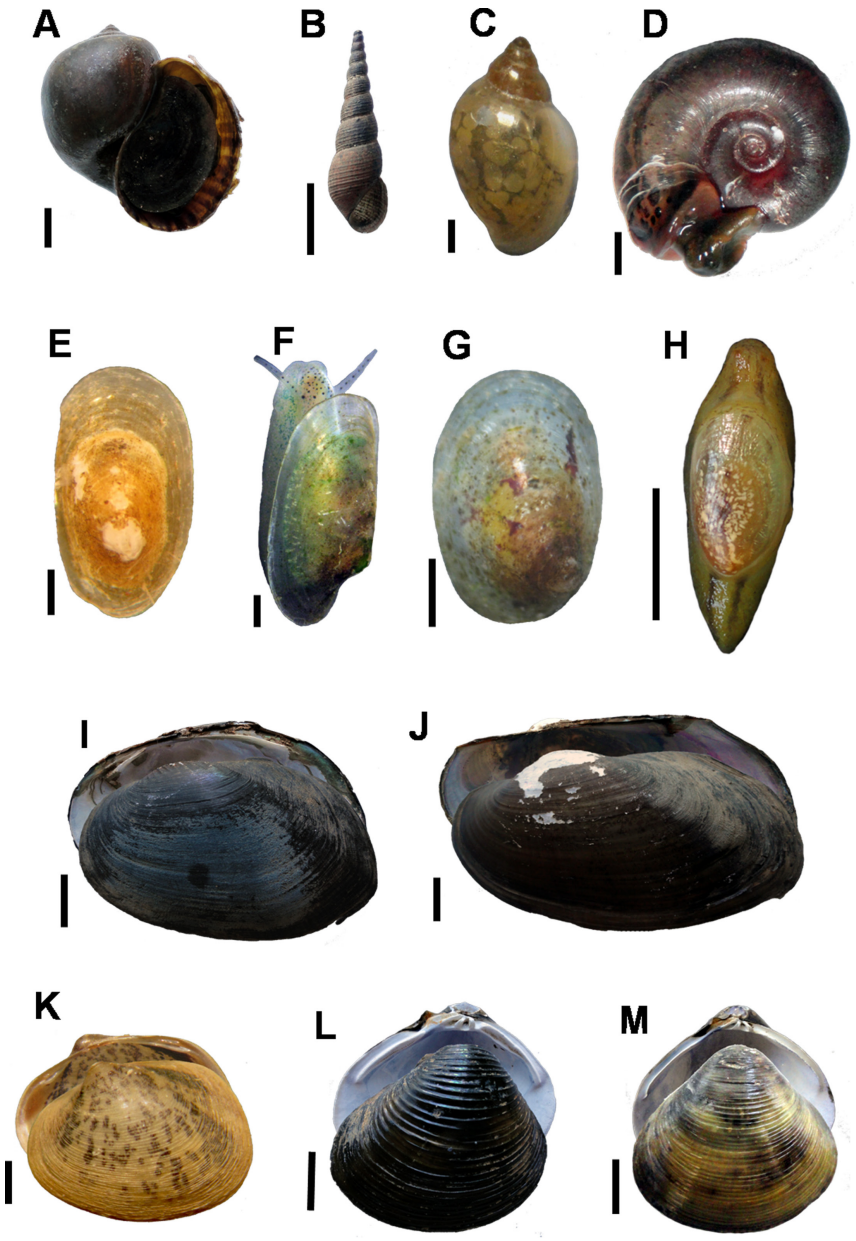

Figure 3. Freshwater molluscs from Guandu River Basin. A- *Pomacea maculata* Perry, 1810. B – *Melanoides tuberculata* (Müller, 1774). C – *Physa acuta* Draparnaud, 1805. D – *Biomphalaria tenagophila* (d'Orbigny, 1835). E – *Ferrissia fragilis* (Tryon, 1863). F – *Gundlachia radiata* (Guilding, 1828). G – *Gundlachia ticaga* (Marcus & Marcus, 1962). H – *Omalonyx matheroni* (Potiez & Michaud, 1835). I – *Diplodon ellipticus* Spix in Wagner, 1827. J – *Anodontites trapesialis* (Lamarck, 1819). K – *Eupera bahiensis* (Spix in Wagner, 1827). L – *Corbicula fluminea* (Müller, 1774). M – *Corbicula largillierti* (Philippi, 1844). Scale bar: A, B, H, I, J, L and M = 1 cm; C, D, E, F, G and K = 1 mm.

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Table 1. Taxonomic list of freshwater molluscs found at Guandu River basin.

Gastropoda			
Caenogastropoda		Ampullariidae	***Pomacea maculata* Perry, 1810** (Figure 3A)
		Thiaridae	***Melanoides tuberculata* (Müller, 1774)** (Figure 3B)
Hygrophila		Physidae	***Physa acuta* Draparnaud, 1805** (Figure 3C)
		Planorbidae	***Biomphalaria tenagophila* (d'Orbigny, 1835)**
			***Ferrissia fragilis* (Tryon, 1863)** (Figure 3E)
			***Gundlachia radiata* (Guilding, 1828)** (Figure 3F)
			***Gundlachia ticaga* (Marcus & Marcus, 1962)** (Figure 3G)
Eupulmonata		Succineidae	***Omalonyx matheroni* (Potiez & Michaud, 1835)** (Figure 3H)
Bivalvia			
Paleoheterodonta	Unionida	Hyriidae	***Diplodon ellipticus* Spix in Wagner, 1827** (Figure 3I)
		Mycetopodidae	***Anodontites trapesialis* (Lamarck, 1819)** (Figure 3J)
Heterodonta	Venerida	Sphaeriidae	***Eupera bahiensis* (Spix in Wagner, 1827)** (Figure 3K)
		Cyrenidae	***Corbicula fluminea* (Müller, 1774)** (Figure 3L)
			***Corbicula largillierti* (Philippi, 1844)** (Figure 3M)

Table 2. Distribution and abundance of freshwater molluscs in Guandu River basin. PR – Piraí, PA – Paracambi, ITA – Itaguaí, JAP – Japeri, SE – Seropédica, NI – Nova Iguaçu. RAP - Rapid Assessment Protocol. I – Impacted, M – Modified, N – Natural.

Species	Sampling sites										Material studied (UERJ numbers)
	PR1	PR2	PA1	PA2	ITA	JAP	SE1	SE2	NI1	NI2	
Pomacea maculata	1	-	3	-	22	1	-	6	9	54	10557-58; 10577; 10588; 10593; 10601; 10610;
Melanoides tuberculata	1	1	3	1	2	22	37	20	-	8	10561; 10582; 10584; 10591; 10597; 10599; 10603; 10606; 10612
Physa acuta	1	-	17	-	-	3	2	2	-	1	10564; 10579; 10585; 10600; 10604; 10608;
Omalonyx matheroni	1	-	3	-	-	-	-	-	-	1	10567; 10576; 10587
Ferrissia fragilis	-	-	-	-	1	-	-	2	-	-	10595; 10554
Gundlachia radiata	-	-	-	-	-	-	-	41	28	91	10409; 10611; 10560
Gundlachia ticaga	6	-	2	-	9	-	-	-	-	-	10578; 10589; 10594
Biomphalaria tenagophila	-	-	12	-	3	-	-	2	-	1	10586;10562; 10592; 10609
Diplodon ellipticus	-	-	-	-	-	-	-	21	12	72	10555; 10566; 10607
Anodontites trapesialis	-	-	-	-	-	-	-	-	3	3	10556; 10570
Eupera bahiensis	-	-	-	-	-	-	-	-	-	96	10559
Corbicula fluminea	17	66	11	55	16	57	37	150	5	17	10565; 10571-72; 10580; 10583; 10590; 10596; 10598; 10602; 10605
Corbicula largillierti	-	14	-	-	-	-	-	-	5	2	10568-69; 10581
Richness	6	3	7	2	6	4	3	8	6	11	-
RAP Score	76	80	48	59	57	55	59	58	38	43	-
RAP Category	N	N	M	M	M	M	M	M	I	M	-

sites (SE2, NI1 and NI2). The other species not presented a distribution limited to any specific section of the basin.

The most abundant species at Guandu River Basin was *C. fluminea* (431 specimens), and the less abundant was *F. fragilis* (3 specimens) and *O. matheroni* (5 specimens) (Table 2). *Gundlachia radiata*, *D. ellipticus* and *E. bahiensis* were restricted to few sampling sites; however these species were abundant locally.

The parasitological survey revealed only the interaction of *G. ticaga* with Longifurcate pharyngeate monostome cercaria (Vivax cercaria) (Trematoda: Digenea) in PR1. The exposition of the other gastropods to light/dark cycles returned negative results.

2. Habitat and environmental evaluation

All bivalves were found buried in soft sediment with some organic matter, except by *E. bahiensis* found attached to the roots of *Eichornia* sp. *Ferrissia fragilis*, *G. radiata*, *G. ticaga* and *P. acuta* were found attached to aquatic plants, decayed debris and on artificial substrates such as plastic bottles. *Melanoides tuberculata* and *P. maculata* were found over soft and hard substrates. *Omalonyx matheroni* was found on plants at interface water-air.

Only PR1 and PR2 were considered as "natural" on RAP; NI1 was characterized as "impacted" and the remaining sites as "modified" (Table 2). The downstream stations received the lowest scores on the RAP.

Discussion

Five exotic species were found: three freshwater snails (*M. tuberculata, P. acuta* and *F. fragilis*) and two freshwater bivalves (*C. fluminea* and *C. largillierti*); except by *F. fragilis*, a cryptic species that were recently reported to Brazil (Lacerda et al. 2015), the other species can also be considered as invasive. Among these species, the most widespread and harmful are *C. fluminea* and *M. tuberculata*. Both species can cause modification of community (Santos et al. 2012). *Melanoides tuberculata* is widespread in Brazil (Fernandez et al. 2003, Thiengo et al. 2007, Santos et al. 2012), reaching high population densities that affect native species (Freitas et al. 1987, Giovanelli et al. 2003, Braga et al. 2014). Furthermore, it is the first host of different parasites that causes human diseases (Vaz et al. 1986, Guimarães et al. 2001, Pinto & Melo, 2010). However, no parasitological interaction was found for this species in Guandu River Basin.

Corbicula fluminea is a widespread species in Brazil compared to *C. largillierti*, that has a restrict distribution (Santos et al. 2012). These

observations are consistent with the situation that we found in the Guandu River Basin, where *C. largillierti* had a restricted distribution whereas *C. fluminea* was found everywhere. Previous record of *C. fluminea* on Guandu River Basin stated only tributaries of Ribeirão das Lajes River (Tubbs-Filho & Vettorazzi 2012), but it is clear that is widespread at the basin. This last species also has caused serious economic damage to industries and power plants, due to obstruction of water pipes and competition with native bivalves (like *D. ellipticus* and *A. trapesialis* that occurs at Guandu River Basin), reducing their populations (Mansur et al. 2004, Santos et al. 2012). *Corbicula fluminea* is also the most abundant species at Guandu River Basin, as already observed by other authors in other sites (e.g., Mansur et al. 2004, Santos et al. 2012, Pereira et al. 2014, Meyer et al. 2017).

The Unionida species needs a minimum amount of nutrients in the water to survive and usually occurs in lower sections of the rivers, where there is large amount of nutrients (Pereira et. al. 2011, 2014), as observed for *D. ellipticus* and *A. trapesialis* at Guandu River Basin. *Gundlachia radiata* also prefer the large section of the river, at least at Guandu River Basin (Table 2), and it is possible that have higher nutrients requirements compared to other ancylids species. The first record of this species was in this section of the river, also occurring downstream of Guandu Reservoir (Lacerda et al. 2011). It is not possible to found a reason to the restricted distributions of *G. ticaga* and *F. fragilis* based in our data.

Eupera bahiensis is recorded for the first time to the state of Rio de Janeiro and it is also the southernmost record of this species. Until now, it was found in the states of Bahia (Mansur & Meier-Brook 2000), Pernambuco (Haas 1939), Ceará (Haas 1939), Pará (Haas 1949 a,b; Haas 1952) and Amazonas (Haas 1949b).

All other species were previously recorded to state of Rio de Janeiro. However some of them, like *A. trapesialis* was rarely reported. This species was recorded only one time to state of Rio de Janeiro at Juturnaíba Reservoir, municipality of Silva Jardim (Alvarenga et al. 1979). *Diplodon ellipticus* is only mentioned to Paraíba do Sul River in the state of Rio de Janeiro (Morretes, 1949). These new records evidence the gaps on the distribution of freshwater mollusks species as a result of the low sampling effort.

We noticed some new municipalities occurrences compared to Thiengo et al (2001): *F. fragilis* to Seropédica; *G. radiata* to Seropédica and Nova Iguaçu; and *M. tuberculata, O. matheroni* and *P. maculata* to Paracambi and Nova Iguaçu.

We noticed only the presence of Longifurcate pharyngeate monostome cercaria (Vivax cercaria) in *G. ticaga.* Previous studies in the state of Rio de Janeiro have pointed out other cercaria types in this species: Gymnocephalous cercaria to the municipality of Angra dos Reis (Lopes et al. 2011), Echinostome cercaria to Itaguaí and Vassouras (Thiengo et al. 2001) and Nova Friburgo (Thiengo et al. 2002). The final host of longifurcate pharyngeate monostome cercaria are birds and mammals (Pinto & Melo 2013).

The RAP classification identified the most upstream collecting sites (PR1 and PR2) as natural environments. In PR1 were found more species than in PR2 (Table 2) due the greater environmental heterogeneity (more habitats available). In PR1 there are more macrophytes and some side pools, habitats for *O. matheroni* and *G. ticaga*. As the Guandu River flows across the cities of Paracambi, Itaguaí, Japeri, Seropédica and Nova Iguaçu, receives domestic and industrial sewage and margins are sharply modified. NI2 was the richest in freshwater molluscs species, and also one of the most clearly anthropized. However, it was on a small bay near the main channel of the river, thus with a good water renovation. In NI1, near to NI2, with same habitats available (soft and hard substrates, as also rooted and floating macrophytes) but with more organic input and less water circulation sustained fewer species (Table 2).

In a dense populated area, in the metropolitan area of Rio de Janeiro, we found new municipalities records, and even a new record to the state of Rio de Janeiro. The dominance and wide distribution of *M. tuberculata* and *C. fluminea* in almost all sampling sites, emphasizes the need for a continuous monitoring and control of the spread of exotic species. Also, biological and ecological aspects of native species must be studied to support conservation strategies and reduce the effects of exotic species.

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Authors Contributions

Igor Christo Miyahira: substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Jéssica Beck Carneiro: substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Isabela Cristina Brito Gonçalves: substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Luiz Eduardo Macedo de Lacerda: substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Jaqueline Lopes de Oliveira: substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Mariana Castro de Vasconcellos: substantial contribution in the concept and design of the study; contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Sonia Barbosa dos Santos: contribution to data collection; contribution to data analysis and interpretation; contribution to manuscript preparation and critical revision.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

References

ALBRECHT, C., KUHN, K. & STREIT, B. 2007. A molecular phylogeny of Planorboidea (Gastropoda, Pulmonata). Zool. scr. 36: 27-39.

ALVARENGA, L.C.F., COELHO, A.C.S., RICCI, C.N., GOMES, L.A.L. & BARROS, H.M. 1979. Resultados preliminares dos trabalhos ecológicos

realizados na lagoa de Juturnaíba, município de Araruama, Estado do Rio de Janeiro, criadouro natural dos bivalves *Diplodon besckeanus* (Dunker, 1849) (Unionoidea; Hyriidae) e *Anodontites trapesialis* (Lamarck, 1819) (Muteloidea; Mycetopodidae). Anais do V Encontro de Malacologistas Brasileiros. 1:73-89.

AMARAL, A.C.Z., RIBEIRO, C.V., MANSUR, M.C.D., SANTOS, S.B., AVELAR, W.E.P., MATTHEWS-CASCON, H., LEITE, F.P.P., MELO, G.A.S., COELHO, P.A., BUCKUP, G.B., BUCKUP, L., VENTURA, C.R.R. & TIAGO, C.G. A situação de ameaça dos invertebrados aquáticos no Brasil. In Livro vermelho da fauna brasileira ameaçada de extinção Série Biodiversidade vol. 19 – I (A.B.M. Machado, G.M. Drummond & A.P. Paglia, orgs). Ministério do Meio Ambiente, Brasília, p. 156-301.

ARRUDA, J.O., GOMES, S.R., RAMIREZ, R. & THOMÉ, J.W. 2006. Morfoanatomia de duas espécies do gênero *Omalonyx* (Mollusca, Gastropoda, Succineidae) com novo registro para Minas Gerais, Brasil. Biociências. 14(1):61-70.

BIELER, R., CARTER, J.G. & COAN, E.V. 2010. Classification of bivalve families. Malacologia. 52(2):113-184.

BOUCHET, P. & ROCROI, J.P. 2005. Classification and nomenclator of gastropods families. Malacologia. 47(1-2):1-396.

BRAGA, R.M.R., MIYAHIRA, I.C., LACERDA, L.E.M., GONÇALVES, I.C.B. & SANTOS, S.B. 2014. The influence of an invasive gastropod on the population dynamics of *Pisidium punctiferum* (Sphaeriidae) in an insular impacted stream in Rio de Janeiro, Brazil. In Medical and Applied Malacology Crossing Boundaries: Integrative Approaches to Malacology (A.R.T. Piza, L.F. Tallarico, G.O. Introíni & S.B. Santos, orgs.). Cambridge Scholars Publishing, Newcastle, p. 97-114.

BOGAN, A.E. 2008. Global diversity of freshwater mussels (Mollusca, Bivalvia) in freshwater. Hydrobiologia 595:139-147.

CALLISTO, M., FERREIRA, W.R., MORENO, P., GOULART, M. & PETRUCIO, M. 2002. Aplicação de um protocolo de avaliação rápida da diversidade de habitats em atividades de ensino e pesquisa (MG-RJ). Acta limnol. bras. 14(1):91-98.

COSTA, M.R., MATTOS, T.M., BORGES, J.L. & ARAÚJO, F.G. 2013. Habitat preferences of common native fishes in a tropical river in Southeastern Brazil. Neotrop. ichthyol. 11(4):871-880.

FERNANDEZ, M.A., THIENGO, S.C. & SIMONE, L.R.L. 2003. Distribution of the introduced freshwater snail *Melanoides tuberculatus* (Gastropoda: Thiaridae) in Brazil. The Nautilus. 117:78-82.

FERNANDEZ, M.A., THIENGO, S.C. & AMARAL, R.S. 2008. Técnicas Malacológicas. In Vigilância e controle de moluscos de importância epidemiológica. (Ministério da Saúde. Departamento de vigilância epidemiológica, ed.). Editora do Ministério da Saúde, Brasília, p. 43-70.

FREITAS, J.R., BEDÊ, L.C., MARCO J.R., ROCHA, L.A. & SANTOS, M.B.L. 1987. Population dynamics of aquatic snails in Pampulha reservoir. Mem. Inst. Oswaldo Cruz. 82 (Suppl. IV):299-305.

GIOVANELLI, A., VIEIRA, M.V. & SILVA, C.L.P.A.C. 2003. Apparent competition through facilitation between *Melanoides tuberculatus* and *Biomphalaria tenagophila* and the control of schistosomiasis. Mem. Inst. Oswaldo Cruz. 98(3):429-431.

GUIMARÃES, C.T., SOUZA, C.P. & SOARES, D.M. 2001. Possible competitive displacement os Planorbids by *Melanoides tuberculata* in Minas Gerais, Brazil. Mem. Inst. Oswaldo Cruz. 96:173-176.

GRAF, D.L. & CUMMINGS, K.S. 2006. Palaeoheterodont diversity (Mollusca: Trigonioida + Unionoida): what we know and what we wish we knew about freshwater mussel evolution. Zool. j. Linn. Soc. 148:343-394.

HAAS, F. 1939. Zur Kenntnis der Binnen-Mollusken NO-Brasiliens. Senckenbergiana. 21(3-4):254-278.

HAAS, F. 1949a. Land- und Süßwassermollusken aus dem Amazonas-Gebiete. Arch. Molluskenkd. 78(4-6):149-156.

HAAS, F. 1949b. On fresh water mollusk from the Amazonian region. An. Inst. Biol. 20:301-314.

HAAS, F. 1952. South American non-marine shells: further remarks and descriptions. Fieldiana Zool. 34(9):107-132.

LACERDA, L.E.M., MIYAHIRA, I.C. & SANTOS, S.B. 2011. Shell morphology of the freshwater snail *Gundlachia ticaga* (Gastropoda, Ancylidae) from four sites in Ilha Grande, southeastern Brazil. Zoologia. 28(3):334-342.

LACERDA, L.E.M., MIYAHIRA, I.C. & SANTOS, S.B. 2013. First record and range extension of the freshwater limpet *Gundlachia radiata* (Guilding, 1828) (Mollusca: Gastropoda: Planorbidae) from southeast Brazil. Checklist. 9(1):125-128.

LACERDA, L.E.M., RICHAU, C.S., AMARAL, C.R.L.; SILVA, D.A.; CARVALHO, E.F. & SANTOS, S.B. 2015. *Ferrissia fragilis* (Tryon, 1863): a freshwater snail cryptic invader in Brazil revealed by morphological and molecular data. Aquat. Invasions. 10(2):157-168.

LOPES, B.G., MATTOS, A.C., FERNANDEZ, M.A., LACERDA, L.E.M., MIYAHIRA I.C., SANTOS, S.B. & THIENGO, S.C. 2011. Primeiro registro de "Gymnocephalous cercaria" (TREMATODA; FASCIOLIDAE) em *Gundlachia ticaga* (Marcus & Marcus, 1962) (GASTROPODA; ANCYLIDAE) NO BRASIL. In XXII Encontro Brasileiro de Malacologia (C.A.O. Meirelles, org.). Sociedade Brasileira de Malacologia, Fortaleza, p.465-468.

LYDEARD, C., COWIE, R.H., PONDER, W.F., BOGAN, A.E., BOUCHET, P., CLARK, S., CUMMINGS, K.S., FREST, T.J., GARGOMINY, O., HERBERT, D.G., HERSHLER, R., PEREZ, K., ROTH, B., SEDDON, M., STRONG, E.E. & THOMPSON, F.G. 2004. The global decline of nonmarine mollusks. BioScience. 54(4):321-330.

MANSUR, M.C.D. & MEIER-BROOK, C. 2000. Morphology of *Eupera* Bourguignat, 1854, and *Byssanodonta* Orbigny, 1846 with contributions to the phylogenetic systematics of Sphaeriidae and Corbiculidae (Bivalvia: Veneroida). Arch. Molluskenkd. 128(1-2):1-59.

MANSUR, M.C.D., CALLIL, C.T., CARODOSO, F.R. & IBARRA, J.A.A. 2004. Uma retrospectiva e mapeamento da invasão de espécies de *Corbicula* (Mollusca, Bivalvia, Veneroida, Corbiculidae) oriundas do sudeste asiático, na América do Sul. In Água de Lastro e Bioinvasão (J.S.V. Silva & R.C.C.L. Souza, orgs.) Editora Interciência, Rio de Janeiro, p. 39-58.

METZGER, J.P. & CASATTI, L. 2006. Do diagnóstico à conservação da biodiversidade: o estado da arte do programa BIOTA/FAPESP. Biota Neotrop. 6(2): 1-23. http://www.biotaneotropica.org.br/v6n2/pt/abstract?point-view+bn00106022006 (último acesso em 12/10/2016).

MEYER, A.A.N., OLIVEIRA, E., SILVA, I.S. & PRESTES, J.G. 2017. Evaluation of density of freshwater bivalves from the Environmental Protection Area (APA) of Verde River, Campo Magro, Paraná, Brazil. Pan-American Journal of Aquatic Sciences 12(1): 21-30.

MIYAHIRA, I.C., SANTOS, S.B., MANSUR, M.C.D. & CARNEIRO, J.B. 2012. Freshwater mussels in Brazil: past, presente and future, at least, we hope they have one. American Conchologist 40(3): 16-18.

MIYAHIRA, I.C., MANSUR, M.C.D. & SANTOS, S.B. 2013. Revision of the type specimens of *Diplodon ellipticus* and *Diplodon expansus* (Bivalvia, Unionoida, Hyriidae). Spixiana. 36(2):173-182.

MORRETES, F.L. 1949. Ensaio do catálogo dos moluscos do Brasil. Arq. mus. Paranaense 7: 5-216.

MOULTON, T.P., MELO, G.A.S., NESSIMIAN, J., SALGADO, N.C., PAIVA, P.C., ABSALÃO, R.S., SANTOS, S.B., VELOSO, V.G. & COSTA, J.M. 2000. Invertebrados aquáticos. In A fauna ameaçada de extinção do estado do Rio de Janeiro (H.G. Bergallo, C.F.D. Rocha, M.A.S. Alves & M. van Sluys, orgs.) Editora UERJ, Rio de Janeiro, p.45-51.

PEREIRA, D., ARRUDA, J.O., MENEGAT, R., PORTO, M.L., SCHWARZBOLD, A. & HARTZ, S.M. 2011. Guildas tróficas, composição e distribuição de espécies de moluscos límnicos no gradiente fluvial de um riacho subtropical brasileiro. Biotemas 24(1): 21-36.

PEREIRA, D., MANSUR, M.C.D., DUARTE, L.D.S., OLIVEIRA, A.S., PIMPÃO, D.M., CALLIL, C.T., ITUARTE, C., PARADA, E., PEREDO, S., DARRIGRAN, G., SCARABINO, F., CLAVIJO, C., LARA, G., MIYAHIRA, I.C., RODRIGUEZ, M.T.R. & LASSO, C. 2014. Bivalve distribution in hydrographic regions in South America: historical overview and conservation. Hydrobiologia 735(1): 15-44.

PINTO, H.A. & MELO, A.L. 2010. *Melanoides tuberculata* (Mollusca: Thiaridae) as an intermediate host of *Centrocestus formosanus* (Trematoda: Heterophyidae) in Brazil. Rev. Inst. Med. Trop. São Paulo. 52(4):207-210.

PINTO, H.A. & MELO, A.L. 2013. Larvas de trematódeos em moluscos do Brasil: panorama e perspectivas após um século de estudos. Rev. Patol. Trop. 42(4): 369-386.

SANTOS, S.B. 2003. Estado atual do conhecimento dos ancilídeos na América do Sul. (Mollusca, Gastropoda, Pulmonata, Basommatophora). Rev. Biol. Trop. 50(3):191-224.

SANTOS, S.B., THIENGO, S.C., FERNANDEZ, M.A., MIYAHIRA, I.C., GONÇALVES, I.C.B., XIMENES, R.F., MANSUR, M.C.D. & PEREIRA, D. 2012. Espécies de moluscos límnicos invasores no Brasil. In Moluscos Límnicos invasores no Brasil - Biologia, prevenção, controle (M.C.D. Mansur, C.P. Santos, D. Pereira, I.C.P. Paz, M.L.L. Zurita, M.T.R. Rodriguez, M.V. Nehrke & P.E.A. Bergonci, eds.). Editora Redes, Porto Alegre, p. 25-49.

SCHELL, S. 1970. How to know the trematodes. Dubuque, WMC Brown Co. Publisher, 355pp.

SIMONE, L.R.L. 2006. Land and freshwater mollusks of Brazil. EGB/FAPESP, São Paulo.

STRONG, E.E., GARGOMINY, O.G., PONDER, W.F. & BOUCHET, P. 2008. Global diversity of gastropods (Gastropoda; Mollusca) in freshwater. Hydrobiologia 595:149-166.

THIENGO, S.C., FERNANDEZ, M.A., BOAVENTURA, M.F., GRAULT, C.E., SILVA, H.F.R., MATTOS, A.C. & SANTOS, S.B. 2001. Freshwater Snails and *Schistosomiasis Mansoni* in the State of Rio de Janeiro, Brazil: I - Metropolitan Mesoregion. Mem. Inst. Oswaldo Cruz. 96 (Suppl.):177-184.

THIENGO, S.C., FERNANDEZ, M.A., BOAVENTURA, M.F., SANTOS, S.B. & MATTOS, A.C. 2002. Freshwater Snails and *Schistosomiasis Mansoni* in the State of Rio de Janeiro, Brazil: II – Centro Fluminense Mesoregion. Mem. Inst. Oswaldo Cruz. 96 (Suppl.):177-184.

THIENGO, S.C., FERNANDEZ, M.A., MATTOS, A.C. & BARBOSA, A.F. 2007. Dispersão do molusco introduzido *Melanoides tuberculatus* (Müller, 1774) (Gastropoda; Thiaridae) no Brasil. In Tópicos em Malacologia - ECOS do XVIII EBRAM (S.B. Santos, A.D. Pimenta, S.C. Thiengo, M.A. Fernandez, & R.S. Absalão, orgs.) SBMa, Rio de Janeiro, p.101-106.

TUBBS-FILHO, D. & VETTORAZZI, J.S. 2012. Presença do molusco bivalve *Corbicula fluminea* em afluentes da bacia hidrográfica do Rio Guandu. In Bacia Hidrográfica dos Rios Guandu, da Guarda e Guandu-Mirim/Comitê da Bacia Hidrográfica Guandu (D. Tubbs-Filho, J.C.O. Antunes & J.S. Vettorazzi, orgs.). INEA, Rio de Janeiro, p. 257-272.

VAZ, J.F., TELES, H.M.S., CORREA, M.A. & LEITE, S.P.S. 1986. Ocorrência no Brasil de *Thiara* (*Melanoides*) *tuberculata* (Muller, 1774) (Gastropoda, Prosobranchia), primeiro hospedeiro intermediário de *Clonorchis sinensis* (Cobbold, 1875) (Trematoda, Plathyhelmintes). Rev. Saúde Pública. 20(4):318-322.

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