Diversity and distribution of mollusks along the Contas River in a tropical semiarid region (Caatinga), Northeastern Brazil

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Abstract: An inventory of macroinvertebrates conducted in the Contas River basin in Northeastern Brazil found 13 species of freshwater mollusks. Most of the community was represented by pulmonate gastropods, including *Physa acuta*, *Drepanotrema anatinum*, *D. cimex*, *D. lucidum*, *Biomphalaria straminea*?, *Gundlachia radiata*?, *G. ticaga* and *Hebetancylus moricandi*; the prosobranchs *Pomacea archimedis*?, *Melanoides tuberculata* and *Littoridina* sp. were also found. Bivalves were less diversified, represented only by *Pisidium pulchellum*? and *Eupera simoni*?. The taxonomic composition and the small size of many species reflect the intermittent condition of the basin. Additionally, the occurrence of shells of five terrestrial species (*Helicina angulata*, *Gastrocopta pellucida hordeacella*?, *Beckianum beckianum*, *Succinea* sp. and Systrophiidae gen. et sp. indet.) in the rivers reflects the occasional heavy rainfalls and floods in the region. The invasive gastropod *M. tuberculata* was the most abundant and widely distributed species. All 13 species were found in the lower course, in the Atlantic Forest region, and most, but not all, were recorded in the upper course, in the Caatinga region. The distribution and the occurrence of the bivalve species exclusively in the Atlantic Forest region indicate that the locally higher annual precipitation provides favorable conditions for the survival of these mollusks, such as a more stable hydroperiod.
Keywords: *Neotropical region, Atlantic Forest, intermittent streams, invasive mollusks, Bahia.*

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Resumo: Treze espécies de moluscos de água doce foram encontradas em um inventário de macroinvertebrados realizado ao longo da bacia do Rio de Contas, no Nordeste do Brasil. A maioria da comunidade foi representada por gastrópodes pulmonados, como *Physa acuta*, *Drepanotrema anatinum*, *D. cimex*, *D. lucidum*, *Biomphalaria straminea*?, *Gundlachia radiata*?, *G. ticaga* e *Hebetancylus moricandi*, embora prosobrânquios, como *Pomacea archimedis*?, *Melanoides tuberculata* e *Littoridina* sp. também tenham sido encontrados. Bivalves foram menos diversificados, e foram representados por *Pisidium pulchellum*? e *Eupera simoni*?. A composição taxonômica e o pequeno tamanho alcançado por muitas espécies refletem a condição intermitente da bacia. Além disso, a ocorrência de conchas de cinco espécies terrestres (*Helicina angulata*, *Gastrocopta pellucida hordeacella*?, *Beckianum beckianum*, *Succinea* sp. e Systrophiidae gen. et sp. indet.) dentro dos rios reflete as fortes chuvas e inundações que ocorrem ocasionalmente na região. O gastrópode invasor *M. tuberculata* foi a espécie mais abundante e bem distribuída. Todas as espécies foram encontradas no curso inferior, na região da Mata Atlântica, e a maioria, mas não todas, foram registradas no curso superior, na região da Caatinga. Esta distribuição e a ocorrência das espécies de bivalves exclusivamente na região da Mata Atlântica indicam que a maior precipitação anual desta região fornece condições favoráveis para a sobrevivência destes moluscos, como um hidroperíodo mais estável.
Palavras-chave: *Região Neotropical, Mata Atlântica, rios intermitentes, moluscos invasores, Bahia.*

Introduction

Knowledge of the diversity and the spatial distribution of the communities that occur in different ecoregions is essential for environmental preservation and conservation programs (Dudgeon et al. 2006). In Brazil, studies on the distribution of communities that inhabit rivers and streams are very limited for the Caatinga, a tropical and semiarid biome located in the northeastern region of the country (Santana et al. 2009, for invertebrates; Leal et al. 2003, for vertebrates). However, this ecoregion is one of the most interesting for ecological studies, because of its complexity (Maltchik 1999). The proximity to the equator ensures a minimum annual temperature ranging from 25 to 30°C, but the annual precipitation varies from 200 to 800 mm, with dry periods that can persist for almost 11 months. Precipitation may be concentrated over a few days, causing large floods. Most of the rivers and streams are intermittent, and characterized by wide fluctuations of the water level (Maltchik 1999). The fauna of this environment usually shows morphological and physiological adaptations, such as a small body size, short life cycle, high dispersal capacity and generalist habits (Maltchik 1999, Diáz et al. 2008, Santana et al. 2009). Communities are often characterized by the presence of endemic species with limited geographical distributions (Abílio et al. 2007). The few studies conducted with macroinvertebrates in semiarid rivers of Brazil show that the communities are dominated by insects and mollusks, and are frequently associated with macrophytes near the riverbanks (Maltchik 1999, Santana et al. 2009).

Freshwater mollusks are among the most threatened faunal group in the world (Lydeard et al. 2004). Damming and agricultural activities are the main factors related to this problem, but invasion by exotic species can also cause great harm to the native species (Neves et al. 1997, Vaughn 2005, Darrigran & Damborenea 2009). In Brazil, it is difficult to determine whether species are threatened, because of the scarcity of information about the structure and distribution of the communities (Mansur et al. 2003). Furthermore, most studies on communities inhabiting running waters are concentrated in the southeastern (e.g., Giovanelli et al. 2005, Vidigal et al. 2005, França et al. 2007) and southern (e.g., Pereira et al. 2001, Pfeifer & Pitoni 2003, Rangel e Souza et al. 2008) regions, and are relatively rare in other parts of Brazil (Midwest region: Martins-Silva & Barros 2001, Colle & Callil 2012; North region: Jesus et al. 2007, Pimpão & Mansur 2009). In the semiarid Northeast region of Brazil, such studies are practically nonexistent (Aleluia et al. 2009, Souza et al. 2010), and malacological research deals, in general, with lentic settings such as reservoirs, "*açudes*" (small reservoirs) and small waterbodies, focusing on vector species of human diseases or on invasive species (e.g, Abílio et al. 2006, Santos & Eskinazi-Sant'Anna 2010, Souto et al. 2011).

In 2011 and 2012, an inventory of aquatic macroinvertebrates was conducted along the Contas River basin, as part of an environmental program for the construction of the West-East Integration Railroad. A previous analysis of the macroinvertebrates collected showed that mollusks occurred at almost all the sampling sites, and were often the dominant fauna. This study aimed to contribute to knowledge of freshwater mollusk diversity in Brazil, reporting i) the identification of mollusks found at the lowest taxonomic level possible; ii) new information about some anatomical and conchological characteristics of some species, by descriptions and/or remarks; and iii) discussion of the species' distribution along the river, from the upper course in the Caatinga, to the lower course in the Atlantic Forest.

Material and Methods

1. Study area

The Contas River basin is located in south-central Bahia state (BA), between the coordinates 12° 55' and 15° 10' S and 39° 00' and 42° 35' W, and covers a drainage area of 55,334 km² (Secretaria… 1993) (Figure 1). The rivers and streams run from west to east. Freshwater springs are located in altitudes reaching ca. 1,500 m, and the river flows for 360 km until its outlet in the Atlantic Ocean (Secretaria… 1993). The grain size of bed sediments in the lower course of the Contas River ranges from coarse to fine sand (Campos 2002). The fluvial regime is essentially torrential, because of the irregular precipitation. Although the main course is perennial throughout, most of the tributaries are intermittent (CENTRO... 1979).

Most of the upper course of the river basin is located within the Caatinga domain, while the lower course runs within the Atlantic Forest domain. Small areas in the westernmost part lie in the Cerrado biome, and near the river mouth are areas of '*restingas*' (coastal dune scrub vegetation) and mangroves (Paula 2010). The predominant climate is type "Aw" according to Köppen's classification, ranging from semiarid in the Caatinga to semihumid in the Atlantic Forest domains (Secretaria… 1993). The mean annual temperature ranges from 19.8 °C to 27.7 °C. The mean annual relative humidity is about 72.9%, and the mean annual evaporation is 1,529 mm (Secretaria… 1993). Climate varies markedly from upstream to downstream. In the west, precipitation reaches 750 mm/year, but in the region near the ocean, the precipitation is heavier and more regular, reaching 1,750 mm/year (Secretaria… 1993).

The original vegetation consists of Steppe in the Caatinga region, and Ombrophilous Dense Forest and Seasonal Semideciduous Forest in the Atlantic Forest region. Currently, more than 90% of the original riparian vegetation along the river banks has been destroyed. The presence of hydroelectric power stations has also contributed to the environmental impacts (Neves et al. 1997).

2. Sampling and identification

Sampling was conducted in March 2011 and May 2012, with a Surber sampler (area 0.0225 m², mesh 500 µm), following the rainy seasons, in order to collect as many macroinvertebrates as possible. Twenty sampling sites located in the main course, and nearby streams and reservoirs, encompassing the Caatinga and the Atlantic Forest biomes, were chosen for study (Figure 1, Table 1). At each site, samples were taken in both backwaters and running waters.

The specimens were conserved in 80% ethanol. Mollusks were identified with the aid of a stereomicroscope to the lowest taxonomic level possible, according to specialized literature and with the assistance of specialists. The species classification at higher taxonomic categories followed Simone (2006). The three largest specimens of each species were measured in order to facilitate the morphological characterization. For studying gastropods, the following measurements were used: length (l) and maximum width (w) for helicoidal shells (Silva 2003); diameter (d) and width (w) for planispiral shells (Paraense 1975); and length (l) and width (w) for patelliform shells (Santos 2003). For bivalves, the following measurements were obtained: maximum length (l), maximum height (h), width (w), distance of the umbones related to the anterior end of the shell (%), and the indices l/h, l/w or h/l and w/l (Ituarte & Dreher-Mansur 1993). The following terminology and abbreviations were used in the Systematics section: specimens collected live (ex.), specimens

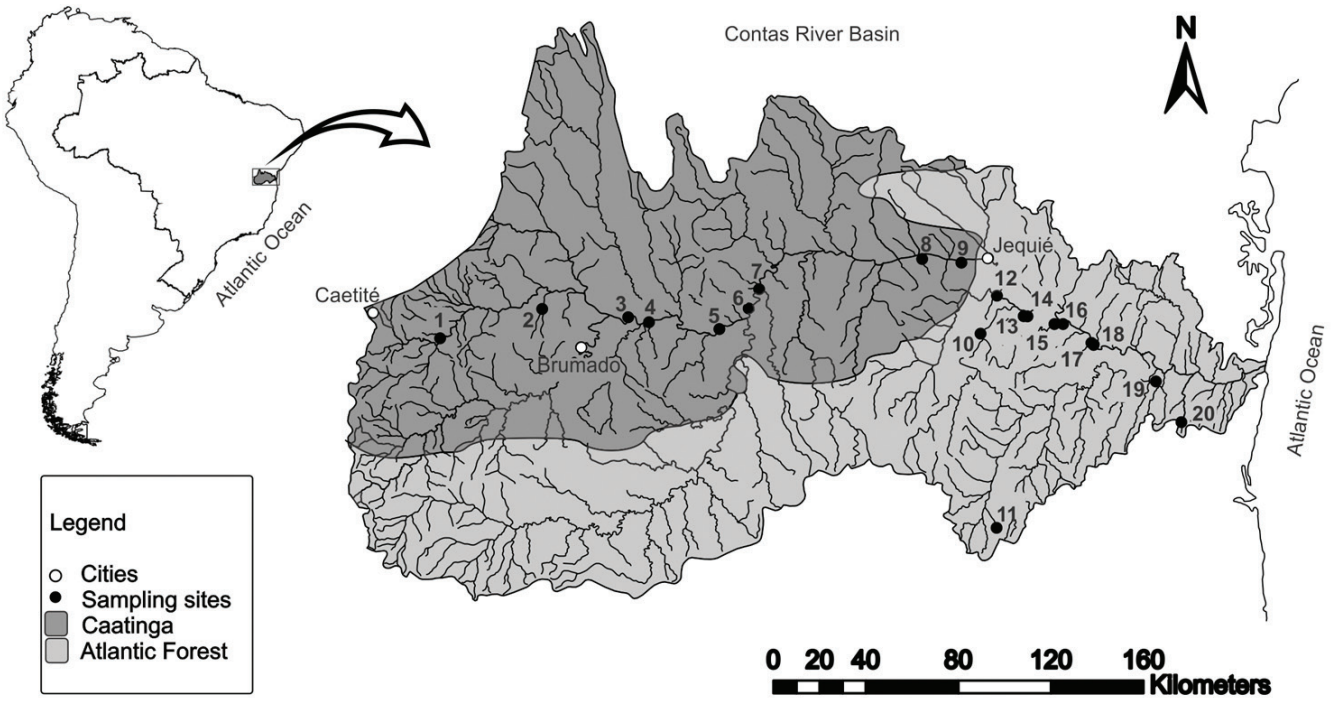

Figure 1. Location and distribution of sampling sites in the Contas River basin, state of Bahia, Brazil.

Table 1. Location of sampling sites and their environmental characterization in the Contas River basin. (Biomes: Caatinga = CA, Atlantic Forest = AF; Vegetation: Steppe = ST, Ombrophilous Dense Forest = ODF, Seasonal Semideciduous Forest = SSF).

Site	Geographical Coordinates	Altitude (m)	Biome	Vegetation
1	14° 09' 51" S and 42° 12' 19" W	508	CA	ST
2	14° 03' 02" S and 41° 49' 13" W	446	CA	ST
3	14° 04' 58" S and 41° 28' 52" W	343	CA	ST
4	14° 06' 07" S and 41° 24' 21" W	339	CA	ST
5	14° 07' 43" S and 41° 07' 53" W	291	CA	ST
6	14° 02' 52" S and 41° 00' 35" W	275	CA	ST
7	13° 58' 26" S and 40° 58' 56" W	268	CA	ST
8	13° 51' 23" S and 40° 20' 32" W	231	CA	ST
9	13° 52' 14" S and 40° 11' 14" W	193	CA	ST
10	14° 08' 47" S and 40° 06' 14" W	491	AF	ODF
11	14° 54' 01" S and 40° 03' 55" W	617	AF	ODF
12	13° 59' 56" S and 40° 02' 53" W	187	AF	ODF
13	14° 04' 45" S and 39° 56' 27" W	170	AF	ODF
14	14° 04' 42" S and 39° 56' 23" W	152	AF	ODF
15	14° 06' 33" S and 39° 49' 27" W	143	AF	SSF
16	14° 06' 31" S and 39° 47' 20" W	138	AF	SSF
17	14° 11' 23" S and 39° 40' 49" W	126	AF	ODF
18	14° 10' 55" S and 39° 40' 18" W	124	AF	ODF
19	14° 19' 53" S and 39° 25' 57" W	65	AF	ODF
20	14° 39' 02" S and 39° 18' 20" W	70	AF	ODF

collected dead (empty shells, c.), and isolated valves of bivalves (v.). The material studied is deposited in the Coleção de Invertebrados, Setor de Zoologia, Departamento de Biologia, Universidade Federal de Santa Maria (CM-UFSM 101.559 to CM-UFSM 101.630) and in the Coleção de Moluscos da Universidade de Caxias do Sul (ZUCS-MOL 738 to ZUCS-MOL 742, ZUCS-MOL 744).

Results

1. Systematics

In all, 1,908 live specimens were collected and assigned to 13 species (Table 2), including three prosobranch and eight pulmonate gastropods, and two non-unionoid bivalves. Additionally, five

Table 2. Occurrence of live mollusk specimens in the Contas River basin.

Order	Family	Species	Biome	
			Caatinga	Atlantic Forest
Caenogastropoda	Ampullariidae	*Pomacea archimedis* Spix, 1827?	X	X
	Thiaridae	*Melanoides tuberculata* (Müller, 1774)	X	X
	Hydrobiidae	*Littoridina* sp.	X	X
Pulmonata	Physidae	*Physa acuta* Draparnaud, 1805	X	X
	Planorbidae	*Drepanotrema anatinum* (Orbigny, 1835)	X	X
		Drepanotrema cimex (Moricand, 1839)	X	X
		Drepanotrema lucidum (Pfeiffer, 1839)	X	X
		Biomphalaria straminea (Dunker, 1848)?	X	X
		Gundlachia radiata (Guilding, 1828)?		X
	Ancylidae	*Gundlachia ticaga* (Marcus & Marcus, 1962)		X
		Hebetancylus moricandi (Orbigny, 1837)	X	X
Veneroida	Pisidiidae	*Pisidium pulchellum* (Orbigny, 1835)?		X
		Eupera simoni (Jousseaume, 1889)?		X

species of terrestrial gastropods were found in the river, most of them represented by empty shells.

Freshwater mollusks

Family AMPULLARIIDAE Gray, 1824

Genus *Pomacea* Perry, 1811

Pomacea archimedis Spix, 1827? (Figure 2a-c)

Description: Shell reaching 10 mm in length and 9 mm in width. Spire very low, with two whorls. Body whorl globose. Suture regularly marked, not forming a channel. Aperture elliptical, vertically elongated. External lip convex, united to the body whorl at the upper 1/6 of its height. Internal lip with no parietal callus. Shell with no umbilicus. Orange-colored with brown spiral bands of varying width, well distributed over the body whorl. Central tooth wider than high, with central cusp higher than the other cusps (Figure 2c). Lateral tooth with three well-developed cusps, the central one higher than the others. Marginal tooth elongated, with two cusps.

Material: 34 ex. and 5 c.: CM-UFSM 101.583 (Jequié, 2 ex.); CM-UFSM 101.584 (Jequié, 5 ex.); CM-UFSM 101.585 (Aiquara, 26 ex., 4 c.); CM-UFSM 101.586 (Aiquara, 1 ex.); CM-UFSM 101.587 (Itagibá, 1 c.).

Remarks: The general shell and aperture form, and the pattern of shell color of the specimens (Figure 2a, b) are similar to those of the holotype of *P. archimedis*, a species previously recorded from Bahia (Simone 2006, page 47, figure 61). However, the spire of *P. archimedis* is higher than the spire of the Contas River specimens. The specimens are also similar to *P. patula* (Reeve, 1856) and *P. pernambucensis* Reeve, 1856, which were recorded in the states of Amazonas and Pernambuco, respectively (Simone 2006, page 57, figure 102; page 58, figure 104). In both species, the lower part of the aperture is wider than in the Contas specimens. On the other hand, the radula of the specimens is similar to the radula of *P. canaliculata* (Lamarck, 1804) (Martín & Negrete 2007, page 723, figure 1), but the central tooth is proportionally wider and the cusps are lower and more widely spaced (Figure 2c). In addition, the cusps of the lateral teeth are more projected and strongly conical. Although *P. archimedis* has been recorded from Bahia (Simone 2006), the Contas specimens were tentatively classified as *P. archimedis*, because of the conchological differences and the similarity to the radula of *P. canaliculata*. The need for a revision of the genus *Pomacea* (Cazzaniga 2002, see revision by Cowie & Thiengo 2003) also hindered us in assigning the specimens with confidence to any previously described species. The thin external lip and the small size of the specimens indicate that they had not reached their maximum size.

Measurement: CM-UFSM 101.586: l =10 mm and w = 9 mm; l =10 mm and w = 5 mm; CM-UFSM 101.585 l = 9.5 mm and w = 4.5 mm.

Occurrence: Most of the specimens were collected in stretches located in the Atlantic Forest region (12, 13, 15, 16), in streams with sandy and stony beds and short riparian vegetation.

Family THIARIDAE Troschel, 1857

Genus *Melanoides* Olivier, 1804

Melanoides tuberculata (Müller, 1774) (Figure 2g-n)

Material: 1387 ex. and 147 c.: CM-UFSM 101.559 (Rio do Antônio, 4 ex.); CM-UFSM 101.560 (Brumado, 1 ex., 4 c.); CM-UFSM 101.561 (Brumado, 1 c.); CM-UFSM 101.562 (Tanhaçu, 8 c.); CM-UFSM 101.563 (Tanhaçu, 46 ex.); CM-UFSM 101.564 (Jequié, 30 ex., 1 c.); CM-UFSM 101.565 (Jequié, 306 ex., 17 c.); CM-UFSM 101.566 (Jequié, 174 ex., 13 c.); CM-UFSM 101.567 (Nova Canaã, 20 ex., 3 c.); CM-UFSM 101.568 (Jequié, 90 ex., 16 c.); CM-UFSM 101.569 (Aiquara, 142 ex., 6 c.); CM-UFSM 101.570 (Aiquara, 21 ex., 6 c.); CM-UFSM 101.571 (Aiquara, 82 ex., 5 c.); CM-UFSM 101.572 (Itagibá, 20 ex., 12 c.); CM-UFSM 101.573 (Itagibá, 309 ex., 24 c.); CM-UFSM 101.574 (Itagibá, 80 ex., 30 c.); CM-UFSM 101.575 (Aurelino Leal, 6 ex.); CM-UFSM 101.576 (Ilhéus, 56 ex., 1 c.).

Remarks: The specimens studied show shell variability, as previously observed in populations from other Brazilian rivers (Santos et al. 2012). The apex is commonly broken in larger specimens (> 15-20 mm) (Figure 2i-n), whereas in small specimens the shell is generally entire. Some specimens have a broken aperture (Figure 2i, j). Variation in shell color occurs due to loss of the periostracum (white), ferruginous oxide deposits (Figure 2i-n), and the presence of red remarks on the shell base (Figure 2g, h), as also observed by Fernandez et al. (2012). The largest specimen is 32 mm in length and 5 mm in width, less than the maximum size recorded for the species (40 mm height × 14 mm width; Brandt 1974). Compared with other Brazilian regions (Rocha-Miranda & Martins-Silva 2006, Santos & Eskinazi-Sant'Anna 2010, Souto et al. 2011), the specimens studied

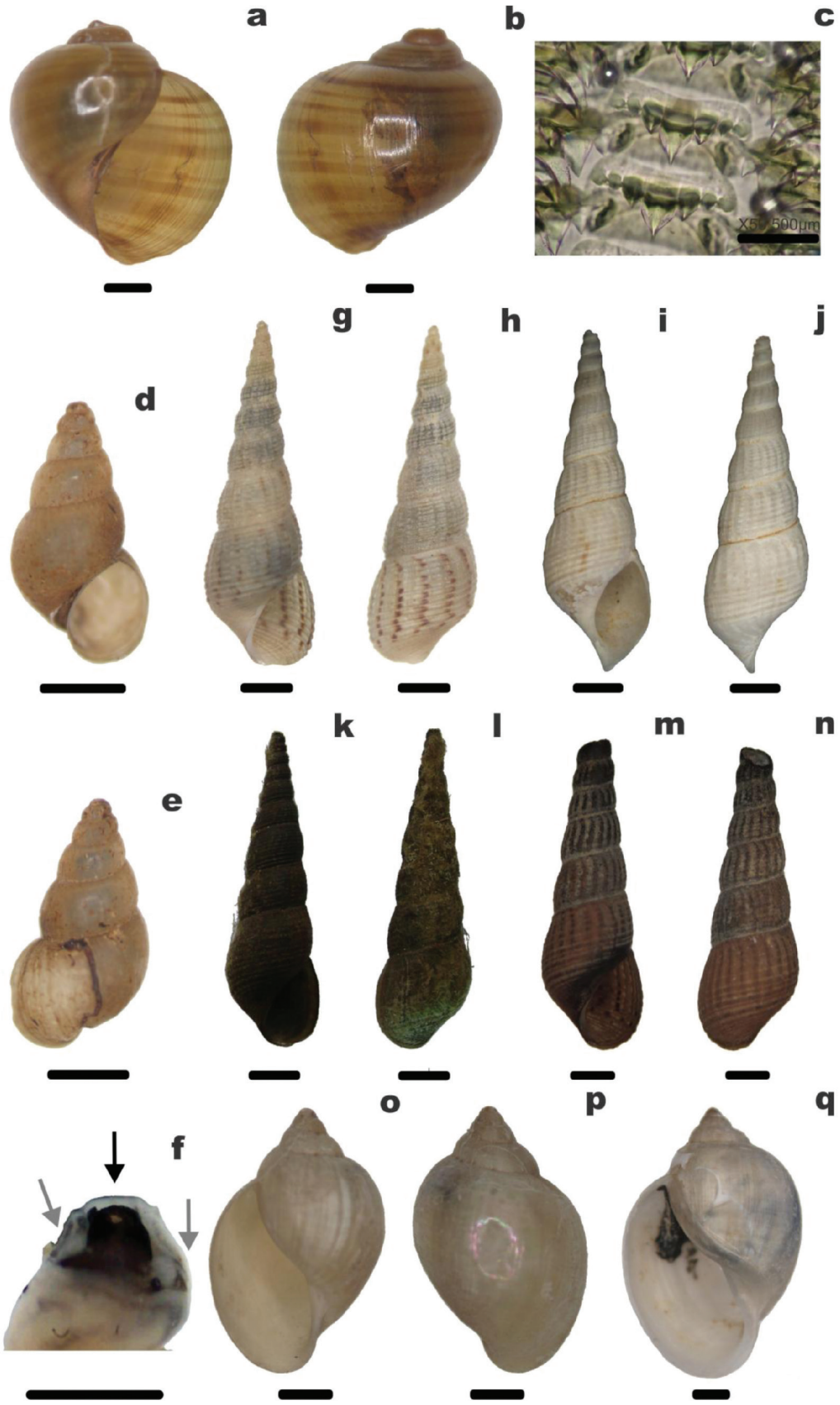

Figure 2. Gastropoda: Ampullariidae, Hydrobiidae, Thiaridae and Physidae. *Pomacea archimedis* (N. 101.585): ventral (a) and dorsal (b) views, radula detail (c); *Littoridina* sp. (N.101.589): ventral (d) and dorsal (e) views, (N.101.590): head region (f), black arrow shows the dark color of the proboscis, gray arrows show the tentacles; *Melanoides tuberculata* (N.101.561): ventral (g) and dorsal (h) view, shell variations (i-n) (N.101.562; N.101.573; N.101.576); *Physa acuta* (N.101.582): ventral (o) and dorsal (p) views, ventral view of a shell showing well-developed parietal callus (q). Scale: 1 mm (except a, b, g-n: 2 mm).

are larger. However, most specimens (860) do not exceed 6 mm in height. Differences in the predominance of size classes in different rivers of the same region, at the same time of year, may indicate that the species reproduces at different times in different environments (Rocha-Miranda & Martins-Silva 2006).

Measurement: CM-UFSM 101.573: l = 32 mm and w = 5 mm; l = 27.5 mm and w = 8.6 mm; l = 26 mm and w = 9.3 mm.

Occurrence: Specimens were found along almost the entire river course (except at sites 3 and 7), in different lentic (‘*açudes’*, ponds, reservoirs) and lotic environments with different substrates (sand, stones, mud), with little riparian vegetation.

Family HYDROBIIDAE Stimpson, 1865

Genus *Littoridina* Eydoux and Souleyet, 1852

Littoridina sp. (Figure 2d-f)

Description: Shell elongate, reaching 3.2 mm in length and 1.6 mm in width. Spire with approximately four whorls, slightly convex, and height slightly greater than height of body whorl. Suture shallow, but well marked. Aperture drop-shaped, with height corresponding to ca. half the height of the body whorl. Shell ornamentation consisting of fine growth lines. Shell orange and translucent. Head with a dark pigmented band that reaches the middle of the proximal portion of proboscis (Figure 2f).

Material: 39 ex.: CM-UFSM 101.588 (Jequié, 24 ex.); CM-UFSM 101.589 (Jequié, 6 ex.); CM-UFSM 101.590 (Itagibá, 9 ex.).

Remarks: The shell morphology of the specimens is uniform, but shows small variations in body whorl width. The shell is very similar to the shell of a syntype of *Littoridina cuzcoensis* (Pilsbry, 1911) illustrated by Simone (2006 page 89, figure 231), in the number of whorls, slope of the suture lines, and aperture shape. However, because of the need for revision of the species of this genus in Brazil (Silva 2003), the attribution of the specimens remains uncertain. Ferruginous deposits occur on the shells of many specimens (Figure 2d, e).

Measurement: CM-UFSM 101.588: l = 3.2 mm and w = 1.6 mm; l = 3.2 mm and w = 1 mm; l = 3 mm and w = 1 mm.

Occurrence: Specimens were found at few sites (9, 12, 18), in sandy channels with slow current, with or without riparian vegetation.

Family PHYSIDAE Fitzinger, 1833

Genus *Physa* Draparnaud, 1801

Physa acuta Draparnaud, 1805 (Figure 2o-q)

Material: 109 ex. and 9 c.: CM-UFSM 101.577 (Jequié, 15 ex., 1 c.); CM-UFSM 101.578 (Jequié, 14 ex., 1 c.); CM-UFSM 101.579 (Jequié, 4 ex., 2 c.); CM-UFSM 101.580 (Aiquara, 2 ex.); CM-UFSM 101.581 (Itagibá, 1 ex.); CM-UFSM 101.582 (Itagibá, 73 ex., 5 c.).

Remarks: The body whorl convexity, the well-marked shoulder and suture, and the wide aperture of the specimens are typical of *P. acuta*. According to Santos et al. (2012), the occurrence of this species is restricted to the small eastern and southeastern Atlantic river basins. However, *P. acuta* has been recorded in other regions of Brazil (Simone 2006, Fernandez 2011), which concords with its wide geographic range, including other continents; Paraense & Pointier (2003). The specimens from this basin have a smaller maximum size (10 mm) and fewer spire whorls (3) than recorded by other authors (ca. 16 mm × 9 mm, and five whorls, according to Paraense & Pointier 2003, Núñez 2011, Santos et al. 2012). The parietal callus of most specimens (Figure 2q) is also straighter and less developed (e.g., Simone 2006, page 101, figure 298B; Núñez 2011, page 104, figure B; Santos et al. 2012, page 48, figure 28). In some specimens, the initial whorls were covered with ferruginous deposits.

Measurement: CM-UFSM 101.582: l = 10 mm and w = 4 mm; l = 9 mm and w = 3.5 mm; l = 8 mm and w = 3.4 mm.

Occurrence: Live specimens were found at many sites along the Contas River (8, 9, 12, 14, 16, 18), in lentic (reservoir) and typical lotic (streams) habitats, in locations with sandy and stony substrates, most of them with sparse riparian vegetation.

Family PLANORBIDAE Rafinesque, 1815

Genus *Drepanotrema* Crosse & Fisher, 1880

Drepanotrema anatinum (Orbigny, 1835) (Figure 3a-c)

Material: 103 ex. and 2 c. CM-UFSM 101.603 (Rio do Antônio, 1 ex.); CM-UFSM 101.604 (Jequié, 98 ex., 2 c.); CM-UFSM 101.605 (Aiquara, 3 ex.); CM-UFSM 101.606 (Aiquara, 1 ex.).

Remarks: The shell and the aperture shape, and the shell punctations (not shown in Figure 3a-c) allowed us to classify the specimens as *D. anatinum*. This species was previously found in other localities in the Northeast (e.g., Souza et al. 2010) and is widely distributed in Brazil (Paraense 1975, Simone 2006). The shell aperture of the Contas specimens is straighter and more symmetrical (Figure 3b) than the aperture of the specimens illustrated by Souza & Lima (1990, page 32, figure 28) and Paraense (1975, page 108, figure 27), and more closely resembles the aperture of the specimen illustrated by Simone (2006, page 102, figure 302A). The Contas specimens also have a smaller size and fewer whorls (≥ 5) than in the description by Paraense (1975, 4.2 mm × 1.9 mm, 6 whorls). Some specimens have ferruginous deposits on the shell.

Measurement: CM-UFSM 101.604: d = 3.2 mm and w = 1.3 mm; d = 3 mm and w = 1.5 mm; d = 3 mm and w = 1.4 mm.

Occurrence: Specimens were found mainly in the lower course of the Contas River (1, 12, 13, 14), in low-order, human-impacted lotic environments.

Drepanotrema cimex (Moricand, 1839) (Figure 3d-f)

Material: 25 ex. and 5 c.: CM-UFSM 101.607 (Rio do Antônio, 3 ex.); CM-UFSM 101.608 (Itagibá, 21 ex., 4 c.); CM-UFSM 101.609 (Aurelino Leal, 1 ex., 1 c.).

Remarks: The number of whorls (6) and the degree of left-size flattening and shell-aperture straightening (Figure 3e) identify the specimens as *D. cimex*, a species that occurs throughout Brazil (Paraense 1975, Simone 2006). In relation to the specimens shown by Paraense (1975, page 111, figure 35, 8 mm in diameter) and Simone (2006, page 102, figure 303, 6 mm), the specimens from the Contas basin have a smaller diameter and fewer whorls. Ferruginous deposits are common on the shells.

Measurement: CM-UFSM 101.608: d = 6 mm and l = 0.5 mm; d = 5 mm and l = 0.5; d = 5 mm and l = 0.5 mm.

Occurrence: Specimens were found at three sites (1, 16, 19), in regulated and non-regulated stream courses.

Drepanotrema lucidum (Pfeiffer, 1839) (Figure 3g-i)

Material: 49 ex. and 3 c.: CM-UFSM 101.610 (Brumado, 1 ex.); CM-UFSM 101.611 (Itagibá, 45 ex., 3 c.); CM-UFSM 101.612 (Aurelino Leal, 3 ex.).

Remarks: The specimens studied were classified as *D. lucidum*. However, the whorls are less globose and convex (Figure 3h), the umbilicus (initial whorls) is shallower (Figure 3g, i) and the aperture is more rounded and less displaced to the left (Figure 3h) than in the specimens illustrated by Paraense (1975, page 110, figure 33). The Contas specimens are very similar to the holotype of *Drepanotrema schubarti* (Haas, 1938) illustrated by Simone (2006, page 105,

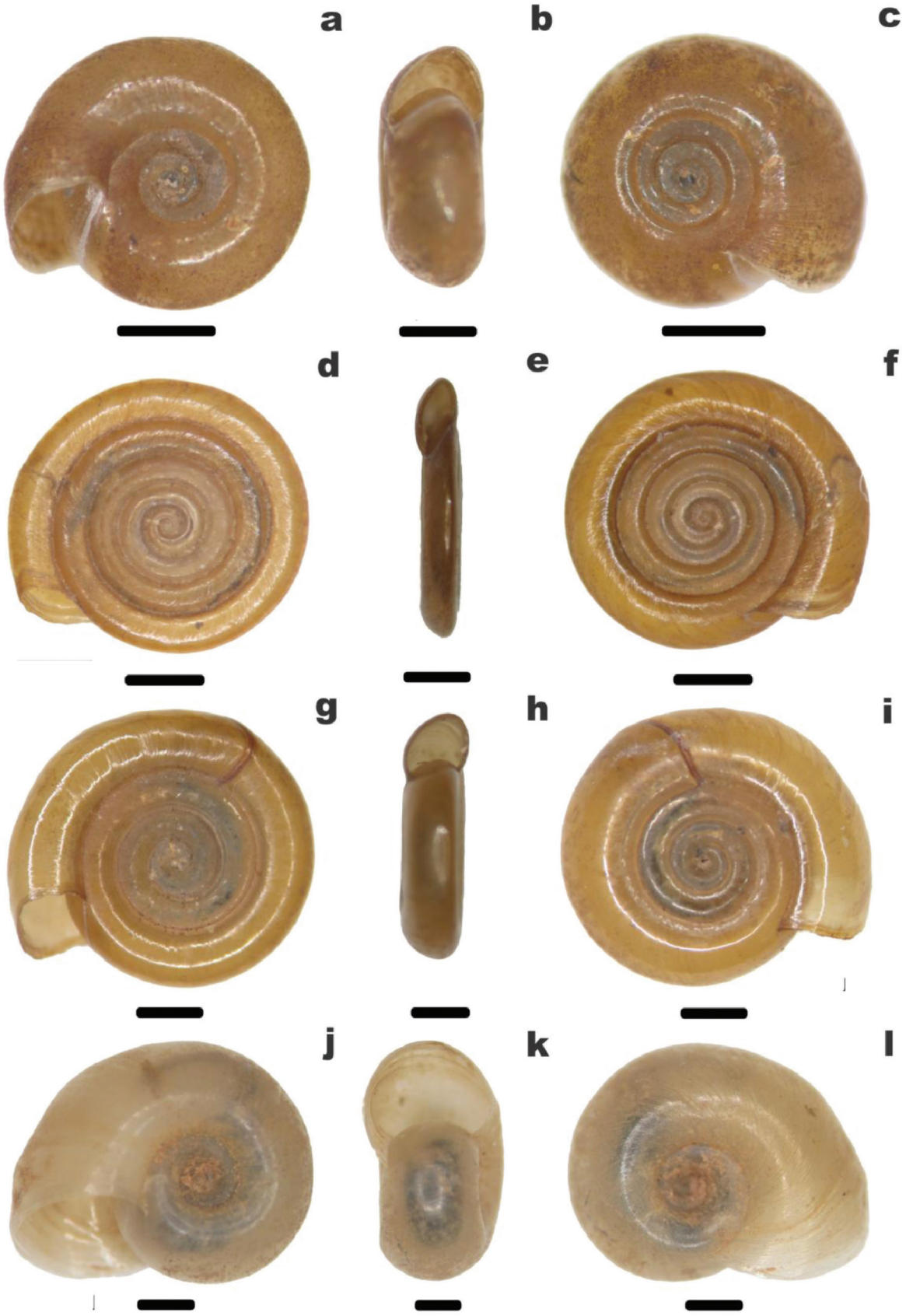

Figure 3. Gastropoda: Planorbidae. *Drepanotrema anatinum* (N.101.604): right lateral (a), ventral (b), and left lateral (c) views; *Drepanotrema cimex* (N.101.608): right lateral (d), ventral (e), and left lateral (f) views; *Drepanotrema lucidum* (N.101.611): right lateral (g), ventral (h), and left lateral (i) views; *Biomphalaria straminea* (N.101.617): right lateral (j), ventral (k), and left lateral (l) views. Scale: 1 mm.

figure 311), a species considered synonym of *D. lucidum* (Paraense 1975, 1983), because of the less-globose whorls and more-rounded lip. *Drepanotrema lucidum* is found throughout Brazil (Paraense 1975, Simone 2006), and has been recorded in other northeastern localities (Souza et al. 2010).

Measurement: CM-UFSM 101.611: d = 6 mm and l = 1.5 mm; d = 5.5 mm and l = 1.5 mm; d = 5 mm and l = 1.3 mm.

Occurrence: Live specimens were found at three sites (3, 16, 19), in streams with different substrates.

Genus *Biomphalaria* Preston, 1910

Biomphalaria straminea (Dunker, 1848)? (Figure 3j-l)

Material: 111 ex. and 14 c.: CM-UFSM 101.613 (Rio do Antônio, 14 ex., 4 c.); CM-UFSM 101.614 (Brumado, 16 ex., 2 c.); CM-UFSM 101.615 (Brumado, 3 ex., 4 c.); CM-UFSM 101.616 (Tanhaçu, 2 ex.); CM-UFSM 101.617 (Tanhaçu, 17 ex.); CM-UFSM 101.618 (Manoel Vitorino, 4 ex.); CM-UFSM 101.619 (Nova Canaã, 9 ex.); CM-UFSM 101.620 (Aiquara, 3 ex.); CM-UFSM 101.621 (Itagibá, 12 ex., 4 c.); CM-UFSM 101.622 (Aurelino Leal, 2 ex.); N.101.623 (Ilhéus, 30 ex.).

Remarks: Features such as the shell with globose whorls and slightly more convex to the left, with pronounced growth (each whorl grows ca. two times in relation to the anterior whorl), well-marked suture, especially to the left, and rounded periphery tending to the left, allow us to classify the specimens as *B. straminea*. In smaller specimens the whorls grow rapidly, so that both sides of the shell have a stronger lateral convexity and a more laterally elongated aperture than large-sized specimens. However, a well-marked carina is never present. Most specimens show orange color, but some are whitish; and have ferruginous deposits on the shell. The size of the Contas specimens is similar to that in other reports of *B. straminea* (Paraense et al. 1984, 8 to 9 mm; Tibiriçá 2006, 6 to 9 mm).

Measurement: CM-UFSM 101.623 d = 8.8 mm and l = 4 mm; d = 8.5 mm and l = 4 mm; d = 8.5 mm and l = 3.5 mm.

Occurrence: Specimens were found along almost the entire course of the river (1, 2, 4, 5, 6, 7, 11, 13, 18, 19, 20), in several environments, including rivers, streams, dams, ponds, and *açudes*.

Family ANCYLIDAE Basch, 1963

Genus *Gundlachia* Pfeiffer, 1849

Gundlachia radiata (Guilding, 1828)? (Figure 4a-e)

Material: 1 ex. and 2 c.: CM-UFSM 101.597 (Aiquara, 1 ex., 2 c.).

Remarks: The shells found are similar to the shell of *G. radiata* in the well-marked radial ornamentation over the entire teleoconch, and in the rounded, but not curved apex, which shows a slight depression (Figure 4a, c) (Santos 2003). This species was previously recorded from the Northeast (Lanzer 1996, Santos 2003). The inverted V-shaped anterior adductor muscle scar, typical of the species, was observed only in specimens found live (not shown in Figure 4b). However, the very centralized apex position observed in the Contas specimens is not common in *G. radiata* (Lanzer 1996, Santos 2003), making it difficult to classify them with confidence.

Measurement: CM-UFSM 101.597: l = 2.7 mm and w = 2 mm; l = 2.3 mm and w = 1.5 mm; l = 1.7 mm and w = 1.3 mm.

Occurrence: The species was found at only one site (13), in the main course of the Contas River, in the Atlantic Forest region.

Gundlachia ticaga (Marcus & Marcus, 1962) (Figure 4j-m)

Material: 14 ex. and 5 c.: CM-UFSM 101.596 (Aiquara, 3 ex., 5 c.); ZUCS-MOL 738 (Fiol 6 Tanhaçu, 6 ex.); ZUCS-MOL 741 (Fiol 5 Tanhaçu, 1 ex.); ZUCS-MOL 742 (Fiol 3 Brumado, 3 ex.); ZUCS-MOL 744 (Fiol 2 Brumado, 1 ex.).

Remarks: The absence of an apical depression (Figure 4j), the shape of the muscle scars, and the mantle pigmentation pattern (Figure 4m) indicate that the Contas specimens are *G. ticaga*. The shells do not show radial striae and are relatively high (Figure 4j, k), resembling some of the shell variations shown by Lacerda et al. (2011). The intensity of the mantle pigmentation is highly variable, and may be absent in the smallest specimens (Figure 4l); and the right anterior adductor muscle scar may be slightly almond-shaped. So far, *G. ticaga* has been recorded from the state of Rio Grande do Sul to Minas Gerais (Lanzer 1996).

Measurement: ZUCS-MOL 742: l = 2.5 mm and w = 1.5 mm; l = 2 mm and w = 1.5 mm; ZUCS-MOL 744: l = 1.8 mm and w = 1.2 mm.

Occurrence: The specimens of *G. ticaga* were found in the Atlantic Forest region (13, 14, 16, 20), mainly in silted streams.

Genus *Hebetancylus* Pilsbry, 1913

Hebetancylus moricandi (Orbigny, 1837) (Figure 4f-h)

Material: 26 ex. and 12 c.: CM-UFSM 101.591 (Jequié, 1 c.); CM-UFSM 101.592 (Jequié, 3 ex., 1 c.); CM-UFSM 101.593 (Aiquara, 14 ex., 10 c.); CM-UFSM 101.594 (Aiquara, 1 ex., 2 c.); CM-UFSM 101.595 (Aiquara, 2 ex.); ZUCS-MOL-739 (Itagibá, 3 ex.); ZUCS-MOL-740 (Rio do Antônio, 3 ex.)

Remarks: The strongly depressed shell, the obtuse and smooth apex with no depression (Figure 4i), located on the right side of the median line, the slightly arched shell ends (Figure 4f, g), the mantle pigmentation pattern (Figure 4h), as well as the rachidian teeth, high with a wide base and small cusps (not shown in the figure), are typical features of *H. moricandi* (Lanzer 1996, Santos 2003). This species has been found previously in the Northeast region (Lanzer 1996). The intensity and distribution of the mantle pigmentation, as well as the shape, can vary slightly.

Measurement: CM-UFSM 101.595: l = 11 mm and w = 5.5 mm; CM-UFSM 101.594: l = 7.5 mm and w = 4 mm; l = 7 mm and w = 4 mm.

Occurrence: This species was found in the Caatinga region (1), but was well distributed in the Atlantic Forest region (12, 13, 14, 15, 18), in silted streams and in a reservoir.

Family PISIDIIDAE Gray, 1857

Genus *Pisidium* Pfeiffer, 1821

Pisidium pulchellum (Orbigny, 1835)? (Figure 5a-i)

Material: 8 ex. and 4 v.: CM-UFSM 101.629 (Jequié, 2 ex., 2 v.); CM-UFSM 101.630 (Aiquara, 6 ex.; 2 v.)

Remarks: The shell shape of the Contas specimens (Figure 5a-d) is similar to that of the specimen of *P. pulchellum* (Orbigny, 1835) [=*Pisidium dorbignyi* Clessin, 1879] illustrated by Simone (2006, page 301 figure 1055). The shell is equilateral, with umbones displaced ca. 45% from the anterior end (*sensu* Ituarte 1996). The dorsal-anterior and the dorsal-posterior shell margins are slightly curved, forming an angle of 27° in relation to the commissure plane axis. The convexity of the anterior margin is marked in the median region, and the ventral margin is regularly convex. However, the maximum shell length (6.3 mm) and the indices of height (H/L) and convexity (W/H) (*sensu* Ituarte 1996) of 0.83 ± 0.06 and 1.40 ± 0.19 respectively, the narrow hinge, the shape of the cardinal and lateral form (Figure 5e-i), and the degree of the projection of the ligament to the shell exterior (Figure 5e) are similar to the corresponding features in *Pisidium sterkianum* Pilsbry, 1897. In fact, when Pilsbry (1897) described *P. sterkianum*, he commented that this species is very similar to *P. pulchellum*, differing from the latter in its larger

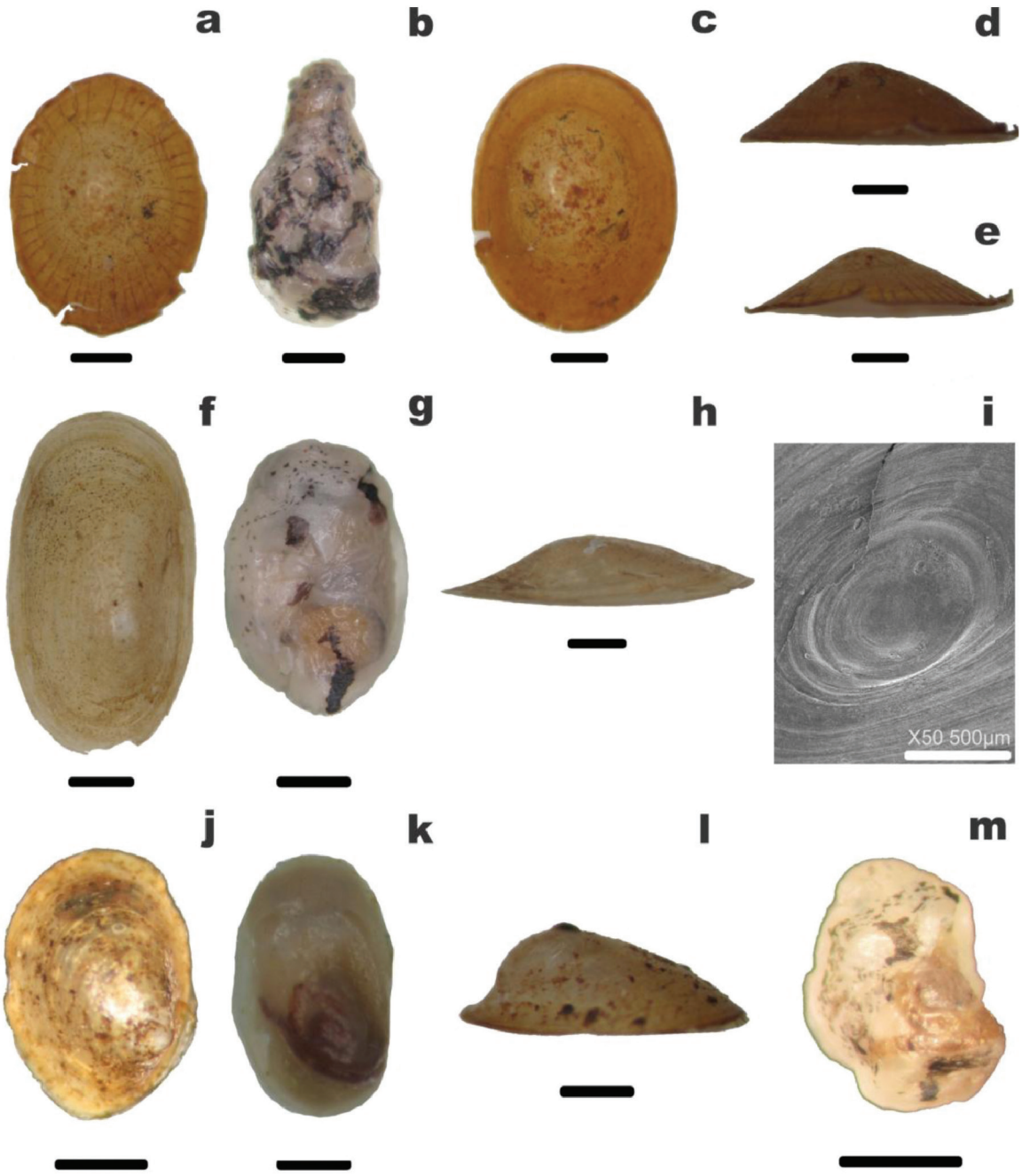

Figure 4. Gastropoda: Ancylidae. *Gundlachia radiata* (N.101.597): dorsal (a,c), lateral (d,e) and mantle (b) view; *Hebetancylus moricandi* (N.101.595): dorsal (f) and lateral (h) views, mantle dorsal view, showing pigmentation pattern (g) and detail of shell apex (i); *Gundlachia ticaga* (ZUCS-MOL 738): dorsal (j) and dorsal mantle (m) views, (N.101.596): lateral (k) and dorsal mantle (l) views. Scale: 0.5 mm (except f, g, h: 1 mm).

size and less-pronounced globosity. The illustration of the specimen by Simone (2006) does not allow one to clearly observe the shell globosity, as well as the hinge and the ligament, which seem to be different and stronger than those of the Contas specimens. Up to the present, the distribution of *P. sterkianum* is restricted to the Paraná and Amazonas basins, while *P. pulchellum* is recorded from the Northeast region (Simone 2006). Therefore, the Contas specimens were classified, but only tentatively, as *P. pulchellum*.

Measurement: CM-UFSM 101.630: l = 6.3 mm, h = 5.1 mm, w = 1.8 mm; CM-UFSM 101.629: l = 4.6 mm, h = 3.8 mm, w = 1.5 mm; l = 3.1 mm, h = 2.4 mm, w = 1.3 mm.

Occurrence: This species was found at two sites (12, 13) in the Atlantic Forest region.

Genus *Eupera* Bourguignat, 1854

Eupera simoni (Jousseaume, 1889)? (Figure 5j-r)

Material: 18 ex. and 13 v.: CM-UFSM 101.624 (Jequié, 10 ex., 9 v.); CM-UFSM 101.625 (Aiquara, 3 ex., 2 v.); CM-UFSM 101.626 (Itagibá, 1 ex.); CM-UFSM 101.627 (Aurelino Leal, 3 ex., 2 v.); CM-UFSM 101.628 (Ilhéus, 1 ex.).

Remarks: The Contas specimens have features of *Eupera klappenbachi* Mansur & Veiteinheimer, 1975, such as the length/

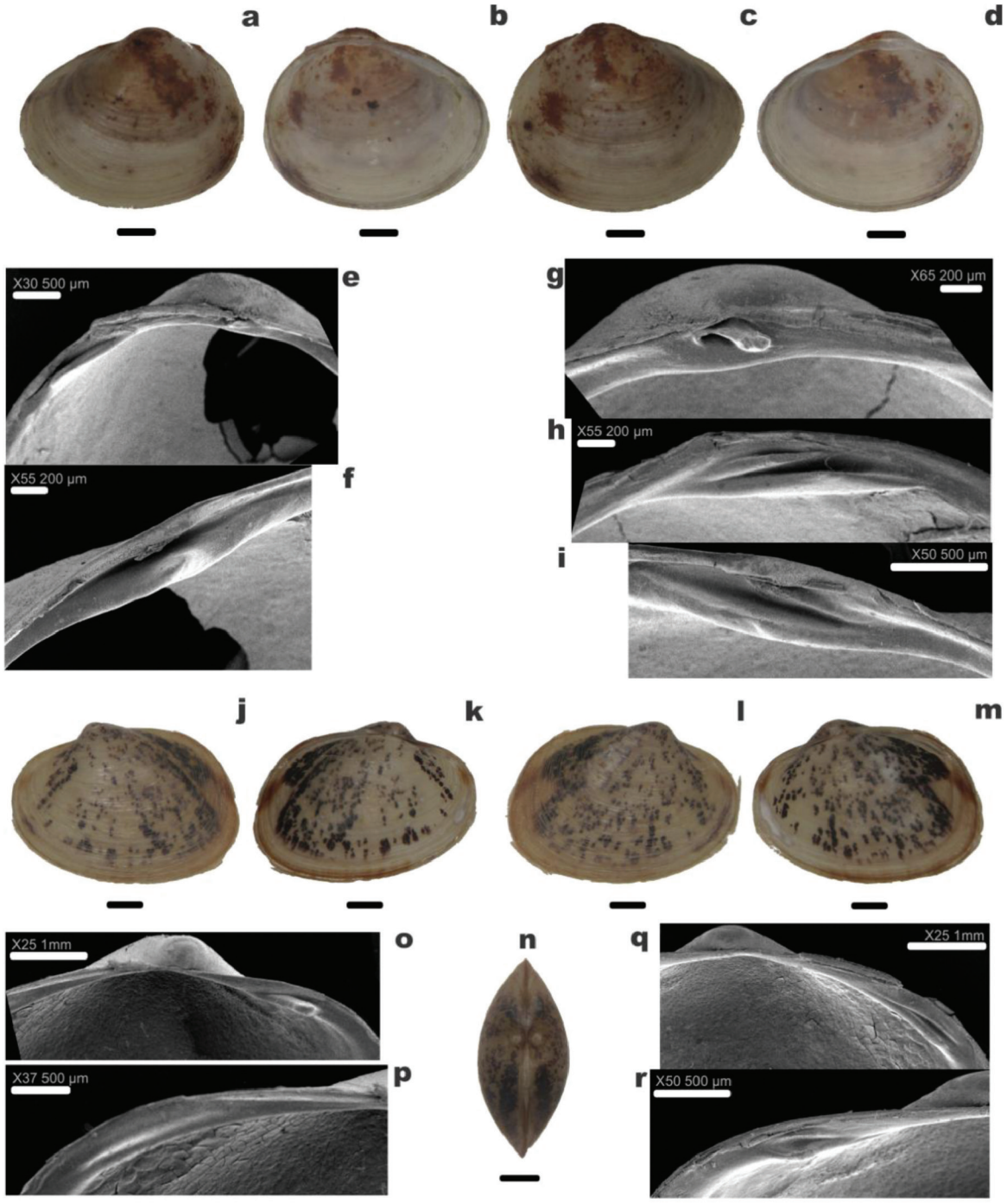

Figure 5. Bivalvia: Pisidiidae. *Pisidium pulchellum* (N.101.630): right valve, external (a) and internal (b) views; left valve, external (c) and internal (d) views (N. 101.630), detail of hinge (e) and of lateral (f) teeth of the right valve, detail of cardinal (g) and lateral teeth (h,i) of the left valve; *Eupera simoni* (N.101.624): left valve, external (j) and internal (k) views; right valve, external (l) and internal (m) views; dorsal view of closed valves (n) (N. 101.624) detail of the hinge (o) and posterior lateral teeth (p) of a left valve, detail of hinge (q) and anterior lateral teeth of the right valve (r). Scale: 1 mm.

height ratio (L/H = 1.26±0.07) and the position of the umbones (*sensu* Ituarte 1996), which are displaced ca. 40% from the anterior end. However, the length/height ratio is very different. The Contas specimens are strongly compressed (L/W = 2.89±0.64), whereas *E. klappenbachi* has a more inflated shell (Ituarte & Dreher-Mansur 1993). *Eupera klappenbachi* can also produce more embryos (24 to 62, Mansur & Veitenheimer 1975), while in one specimen studied, ca. 5 mm long, only 18 embryos were found. The shell of the Contas specimens is inequilateral and modioliform (Figure 5j-m), similar to the shell of *E. simoni*, according to the illustrations of Simone (2006, page 304, figure 1069), although some specimens of this species can be more equilateral (Pimpão & Mansur 2009, page 399, figure 10). The color pattern of the Contas specimens (Figure 5j-m) is similar to the pattern of *E. bahiensis* (Spix, 1827), a species that occurs in the Northeast region (Simone 2006, page 302, figure 1060), but shows a more equilateral shell shape. Further, the specimens studied are almost twice (8.8 mm) the size of *E. simoni* and *E. bahiensis*. The hinge and the cardinal teeth, which have been commonly used to

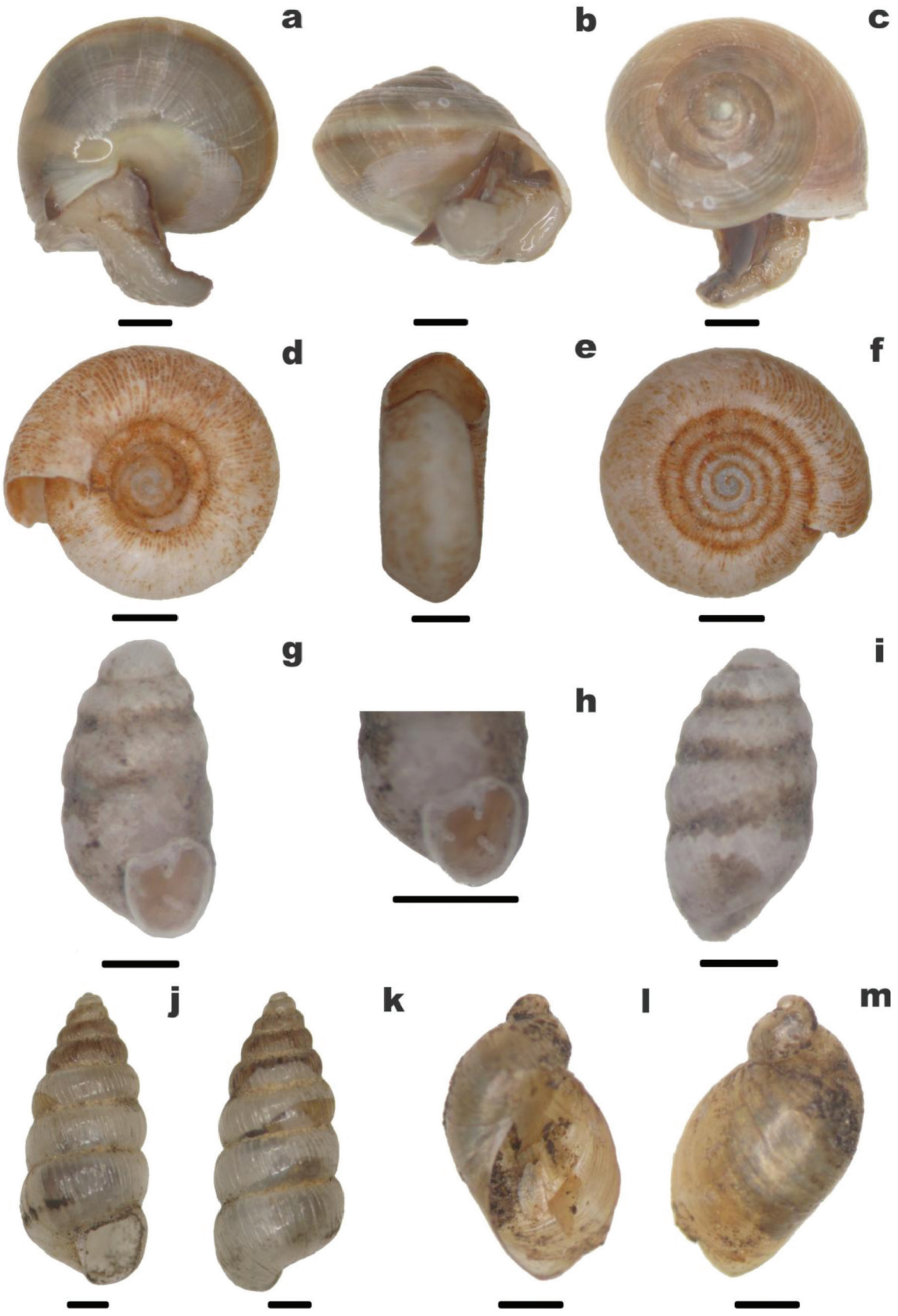

Figure 6. Gastropoda: Helicinidae, Systrophiidae, Vertiginidae, Subulinidae, and Succineidae. *Helicina angulata* (N.101.598): ventral (a), aperture (b), dorsal (c) views; Systrophiidae (N.101.601): right lateral (d), ventral (e), and left lateral (f) views; *Gastrocopta pellucida hordeacella*? (N.101.599): ventral view (g); aperture showing lamellae (h), dorsal view (i); *Beckianum beckianum* (N.101.600): ventral (j), and dorsal (k) views; *Succinea* sp. (N.101.602): ventral (l) and dorsal (m) views. Scale: 1 mm (except h: 0.5 mm).

Table 3. Distribution of mollusk species at the 20 sampling sites in the Contas River. Legend: (+) live specimens; (●) shell only; (+●) live specimens and shell.

Species	Sites																		
	Caatinga									Atlantic Forest									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
P. archimedis ?								+				+	+●		+	●				
M. tuberculata	+	+●		●	●	+		+●	+●	+●	+●	+●	+●	+●	+●	+●	+●	+●	+	+●
Littoridina sp.									+			+						+		
P. acuta								+●	+●			+●		+		+		+●		
D. anatinum	+											+●	+	+						
D. cimex	+															+●			+●	
D. lucidum			+													+●			+	
B. straminea?	+	+●		+●	+	+	+				+		+					+●	+	+
G. radiata													+●							
G. ticaga													+●	+		+				+
H. moricandi	+				+		+		+			+●	+●	+●	+					
P. pulchellum?												+●	+●							
E. simoni?												+●	+●					+	+●	+

characterize the species of *Eupera*, are little developed in the Contas specimens (Figure 5o-r), and almost invisible (Figure 5o, q). Thus, the Contas specimens are most similar to *E. simoni*. However, the scarcity of studies on *E. simoni*, as well as many other species of Brazilian *Eupera,* prohibits a definitive classification.

Measurement: CM-UFSM 101.624: l = 8.8 mm, h = 6.5 mm, w = 4.2 mm; l = 6.3 mm, h = 5.1 mm, w = 2.9 mm; l = 6 mm, h = 4.9 mm, w = 2.6 mm.

Occurrence: The species was found at sites in the Atlantic Forest region (12, 13, 18, 19, 20), in lotic environments, with sandy and stony substrates.

Terrestrial gastropods

Family HELICINIDAE Férussac, 1822

Genus *Helicina* Lamarck, 1799

Helicina angulata Sowerby, 1873 (Figure 6a-c)

Material: One ex.: CM-UFSM 101.598 (Aiquara, 1 ex.).

Remarks: The darker color band below the shell margin, the pronounced angular external lip, as well as the aperture width, are features of *H. angulata*, a species previously recorded for the state of Bahia, with a diameter reaching 6-7 mm (Simone 2006). The only specimen found in the Contas River was collected live, and lacks the thick lip (Figure 6a) typical of this species, which indicates that this specimen had not reached the maximum size of the species.

Measurement: CM-UFSM 101.598: h = 5 mm and w = 7.5 mm.

Occurrence: The specimen was found in the main course of the Contas River (13), in the Atlantic Forest region.

Family VERTIGINIDAE Fitzinger, 1833

Genus *Gastrocopta* Wollaston, 1878

Gastrocopta pellucida hordeacella Pilsbry, 1890? (Figure 6g-i)

Material: Two shells. CM-UFSM 101.599 (Itagibá, 2 c.).

Remarks: The general features of the shell, especially the number of whorls and the lamellae of the shell aperture are similar to those of the specimen of *Gastrocopta pellucida hordeacella* Pilsbry, 1890 illustrated by Simone (2006, page 116, figure 350). However, the lamellae in the Contas specimens are less developed (Figure 6h). This difference, and also because *G. pellucida hordeacella* has been recorded in Brazil only in the Fernando de Noronha Archipelago (Simone 2006), the attribution of these specimens is doubtful.

Measurement: CM-UFSM 101.599: h = 2.5 mm and w = 1.5 mm; h = 2 mm and w = 1 mm.

Occurrence: The shells were found in rivers (16, 18) in the Atlantic Forest region.

Family SUBULINIDAE Fischer & Crosse, 1877

Genus *Beckianum* Baker, 1961

Beckianum beckianum (Pfeiffer, 1846) (Figure 6j, k)

Material: One shell: CM-UFSM 101.600 (Rio do Antônio, 1 c.).

Remarks: The number of spire whorls, the aperture shape, and the ornamentation indicate that the shell found is *Beckianum beckianum* (Pfeiffer, 1846). According to Simone (2006, page 187, figure 685) and Almeida & Mota (2011), this species occurs from São Paulo state to northern Brazil.

Measurement: CM-UFSM 101.600: h = 7 mm and w = 3 mm.

Occurrence: The shell was found in one '*açude'* (1) in the Caatinga region.

Family SYSTROPHIIDAE Thiele, 1926

Gen. et sp. indet. (Figure 6d-f)

Description: Shell planispiral, reaching 4.3 mm in diameter and 1.8 mm in width; constituted by six whorls that gradually increase in diameter. Each whorl laterally encompasses the anterior whorl, more to the right than to the left. Right side strongly planar; left side deeply concave, forming a conical surface. Sutures moderately marked on the right side, deeply marked on the left side by a ferruginous line. Whorls flattened on both right and left sides, forming a low angle at the shell periphery. Periphery rounded. Aperture narrow, sickle-shaped, with both sides slightly asymmetrical, with a stronger curvature on the left end. Concentric ornamentation, constituted by low, regularly spaced lamellae. Color whitish.

Material: One shell: CM-UFSM 101.601 (Brumado, 1 c.).

Remarks: The concentric, lamellar and irregular ornamentation, the well-calcified and especially the symmetrical planispiral shell shape indicate that this shell is a species of Systrophiidae.

Measurement: CM-UFSM 101.601: d = 4.3 mm and w = 1.8 mm.

Occurrence: The shell was found in a stream (3) with riparian vegetation, in the Caatinga region.

Family SUCCINEIDAE Beck, 1837

Genus *Succinea* Draparnaud, 1801

Succinea sp. (Figure 6l, m)

Description: Shell dextral and very thin, 4.2 mm long and approximately 2.5 mm wide. Spire low, constituted by two whorls. Body whorl large. Aperture wide and vertically elongated. Growth lines well marked. Shell color yellow and translucent.

Material: One shell: N.101.602 (Aiquara, 1 c.).

Remarks: The shells of *Succinea* species recorded in Brazil are very similar, and it is not possible to distinguish the species based on their features.

Measurement: N.101.602: h = 4.2 mm and w = 2.5 mm.

Occurrence: The shell was found in a stream (3) with riparian vegetation, in the Caatinga region.

2. *Distribution*

All the specimens of freshwater mollusks found in the Contas River basin were recorded in the Atlantic Forest region, and most, but not all, also in the Caatinga region (Table 2). The invasive species *M. tuberculata* was dominant (68.5%) and most frequent, occurring at 90% of the sampling sites (Table 3). *Biomphalaria straminea* and *P. acuta* were also well represented numerically, with specimens found at 55% and 30% of the sampling sites, respectively. Only *M. tuberculata* and *B. straminea* were well distributed in both biomes. The occurrence of the bivalves (*Eupera simoni*? and *P. pulchellum*?) was limited to the Atlantic Forest region, and the ancylids and *P. archimedis*? were found predominantly in this biome. Among the terrestrial gastropods, only the unidentified systrophiid was recorded in the Caatinga region.

Discussion

Live freshwater mollusks were found at more than 80% of the sampling sites along the Contas River, and represented 13 species. Records of wide distribution of mollusk communities along rivers, as recorded in the present study, are rare in studies of macroinvertebrates conducted in many Brazilian regions, especially when the studies use a Surber sampler. In these cases, the malacofauna is generally undersampled, and the records indicate a much localized occurrence (e.g., Ligeiro et al. 2010, Hepp et al. 2010). Thus, the use of an inappropriate sampler to collect mollusks seems to not have affected knowledge of the diversity of the Contas River malacofauna. The results obtained in this study also concord with the findings of the few available studies on the macroinvertebrate communities of semiarid rivers in the Brazilian Northeast region, in which insects are the most diversified and abundant group, but mollusks are also frequent, with some dominant taxa such as the invasive *M. tuberculata* (Maltchik 1999, Callisto et al. 2005, Andrade et al. 2008, Calazans et al. 2009, Santana et al. 2009). On the other hand, it should be expected that mollusk richness in tropical semiarid regions, where the dry period is prolonged and creates adverse conditions for the freshwater malacofauna, will be smaller than the mollusk richness in regions with more permanent waterbodies. However, the richness of the mollusk community recorded in the Contas River is not very different from levels reported in temperate intermittent rivers of many regions of the world, where the number of species ranges from 7 to 20 (e.g., Cheatum & Allen 1963, Murphy 2012, Pérez-Quintero 2012, De Francesco & Hassan 2013), including southern Brazil (e.g., Pereira et al. 2001, 2011).

The presence of a relatively diversified and well-distributed malacofauna in the Contas River is related to the predominance of pulmonate gastropods. These mollusks have a high capacity to tolerate oxygen scarcity, and they are also more tolerant to extreme variations of temperature than are most prosobranchs (McMahon 1983, Brown et al. 1998). The pulmonates *P. acuta* and *B. straminea* have been recorded in lentic environments with low oxygen concentration in many parts of Brazil (Martins-Silva & Barros 2001, Vidigal et al. 2005, Tibiriçá 2006, Santos et al. 2012) and in nearby countries (Rumi & Hamann 1990, De Francesco & Hassan 2009). Among the Brazilian species of *Biomphalaria*, *B. straminea* is the best adapted to dry climates (Paraense 1977). Besides, *P. acuta* and *B. straminea* are monoecious and capable of self-fertilization under unfavorable environmental conditions (Jarne et al. 2000), an important feature for reestablishing their populations after prolonged droughts (Otermin et al. 2002). Other pulmonates found in the Contas basin (*Drepanotrema* and Ancylidae), although not widely distributed in the river, have also been recorded in lentic environments, with weak water current and prone to drying (Bonetto et al. 1982, Lanzer 1996, Abílio et al. 2006). Studies on some species of *Drepanotrema* show that they are also capable of tolerating dry and anoxic periods (Teles & Marques 1989).

Melanoides tuberculata, the most abundant and well-distributed species in the Contas basin, is a non-pulmonate gastropod (prosobranch) that occurs in both lentic and lotic environments (Giovanelli et al. 2005). Several features allow this invasive species to dominate, including the capability of aestivating (Abílio et al. 2007), tolerance to low dissolved-oxygen concentrations, high temperatures (Mitchell & Brandt 2005), and brackish and saline waters, and also because it can reproduce parthenogenetically (see references in Santos et al. 2012). The dominance of *M. tuberculata* in rivers and reservoirs of semiarid regions in northeastern Brazil has been mentioned in the literature (e.g., Abílio et al. 2006, Santana et al. 2009, Lima et al. 2013). *Melanoides tuberculata* is also considered to be responsible for the decline or extirpation of some native Brazilian species, such as members of *Biomphalaria* and *Pomacea* (see references and discussion in Vidigal et al. 2005). Populations of *M. tuberculata* found in the Northeast region can decline in rainy periods (Giovanelli et al. 2005, Abílio et al. 2006). Therefore, the Contas River populations are likely to be more numerous, and are probably causing the decline of the populations of other mollusks.

In general, many species found in the Contas River are able to survive in both lentic and lotic settings, but are more common in the former, such as species of Planorbidae, Physidae (Bonetto et al. 1982), Ancylidae (Tietze & De Francesco 2010) and Ampullaridae (Martín et al. 2001). Thus, many of the specimens found in this study could have been carried in from lentic marginal environments (e.g., small açudes) or from terrestrial environments into the river, during the rainy period that preceded the sampling. This process has been reported for species of *Biomphalaria* and *Pomacea* in other parts of the country (Chieffi & Moretti 1979, Martello et al. 2006). The accidental presence of terrestrial gastropods in the rivers studied supports this supposition.

The small size reached by many species found in the region, in relation to those reached in other Brazilian regions (see Systematics), also reflects the intermittent character of the Contas River basin. Macroinvertebrate species commonly mature more rapidly under adverse conditions (Resh et al. 2012). Specimens of many macroinvertebrate species that grow to less than their potential maximum size have been recorded in other river basins in semiarid regions (Diáz et al. 2008, Santana et al. 2009). Small specimens of *M. tuberculata* were also identified in a previous study conducted in a semiarid river in the Brazilian Northeast (Santos & Eskinazi-Sant'Anna 2010).

The higher richness of species recorded in the lower course of the Contas River is likely related to the climatic differences between the

Caatinga and Atlantic Forest biomes. In the Atlantic Forest, the annual precipitation is higher than in the Caatinga (Secretaria… 1993), allowing greater flow in the lower course, and consequently a more permanent hydroperiod (Silveira et al. 2006). These conditions favor the presence of bivalves, which are filter feeders and also depend on well-oxygenated waters to survive (Vaughn 2005). The bivalves *P. pulchellum*? and *E. simoni*? were found exclusively in the Atlantic Forest region, although species of Pisidiidae can also tolerate exposure to air (McMahon & Bogan 2001). On the other hand, a permanent hydroperiod also allows the populations of macrophytes to increase, which is an important driver for mollusks such as Ampullaridae (Veitenheimer-Mendes et al. 1992, Pfeifer & Pitoni 2003) and *Eupera* (Mansur & Valer 1992). Many members of Ancylidae commonly live on macrophytes. *Gundlachia ticaga*, which was found only in the lower course of the river, occurs in lentic environments, on stems and leaves of aquatic plants (Lanzer & Veitenheimer-Mendes 1985). The high diversity of macroinvertebrates in macrophyte stands along the river margins in the Northeast region was previously mentioned by Santana et al. (2009). The failure to record unionoid bivalves in the Contas River may be a consequence of the Surber sampler used. Freshwater mussels usually reach a large size (ca. 6 cm) and are burrowers. However, as they are very sensitive to prolonged droughts (Johnson et al. 2001), it is possible that they are rare or do not occur in the basin, although many unionoids have been recorded elsewhere in the Northeast (Jaeckel 1952, Simone 2006).

In the Caatinga, the mean air temperature is higher and the annual cumulative precipitation is lower than in the Atlantic Forest. These conditions may have made the upper course less favorable for the mollusks, because many stretches of the river may dry, reducing the survival of many species. The scarcity of water can also reduce the development of macrophytes. Thus, the occurrence of *M. tuberculata* and *B. straminea* in the Caatinga region can be explained by their tolerance to dry periods. Species of *Pomacea* and Ancylidae can also tolerate water and oxygen scarcity (Castellanos & Fernández 1976, Fernández 1981), explaining the occurrence of *P. archimedis*? and *H. moricandi* in the upper course of the river.

Conclusions

The results obtained in this study illustrate the need for further investigations of the rivers of the Brazilian semiarid regions. Although many watercourses are intermittent, the malacofauna found in the Contas River basin is diversified, and constituted mainly by pulmonate gastropods. However, this intermittent hydroperiod is unfavorable for mollusk survival, because most of the specimens collected had smaller body sizes than in populations of the same species in wetter regions, and because they are more abundant in the Atlantic Forest part of this basin. Morphological and anatomical features observed in certain species demonstrate that mollusk populations in the Northeast can show intra-specific differences from those in other Brazilian regions. Some species with doubtful identifications, after further study, might be considered new species. The dominance and wide distribution of *Melanoides tuberculata* along the entire Contas River show that public administrators must give special attention to Brazilian semiarid regions. This species is a vector of human disease in other regions of the world (Pinto & Melo 2011), and also competes with native species, reducing their populations.

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