COLONIZATION OF HYDROELECTRIC RESERVOIRS IN BRAZIL BY FRESHWATER SPONGES, WITH SPECIAL ATTENTION ON ITAIPU

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SUMMARY

The news that workers reported itchiness when cleaning fish breeding cages in the Itaipú Binational Hydroelectric Reservoir led the authors to carry out a survey to detect sponges along all the Brazilian bank of the Lake. The proposal was based on existing knowledge, the occupation of both lakes and the hydroelectric power station (HPS) turbines in Brazil by this fauna, and of dermatological irritation and eye pathologies caused by the siliceous spicules from sponges in Amazonian rivers. The survey carried out along the bank-side vegetation, the fish breeding cages and their buoying devices, and sampled sediments revealed sponge incrustation on the fish breeding cages, the bank-side vegetation and on rocky substrates, as well as loose spicules in the sediments, with specificity in relation to the preferred substrates. Hence, Radiospongilla amazonensis *was only detected on the leaves and stalks of* Egeria *sp.,* Polygonum hydropiperoides *and roots of* Oxycarium cubensis*; and* Corvospongilla seckti *on the walls of the breeding cages;* Trochospongilla repens *on the rigid surface of polyethylene floats of some of the cages and, as with* Oncosclera navicella *and* Potamophloios guairensis *n. sp. on rocky substrates at the head of the Lake. The sponges were seen to compete for substrate with the exotic bivalve* Limnoperna fortunei. *The results are compared with those reported for other HPS reservoirs in Brazil. The possibility of carrying out freshwater sponguiculture experiments in these reservoirs, and the prevention of the effects of human contact with the spicules, are considered.*

Construction of the Itaipu Hydroelectric Power Station began in 1974. The dam was completed and the floodgates closed to enable the formation of the lake in October 1982. The lake formed in 14 days, with the water rising 100m and reaching the gates of the spillway at 10:00 on October 27th, while covering an area of 1350km^2 (Miranda, 2008). The installed potential of the station is 13300MW, with 19 units generating 700MW each. The production record for the generation of power occurred in the year 2000 (93.6×10^{6}MWh). It is responsible for supplying 95% of the electrical energy consumed in Paraguay and 24% of the demand from the Brazilian market (IB, 2007).

The formation of the lake directly affected 15 municipalities in the State of Paraná. Since 1985, when *Itaipu Binacional* entered into commercial operation, these municipalities have received royalties that, in the period 1985-2006, amounted to R$ 2,970,164,600.00 (IB, 2006). Royalties will be paid until 2023. Therefore, the municipal authorities involved and, mainly, the local populations, need to take special care regarding the efficient application of these financial resources (Iwake, 2005); according to this author, in some municipalities these royalties represent ~90% of the total revenues. *Itaipu Binacional* has encouraged, among other initiatives, research into and installation of fish farming (breeding cages), as an alternative where traditional fish-breeding techniques (using tanks excavated in the ground) is unfeasible due to handling difficulties (IB, 2007).

In the second half of 2006, a research team from the Limnological Ictiological and

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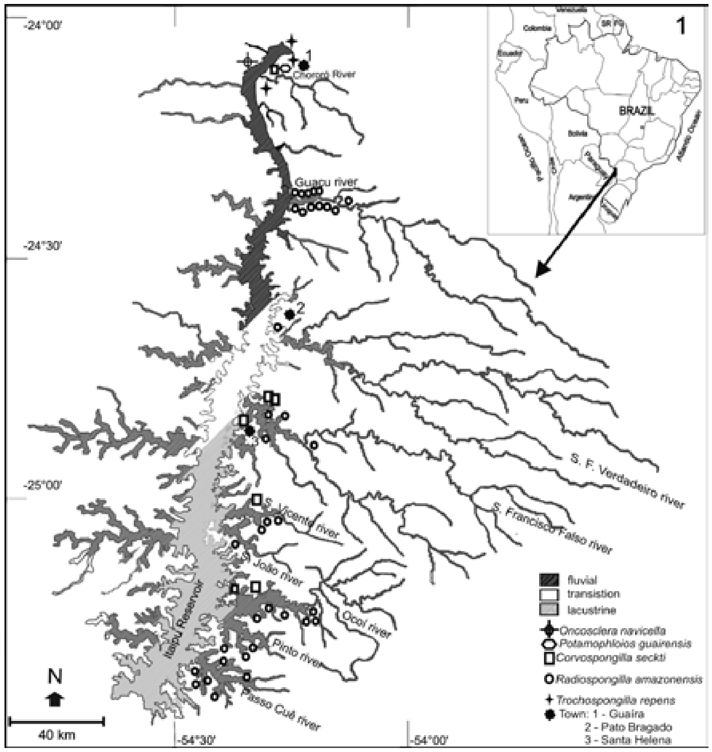


Figure 1. Map of the Itaipu HPS reservoir, indicating the three lake compartments according to Hahn *et al*., (1998) and the distribution of the sponge species detected along the Brazilian side of the lake.

Water-Resource Research Center (*Núcleo de Pesquisa em Limnologia Ictiologia e Aqüicultura - Nupelia)* from the State University of Maringá, detected the presence of sponges encrusted both on the macrophytes and the walls of the fish breeding cages in some rivers that drain into the Itaipu reservoir and personally reported their observations to Mauro Parolin. In January 2007, the authors of the present paper participated in a campaign with the *Nupelia* team that aimed to establish a research project to confirm and map such occurrences. On that occasion, people responsible for their maintenance reported itching when cleaning the cages.

Reports of occupation of hydroelectric reservoirs by sponges are rare. The first, and until then the only one for tropical areas, was from Begg and Junor (1971) in Lake Kariba, Africa. The first report of occupation of a hydroelectric lake by sponges in South America was made by Volkmer-Ribeiro and Hatanaka (1991) for the Tucuruí reservoir, PA, Brazil. Thereafter, various specimens from substrate occupation in similar reservoirs were identified, with particular concern regarding the problems caused by the incrustation of sponges on the walls of turbine rotors. For the purposes of comparison with Itaipu, these specimens have been processed and their identification is included herein. Given the reports of dermatological irritation (Magalhães *et al*., 2005, 2006) and eye pathologies caused by siliceous spicules from these sponges (Volkmer-Ribeiro *et al*., 2006, 2008; Volkmer-Ribeiro and Batista, 2007), Vasconcelos-Santos *et al*., 2010, previously identified in Amazonian rivers, the mapping of the occupation in the Itaipu reservoir was recommended.

The present paper reports and compares all the results obtained and presents, for the first time, a map of the occupation of a HPS by species of this fauna, the advantages resulting from the occupation, a prognosis of its evolution, and measures intended to prevent contact with these organisms. Due to the detection, at the head of the Itaipu reservoir, of a new species of sponge, its preliminary description and illustration is offered.

Methods and Materials

Four campaigns were carried out along the left bank (Brazilian) of the Itaipu reservoir in order to detect and sample sponges (Figure 1). For this purpose the following locations were selected: the Paraná River, at the head of the lake, the Guaira region (Sete Quedas), close to the Ayrton Senna bridge and the full length of the tributaries (the rivers Chororó, Guaçu, São Francisco Verdadeiro, São Francisco Falso, São João, Ocoí, Pinto and Passo Cuê). These campaigns were carried out in February, June and November 2007 and March 2008. The sponges collected from the same bank of the lake by the *Nupelia* team in the months of November 2006 and September 2007 were also identified. The sponges were gathered manually on board a boat and placed in a botanical oven for drying. Material extracted from the stomach contents of fish from the Itaipu Lake was also identified. In addition to these materials, samples were identified from other hydroelectric reservoirs in Brazil, including the HPS lakes of Tucuruí (River Tocantins) and Curuá-Una (River Curuá-Una), Pará; Cachoeira Dourada and Emborcação (River Paranaíba), Minas Gerais; *Pequena Central Hidroelétrica Garganta de Jararaca* (River do Sangue), Mato Grosso; Passo Real (River Jacuí), Rio Grande do Sul. Duplicates of each species were deposited and catalogued in the Porifera collection of the Natural History Museum of the Zoobotanic Foundation of Rio Grande do Sul (MCN-POR). A Van Veen grab sampler was used to collect the bankside sediments from the resorts on the rivers São Francisco Falso (municipality of Santa Helena) and São Francisco Verdadeiro (municipality of Entre Rios). For the purposes of taxonomic identification, fragments of the sponges and portions of the sampled sediments were processed for cleaning the spicules and mounting on permanent slides, using optical microscopy (Volkmer-Ribeiro and Pauls, 2000). The collection sites were georeferenced based on the global positioning system (GPS), plotted on topographical maps at a scale of 1:50000 and on images from Google Earth® with the use of Auto Cad® and GPS Track Marker® softwares.

Characterization of the Itaipu Reservoir Area

In Brazilian territory, the study area covers nine rivers along the left bank of the Itaipu Lake, as well as the beginning of the lake, still under the influence of the River Paraná, at the Ayrton Senna Bridge, which links the State of Paraná with that of Mato Grosso do Sul. Geologically the region is inserted in an area with cretaceaous sedimentary cover with basal effusive rocks (basalt) belonging geomorphologically to the third Paranaense Plain (Kaul, 1992). According to Nimer (1992) the highest average temperatures are recorded in January (26ºC) and the lowest in July (15ºC); annual rainfall is 1500-1750mm, June, July and August being the driest months.

The original vegetation in the area in which the lake is situated was a semidecidual seasonal forest (Leite and Klein, 1992), which today comprises secondary vegetation, restricted to legal reserves and areas of riparian vegetation, now greatly altered due to the expansion of farming in the region. Seasonal crops such as soybean, corn and wheat are planted. In the islands and along the banks of the reservoir the predominance of the exotic species *Leucaena leucocefala* (Lam.) De Wit can be noted.

For Thomaz *et al*. (1999) and Bini *et al*. (1999), the construction of the Itaipu reservoir favored the appearance of an abundant aquatic macrophytic flora, dominated by a few species. The floating submerged species have developed the most, mainly *Pistia stratiotes* Linn, *Salvinia auriculata* Aublet and *Eichhornia crassipes* (Mart.) Solms. The same authors argue that, of the submerged species, *E. najas* was found in all the branches along the left reservoir bank, registering high levels among the composition of the biomass.

The average time of water residence in the reservoir is 40 days, and the circulation is of the hot monomithic type (Brunkow *et al*., 1988). In relation to its limnological, ictiofaunistic and fishing characteristics, Hahn *et al*. (1988) report that the reservoir has a strong longitudinal gradient in which three distinct zones (Figure 1) can be recognized, the fluvial zone (between the municipalities of Guaira and Pato Bragado), the transitional zone (Pato Bragado to Vila Celeste) and the lacustrine zone (Vila Celeste to Foz do Iguaçu).

Research by Benedito-Cecílio *et al*. (1997) on the ictiofauna and related to the space-time variations in the specific composition and diversity during the process of occupation of the Itaipu reservoir, indicated that five years after the formation of the reservoir two species were predominant: *Auchenipterus nuchalis* Spix & Agassiz, 1829 and *Hypophthalmus edentatus* Spix, 1829, while in the lake tributaries *Loricariichthys* sp. and *Steindachnerina insculpta* Fernández-Yépez 1948 are predominant. The same authors also recorded that the diversity of species was greater in the Itaipu reservoir, the largest contribution being from the area close to the region of Guaira. In the tributaries, where there are fish breeding cages, only the native species bred: Jundiá, *Rhamdia quelen* (Quoy and Gaimard, 1824), Curimba, *Prochilodus lineatus* (Valenciennes, 1836) and Pacu, *Piaractus mesopotamicus* Holmberg, 1887 (Silva, 2008).

Results and Discussion

Taxonomy

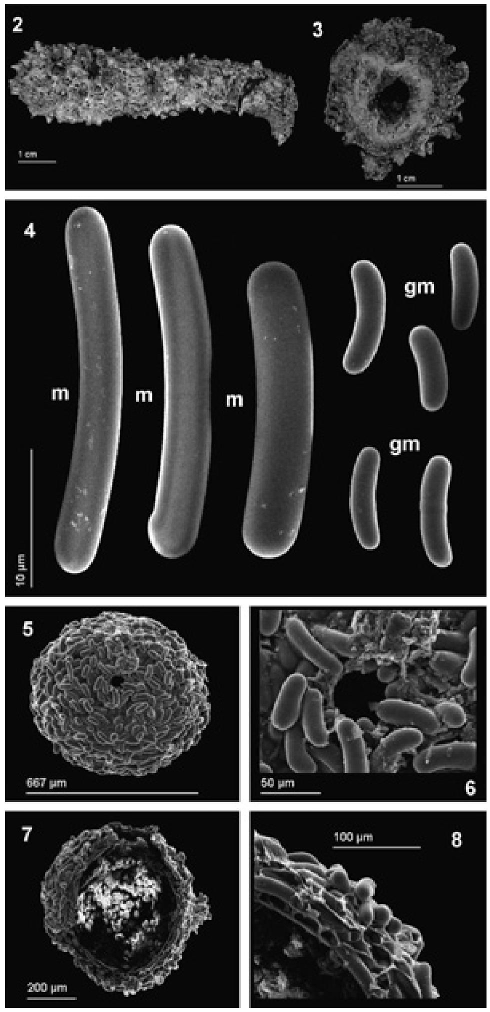
The discovery of a new species of freshwater sponge at the head of the Itaipu Reservoir necessitates its description.

Phylum Porifera
Class Demonspongiae
Family Potamolepidae Brien, 1967
Genus *Potamophloios* Brien 1969
Potamophloios guairensis n. sp.
(Figures 2-8 and 12)

Examined materials

Type material: Holotype MCN-POR 7860. Guaira, Paraná River, at the Itaipu Reservoir, by the mouth of the Xororó River, PR, Brazil. 13-XI-2007. F.P. Santos col.; Paratypes. MCN-POR 3533, 3534. Guaira, Paraná River, at the Itaipu Reservoir, PR, Brazil. 20-IV-1997, Rosilene Luciana Delariva col.

Etymology: The species is named upon its type locality, Guaira, the site where the famous Seven Falls existed and were submerged by the damming of the Paraná River to form the Itaipu Reservoir.



Figures 2-8. *Potamophloios guairensis* n. sp. 2: holotype, 3: cross section of the holotype showing the three differing areas of the skeleton, 4-8: SEM of, respectively, 4: megascleres (m) and gemmoscleres (gm), 5: gemmule and foraminal orifice, 6: The foraminal orifice, 7: cross section of gemmule and foraminal aperture, 8: gemmular coat with gemmosclere irregular setting and absence of a pneumatic coat.

Type locality: The Guaira region at the Itaipu Reservoir. Distribution: Probably encompassing the deep rocky substrates of the upper reaches of the Paraná River beyond the Itaipu Reservoir.

Habitat: Rocky or any hard substrates permanently or long submerged in quite deep turbulent waters.

Diagnosis: Sponges forming stout, grayish thick crusts. Surface reticulate, hispid, conulose, oscular apertures on top of the conular projections. Skeleton composing three areas of differing reticular condensation: very closed but cavernous reticulum full of gemmules at the base, close and continuos reticulum in the middle, and an open reticulum with thick fibers towards the surface; original main fibers can be however perceived extending from the base up to the conulose projections. Spongin scarce. Gemmules abundant, single or in groups, spheric, with one single foramen, foraminal tubule absent, the gemmoscleres disorderly glued in the inner gemmular layer, pneumatic layer absent. Megascleres large, stout, smooth, straight to sligthly curved amphistrongyla. Gemoscleres from straight to curved, smooth, small, stout amphystrongyla, the small ones reaching the spheric shape. Dimensions of spicules and gemmules are shown in Table I.

Description: Sponges forming quite hard, grayish crusts on rocky substrates or cilindrical growths around fishing lines. Surface reticulate, hispid, conulose with the conules distributed in alignements. Oscules conspicous. Oscular apertures of differing sizes may form on top of the conular projections (Figure 2). Skeleton composing three areas of differing reticular condensation, the basal one composing a thick crust with cavernous spaces full of gemmules, the middle one wholy solid, the outer part a regular reticulum with very thick fibers (Figure 3). A close scrutiny may, however, uncover the original main fibers extending up to the conulose projections at the sponge surface. Megascleres large, stout, smooth, straight to curved or angulated amphistrongyla which initiate as slim sharply pointed oxea. Microscleres absent. Gemoscleres from straigt to curved, smooth, small, stout amphystrongyla, the small ones reaching a spheric shape (Figures 4, 12). Gemmules abundant, single or in groups, spheric, with one single foramen, foraminal tube absent (Figures 5, 6), the gemmoscleres disorderly glued on the inner gemmular layer, pneumatic layer absent (Figure 7). Size of spicules and gemmules are shown in Table I.

Remarks: The holotype was donated by Fdson Pereira Santos, a fisherman at the Guaira region, to Parolin and Volkmer Ribeiro at the field. He told that the specimen had grown around a fishing line and that these sponges were commonly found adhering to such lines or other fishing devices immersed for long periods in the river waters. The paratypes were caught toghether with fishes captured in a fishing cast net at the same region. Genus *Potamophloios* was originally proposed for materials of the Ethiopian Region and its distribution was up to now restricted to that region. For that reason the holotype and paratypes of *P. guairensis* n. sp. were compared with materials of some of the *Potamophloios* species proposed by Brien (1970) i. e. *P. symoensi* Brien 1967 (MCN-POR: 8222, Esquizoparatype), *P. gilberti* Brien 1969 (MCN-POR: 8223, Esquizoholotype), *P. songoloensis* Brien 1969

TABLE I
DIMENSIONS (μm) OF SPICULES OF
Potamophloios guairensis N. SP.*

	Megascleres		Gemmoscleres		Gemmules
	Length	Width	Length	Width	Width
Min	259	22.94	48.47	9.62	690
Max	336.7	65.49	157.25	34.04	998.2
Ave	307.68	45.94	87.20	25.09	839.43
SD	20.53	7.81	23.05	4.46	72.42

* MCN-POR: 7860 3533, 3534.

(MCN-POR: 8224, Esquizoholotype) and *P. hispida* Brien 1969 (MCN-POR: 8225, Esquizoholotype). The Neotropical materials conform all the characteristics proposed for the genus but show consistent larger size of spicules and gemmules besides different shape and size of the sponges when compared to the Ethiopian species.The family Potamolepidae was extended to the Neotropical Region by Volkmer-Ribeiro and De Rosa-Barbosa (1978) who considered this family to have a Gonduanic distribution. This proposition, afterwards endorsed by Manconi and Pronzato (2002), is now reinforced with the detection of genus *Potamophlois* in South America.

Sponges colonizing Itaipu

Five species of sponges, belonging to five genera and two families (Table II) were detected occupying distinct substrates on the Brazilian bank of the Itaipu Lake: *Trochospongilla repens* (Hinde, 1888; Figure 14), *Corvospongilla seckti* Bonetto & Ezcurra de Drago, 1966 (Figures 9-11, 15) and *Radiospongilla amazonensis* Volkmer-Ribeiro & Maciel, 1983 (Figure 16), the three belonging to the Spongillidae Gray, 1867 family, *Oncosclera navicella* (Carter, 1881; Figure 13), and *Potamophloios guairensis* n. sp. (Figures 2-8, 12) of the Potamolepidae Brien, 1967 family.

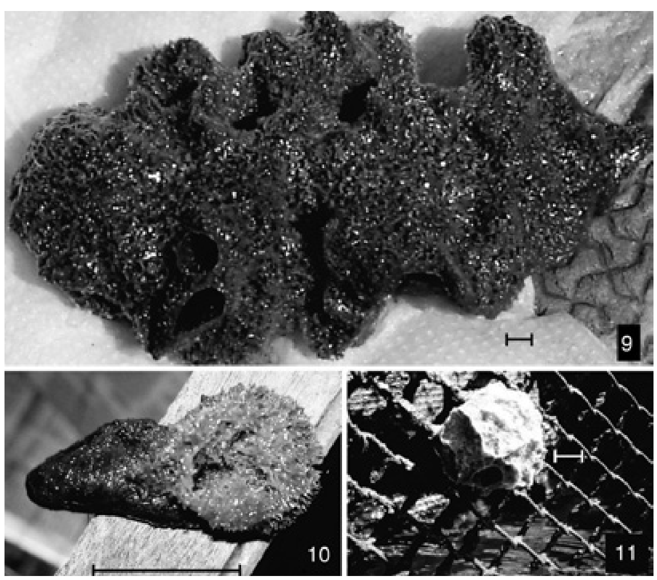
Examination of Table II and the map in Figure 1 reveals that the community of sponges colonizing the lake is composed of two distinct groups, considering their distribution within the distinct compartments of the reservoir, and their preference by preference for substrates and the silica content of the sponge skeleton. The first group, consisting of the sponge species T. *repens*, *O. navicella*, *P. guairensis* n. sp. and *C. seckti*, which are concentrated in the lotic segments of the reservoir (Hahn *et al.* 1988), attach themselves to hard substrates such as rocks at the lake head or on the lake bed, the surface of the polyethylene or rubber floats that support the cages as well as the metal walls of the cages and have rigid skeletons with robust spicules and a reduced quantity of spongine. The fragments of *O. navicella* found in the stomach contents of the fish *Hipostomus regania* (armored catfish) and *Megalancystrus aculetatus* (pineapple catfish) also originated from the region at the head of the lake and consisted of pieces of skeleton with gemmules, indicating detachment from firm crusts settled on rocky substrates.

The second group, composed of *R. amazonensis* and, rarely, *C. seckti*, is concentrated within the area of transition, and particularly in the case of the former species, in the lentic segment of the reservoir (Hahn *et al.* 1988). These are sponges that prefer soft substrates, such as bank-side macrophytes and particularly, among them, *Egeria najas* and *E. densa*. These environments with reduced flow in the reservoir favor the establishment of submerged macrophytes with soft stalks and leaves (Bini *et al.* 1999). Both *R. amazonensis* and *C. seckti*, which are present within the lentic segment of the reservoir, are species rich in spongine, with a reduced quantity of thin spicules, which would indicate a reduced availability of silica dissolved in the water. It should be considered that environments with lentic characteristics are also established at the mouth of tributaries, due to the flow impediment that, within the reservoir, is offered to the tributaries (Figure 1).The same does not occur with sponges that choose the hard substrates situated within the lotic portion of the lake, which receives silica brought by the Paraná River.

T. repens and *C. seckti* had already been recorded in the Corumbá River, a tributary of the Paraná River in the State of Goiás (Batista and Volkmer-Ribeiro, 2002) and both, together with *O. navicella,* in the middle course of the Paraná River, in Argentina (Bonetto and Ezcurra de Drago, 1967, 1970). In all cases, these species encrusted hard, rocky substrates within lotic beds, demonstrating that they are common within such habitats in the basin. *R. amazonensis* is, on the other hand, a species typically found in lentic eutrophic systems as, for instance, the peaty environments of the Cerrado/Savanah (Volkmer-Ribeiro and Motta, 1995).

Regarding the biological aspects of the sponges, it was found that *R. amazonensis* was the only species that occurred seasonally within the reservoir, as it was practically absent in the spring. This species is also noteworthy because it presented rare specimens with gemmules. These specimens were then used as paradigms, in terms of color, constitution of the skeleton and shape of the megascleres, when determining the others that presented the same characteristics. The fact that the species is more abundant in the lentic compartment of the reservoir, is seasonal, and does not present gemmules indicates that the occupation is being carried out by gemmules produced in the upper reaches of the tributaries that are carried by the flow to downstream regions, and accumulate precisely in the compartments with less flow. At the propitious season, the gemmules give rise to new specimens which, complying with the known biological cycle for freshwater sponges (Frost, 1991), they expand the occupation of the bank-side macrophytes by sexual reproduction and the formation of larvae, producing relatively voluminous individuals. The absence of gemmules, which represent bodies capable of resisting adverse conditions is explained by the permanent immersion of the substrates. This absence of gemmules and the seasonal absence of *R. amazonensis* in these substrates may be linked to the fetch reported by Thomas *et al.* (2003) for the Itaipu reservoir. A line of uprooted and decomposing macrophytes along the bank was constantly observed during the present study.

Upon examination of the hard substrates available in the reservoir,



Figures 9-11. *Corvospongilla seckti*. 9: a large specimen detached from the walls of a fish breeding cage, 10: specimen incrusted on the valves of the golden mussel *Limnoperna fortunei*, 11: *in situ* photograph of a specimen incrusted on the walls of a fish breeding cage.

TABLE II
LOCATIONS AND SUBSTRATES IN WHICH THE PRESENCE OF SPONGES WAS DETECTED ALONG THE BRAZILIAN BANK OF THE ITAIPU HPS LAKE

Location	Species	Frequency	Substrate	MCN-POR
Paraná river, Guaira region	*Potamophloios guairensis* n. sp.	+++	Rocky	7860
	Oncosclera navicella	+++	Rocky	3532
		+++	Stomach contents of fish	3531, 3535
Paraná river, bar of the Chororó river	*Trochospongilla repens*	++	Rocky	8260
	Potamophloios guairensis n. sp.	+++	Ropes supporting the fishing lines and fishing nets	3533, 3534
Chororó river	*Trochospongilla repens*	++	Fish breeding cage polyethelene bouys	8274
	Radiospongilla amazonensis	+++	Buoy tires of the fish cages and on *Limnoperna fortunei* valves	8275
Guaçu stream	*Radiospongilla amazonensis*	+++	*Egeria* sp.	7852, 8259
São Francisco Verdadeiro river	*Radiospongilla amazonensis*	+	*Egeria* sp. and roots of *Oxycaryum cubense*	7850
São Francisco Falso river	*Radiospongilla amazonensis*	++	*Egeria* sp. and tree trunks	7847, 8257
	Corvospongilla seckti	+++	Bouy tires and walls of the fish cages and on *Limnoperna fortunei* valves	8256
São Vicente river	*Radiospongilla amazonensis*	++	*Egeria* sp.	8258
	Corvospongilla seckti	+++	Bouy tires and walls of the fish cages and on *Limnoperna fortunei* valves	8273
São João river	*Radiospongilla amazonensis*	+	Egeria sp.	7851
Ocoí river	*Radiospongilla amazonensis*	+++	*Egeria* sp., *Polygonum hydropiperoides*, gramíneas e troncos de árvores.	8276
	Corvospongilla seckti	+++	Bouy tires and walls of the fish cages and on *Limnoperna fortunei* valves	7848, 7849
Pinto river	*Radiospongilla amazonensis*	+++	*Egeria* sp.	8277
Passo Cuê river	*Radiospongilla amazonensis*	+++	*Egeria* sp.	7846

it was found that *T. repens* and *C. seckti* compete with the golden mussel, *Limnoperna fortunei* on these substrates, and that the former species and the mussel exclude each other. *C. seckti*, in contrast, as well as attaching itself to the walls of the cages (Figsures 9-11), ruber floats fixed to the cages and to the mussels themselves, even spreads over their valves (Figure 10). *R. amazonensis*, by encrusting itself on *Egeria* sp. avoids the competition with the mussel, as this macrophyte is not sufficiently rigid to support the weight of the mussel.

Sponges colonizing other Brazilian reservoirs

The comparison of the colonization underway in Itaipu with the reports, though still sparse and fortuitous, of sponges found in other reservoirs in Brazil (Table III) makes it possible to distinguish differentiated contexts, particularly in relation to the geographical distribution of this fauna, as well as the ability to adapt to different flows demonstrated by some species. In the geographical context, for example, it is seen that the colonization operated by *Spongilla spoliata*, *Drulia conifera*, *Oncosclera intermedia* and *O. spinifera*, species presently detected only in the beds of Amazonian rivers, does occur in Amazonian reservoirs. On the other hand, sponges typically found in Amazonian floodplain lakes, such as *Metania spinata*, *Drulia browni*, *Saturnospongilla carvalhoi* and *Heteromeyenia cristalina* (Batista *et al*., 2003; Batista and Volkmer-Ribeiro, 2007) do not appear in the occupations of reservoirs in that region, certainly because of the immersion factor permanently provided by the reservoirs. The fact is repeated in the dammed river beds in other regions of the country, such as Sobradinho (Bahia), Cachoeira Dourada (Goiás), Itaipu (Paraná), Barragem Corte Real (Rio Grande do Sul). The occupation of the reservoirs is carried out by sponges typical of lotic beds such as *Oncosclera navicella*, *Trochospongilla repens*, *Drulia uruguayensis* and *Corvospongilla seckti*. However, the operated selection appears to take into account both the species originally most abundant in the river bed and their potential to adapt to the distinct flows existing within the dammed perimeter. *C. seckti* and *D. uruguayensis* also occur in locations with calmer waters, while maintaining the preference for hard substrates, though forming voluminous sponges, with delicate texture, due to the silica-poor skeletons, but rich in spongine.

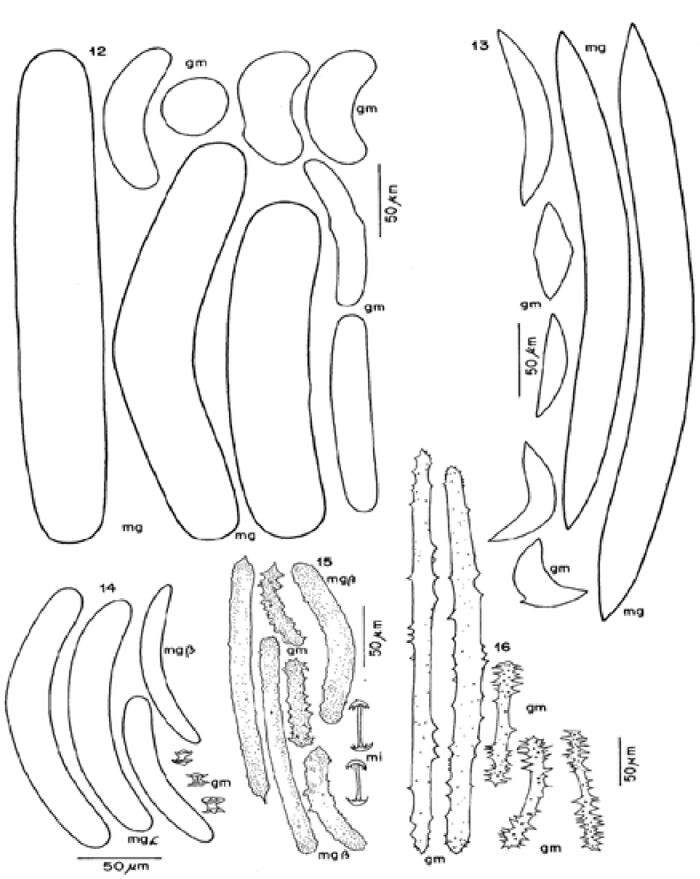
Examination of the substrates occupied in the distinct reservoirs studied shows that they vary from the flooded riparian vegetation to the walls of the submerged houses and villages, the internal face of the dams or the ducts and turbines of the HPSs, as well as the fishing devices used in the waters.

One of the rare, if nor the only existing records of sponges occupying hydroelectric reservoirs in tropical areas was made by Begg and Junor (1971) for Lake Kariba, in Africa, which dammed the River Zambezi on the border between Zambia and Zimbabwe in 1958, and was filled by 1963. The colonizing sponge was precisely a species of the genus *Corvospongilla*, in this case *C. zambeziana* Kirkpatrick l906, found by divers in the reservoir. It was distributed down to a depth of 15m, with a preferential level of occupation around 1m below the surface. Its crusts were adhered to jetties, boat hulls, mooring buoy chains, hawsers and dead trees, and specimen sizes went from a few centimeters to spheres 21cm in diameter. In this case, eight years passed from the filling of the lake to the register of this generalized occupation by a sponge orginating from the bed of the Zambesi river.

Given the register made for Lake Kariba and the level of occupation found in the Itaipu reservoir, the colonization underway in the latter can be expected to continue and probably expand. As far as water quality is concerned, the sponges are desirable constituents in reservoirs since, being filtering organisms, they remove bacteria and organisms up to 50µm in diameter (Simpson, 1984).

However, in relation to the encrustations, if these are located in the HPS duct system that leads directly to the power generation units, the friction of the water with the walls covered by encrusted sponges will result in a reduction in flow energy, even requiring stoppages to permit scraping to remove the crust. It is precisely at this moment, during the reduction in the energy of the circulating water, that the gemmules suspended in the water column in the ducts have the opportunity to adhere to the walls. Given their microscopic size (100-300µm) they remain unnoticed and use the scratchmarks produced by previous scraping on the walls of the rotors to secure a foothold. Within this context, it is suggested that spongiculture experiments should be carried out, aiming to capture gemmules from the reservoir itself in order to produce both biosilica and organic products.

There is increasing interest in tests relating to the antimicrobial and antitumoral activities of sponges, which up till now been carried out with marine sponges (Silva *et al*., 2006; Jimenez *et al*., 2004; Marques *et al*., 2007). This has been limited in its application due to the impossibility of obtaining material on a large scale from nature and by the difficulties encountered to date in cultivating marine sponges (Duckwort *et al*., 2007). In addition, there are several research projects examining the physical properties of the biosilica produced by sponges, represented by their spicules, with possible applications in distinct industrial processes (Morse, 1999; Woesz *et al*. 2006; Eherlich and Worch, 2007; Schroder *et al*. 2007; Müller and Grachev, 2009).



Figures 12-16. *Camera lucida* drawings of the set of spicules of 12: *Potamophloios guairensis* n. sp., 13: *Oncosclera navicella*, 14: *Trochospongilla repens*, 15: *Corvospongilla seckti*, 16: *Radiospongilla amazonensis*. mg: megascleres, gm: gemmoscleres, mgα: alfa megascleres, mgβ: beta megascleres, and mi: microscleres.

Considering the above-mentioned factors, the HPS lakes situated in tropical and sub-tropical areas of South America seem to offer an ideal situation for tests about the cultivation of freshwater sponges, with the dual aim of further investigating their industrial application and develop management methods to reduce encrustations in pipes and turbines in HPSs, using either gemmules imported from upstream or produced in the reservoir itself.

In this context, based on the observations made in Itaipu, distinct compartments can be distinguished that could be used for trials of sponge cultivation, depending on whether the purpose is production of biosilica for new materials, or the production of fibrous and cellular components for the pharmacological area. In the first case, the semi-lotic portion of the reservoir is recommended for the production of hard sponges because of the immediate availability of silica provided by the river, while, in the second case, the lentic portion is suitable, where the production of soft voluminous specimens was generalized, due to the greater quantities of spongin and organic components and the reduced number of spicules within the structure of the sponges. Given the sponge encrustation occurring in the fish breeding cages, some precautions are recommended to be taken when working with them: a) use gloves, b) use protective eyewear, c) use long-sleeve shirts, d) use diving masks. Skin areas in eventual contact with the sponge spicules should be well washed with soap and tap water as soon as the person gets back to the laboratory.

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TABLE III
LOCATIONS AND SUBSTRATES IN WHICH THE OCCURRENCE OF SPONGES WAS DETECTED IN HPSS IN BRAZIL

Location	Species	Substrate	MCN-POR
HPS Tucuruí Pará: Tucuruí. Lake - right bank. River Tocantins	*Corvospongilla seckti*	Flooded tree trunks, exposed during reduction of 3-4m of water level in the reservoir. Water O_2 at such depths is $4.0\text{-}5.0 mg \cdot l^{-1}$ O_2 throughout the year	2788-9, 2792, 2717
		Bark of flooded palm tree	2194, 2196
		Bark of flooded tree	2178, 2716
		Forest leaves fallen along the bankwater	2721
	Oncosclera spinifera	Tree bark	2713-15
		Bark of an "angelim tree" being cut out of the lake from 4-5m depth	2718
		Forest leaves fallen along the bank water	2720
		Sponge on the bark/ trunk of a palmtree	2195
	Drulia conifera	Flooded tree trunks, exposed during reduction of 3-4m of the water level	2790-1
Curuá-Una HPS Pará Santarém. HPS lake	*Spongilla spoliata*	Tree bark	2335-6,2342, 2344-5, 2347
	Trochospongilla variabilis	Tree bark	2337, 2744
	Oncosclera spinifera	Tree bark	2745-7
	Oncosclera intermedia	Tree bark	2334,2338-9, 2343, 2346
		Rocky	2340
HPS Cachoeira Dourada. River Paranaiba Goiás/ Minas Gerais	*Trochospongilla repens*	Metal walls of the turning pulps of the axial flow turbines	6352
	Corvospongilla seckti	Metal walls of the turning pulps of the axial flow turbines	6355, 6362
	Drulia uruguayensis	Walls of the floodgate	6353-4, 6356-60
HPS Emborcação Minas Gerais Araguari. Paraná Basin. Paranaiba river	*Radiospongilla amazonensis*	Tree logs and bark	3911, 3942
	Trochospongilla paulula	Rocky	3913, 3940
	Trochospongilla lanzamirandai	Tree bark	3912, 4946
	Oncosclera navicella	Bivalve shells and tree logs	3914, 3941, 3943, 4944
HPS Pequena Central Hidroelétrica Garganta de Jararaca. Mato Grosso: Campo Novo dos Parecís. Do Sangue river	*Metania spinata*	Sponge on Cyperaceae: *Welesteria confervoides* and *Eleocharis* sp.	8219
HPS Passo Real. Rio Grande do Sul: Quinze de Novembro. Passo do Lagoão. Jacuí-Mirim river	*Radiospongilla amazonensis*	Sponge attached to flooded tree trunks	6584, 6586
	Trochospongilla paulula	Sponges attached to the brick walls of flooded houses	6585

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COLONIZACIÓN DE RESERVORIOS DE PLANTAS HIDROELÉCTRICAS EN BRASIL POR ESPONJAS DE AGUA DULCE, CON ÉNFASIS EN EL DE ITAIPÚ

Cecilia Volkmer-Ribeiro, Mauro Parolin, Karina Fürstenau-Oliveira y Elton Rogério de Menezes

RESUMEN

Las noticias de que operarios que reportaron picazón al limpiar tanques de cría de peces en el Reservorio Hidroeléctrico Binacional de Itaupú llevaron a los autores a realizar un levantamiento a lo largo de la margen brasilera del lago. La propuesta se basó en conocimiento previo de la ocupación de ambos lagos y de las turbinas de la estación de generación hidroeléctrica (EGH) en Brasil por esta fauna, y en la irritación dérmica y patologías oculares causadas por las espículas silíceas de esponjas de ríos amazónicos. El estudio realizado en la vegetación ribereña, tanques de cría y sus boyas, así como en muestras de sedimentos, reveló incrustaciones en los tanques, la vegetación y sustratos rocosos, así como espículas sueltas en los sedimentos, evidenciando especificidad en relación a sustratos preferidos. Así, Radiospongilla amazonensis *solo fue detectada en hojas y tallos de* Egeria *sp. y* Polygonum hydropiperoides*, y en raíces de* Oxycarium cubensis*; y* Corvospongilla seckti *en las paredes de tanques de cría;* Trochospongilla repens *sobre la superficie rígida de flotadores de polietileno de algunos de los tanques y, como en el caso de* Oncosclera navicella *y* Potamophloios guairensis *n. sp. en sustratos rocosos en las cabeceras del lago. Las esponjas fueron vistas en competencia por sustrato con el bivalvo exótico* Limnoperna fortunei. *Los resultados son comparados con los reportados para otros reservorios de EGH en Brasil. Se consideran la posibilidad de adelantar experimentos de espongiocultura de agua dulce en estos reservorios, y la prevención de los efectos del contacto humano con las espículas.*

COLONIZAÇÃO DE RESERVATÓRIOS DE HIDROELÉTRICAS NO BRASIL POR ESPONJAS DE ÁGUA DOCE, COM DESTAQUE PARA O DE ITAIPÚ

Cecilia Volkmer-Ribeiro, Mauro Parolin, Karina Fürstenau-Oliveira e Elton Rogério de Menezes

RESUMO

As notícias que trabalhadores, que operam os tanques-rede de criação de peixes no Lago de Itaipu, queixavam-se de coceiras após limpeza dos tanques, levaram os autores a realizar um levantamento para detecção de esponjas ao longo da margem brasileira do lago. O projeto assentava no conhecimento existente, tanto da ocupação de reservatórios e, até mesmo das turbinas de usinas hidrelétricas de energia (UHE), no Brasil por essa fauna, aliado a registros de irritações dermatológicas e patologias oftalmológicas causadas pelas espículas silicosas dessas esponjas em rios da Amazônia. O levantamento operado contemplou a vegetação marginal, as paredes dos tanques-rede e coleta de sedimentos, que revelaram incrustações por distintas espécies de esponjas nos tanques rede, nas suas bóias de flutuação, na vegetação marginal e nos substratos rochosos, alem de espículas esparsas nos sedimentos, evidenciando especificidade em relação aos substratos preferidos. Radiospongilla amazonensis *foi detectada somente sobre as folhas e caules de* Egeria *sp.,* Polygonum hydropiperoides *e raizes de* Oxycarium cubensis*;* Corvospongilla seckti *encrusta as paredes dos tanques-rede;* Trochospongilla repens *forma crostas na superfície rígida dos flutuadores de polietileno de alguns tanques-rede e, bem assim como* Oncosclera navicella *e* Potamophloios guairensis *n. sp. fixa-se em substratos rochosos na cabeceira do lago. As esponjas estão competindo por substrato com o bivalve exótico* Limnoperna fortunei. *Os resultados são comparados com os relatados para outros reservatórios de UHEs no Brasil. São consideradas as possibilidades de se desenvolverem experimentos de espongicultura de água doce nesses reservatórios e medidas visando prevenir o contato humano com essas espículas.*