

SPATIAL DISTRIBUTION OF LYMNAEIDAE (MOLLUSCA, BASOMMATOPHORA), INTERMEDIATE HOST OF *Fasciola hepatica* LINNAEUS, 1758 (TREMATODA, DIGENEA) IN BRAZIL

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SUMMARY

Snails of the family Lymnaeidae act as intermediate hosts in the biological cycle of *Fasciola hepatica*, which is a biological agent of fasciolosis, a parasitic disease of medical importance for humans and animals. The present work aimed to update and map the spatial distribution of the intermediate host snails of *F. hepatica* in Brazil. Data on the distribution of lymnaeids species were compiled from the Collection of Medical Malacology (Fiocruz-CMM, CPqRR), Collection of Malacology (MZUSP), "SpeciesLink" (CRIA) network and through systematic surveys in the literature. Our maps of the distribution of lymnaeids show that *Pseudosuccinea columella* is the most common species and it is widespread in the South and Southeast with few records in the Midwest, North and Northeast regions. The distribution of the *Galba viatrix*, *G. cubensis* and *G. truncatula* showed a few records in the South and Southeast regions, they were not reported for the Midwest, North and Northeast. In addition, in the South region there are a few records for *G. viatrix* and one occurrence of *Lymnaea rupestris*. Our findings resulted in the first map of the spatial distribution of Lymnaeidae species in Brazil which might be useful to better understand the fasciolosis distribution and delineate priority areas for control interventions.

KEYWORDS: Lymnaeids; Fasciolosis; Spatial distribution; Snails; Brazil.

INTRODUCTION

Snails of the family Lymnaeidae are small Basommatophora hermaphrodites, approximately 10 mm long and 6 mm wide. The lymnaeids species is widely distributed around the tropical and subtropical areas of the Americas, Europe, Asia, Africa, and Oceania³⁶ and inhabits natural (streams, ponds, swamps) or artificial (irrigation ditches, small dams, floodplain) types of water collections²³.

The importance of the lymnaeids is due to the fact that they act as intermediate hosts in the biological cycle of the digenetic trematode *Fasciola hepatica* Linnaeus, 1758 (Trematoda, Digenea), biological agent of fasciolosis, which is a parasitic disease of medical importance for both humans and animals.

Based on an increasing number of human cases since 1980, MAS-COMA *et al.*⁵⁰ proposed that fasciolosis should be considered an important parasitic human disease rather than just a secondary zoonotic disease with an estimated number of infected people of more than 2.4 million people worldwide¹⁰⁸. The economic losses caused by this disease include a significant impact on the livestock industry due to the high costs for therapeutic treatments in cattle, goat, and sheep breeding^{24,29,43,49,83}. SMOOKER *et al.*⁸⁴ calculated a global cost of more than two billion dollars a year because of the infection.

In Brazil, the lymnaeids species already recorded are: *Pseudosuccinea columella* (Say, 1817), *Galba viatrix* d'Orbigny, 1835, *Galba truncatula* (Müller, 1774), *Galba cubensis* Pfeiffer, 1839 and *Lymnaea rupestris* Paraense, 1982. Except for *L. rupestris*, the other species have proved to be susceptible to infection by *F. hepatica*. Regarding the identification of lymnaeids species, their systematics is confused and there are a lot of difficulties in identifying some species using only morphological characters^{28,77}, so molecular markers are frequently necessary. Here, we used the taxonomy proposed by BAKER¹³ for the species *P. columella*.

The present work aimed to update and map the spatial distribution of the intermediate host snails of *F. hepatica* in Brazil.

MATERIAL AND METHODS

Malacological data: Data on the distribution of lymnaeids species were obtained from: i) Collection of Medical Malacology (Fiocruz-CMM) of the Laboratory of Medical Helminthology and Malacology, René Rachou Research Center (Fiocruz/MG); ii) Collection of Malacology of the Museum of Zoology of University of São Paulo (MZUSP); iii) "SpeciesLink" (CRIA) network (<http://www.splink.org.br/>), by using the keyword Lymnaeidae in the database search; iv) systematic surveys in scientific articles, gray literature, dissertations, theses, and communications, by using the combined keywords: *Lymnaea*/

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Galba/Pseudosuccinea/Lymnaeidae + occurrence + Brazil; *Lymnaea/Galba/Pseudosuccinea*/Lymnaeidae + distribution + Brazil; *Lymnaea/Galba/Pseudosuccinea*/Lymnaeidae + record + Brazil; *Lymnaea/Galba/Pseudosuccinea*/Lymnaeidae + collection + Brazil; *Fasciola* + occurrence + Brazil; *Fasciola* + distribution + Brazil; *Fasciola* + record + Brazil; Fasciolosis + occurrence + Brazil; Fasciolosis + distribution + Brazil and Fasciolosis + record + Brazil. According to the type of database (or sites), terms were used in English or Portuguese: Google scholar, Web of Knowledge, Scielo, PubMed, Periódicos Capes (*Capes Journals*) and Banco Digital de Teses e Dissertações (*Theses and Dissertations Digital Database*). The data collected had information relative to the occurrence of lymnaeids per state and municipalities of Brazilian regions and if the snails were found naturally infected by *F. hepatica*.

In the majority of the data used, the identification of the lymnaeids species was made using only morphological characters except when the data are from Fiocruz-CMM, where molecular markers were utilized to confirm the morphological identification. The molecular technique used was the polymerase chain reaction and restriction fragment length polymorphism (PCR-RFLP) targeted to the first and second internal transcribed spacers (ITS1 and ITS2) rDNA and to the mitochondrial 16S ribosomal gene (16S rDNAm)^{19,22}.

Data management and mapping: Data management, visualization and mapping were carried out in ArcGIS version 9.3 (ESRI; Redlands, CA, USA).

RESULTS

Reports on five species of Lymnaeidae were found in Brazil. Tables 1 and 2 summarize the distribution per locality of species in the five regions of Brazil (Fig. 1 and 2), South (Fig. 3), Southeast (Fig. 4), Midwest, North and Northeast regions (Fig. 5). In the "SpeciesLink" (CRIA) network, we found data relative to four collections: Collection of Molluscs of Museum of Science and Technology, PUCRS; Collection of Molluscs of National Institute of Research of Amazônia, INPA; Malacological Collection of Biological Science Department, DCBio/UFES and Collection of Malacology of Oswaldo Cruz Institute, Fiocruz-CMIOC. The information about the localities where the specimens occurred was not available from the Collection of Malacology of Oswaldo Cruz Institute, Fiocruz-CMIOC, because of this, we did not add these data to our results. The data from the Collection of Medical Malacology, Fiocruz-CMM, were already available to us.

Lymnaeids snails were reported in 417 municipalities and one ecological reserve (Taim) of 16 states, which corresponds to 7.5% of all municipalities in Brazil. *Pseudosuccinea columella* was reported in 400 (95.7%) localities while *G. viatrix* in 10 (2.4%), *G. cubensis* in six (1.4%), *G. truncatula* in three (0.7%) and *L. rupestris* in one (0.2%). In 25 (6%) municipalities: Bom Jesus, Cambará do Sul, Erval Grande, Estrela, Ibirubá, Porto Alegre, São Borja, São Francisco de Paula, Selbach, Três Coroas, Vacaria and Viamão of Rio Grande do Sul State; Piracicaba, Presidente Prudente, São Paulo and Ubatuba of São Paulo State; Rio de Janeiro, Nova Friburgo, Teresópolis and Vassouras of Rio de Janeiro State; Ouro Branco and Careaçú of Minas Gerais State; Campos Novos/SC; Curitiba/PR and Belém/PA, it was not possible to accomplish a complete identification of the specimens collected. Occurrence of more

than one species was reported in 13 municipalities (3.1%): Dom Pedrito, Pelotas and Santa Vitória do Palmar in the state of Rio Grande do Sul; Florianópolis (*P. columella* and *G. viatrix*) and Seara (*L. rupestris*, *P. columella* and *G. viatrix*) in the state of Santa Catarina; Teresópolis (*P. columella*; *G. cubensis* and *G. truncatula*), Nova Friburgo (*P. columella* and *G. truncatula*), Paraíba do Sul, Petrópolis, Rio de Janeiro and Três Rios (*P. columella* and *G. cubensis*) in the state of Rio de Janeiro; Belo Horizonte (*P. columella*, *G. viatrix* and *G. cubensis*) and Rio Acima (*P. columella*, *G. viatrix* and *G. truncatula*) in the state of Minas Gerais.

Specimens of *P. columella* and *G. viatrix* were reported in 403 localities (96.4%). *P. columella* was reported naturally infected with *F. hepatica* in 11 municipalities of the states of Rio Grande do Sul, São Paulo, Minas Gerais and Rio de Janeiro, *G. viatrix* was found naturally infected in three municipalities of Rio Grande do Sul while *Lymnaea* sp. was found in one municipality of Minas Gerais. In Dom Pedrito/RS, both species were found naturally infected.

DISCUSSION

Our study resulted in the first map of the spatial distribution of Lymnaeidae species, intermediate host snails of *F. hepatica* in Brazil. The presence of host snails could reflect the disease distribution, and these data are essential for describing the risk areas of fasciolosis since there is an increase of the association between the global number of human cases and the presence of the intermediate host snail⁹⁰.

PARAENSE⁶⁵ showed that *G. viatrix* had few records in the South and *P. columella* was distributed mainly in the South and Southeast, where a high number of fasciolosis cases occurs³⁶, with few records in the Midwest region. After that, the same author reported two new localities of *P. columella* for the states of Amazonas and Bahia⁶⁷ in the North and Northeast respectively. This agrees with our study where we also reported a low presence of this species in these regions. Our final maps about spatial distribution of lymnaeids snails show that *P. columella* is the most common species and it is widespread in the South and Southeast with few records in the Midwest, North and Northeast regions. *Galba viatrix* is predominantly distributed in the South (eight records) with only two records for the Southeast region (Belo Horizonte and Rio Acima, Minas Gerais State). The distribution of *G. viatrix*, *G. cubensis* and *G. truncatula* comprises few records in Southeast and South regions. They were not reported for the Midwest, North and Northeast. For the South region, the species *L. rupestris* was only described and found in the Nova Teutônia district in Seara municipality at Santa Catarina State⁶⁴.

Despite the few records showed by *G. viatrix* in our study, according to MATTOS & UENO⁵² this intermediate host is considered the most efficient species in the transmission of *F. hepatica* due to its high susceptibility when compared with *P. columella*⁵². However, *P. columella* showed to be the most distributed species (Fig. 1; 95.7%) and is certainly the most important intermediate host in Brazil. This is probably due to its biological aspects, such as its high capacity for self-fertilization, favorable condition in dispersion and colonization of new habitats^{20,35}. *Pseudosuccinea columella* is commonly found in most human or animal fasciolosis outbreaks while the occurrence of *G. viatrix* is, currently, restricted to the state of Rio Grande do Sul^{24,33,63,76,101} and in Minas Gerais²².

Table 1
Distribution of *Pseudosuccinea columella* per municipalities and regions of Brazil

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network	
1) South					
Rio Grande do Sul	Agudo	29s38/53w15	<i>P. columella</i>	1	
	Arroio Grande	32s14/53w05	<i>P. columella</i>	2	
	Cachoeira do Sul	30s02/52w53	<i>P. columella</i>	4	
	Camaquã	30s51/51w48	<i>P. columella</i> ⁺	4; 5; 6	
	Candiota	31s35/53w43	<i>P. columella</i>	MCP-Moluscos	
	Capão do Leão	31s46/52w30	<i>P. columella</i>	4; 2	
	Dom Pedrito	30s58/54w40	<i>P. columella</i> ⁺	4	
	Eldorado do Sul	29s50/51w18	<i>P. columella</i>	81	
	Gramado	29s23/50w52	<i>P. columella</i>	Fiocruz-CMM	
	Guaíba	30s06/51w19	<i>P. columella</i>	4	
	Morro Reuter	29s32/51w04	<i>P. columella</i>	4	
	Nova Petrópolis	29s20/51w10	<i>P. columella</i>	4	
	Pelotas	31s46/52w20	<i>P. columella</i>	8; 9; Fiocruz-CMM	
	Porto Alegre	30s01/51w13	<i>P. columella</i>	11; 4	
	Rosário do Sul	30s15/54w55	<i>P. columella</i> ⁺	12	
	Santa Maria	29s41/53w48	<i>P. columella</i>	13	
	Santa Vitória do Palmar	33s31/53w22	<i>P. columella</i>	4	
	Santo Antônio da Patrulha	29s49/50w30	<i>P. columella</i>	84	
	São Borja	28s39/55w59	<i>P. columella</i>	15	
	São Leopoldo	29s45/51w08	<i>P. columella</i>	MZUSP	
	São Martinho da Serra	29s32/53w51	<i>P. columella</i>	13	
	Sapucaia do Sul	29s49/51w09	<i>P. columella</i> ⁺	12	
	Reserva ecológica do Taim	32s29/52w35	<i>P. columella</i>	4	
	Rio Pardo	29s99/52w35	<i>P. columella</i>	MCP-Moluscos	
	Taquara	29s38/50w46	<i>P. columella</i>	4; 87	
	Tramandaí	29s59/50w07	<i>P. columella</i>	4	
	Triunfo	29s56/51w43	<i>P. columella</i>	16; Fiocruz-CMM	
	Viamão	30s04/51w01	<i>P. columella</i>	4	
	Santa Catarina	Araranguá	28s56/49w28	<i>P. columella</i>	4
		Biguaçu	27s29/48w39	<i>P. columella</i>	18; 19; 20
Blumenau		26s54/49w04	<i>P. columella</i>	18; 19; 20	
Brusque		27s05/48w55	<i>P. columella</i>	18; 19; 20	
Camboriú		27s01/48w39	<i>P. columella</i>	18; 19; 20	
Criciúma		28s41/49w22	<i>P. columella</i>	18; 19; 20	
Florianópolis		27s35/48w33	<i>P. columella</i>	4; 17; 18; 19; 20	
Itá		27s29/52w32	<i>P. columella</i>	MCP-Moluscos	
Joinville		26s17/48w50	<i>P. columella</i>	4	
Lages		27s48/50w19	<i>P. columella</i>	4	
Lauro Müller		28s23/49w24	<i>P. columella</i>	MZUSP	
Nova Trento		27s17/48w55	<i>P. columella</i>	18; 19; 20	
Palhoça		27s38/48w40	<i>P. columella</i>	18; 19; 20	
São João do Sul		29s13/49w48	<i>P. columella</i>	18; 19; 20	
Seara		27s12/52w19	<i>P. columella</i>	4; 24 Fiocruz-CMM	

Table 1
Distribution of *Pseudosuccinea columella* per municipalities and regions of Brazil (cont.)

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network
Santa Catarina	Tubarão	28s28/49w00	<i>P. columella</i>	18; 19; 20
	Urubici	28s00/49w35	<i>P. columella</i>	25
Paraná	Antonina	25s42/48w71	<i>P. columella</i>	91
	Balsa Nova	25s58/49w63	<i>P. columella</i>	91
	Bocaiúva do Sul	25s12/49w06	<i>P. columella</i>	26; 91
	Cambará	23s02/50w04	<i>P. columella</i>	Fiocruz-CMM
	Campina Grande do Sul	25s30/49w05	<i>P. columella</i>	91
	Campo Largo	25s45/49w53	<i>P. columella</i>	91
	Contenda	25s67/49w52	<i>P. columella</i>	91
	Curitiba	25s25/49w16	<i>P. columella</i>	27; 4; 28; 24; 87; 52; 91; Fiocruz-CMM MZUSP
	Dionísio Cerqueira (Barracão)	26s15/53w38	<i>P. columella</i>	4
	Morretes	25s28/48w49	<i>P. columella</i>	4; 91
	Paranaguá	25s30/48w30	<i>P. columella</i>	MZUSP
	Quatro Barras	25s36/49w07	<i>P. columella</i>	91
	Rio Branco do Sul	25s19/49w31	<i>P. columella</i>	91
	São José dos Pinhais	25s32/49w12	<i>P. columella</i>	87; 91
	Tunas do Paraná	24s58/49w05	<i>P. columella</i>	26; MZUSP
	2) Southeast			
São Paulo	Águas de Santa Bárbara	22s52/49w14	<i>P. columella</i>	29
	Altinópolis	21s04/47w22	<i>P. columella</i>	30
	Álvares Machado	22s04/51w28	<i>P. columella</i>	31
	Americana	22s44/47w19	<i>P. columella</i>	80
	Américo Brasiliense	21s43/48w06	<i>P. columella</i>	30
	Angatuba	23s29/48w24	<i>P. columella</i>	29
	Anhembi	22s47/48w07	<i>P. columella</i>	29
	Araçoiaba da Serra	23s30/47w36	<i>P. columella</i>	29
	Aramina	20s05/47w47	<i>P. columella</i>	30
	Arandu	23s08/49w03	<i>P. columella</i>	29
	Araraquara	21s47/48w10	<i>P. columella</i>	30
	Areiópolis	22s40/48w39	<i>P. columella</i>	29
	Atibaia	23s69/46w33	<i>P. columella</i>	80
	Avanhandava	21s27/49w56	<i>P. columella</i>	MZUSP
	Avaré	21s54/49w21	<i>P. columella</i>	29
	Barão de Antonina	23s37/49w33	<i>P. columella</i>	29
	Barra Bonita	22s29/48w33	<i>P. columella</i>	33
	Barretos	20s33/48w34	<i>P. columella</i>	30
	Batatais	20s53/47w35	<i>P. columella</i>	30
	Bebedouro	20s56/48w28	<i>P. columella</i>	30
	Boa Esperança do Sul	21s59/48w23	<i>P. columella</i>	30
Bofete	23s05/48w15	<i>P. columella</i>	29	
Boituva	23s17/47w40	<i>P. columella</i>	29	
Borborema	21s37/49w04	<i>P. columella</i>	30	
Botucatu	22s53/48w26	<i>P. columella</i>	29	

Table 1
Distribution of *Pseudosuccinea columella* per municipalities and regions of Brazil (cont.)

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network
São Paulo	Brodowski	20s59/47w39	<i>P. columella</i>	30
	Brotas	22s17/48w07	<i>P. columella</i>	MZUSP
	Buri	23s47/48w35	<i>P. columella</i>	29
	Cabreúva	23s18/47w07	<i>P. columella</i>	29
	Caçapava	23s05/45w42	<i>P. columella</i>	4; 80
	Caiuá	21s49/51w59	<i>P. columella</i>	31
	Cajurú	21s16/47w18	<i>P. columella</i>	30
	Campinas	22s53/47w05	<i>P. columella</i>	34; 4; 35; 36; 80
	Cândido Rodrigues	21s19/48w37	<i>P. columella</i>	30
	Capão Bonito	24s00/48w20	<i>P. columella</i>	29
	Capela do Alto	23s27/47w44	<i>P. columella</i>	29
	Caraguatatuba	23s27/45w24	<i>P. columella</i>	MZUSP
	Cássia dos Coqueiros	21s16/47w10	<i>P. columella</i>	30
	Catiguá	21s03/49w03	<i>P. columella</i>	37
	Cerqueira Cesar	23s01/49w09	<i>P. columella</i>	29
	Cerquilha	23s09/47w44	<i>P. columella</i>	29
	Cesário Lange	23s13/47w57	<i>P. columella</i>	29
	Colina	20s43/48w32	<i>P. columella</i>	30
	Colômbia	20s10/48w41	<i>P. columella</i>	30
	Conchas	23s01/48w00	<i>P. columella</i>	29
	Coronel Macedo	23s38/49w18	<i>P. columella</i>	29
	Cravinhos	21s20/47w43	<i>P. columella</i>	30
	Cristais Paulista	20s23/47w25	<i>P. columella</i>	30
	Descalvado	21s54/47w37	<i>P. columella</i>	30
	Dourado	22s06/48w18	<i>P. columella</i>	30
	Eldorado	24s30/48w05	<i>P. columella</i> ⁺	41
	Estrela do Norte	22s29/51w39	<i>P. columella</i>	31
	Fernando Prestes	21s15/48w41	<i>P. columella</i>	30
	Franca	20s31/47w23	<i>P. columella</i>	30
	Guaíra	20s19/48w19	<i>P. columella</i>	30
	Guapiaçú	20s47/49w13	<i>P. columella</i>	37
	Guapiara	24s10/48w32	<i>P. columella</i>	29
	Guará	20s25/47w49	<i>P. columella</i>	30
	Guaraci	20s29/48w56	<i>P. columella</i>	37
	Guareí	23s22/48w10	<i>P. columella</i>	29
	Guarujá	23s58/46w15	<i>P. columella</i>	MZUSP
	Ibaté	21s57/47w59	<i>P. columella</i>	30
	Ibirá	21s04/49w14	<i>P. columella</i>	37
	Ibitinga	21s45/48w49	<i>P. columella</i>	30
	Ibiúna	23s38/47w13	<i>P. columella</i>	29
Iepê	22s38/51w06	<i>P. columella</i>	31	
Igarapava	20s02/47w44	<i>P. columella</i>	30; Fiocruz-CMM	
Indiana	22s08/51w15	<i>P. columella</i>	31	
Iperó	23s21/47w42	<i>P. columella</i>	29	

Table 1
Distribution of *Pseudosuccinea columella* per municipalities and regions of Brazil (cont.)

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network
São Paulo	Irapuã	21s17/49w24	<i>P. columella</i>	37
	Itaberá	23s51/49w208	<i>P. columella</i>	29
	Itaí	23s24/49w05	<i>P. columella</i>	29
	Itapetininga	23s36/48w03	<i>P. columella</i>	29
	Itapeva	23s58/48w52	<i>P. columella</i>	29
	Itápolis	21s35/48w48	<i>P. columella</i>	30
	Itaporanga	23s42/48w29	<i>P. columella</i>	29
	Itararé	24s06/49w20	<i>P. columella</i>	29
	Itariri	24s17/47w03	<i>P. columella</i>	4; 32
	Itatinga	23s06/48w36	<i>P. columella</i>	29
	Itu	23s15/47w17	<i>P. columella</i>	29
	Itupeva	23s08/47w04	<i>P. columella</i>	MZUSP
	Ituverava	20s20/47w47	<i>P. columella</i>	30
	Jaboticabal	21s15/48w18	<i>P. columella</i>	30
	Jaguariúna	22s42/46w59	<i>P. columella</i>	36
	Jardinópolis	21s01/47w45	<i>P. columella</i>	30
	João Ramalho	22s15/50w46	<i>P. columella</i>	31
	Junqueirópolis	21s31/51w26	<i>P. columella</i>	31
	Louveira	23s05/46w58	<i>P. columella</i>	36
	Luis Antônio	21s33/47w42	<i>P. columella</i>	30
	Mairinque	23s32/47w11	<i>P. columella</i>	29
	Marinópolis	20s26/50w49	<i>P. columella</i>	37
	Martinópolis	22s08/51w10	<i>P. columella</i>	31
	Matão	21s36/48w21	<i>P. columella</i>	30
	Miguelópolis	20s10/48w01	<i>P. columella</i>	30
	Miracatu	24s16/47w27	<i>P. columella</i> ⁺	36; 41
	Monte Alto	21s15/48w29	<i>P. columella</i>	30
	Monte Aprazível	20s45/49w42	<i>P. columella</i>	37
	Monte Azul Paulista	20s54/48w38	<i>P. columella</i>	30
	Morro Agudo	20s43/48w03	<i>P. columella</i>	30
	Narandiba	22s24/51w31	<i>P. columella</i>	31
	Nova Europa	21s46/48w33	<i>P. columella</i>	30
	Nova Granada	20s31/49w18	<i>P. columella</i>	37
	Novo Horizonte	21s28/49w13	<i>P. columella</i>	37
	Olímpia	20s44/48w54	<i>P. columella</i>	37
	Orlândia	20s43/47w53	<i>P. columella</i>	30
	Oswaldo Cruz	23s37/46w34	<i>P. columella</i>	31
	Palestina	20s21/49w25	<i>P. columella</i>	37
	Palmital	22s46/50w12	<i>P. columella</i>	Fiocruz-CMM
	Panorama	21s20/51w51	<i>P. columella</i>	31
Paraíso	20s59/48w46	<i>P. columella</i>	37	
Paranapanema	23s23/48w43	<i>P. columella</i>	29	
Parapuã	21s46/50w47	<i>P. columella</i>	31	
Pardinho	23s04/48w22	<i>P. columella</i>	29	

Table 1
Distribution of *Pseudosuccinea columella* per municipalities and regions of Brazil (cont.)

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network
São Paulo	Patrocínio Paulista	20s37/47w16	<i>P. columella</i>	30
	Pedregulho	20s14/47w28	<i>P. columella</i>	30
	Pereiras	23s04/47w58	<i>P. columella</i>	29
	Piedade	23s41/47w25	<i>P. columella</i>	29
	Pilar do Sul	23s48/47w43	<i>P. columella</i>	29
	Piquerobi	21s52/51w43	<i>P. columella</i>	31
	Piquete	22s36/45w10	<i>P. columella</i> ⁺	38; 39; 75; MZUSP
	Piracicaba	22s43/47w39	<i>P. columella</i>	36
	Pirangi	21s09/48w39	<i>P. columella</i>	30
	Pirassununga	21s59/47w25	<i>P. columella</i>	4; 36; 80
	Pitangueiras	20s59/48w12	<i>P. columella</i>	30
	Planalto	21s21/49w55	<i>P. columella</i>	37
	Pontal	20s59/48w02	<i>P. columella</i>	30
	Porangaba	20s54/47w53	<i>P. columella</i>	29
	Porto Feliz	23s12/47w31	<i>P. columella</i>	29
	Pradópolis	21s21/48w03	<i>P. columella</i>	30
	Presidente Bernardes	22s00/51w33	<i>P. columella</i>	31
	Rancharia	22s13/50w53	<i>P. columella</i>	31
	Redenção da Serra	23s13/45w32	<i>P. columella</i>	38
	Regente Feijó	22s13/51w18	<i>P. columella</i>	31
	Registro	24s29/47w51	<i>P. columella</i>	36
	Restinga	20s34/47w29	<i>P. columella</i>	30
	Ribeirão Bonito	20s02/48w10	<i>P. columella</i>	30
	Ribeirão Branco	24s11/48w46	<i>P. columella</i>	29
	Ribeirão Preto	21s10/47w48	<i>P. columella</i>	4; 30; MZUSP
	Rincão	21s34/48w04	<i>P. columella</i>	30
	Rinópolis	21s43/50w43	<i>P. columella</i>	31
	Rio Claro	22s23/47w33	<i>P. columella</i>	4
	Riversul	23s48/49w24	<i>P. columella</i>	29
	Rubinéia	20s10/50w59	<i>P. columella</i>	37
	Sales	21s20/49w30	<i>P. columella</i>	37
	Sales Oliveira	20s46/47w56	<i>P. columella</i>	30
	Salesópolis	23s31/45w50	<i>P. columella</i>	78; MZUSP
	Salto	23s11/47w17	<i>P. columella</i>	29
	Salto de Pirapora	23s38/47w34	<i>P. columella</i>	29
	Sandovalina	22s26/51w46	<i>P. columella</i>	31
	Santa Adélia	21s14/48w47	<i>P. columella</i>	37
	Santa Mercedes	21s20/51w45	<i>P. columella</i>	31
	Santa Rita do Passa Quatro	21s42/47w28	<i>P. columella</i>	30
	Santa Rosa do Viterbo	21s28/47w21	<i>P. columella</i>	30
Santo Anastácio	21s57/51w38	<i>P. columella</i>	31	
Santo Expedito	21s50/51w23	<i>P. columella</i>	31	
São Carlos	21s59/47w53	<i>P. columella</i>	30	
São Joaquim da Barra	20s34/47w52	<i>P. columella</i>	30	

Table 1
Distribution of *Pseudosuccinea columella* per municipalities and regions of Brazil (cont.)

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network
São Paulo	São José do Rio Preto	20s40/49w17	<i>P. columella</i>	37
	São José dos Campos	23s11/45w52	<i>P. columella</i>	4
	São Manoel	22s43/47w18	<i>P. columella</i>	29
	São Miguel Arcanjo	23s52/47w59	<i>P. columella</i>	29
	São Paulo	23s32/46w38	<i>P. columella</i>	4; MZUSP
	São Roque	23s31/47w08	<i>P. columella</i>	29
	São Simão	21s28/47w33	<i>P. columella</i>	30
	São Vicente	23s57/46w22	<i>P. columella</i>	MZUSP
	Sarapuí	23s37/47w49	<i>P. columella</i>	29
	Serrana	21s12/47w36	<i>P. columella</i>	30
	Sertãozinho	21s06/47w59	<i>P. columella</i>	30
	Sorocaba	23s28/47w25	<i>P. columella</i>	29
	Tabatinga	21s42/48w40	<i>P. columella</i>	30
	Taiacu	21s08/48w30	<i>P. columella</i>	30
	Taiuva	21s06/48w26	<i>P. columella</i>	30
	Tapuaí	21s54/49w21	<i>P. columella</i>	29
	Taquaritinga	21s24/48w29	<i>P. columella</i>	30
	Taquarituba	23s31/49w14	<i>P. columella</i>	29
	Tarabaí	22s17/51w33	<i>P. columella</i>	31
	Tatuí	23s21/47w50	<i>P. columella</i>	29
	Taubaté	23s00/45w33	<i>P. columella</i>	4; 80
	Terra Roxa	20s46/48w19	<i>P. columella</i>	30
	Tietê	23s05/47w42	<i>P. columella</i>	29
	Urupês	21s08/49w15	<i>P. columella</i>	37
	Vista Alegre do Alto	21s09/48w38	<i>P. columella</i>	30
	Votorantim	23s32/47w26	<i>P. columella</i>	29
	Rio de Janeiro	Angra dos Reis	23s00/44w19	<i>P. columella</i>
Aperibé		21s37/42w06	<i>P. columella</i>	43
Araruama		22s50/42w20	<i>P. columella</i>	44
Areal		22s13/43w06	<i>P. columella</i>	45
Barra do Pirai		22s27/43w48	<i>P. columella</i>	42
Barra Mansa		22s32/44w10	<i>P. columella</i>	42
Bom Jardim		22s09/42w25	<i>P. columella</i>	45
Bom Jesus de Itabapoana		21s07/41w40	<i>P. columella</i>	43
Cachoeiras de Macacu		22s31/42w42	<i>P. columella</i> ⁺	46; 76
Cambuci		21s33/41w54	<i>P. columella</i>	43
Campos dos Goytacazes		21s45/41w20	<i>P. columella</i> ⁺	47; 48; 49
Cantagalo		21s58/42w22	<i>P. columella</i>	45
Cardoso Moreira		21s38/41w45	<i>P. columella</i>	49
Carmo		21s54/42w36	<i>P. columella</i>	45
Casimiro de Abreu		22s27/42w12	<i>P. columella</i>	44
Comendador Levy Gasparian		22s00/43w12	<i>P. columella</i>	45
Conceição de Macabu		22s03/41w51	<i>P. columella</i>	49
Cordeiro		22s00/42w21	<i>P. columella</i>	45

Table 1
Distribution of *Pseudosuccinea columella* per municipalities and regions of Brazil (cont.)

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network
Rio de Janeiro	Duas Barras	22s02/42w31	<i>P. columella</i>	45
	Engenheiro Paulo de Frontin	22s33/43w41	<i>P. columella</i>	46
	Guapimirim	22s29/42w59	<i>P. columella</i>	50
	Itaboraí	22s43/42w51	<i>P. columella</i>	46
	Itaguaí	22s51/43w46	<i>P. columella</i> [*]	46; 51; 85
	Italva	21s27/41w40	<i>P. columella</i>	43
	Itaocara	21s38/42w04	<i>P. columella</i>	43
	Itaperuna	21s10/41w53	<i>P. columella</i>	43
	Itatiaia	22s25/44w33	<i>P. columella</i>	42
	Japeri	22s38/43w39	<i>P. columella</i>	46
	Laje do Muriaé	21s11/42w07	<i>P. columella</i>	43
	Macaé	22s21/41w46	<i>P. columella</i>	49
	Magé	22s38/43w02	<i>P. columella</i>	50; 51
	Mangaratiba	22s56/44w02	<i>P. columella</i>	46
	Maricá	22s54/42w49	<i>P. columella</i>	46
	Mendes	22s31/43w44	<i>P. columella</i>	46
	Miguel Pereira	22s26/43w28	<i>P. columella</i>	46
	Miracema	21s22/42w12	<i>P. columella</i>	43
	Natividade	21s01/41w58	<i>P. columella</i>	43
	Niterói	22s52/43w07	<i>P. columella</i>	46; 53
	Nova Friburgo	22s15/42w31	<i>P. columella</i>	45
	Nova Iguaçu	22s44/43w27	<i>P. columella</i>	46
	Paracambi	22s29/43w41	<i>P. columella</i>	46
	Paraíba do Sul	22s08/43w16	<i>P. columella</i>	45
	Parati	23s10/44w43	<i>P. columella</i>	42
	Paty dos Alferes	22s25/43w25	<i>P. columella</i>	46
	Petrópolis	22s21/43w08	<i>P. columella</i>	50
	Pinheiral	22s31/44w00	<i>P. columella</i>	42
	Piraí	22s30/44w00	<i>P. columella</i>	42
	Porciúncula	20s57/42w02	<i>P. columella</i>	43
	Quatis	22s40/44w27	<i>P. columella</i>	42
	Resende	22s27/44w26	<i>P. columella</i>	42
	Rio Bonito	22s40/42w37	<i>P. columella</i>	46
	Rio Claro	22s72/44w13	<i>P. columella</i>	42
	Rio das Flores	22s15/43w58	<i>P. columella</i>	42
	Rio das Ostras	22s29/42w59	<i>P. columella</i>	44
	Rio de Janeiro	22s53/43w12	<i>P. columella</i>	4; 46; 54; 86
	Santa Maria Madalena	21s97/41w99	<i>P. columella</i>	45
	Santo Antônio de Pádua	21s53/42w18	<i>P. columella</i>	43
	São Fidélis	21s37/41w44	<i>P. columella</i>	49
São Gonçalo	22s83/43w05	<i>P. columella</i>	46; 51	
São João de Meriti	22s80/43w37	<i>P. columella</i>	46	
São José de Ubá	21s36/41w93	<i>P. columella</i>	43	
São José do Vale do Rio Preto	22s08/42w55	<i>P. columella</i>	50	

Table 1
Distribution of *Pseudosuccinea columella* per municipalities and regions of Brazil (cont.)

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network
Rio de Janeiro	São Sebastião do Alto	21s95/42w14	<i>P. columella</i>	45
	Sapucaia	21s99/42w90	<i>P. columella</i>	45
	Saquarema	22s93/42w49	<i>P. columella</i>	44
	Seropédica	22s51/43w45	<i>P. columella</i>	56; 89; Fiocruz-CMM
	Silva Jardim	22s37/42w23	<i>P. columella</i>	44
	Sumidouro	22s04/42w67	<i>P. columella</i>	45
	Tamoios	22s72/42w01	<i>P. columella</i>	44
	Teresópolis	22s23/42w58	<i>P. columella</i>	50
	Trajano de Moraes	22s07/42w06	<i>P. columella</i>	45
	Três Rios	22s05/43w12	<i>P. columella</i>	4; 45
	Valença	22s24/43w70	<i>P. columella</i>	42
	Varre-Sai	20s93/41w87	<i>P. columella</i>	43
	Vassouras	22s40/43w66	<i>P. columella</i>	11; 46
	Volta Redonda	22s52/44w10	<i>P. columella</i>	42
Minas Gerais	Alfenas	21s25/45w56	<i>P. columella</i>	Fiocruz-CMM
	Barbacena	21s13/43w46	<i>P. columella</i>	4
	Belo Horizonte	19s55/43w56	<i>P. columella</i>	11; 4; 58; 59; 23; 24 Fiocruz-CMM INPA-Mollusca
	Betim	19s58/44w04	<i>P. columella</i>	4; 59; 61 Fiocruz-CMM
	Bicas	21s43/43w04	<i>P. columella</i>	61
	Brasópolis	22s27/45w36	<i>P. columella</i>	61
	Cachoeira de Minas	22s20/45w46	<i>P. columella</i>	61
	Careaçu	22s02/45w41	<i>P. columella</i>	61
	Diamantina	18s13/43w35	<i>P. columella</i>	4
	Ferros	19s12/43w01	<i>P. columella</i>	4
	Igarapé	20s04/44w18	<i>P. columella</i>	61
	Itabirito	20s14/43w47	<i>P. columella</i>	61
	Itajubá	22s25/45w28	<i>P. columella</i> ⁺	9; 61; 62; 24; 8 Fiocruz-CMM
	Jaboticatubas	19s30/43w44	<i>P. columella</i>	8; 63; Fiocruz-CMM
	Januária	15s26/44w21	<i>P. columella</i>	64
	Juiz de Fora	21s45/43w20	<i>P. columella</i>	4; 65; 61; 83 Fiocruz-CMM
	Lagoa Santa	19s37/43w53	<i>P. columella</i>	59
	Machado	21s39/45w55	<i>P. columella</i>	Fiocruz-CMM
	Mariana	20s21/43w25	<i>P. columella</i>	66
	Nova Lima	19s58/43w50	<i>P. columella</i>	59
	Ouro Fino	22s16/46w22	<i>P. columella</i>	4
	Passos	20s42/46w36	<i>P. columella</i>	MZUSP
	Pedro Leopoldo	19s36/44w02	<i>P. columella</i>	59
	Perdões	21s09/45w08	<i>P. columella</i>	Fiocruz-CMM
	Piranguinho	22s23/45w32	<i>P. columella</i>	61
	Raposos	19s57/43w48	<i>P. columella</i>	Fiocruz-CMM

Table 1
Distribution of *Pseudosuccinea columella* per municipalities and regions of Brazil (cont.)

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network
Minas Gerais	Ribeirão das Neves	19s45/44w04	<i>P. columella</i>	59
	Rio Acima	20s03/43w47	<i>P. columella</i>	Fiocruz-CMM
	Rio Doce	20s14/42w53	<i>P. columella</i>	8
	Sabinópolis	18s39/43w04	<i>P. columella</i>	4
	Santa Luzia	19s44/43w53	<i>P. columella</i>	59
	Santa Rita do Sapucaí	22s14/45w43	<i>P. columella</i>	61
	São Gonçalo do Sapucaí	22s19/46w19	<i>P. columella</i>	11; 61
	Sete Lagoas	19s26/44w14	<i>P. columella</i>	11
	Timóteo	19s34/42w38	<i>P. columella</i>	Fiocruz-CMM
	Três Pontas	21s21/45w30	<i>P. columella</i>	24; Fiocruz-CMM
	Ubá	21s07/42w56	<i>P. columella</i>	4
	Varginha	21s33/45w26	<i>P. columella</i>	61
	Vespasiano	19s41/43w55	<i>P. columella</i>	59
	Viçosa	20s45/42w52	<i>P. columella</i>	11; 4
Espírito Santo	Alegre	20s45/41w31	<i>P. columella</i>	68
	Atílio Vivacqua	20s53/41w11	<i>P. columella</i>	68
	Cachoeiro do Itapemirim	20s49/41w06	<i>P. columella</i>	68
	Castelo	20s36/41w12	<i>P. columella</i>	68
	Guaçuí	20s45/41w40	<i>P. columella</i>	68
	Guarapari	20s65/40w51	<i>P. columella</i>	UFES-Malacologia
	Jerônimo Monteiro	20s47/41w23	<i>P. columella</i>	68
	Marataízes	21s00/40w49	<i>P. columella</i>	68
	Mimoso do Sul	21s03/41w22	<i>P. columella</i>	68
	Muniz Freire	20s27/41w24	<i>P. columella</i>	68
	Muqui	20s56/41w20	<i>P. columella</i>	68
	Piúma	20s49/40w43	<i>P. columella</i>	68
	Presidente Kennedy	21s04/41w01	<i>P. columella</i>	68
	Serra	20s12/40w30	<i>P. columella</i>	UFES-Malacologia
	Vartem Alta	20s40/41w00	<i>P. columella</i>	68
	Itapemirim	21s00/40w49	<i>P. columella</i>	68
3) Midwest				
Goiás	Barro Alto	14s58/48w55	<i>P. columella</i>	69
	Brasília	15s46/47w55	<i>P. columella</i>	4
	Campinaçu	13s44/48w34	<i>P. columella</i>	69
	Campinorte	14s18/49w88	<i>P. columella</i>	69
	Colinas do Sul	14s08/48w04	<i>P. columella</i>	69
	Formosa	15s30/47w20	<i>P. columella</i>	4
	Goiânia	16s41/49w13	<i>P. columella</i>	4; 24; 77 Fiocruz-CMM
	Minaçu	13s31/48w13	<i>P. columella</i>	69
	Mineiros	17s30/52w32	<i>P. columella</i>	70
	Niquelândia	14s26/48w27	<i>P. columella</i>	69
	Santa Rita do Novo Destino	15s06/49w06	<i>P. columella</i>	69
Uruaçu	14s29/49w07	<i>P. columella</i>	69	

Table 1
Distribution of *Pseudosuccinea columella* per municipalities and regions of Brazil (cont.)

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network
Mato Grosso	Cuiabá	15s35/56w05	<i>P. columella</i>	4
Mato Grosso do Sul	Aquidauana	20s27/55w46	<i>P. columella</i>	4
	Bela Vista	22s04/56w31	<i>P. columella</i>	4
4) Northeast				
Bahia	Salvador	12s58/38w32	<i>P. columella</i>	71
Ceará	Fortaleza	3s45/38w32	<i>P. columella</i>	8; Fiocruz-CMM
Paraíba	Campina Grande	7s12/35w53	<i>P. columella</i>	72; 73
5) North				
Amazonas	Benjamin Constant	4s22/70w01	<i>P. columella</i>	74
	Careiro	3s81/60w34	<i>P. columella</i>	Fiocruz-CMM
	Coari	4s05/63w08	<i>P. columella</i>	Fiocruz-CMM
	Manaus	3s06/60w03	<i>P. columella</i>	74
	Tefé	3s18/64w42	<i>P. columella</i>	71; Fiocruz-CMM
	Irlanduba	3s28/60w18	<i>P. columella</i>	INPA-Mollusca
Acre	Rio Branco	9s58/67w48	<i>P. columella</i>	24; Fiocruz-CMM

Table 2
Distribution of *Galba viatrix*, *G. rupestris*, *G. cubensis*, *Lymnaea truncatula* and *Lymnaea* sp. per municipalities and regions of Brazil

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network
1) South				
Rio Grande do Sul	Bagé	31s19/54w06	<i>G. viatrix</i>	3
	Bom Jesus	28s66/50w43	<i>Lymnaea</i> sp.	MCP-Moluscos
	Cambará do Sul	28s97/50w31	<i>Lymnaea</i> sp.	MCP-Moluscos
	Dom Pedrito	30s58/54w40	<i>G. viatrix</i> ⁺	4; 3; 7; 82
	Ervál Grande	27s38/52w57	<i>Lymnaea</i> sp.	MCP-Moluscos
	Estrela	28s86/51w17	<i>Lymnaea</i> sp.	MCP-Moluscos
	Ibirubá	28s54/53w09	<i>Lymnaea</i> sp.	MCP-Moluscos
	Jaguarão	32s33/53w22	<i>G. viatrix</i> ⁺	4; 3
	Lavras do Sul	30s48/53w53	<i>G. viatrix</i>	3
	Pelotas	31s46/52w20	<i>G. viatrix</i>	10
	Porto Alegre	30s01/51w13	<i>Lymnaea</i> sp.	MCP-Moluscos
	Santa Vitória do Palmar	33s31/53w22	<i>G. viatrix</i> ⁺	4; 14; 3; 89 Fiocruz-CMM
	São Borja	28s39/55w59	<i>Lymnaea</i> sp.	MCP-Moluscos
	São Francisco de Paula	29s26/50w35	<i>Lymnaea</i> sp.	MCP-Moluscos
	Selbach	28s37/52w56	<i>Lymnaea</i> sp.	MCP-Moluscos
	Três Coroas	29s30/50w46	<i>Lymnaea</i> sp.	MCP-Moluscos
	Vacaria	28s48/50w92	<i>Lymnaea</i> sp.	MCP-Moluscos
Viamão	30s04/51w01	<i>Lymnaea</i> sp.	MCP-Moluscos	
Santa Catarina	Campos Novos	27s40/51w22	<i>Lymnaea</i> sp.	MCP-Moluscos
	Florianópolis	27s35/48w33	<i>G. viatrix</i>	21

Table 2
Distribution of *G. viatrix*, *G. rupestris*, *G. cubensis* and *L. truncatula* and *Lymnaea* sp. per municipalities and regions of Brazil (cont.)

Regions/States	Localities	Geographic coordinates	Species	Articles/"SpeciesLink" (CRIA) network	
Santa Catarina	Seara	27s12/52w19	<i>G. viatrix</i>	22; 4	
			<i>L. rupestris</i>	23	
Paraná	Curitiba	25s25/49w16	<i>Lymnaea</i> sp.	MZUSP	
2) Southeast					
São Paulo	Piracicaba	22s43/47w39	<i>Lymnaea</i> sp.	MZUSP	
	Presidente Prudente	22s07/51w23	<i>Lymnaea</i> sp.	40	
	São Paulo	23s32/46w38	<i>Lymnaea</i> sp.	MZUSP	
	Ubatuba	23s25/45w04	<i>Lymnaea</i> sp.	MZUSP	
Rio de Janeiro	Nova Friburgo	22s15/42w31	<i>Lymnaea</i> sp.	45	
			<i>G. truncatula</i>	Fiocruz-CMM	
	Paraíba do Sul	22s08/43w16	<i>G. cubensis</i>	51	
	Petrópolis	22s21/43w08	<i>G. cubensis</i>	51	
	Rio de Janeiro	22s53/43w12	<i>G. cubensis</i>	55	
			<i>Lymnaea</i> sp.	MZUSP	
	Teresópolis	22s23/42w58	<i>Lymnaea</i> sp.	50	
			<i>G. cubensis</i>	51	
				<i>G. truncatula</i>	Fiocruz-CMM
				<i>G. cubensis</i>	51; 90
Vassouras	22s40/43w66	<i>Lymnaea</i> sp.	57		
Minas Gerais	Belo Horizonte	19s55/43w56	<i>G. cubensis</i>	60; Fiocruz-CMM	
			<i>G. viatrix</i>	4	
	Caraçu	22s02/45w41	<i>Lymnaea</i> sp.*	79	
	Ouro Branco	20s30/43w41	<i>Lymnaea</i> sp.	67	
	Rio Acima	20s03/43w47	<i>G. viatrix</i>	63	
			<i>G. truncatula</i>	60; Fiocruz-CMM	
3) North					
Pará	Belém	1s26/48w29	<i>Lymnaea</i> sp.	MZUSP	

Legends for the tables 1 and 2: The numbers at the column Articles of the tables 1 and 2 are references to the authors that record the occurrence of specimens of Lymnaeidae. 1: Simões (2002); 2: Amaral *et al.* (2007); 3: Ueno *et al.* (1982); 4: Paraense (1982a); 5: Mattos *et al.* (1997); 6: Pereira *et al.* (2000a); 7: Mattos & Ueno (1985); 8: Coelho (2007); 9: Coelho *et al.* (2009); 10: Rey (1957); 11: Dacal *et al.* (1988); 12: Gonzales *et al.* (1974); 13: Indrusiak (1983); 14: Müller *et al.* (1998); 15: Martello *et al.* (2008); 16: Pereira *et al.* (2000b); 17: Agudo (2004) *apud* Agudo-Padrón (2008); 18: Agudo (2005); 19: Agudo (2007); 20: Agudo (2006); 21: Agudo-Padrón (2008); 22: Hubendick (1951); 23: Paraense (1982b); 24: Cardoso *et al.* (2006); 25: Bellato *et al.* (1996); 26: Queiroz *et al.* (2002); 27: Amaral & Buseti (1979) *apud* Buseti (1982); 28: Buseti (1982); 29: Vaz *et al.* (1987); 30: Vaz *et al.* (1986); 31: Vaz *et al.* (1983); 32: Muniz (2007); 33: Gouveia & Henry (1990); 34: Ueta (1976); 35: Magalhães *et al.* (1991); 36: Carvalho *et al.* (2001); 37: Vaz *et al.* (1992); 38: Maure *et al.* (1998); 39: Ueta (1980); 40: Tostes *et al.* (2004); 41: Oliveira *et al.* (2002); 42: Thiengo *et al.* (2004a); 43: Thiengo *et al.* (2006); 44: Thiengo *et al.* (2002b); 45: Thiengo *et al.* (2002a); 46: Thiengo *et al.* (2001); 47: Gomes *et al.* (2002); 48: Fiuza *et al.* (2006); 49: Thiengo *et al.* (2004b); 50: Thiengo *et al.* (1998); 51: Rezende *et al.* (1973); 52: Andrade Neto *et al.* (1999); 53: Medeiros *et al.* (2002); 54: Fernandez *et al.* (2001); 55: Nuernberg (1978); 56: Pinheiro & Amato (1996); 57: Lutz (1921); 58: Souza *et al.* (2002); 59: Souza *et al.* (1998); 60: Cardoso (2004); 61: Lima *et al.* (2009); 62: Coelho & Lima (2003); 63: Carvalho *et al.* (2004); 64: Vianna *et al.* (2007); 65: Martins & Alves (2008); 66: Souza *et al.* (2006); 67: Silva *et al.* (1994); 68: Almeida (2010); 69: Thiengo *et al.* (2005); 70: Teles *et al.* (1991); 71: Paraense (1986); 72: Abílio & Watanabe (1998); 73: Abílio *et al.* (2006); 74: Paraense (1983); 75: Amato *et al.* (1986); 76: Bruno *et al.* (1995); 77: Araújo *et al.* (1995); 78: Silva (2010); 79: Oliveira (2008); 80: Ueta (1977); 81: Silva-Santos *et al.* (1994); 82: Silva-Santos *et al.* (1987); 83: Martins & Alves (2010); 84: Veitenheimer-Mendes (1992); 85: Pile *et al.* (1999); 86: Braun (2005); 87: Morretes (1949); 88: Pinheiro *et al.* (2009); 89: Lara *et al.* 1988; 90: Nuernberg *et al.* 1983; 91: Luz *et al.* (1994). Fiocruz-CMM represents data obtained from the Collection of Medical Malacology, CPqRR, Fiocruz/MG. MCP-Moluscos represents data obtained from the Collection of Molluscs of Museum of Science and Technology, PUCRS. INPA-Mollusca represents data obtained from the Collection of Molluscs of National Institute of Research of Amazônia, INPA. UFES-Malacologia represents data obtained from the Malacological Collection of Biological Science Department, DCBio/UFES. MZUSP represents data obtained from the Malacological Collection of Zoology Museum of University of São Paulo. The symbol * represents snails found naturally infected with *Fasciola hepatica*.

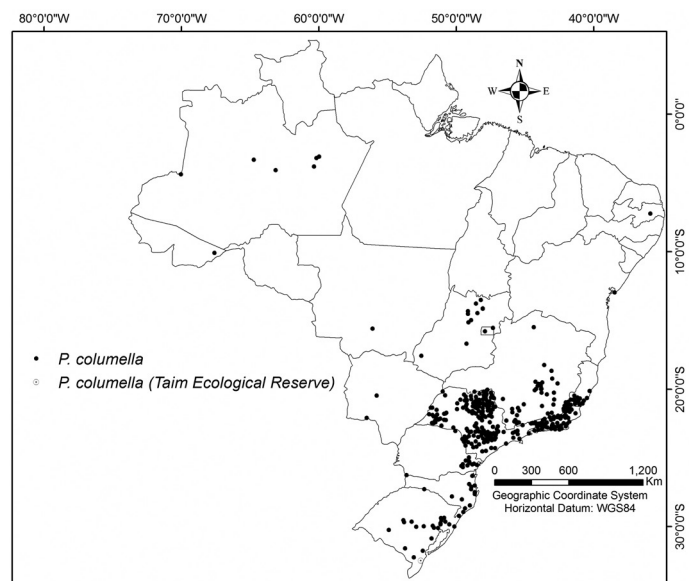


Fig. 1 - Spatial distribution of *Pseudosuccinea columella* in Brazil.

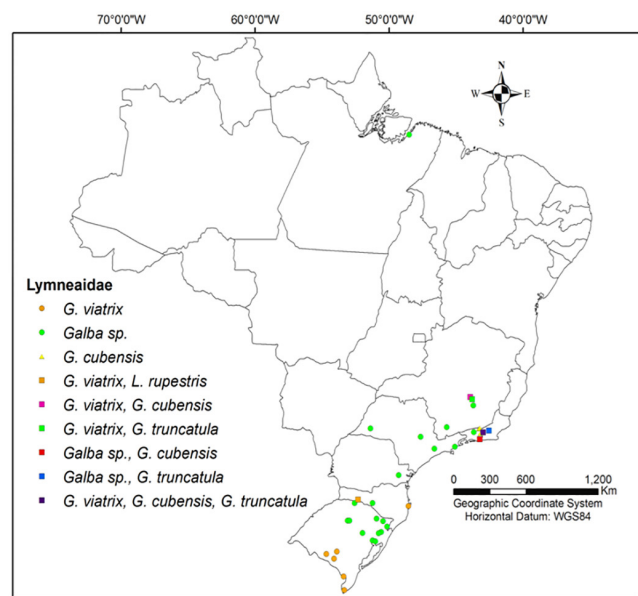


Fig. 2 - Spatial distribution of *Galba viatrix*, *G. cubensis*, *G. truncatula*, *Lymnaea rupestris*, and *Lymnaea* sp. in Brazil.

In relation to the others susceptible species, *G. cubensis* occurs only in the Southeast, mainly in Rio de Janeiro State^{19,60,76}. There was a gap of 30 years in its record and until now its presence in other regions was not reported. *Galba truncatula* is also susceptible to *F. hepatica*, however with few records (0.7%) it has never been found naturally infected in Brazil. *Lymnaea rupestris* was only described and found in one locality and there is no information about its susceptibility. Due to these facts, the role in the transmission of fasciolosis of the species above mentioned remains unknown.

In the present study, it was possible to observe the occurrence of

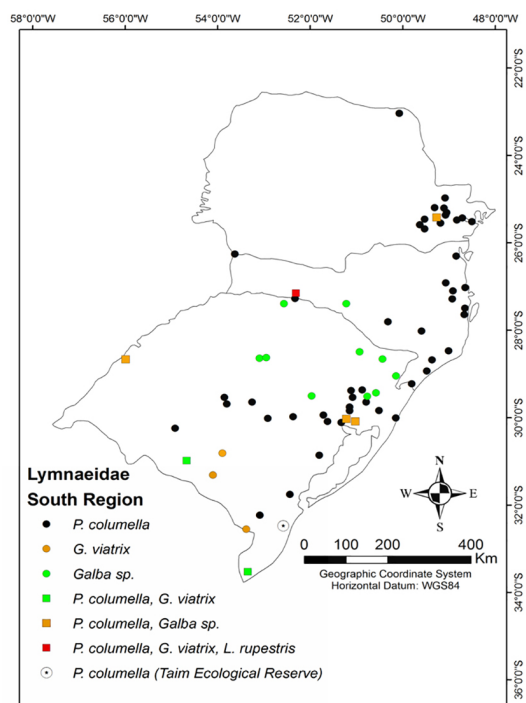


Fig. 3 - Spatial distribution of Lymnaeidae in the South region of Brazil.

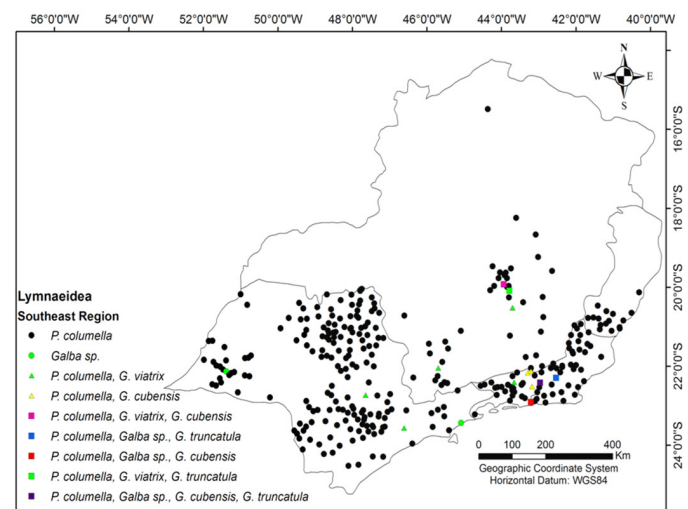


Fig. 4 - Spatial distribution of Lymnaeidae in the Southeast region of Brazil.

P. columella in several localities of the South (four municipalities) and Southeast (seven municipalities) and of *G. viatrix* in the South (three municipalities) naturally infected by *F. hepatica* (Table 1 and 2). In the South region, the presence of extensive endemic areas of fasciolosis is frequent, while in the Southeast and Midwest regions there are only small endemic areas⁴¹. Some environmental and climatic factors in the South region provide favorable habitats for the intermediate host snails of *F. hepatica*, such as low elevation (where there are numerous rice fields), clay soil, humid areas, and a temperate climate. These habitats, as shown by UENO *et al.*⁹⁸, contribute to the maintenance of the snails' life cycle in this region.

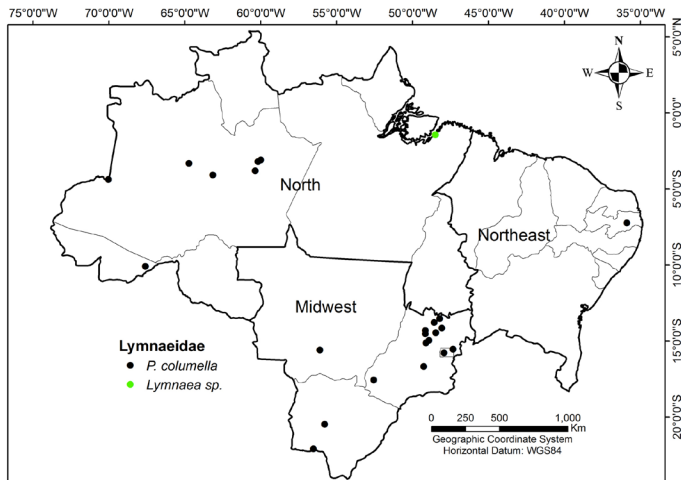


Fig. 5 - Spatial distribution of Lymnaeidae in the Midwest, North and Northeast regions of Brazil.

Despite the great efforts made by research groups, some important issues related to the nature and precision of the presence of lymnaeid species in Brazil need to be considered when interpreting our findings. The complete distribution of intermediate host snails of *F. hepatica* in Brazil remains unknown, especially due to the large areas that need to be surveyed mainly in the North and Midwest regions. Other restraining factors include the insufficient number of researchers involved in the taxonomy area, which may cause difficulties in identifying the snails at a species level due to the confusing taxonomic situation of the Lymnaeidae family. It was confirmed by our study that in several localities (25 municipalities; 6%) the specific identification was not possible to be done. The identification of specimens is important since knowing the species that act as intermediate hosts in a particular area, we can define priority strategies regarding intermediate hosts biology to control fasciolosis. In Careagu, MG, the occurrence of naturally-infected specimens without specific identification was reported (Table 2).

Another important point concerns the validity of the species identification used from the literature data and malacological collections due to systematics confusion of lymnaeids snails. This identification is essential in order to justify the distribution of lymnaeid species in Brazil. Regarding *L. rupestris* and *P. columella*, there is no problem because these two species can be easily identified using a set of reliable morphological characters and the literature data can be used with a reasonable confidence. However, this is not the case regarding the three other remaining species, *G. viatrix*, *G. cubensis* and *G. truncatula*, because these small species cannot be separated morphologically and only molecular markers allow a clear separation^{14,27,28,56,73,77}. In our literature search we identified only 19 localities where the specific identification might be a concern (10 localities with *G. viatrix*, six localities with *G. cubensis* and three localities with *G. truncatula*). Only in the occurrence of *G. cubensis* for Belo Horizonte, MG¹⁹, *G. truncatula* for Rio Acima, MG²² and the data from Fiocruz-CMM have the authors already carried out molecular identification.

Studies on the lymnaeid fauna should be increased all over Brazil, mainly where the information is scarce or nonexistent, with the objective

to learn more about the spatial distribution of the intermediate host snail of *F. hepatica*. The methodology used and the intermediate host snail final maps could be useful in identifying priority areas for control interventions of fasciolosis, so that limited resources could be allocated most effectively.

RESUMO

Distribuição espacial de Lymnaeidae (Mollusca, Basommatophora), hospedeiros intermediários de *Fasciola hepatica* Linnaeus, 1758 (Trematoda, Digenea) no Brasil

Moluscos da família Lymnaeidae são hospedeiros intermediários no ciclo biológico de *Fasciola hepatica*, agente etiológico da fasciolose, doença parasitária de importância médica para humanos e animais. O presente trabalho teve como objetivo datar e mapear a distribuição espacial dos hospedeiros intermediários de *F. hepatica* no Brasil. Os dados de distribuição das espécies de limneídeos foram obtidos das Coleções de Malacologia Médica (Fiocruz-CMM, CPqRR) e de Malacologia do Museu de Zoologia da Universidade de São Paulo (MZUSP), rede "SpeciesLink" (CRIA) e através de pesquisas sistemáticas na literatura. Os mapas de distribuição dos limneídeos mostram que *Pseudosuccinea columella* é a espécie mais comum e distribuída nas regiões Sul e Sudeste com poucos registros nas regiões Centro-Oeste, Norte e Nordeste. Além disso, na região Sul os registros para *G. viatrix* são escassos e existe apenas um único relato de ocorrência para *L. rupestris*. Os dados obtidos resultaram no primeiro mapa de distribuição espacial das espécies de Lymnaeidae no Brasil, informação básica e relevante para estruturação de políticas de controle da fasciolose humana e animal.

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