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Rediscovery after three decades of the freshwater sponge *Metania kiliani* on a terrestrial fern

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ABSTRACT

This study presents the second record of *Metania kiliani* (Porifera: Metaniidae) three decades after its description in 1992. The sponge was found on a herbarium specimen of the terrestrial fern *Actinostachys pennula* (Schizaeaceae), which is typically known to be absent from flooded environments. As sponges need at least some weeks to establish themselves on a support, this first record of a freshwater sponge on this fern suggests that *A. pennula* can withstand prolonged submergence. This is the first record of *M. kiliani* for the state of Roraima, Brazil.

KEYWORDS: *Actinostachys*, Amazonia, Metaniidae, Porifera, Schizaeaceae, white-sand vegetation

Redescoberta após três décadas da esponja de água doce *Metania kiliani* sobre uma samambaia terrestre

RESUMO

Este estudo apresenta o segundo registro de *Metania kiliani* (Porifera: Metaniidae) três décadas após sua descrição em 1992. A esponja foi encontrada sobre um espécime de herbário da samambaia terrestre *Actinostachys pennula* (Schizaeaceae), tipicamente conhecida por estar ausente em ambientes alagados. Como as esponjas precisam de pelo menos algumas semanas para se estabelecerem sobre um suporte, este primeiro registro de uma esponja de água doce nesta samambaia sugere que *A. pennula* pode suportar submersão prolongada. Este é o primeiro registro de *M. kiliani* para o estado de Roraima, Brasil.

PALAVRAS-CHAVE: *Actinostachys*, Amazônia, Metaniidae, Porifera, Schizaeaceae, vegetação de areia branca

Freshwater sponges are sessile filtering organisms that need support to grow, such as rocks, trunks, branches, leaves, or roots of submerged vegetation, and can grow on different types of substrates (Manconi and Pronzato 2002). They can be found in permanent or seasonal freshwater environments. As sessile filtering organisms, freshwater sponges tend to settle on substrates far from the bottom sediments of the water body, as a high amount of suspended particles can clog their pores. Usually, they prefer pristine aquatic environments, which makes them good bioindicators (Volkmer-Ribeiro and Parolin 2010). Worldwide, there are 9,602 known species of benthic sponges (de Voogd et al. 2023). The monophyletic order Spongillida Manconi & Pronzato, 2002 is composed exclusively of about 250 freshwater species (Morrow and Cárdenas 2015) distributed in continental aquatic ecosystems (Pinheiro and Calheira 2020). The catalog of Brazilian Porifera lists 61 species of freshwater sponges (Pinheiro et al. 2025).

In areas subject to periodic flooding, freshwater sponges can use trees as support (Manconi and Pronzato 2016). In Amazonia, there are abundant floodplain forests that may be flooded by blackwater or whitewater rivers (known as *igapó* and *várzea*, respectively) (Prance 1979) as well as lower white-sand vegetation (known as *campinas* or *campinaranas*) (Adeney et al. 2016). These environments are subject to strong seasonal cycles, variable water table levels, and different levels of hydromorphism, resulting in different plant communities and phytophysiognomies (Prance 1979; Adeney et al. 2016). In such variable environments, some species of freshwater sponges are subject to seasonal stages of growth and budding through gemmules. Gemmules are cryptobiotic asexually formed resistant structures containing totipotent cells covered by collagen and silica that can resist desiccation and anoxia. They can regenerate the entire animal during the next flood season (Manconi and Pronzato 2016).

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Because of gemmules, freshwater sponges present a random distribution and a wide geographic scale (Pronzato and Marconi 1994).

Ferns are a monophyletic group, sister to seed plants (Pryer et al. 2001). Their photosynthetic organs, the fronds, are also responsible for vegetative reproduction, spore dispersal, and other functions (Corvez et al. 2012). They exhibit an extensive spectrum of antagonistic and mutualistic relationships with fungi and animals (Mehltreter et al. 2010). Most interactions between ferns and other organisms are neutral (e.g., Moran et al. 2003) or mutualistic (e.g., Gómez 1974; Almeida 2018). There is no known interaction between poriferans and ferns.

Schizaeaceae is a fern family with two genera, *Actinostachys* Wall. with 15 species, and *Schizaea* Sm. with about 20 species (Kessler and Smith 2017). *Actinostachys* is widely distributed in tropical regions (Kessler and Smith 2017). In the Amazon region, *A. pennula* (Sw.) Hook. is commonly found in savannas, *terra firme* forests, coastal vegetation, riparian forests, and *campinaranas* (Santiago and Almeida 2023). While most ferns thrive in wet environments, as they need water for reproduction (Page 2002), only a few can withstand submersion (Walker and Sharpe 2010). Notably, there is no record in the literature of this tolerance in *A. pennula*.

Here we report the first record of the freshwater sponge, *Metania kiliani* Volkmer-Ribeiro & Costa, 1992 (Metaniidae) growing on a fern, *Actinostachys pennula* (Schizaeaceae), based on a herbarium record. The presence of an *M. kiliani* specimen was noted on an *A. pennula* specimen deposited in the herbarium at Universidade Federal de Pernambuco - UFPE (UFP89884) (acronym according to Thiers 2023) (Figure 1). The *A. pennula* material was composed of seven fronds of about 28 cm in length (Figure 1a). *Metania kiliani* was observed growing on one of the fronds, approximately 6 cm in size, at 9 cm above ground level (Figure 1a). The sponge specimen was detached and deposited in the Porifera collection at UFPE (UFPEPOR2999).

The material was collected in Caracaraí, Roraima state, Brazil (0º54'01"S, 62º16'48"W) (Figure 2), on February 6th, 2018, in a seasonally flooded *campinarana* area, as indicated on the specimen label. The climate in the collection area type AF (Köppen classification), with average annual temperature >26°C and rainfall of 2500-2800 mm (Alvarez et al. 2013). The soil is dystrophic Tb gleysol (IBGE 2006), and the area of the Rio Branco-Rio Negro Domain in Holocene alluvial deposits (IBGE 2005).

The fern and the sponge were identified with the aid of specialized literature (Santiago and Almeida 2023; Volkmer-Ribeiro and Costa 1992). Spicule slides and preparations of spicules for scanning electron microscopy (SEM) were made following Hajdu et al. (2011). Spicules were viewed on Tabletop SEM Hitachi TM4000PLUSII at the Zoology Department at UFPE.

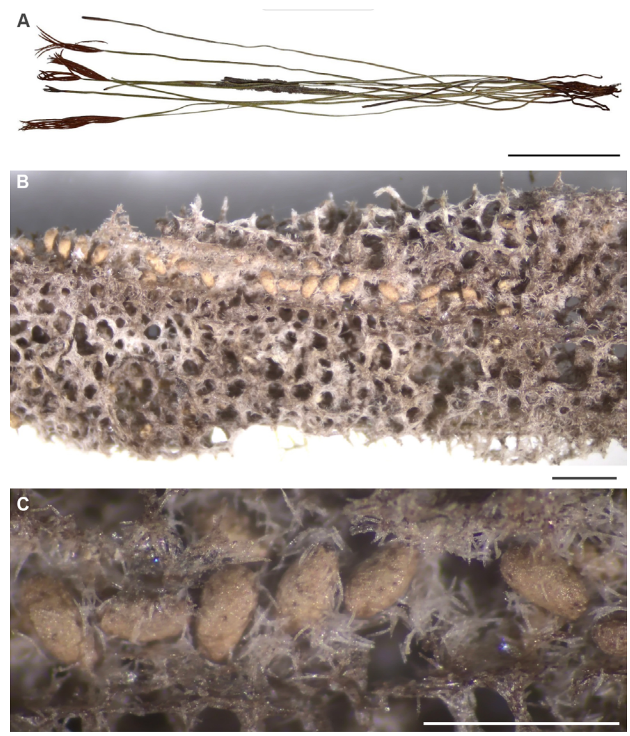

Figure 1. A – Specimen of the sponge *Metania kiliani* (UFPEPOR2999) growing on the fronds of the fern *Actinostachys pennula* (UFP89884); **B** – *Metania kiliani* in detail; **C** – Gemmules of *M. kiliani* in detail. Scale bars = 1 cm (B); 5 cm (A,C).

Description: The sponge formed small, thin, fragile crusts with a reticulated skeleton and brown color. Gemmules aligned side by side near the fronds (Figure 1b-c). Spicules: Alpha-megascleres (Figure 3a) smooth, short, stout, straight or slightly curved oxea with abruptly pointed extremities. Beta-megascleres (Figure 3b) short, stout, spined, straight to curved oxea with abruptly pointed extremities. Spines more concentrated in the middle part of the spicules. Microscleres minute anisochelaes (Figure 3c-e). Microscleres acanthomicroxea not present. In the original description, Volkmer-Ribeiro and Costa (1992) mentioned that they are rare and restricted to the pinacoderm. The present material was collected dry and probably lost part of the pinacoderm. Gemmoscleres (Figure 3f-g) short, stout, boletiform. Shafts straight or slightly curved with a typical collar of spines under the lower rotule or for one or two spines close to the upper rotule. Lower rotule small, thick, slightly umbonate, conspicuously polygonal, and with reduced margins. Upper rotule usually well-formed and bearing at its border six large, regular, incurved hooks. Gemmules abundant (Figures 1b-c; 3h-j), free, large, cocoon-shaped, forming a basal layer one gemmule thick. Micropile long but always sunken in a very thick pneumatic coat. First layer of gemmoscleres radially arranged around the inner coat with the lower rotules setting in this coat and the upper ones embedded in the pneumatic coat. Some upper rotules protruding from the outer gemmular coat (Figure 3i-j). The sponge was found in the budding phase.

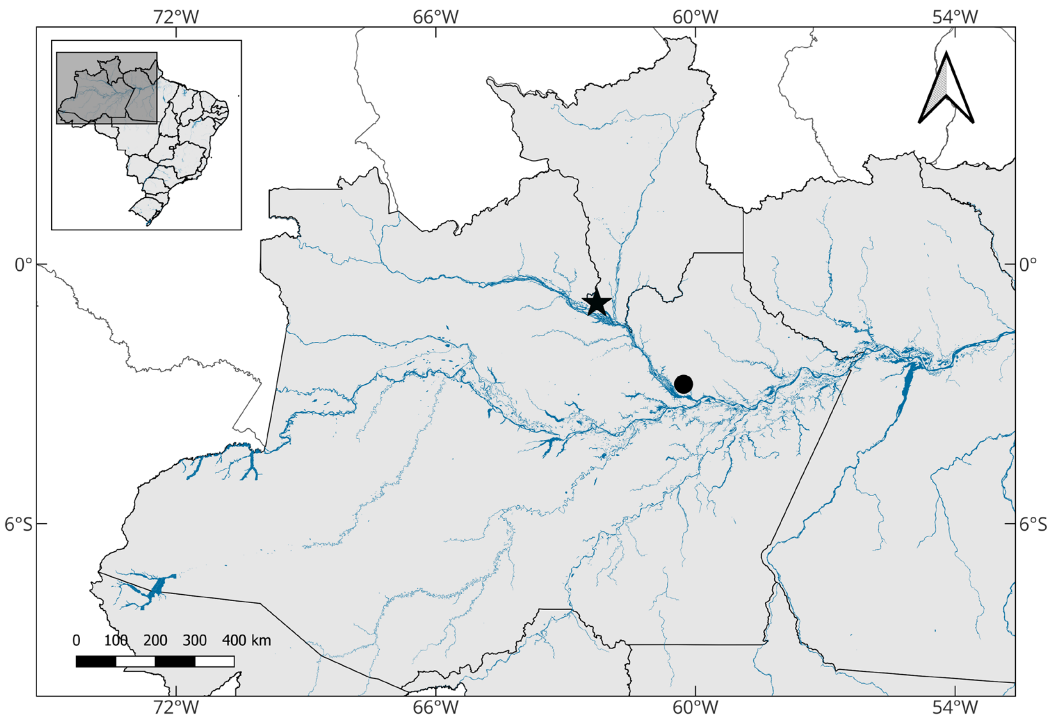

Figure 2. Distribution of *Metania kiliani* in Amazonas and Roraima states (Brazil) Black circle = type locality; black star = new record presented here.

Until now, *M. kiliani* had only been recorded in its original description for the Cuieiras River in the state of Amazonas (Brazil), encrusted "on leaves or around twigs reached by flood waters", as stated in the original description by Volkmer-Ribeiro and Costa (1992). Therefore, this is the second record of the species and the first for the state of Roraima (Figure 2). The lack of previous records of *M. kiliani* on this or another fern may indicate that *A. pennula* was only a random support for the sponge. One association is known of an Amazonian moss, *Fissidens brachypus* Mitt. (Fissidentaceae) that uses a freshwater sponge of the genus *Metania* as a growth substrate when the water level is low (Buck and Pursell 1980).

The fronds of *Actinostachys* are peculiar, being undivided, narrow, linear, axis-like, photosynthetic, and with stomata arranged in two lines along its length (Salino et al. 2023), with sporangia at the apex (Figure 1). It occurs preferentially in sandy or rocky soils (Takeuchi 1960). There was no published record of this species being able to withstand flooding, although field observations show Schizaeaceae growing in periodically flooded areas in the states of Amazonas, Pará, and Roraima (T.E. Almeida, pers. comm.). In *campinaranas* of central Amazonia, *A. pennula* was one of the most abundant species within the shrubby group (open savannah), a functional group in which there are flood-tolerant species (Nogueira 2014). Few studies have examined morphophysiological adaptations of ferns to flooding in Brazil, with a conspicuous gap, particularly in the Amazon, where flooded areas are common. As the sponge needs some weeks to establish itself on the substrate (Calheira et al. 2019), the presence of *M. kiliani* indicates that *A. pennula* has the potential to survive for a long period submerged, although it is not known whether the fronds are long-lived and can withstand more than one flooding season.

The use of plants as growth support by sponges is common in Amazonian flooded areas, where it is usually possible to observe sponge remnants on trees after the water levels drop (Volkmer-Ribeiro and Parolin 2010). Sponges have even been used as indicators of the water level during the flood season (Keel and Prance 1979). However, it should be noted that sponges are generally found on trees that occur in floodplain areas and are physiologically adapted to withstand the flooding period (Prance 1979). In this context, it is important to study the life cycle and phenology of ferns in seasonal climates to understand their responses to abiotic factors such as temperature and rainfall (Sharpe and Mehltreter 2010). Climatic seasonality can influence the phenological patterns of ferns, as well as their fertility and growth patterns (Mehltreter and Palacios-Rios 2003; Sharpe and Mehltreter 2010), while some species are more resilient to seasonality (Muller and Schmitt 2019). Future studies should address the morphophysiological adaptations of ferns like *A. pennula* to flooding, as well as the conditions that facilitate sponge colonization, to improve our understanding of the biology of these species.

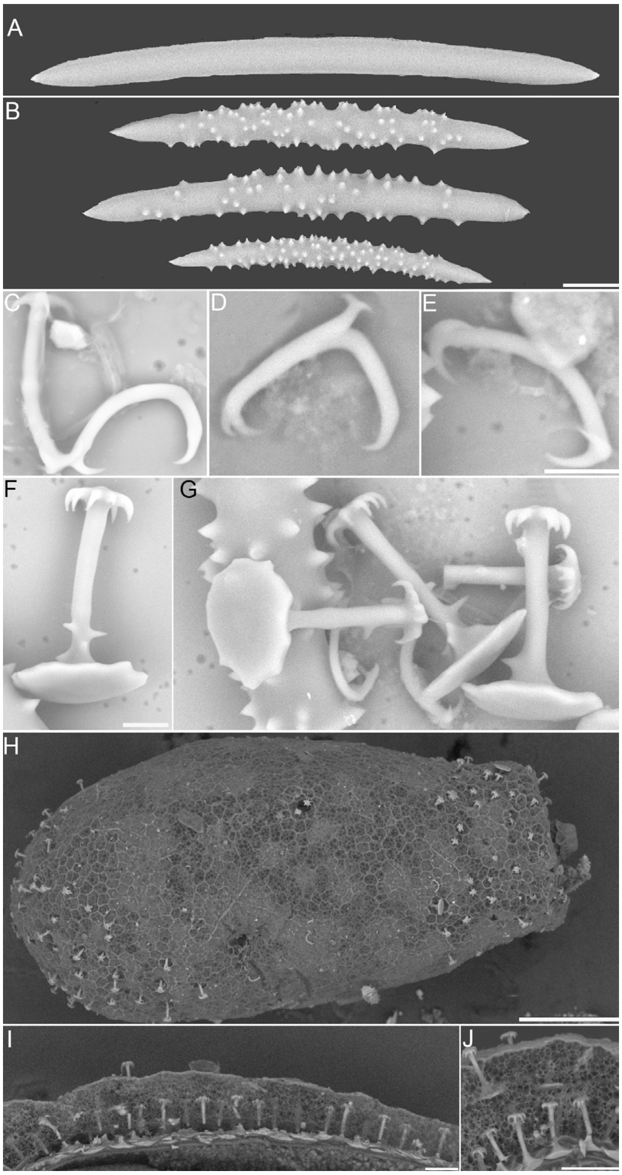

Figure 3. SEM images of the spicules of *Metania kiliani* (UFPEPOR2999). **A** – Alpha-megasclere; **B** – Beta-megascleres; **C**-**E** – Anisochelaes gemoscleres; **F**-**G** – Boletiform gemmocleres; **H**-**J** – Gemmule. Scale bar = 10 µm (A-B); 5 µm (C-G); 100 µm (H); 10 µm (I); 20 µm (J).

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REFERENCES

Adeney, J.M.; Christensen, N.L.; Vicentini, A.; Cohn-Haft, M. 2016. White-sand ecosystems in Amazonia. *Biotropica* 48: 7–23.

Almeida, T.E. 2018. Ant-fern association in *Microgramma megalophylla*. *American Fern Journal* 108: 62–64.

Alvares, C.A.; Stape, J.L.; Sentelhas, P.C.; De Moraes Gonçalves, J.L.; Sparovek, G. 2013. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift* 22: 711–728.

Buck, W.R.; Pursell, R.A. 1980. *Fissidens brachypus*: A moss restricted to a freshwater Amazonian sponge. *Amazoniana* 7: 81–85.

Calheira, L.; Lanna, E.; Pinheiro, U. 2019. Tropical freshwater sponges develop from gemmules farst than their temperate-region counterparts. *Zoomorphology* 138: 425–436.

Corvez, A.; Barriel, V.; Dubuisson, J.-Y. 2012. Diversity and evolution of the megaphyll in Euphyllophytes: Phylogenetic hypotheses and the problem of foliar organ definition. *Comptes Rendus Palevol* 11: 403–418.

de Voogd, N.J.; Alvarez, B.; Boury-Esnault, N.; Carballo, J.L.; Cárdenas, P.; Díaz, M.-C.; *et al.* 2023. World Porifera Database. (https://www.marinespecies.org/porifera). Accessed on 04 Apr 2023.

Gómez, LD. 1974. Biology of the potato-fern *Solanopteris brunei*. *Brenesia* 4: 37–61.

Hajdu, E; Peixinho, S.; Fernandez, J.C.C. 2011. *Esponjas Marinhas da Bahia: Guia de Campo e Laboratório*. Série Livros 45. Museu Nacional, Rio de Janeiro, 276p.

IBGE. 2005. Estado de Roraima: Geologia. Instituto Brasileiro de Geografia e Estatística. (https://www.ibge.gov.br/geociencias/informacoes-ambientais/geologia/15822-geologia-1-250-000.html?=&t=acesso-ao-produto). Acessed on 24 Feb 2023.

IBGE. 2006. Mapa de solos do Brasil. Instituto Brasileiro de Geografia e Estatística. (https://www.ibge.gov.br/geociencias/informacoes-ambientais/pedologia/15829-solos.html?=&t=downloads). Accessed on 24 Feb 2023.

Keel, S.H.K.; Prance, G.T. 1979. Studies of the vegetation of a white-sand black-water igapó (Rio Negro, Brazil). *Acta Amazonica* 9: 645–655.

Kessler, M.; Smith, A.R. 2017. Prodromus of a fern flora for Bolivia. XIV. Schizaeaceae. *Phytotaxa* 329: 090–092.

Manconi, R.; Pronzato, R. 2002. Suborder Spongillina subord. nov.: Freshwater sponges. In: Hooper, J.N.A.; Soest, R.W.M.; Willenz, P. (Ed.). *Systema Porifera: A Guide to the Classification of Sponges*. Springer, New York, p.921–1019.

Manconi, R.; Pronzato, R. 2016. How to survive and persist in temporary freshwater? Adaptive traits of sponges (Porifera: Spongillida): A review. *Hydrobiologia* 782: 11–22.

Mehltreter, K.; Palacios-Rios, M. 2003. Phenological studies of *Acrostichum danaeifolium* (Pteridaceae, Pteridophyta) at a mangrove site on the Gulf of Mexico. *Journal of Tropical Ecology* 7: 155–162.

Mehltreter, K.; Walker, L.R.; Shaper, J.M. 2010. *Fern Ecology*. 1st ed. Cambridge University Press, New York. 429p.

Moran, R.C.; Klimas, S.; Carlsen, M. 2003. Low trunk epiphytic ferns on tree ferns versus angiosperms in Costa Rica. *Biotropica* 8: 48–56.

Morrow, C.; Cárdenas, P. 2015. Proposal for a revised classification of the Demospongiae (Porifera). *Frontiers in Zoology* 12: 7. doi.org/10.1186/s12983-015-0099-8.

Muller, A.; Schmitt, J.L. 2019. Fenologia de samambaias e licófitas no Brasil: uma abordagem metodológica e ecológica. *Revista Brasileira de Geografia Física* 14: 1197–1211.

Nogueira, C.L.B. 2014. *Ecologia funcional de campinaranas*. Master's dissertation, Universidade Federal de Viçosa, Brazil, 31p. (http://www.locus.ufv.br/handle/123456789/6578).

Page, C.N. 2002. Ecological strategies in fern evolution: a neopteridological overview. *Review of Palaeobotany and Palynology* 119: 1–33.

Pinheiro, U.S.; Calheira, L. 2020. Phylum Porifera. In: Rogers, D.C.; Damborenea, C. (Ed.). *Thorp and Covich's Freshwater Invertebrates, v.5: Keys to Neotropical and Antarctic Fauna*, 4th ed. Elsevier, San Diego. p.1–672.

Pinheiro, U.S.; Sandes, J.; Annunziata, B.B.; Lopes, M.V.; Muricy, G. 2025. Spongillida in Catálogo Taxonômico daFauna do Brasil. (http://fauna.jbrj.gov.br/fauna/faunadobrasil/372). Accessed on: 17 Abr 2025.

Prance, G.T. 1979. Notes on the vegetation of Amazonia III. The terminology of Amazonian forest types subject to inundation. *Brittonia* 31: 26–38.

Pronzato, R.; Manconi, R. 1994. Adaptive strategies of sponges in inland waters. *Bollettino di Zoologia* 61: 395–401.

Pryer, K.M.; Schneider, H.; Smith, A.R.; Cranfill, R.; Wolf, P.G.; Hunt, J.S.; et al. 2001. Horsetails and ferns are a monophyletic group and the closest living relatives to seed plants. *Nature* 409: 618–622.

Salino, A.; Almeida, T.E.; Dittrich, V.A.O.; Góes-Neto, L.A.A.; Gasper, A.L. 2023. Sinopse das famílias e gêneros de samambaias e licófitas do Brasil. In: Guerra, M.S.; Santiago, A.C.P.; Sylvestre, L.S (Eds.). *Samambaias e Licófitas do Brasil: Biologia e Taxonomia*. EdUERJ, Rio de Janeiro, p.242–465.

Santiago, A.C.P.; Almeida, T.E. Schizaeaceae in *Flora e Funga do Brasil*. Jardim Botânico do Rio de Janeiro. (http://floradobrasil.jbrj.gov.br/reflora/floradobrasil/FB92038). Accessed on 24 Feb 2023.

Sharpe, J.M.; Mehltreter, K. 2010. Ecological insights from fern population dynamics. In: Mehltreter, K.; Walker, L.R.; Sharpe, J.M. (Eds.). *Fern Ecology*. Cambridge University Press, Cambridge, p.61–110.

Takeuchi, M. 1960. O gênero *Schizaea* na Amazônia. *Boletim do Museu Paraense Emílio Goeldi* 5: 1–31.

Volkmer-Ribeiro, C.; Costa, P.R.C. 1992. On *Metania spinata* (Carter, 1881) and *Metania kiliani* sp.n.: Porifera, Metaniidae Volkmer-Ribeiro. *Amazoniana* 12: 7–16.

Volkmer-Ribeiro, C.; Parolin, M. 2010. As esponjas. In: Parolin, M.; Volkmer-Ribeiro, C.; Leandrini, J.A. (Eds). *Abordagem Ambiental Interdisciplinar em Bacias Hidrográficas no Estado do Paraná*. Editora da Fecilcam, Campo Mourão, p.105–130.

Walker, L.R.; Sharpe, J.M. 2010. Ferns, disturbance and succession. In: Mehltreter, K.; Walker, L.R.; Sharpe, J.M. (Eds.). *Fern Ecology*. Cambridge University Press, Cambridge, p.177–219.

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