Phyllomedusa 22(2):185–194, 2023

ISSN 1519-1397 (print) / ISSN 2316-9079 (online)
doi: http://dx.doi.org/10.11606/issn.2316-9079.v22i2p185-194

Short Communication

New records of phoresy of *Elpidium* (Ostracoda: Limnocytheridae) by anurans in the Brazilian Atlantic Forest

Maria Eduarda B. Cunha,[1,2] Ubiratã Ferreira Souza,[3,4] Lucas R. Mendonça,[5] Thiago Silva-Soares,[6] Leo R. Malagoli,[7] Deivid Pereira,[2] Marcelo D. Freire,[1] and Patrick Colombo[1,2,8]

[1] Universidade Federal do Rio Grande do Sul, Programa de Pós-graduação em Biologia Animal. 90650-001, Porto Alegre, RS, Brazil. E-mail: eduardabercunha@gmail.com.

[2] Museu de Ciências Naturais da Secretaria do Meio Ambiente e Infraestrutura do Rio Grande do Sul. 90690-000, Porto Alegre, RS, Brazil.

[3] Universidade Estadual de Campinas, Instituto de Biologia, Departamento de Biologia Animal, Laboratório de História Natural de Anfíbios Brasileiros (LaHNAB). 13083-862, Campinas, SP, Brazil.

[4] Universidade Estadual de Campinas, Programa de Pós-graduação em Ecologia. 13083-862, Campinas, SP, Brazil

[5] Universidade Federal do Amazonas, Departamento de Biologia, Programa de Pós-graduação em Zoologia. 69067-005, Manaus, AM, Brazil.

[6] Universidade Federal do Espírito Santo, Departamento de Biologia, Laboratório de Genética e Evolução Molecular. 29075-010, Vitória, ES, Brazil.

[7] Polo Socioambiental SESC Pantanal. 78175-000, Poconé, MT, Brazil.

[8] Secretaria do Meio Ambiente e Infraestrutura do Rio Grande do Sul e Universidade Estadual do Rio Grande do Sul, Programa de Pós-graduação em Sistemática e Conservação da Diversidade Biológica, RS, Brazil.

Keywords: Bromeliads, Bromelicolous, Bromeligenous, Dispersal hosts, Dispersion, Phoronts.

Palavras-chave: Bromeliáceas, Bromelícolas, Bromelígenas, Dispersão, Forontes, Hospedeiro forético.

One of the most common types of commensalism is phoresy (Houck and O'Connor 1991). Phoresy occurs when one organism, the phoront, attaches itself to another organism, the host, to be dispersed to a new habitat (Houck and O'Connor 1991, Bartlow and Agosta 2021). This strategy is commonly used by species with reduced size and restricted dispersal abilities that inhabit ephemeral and isolated habitats (Binns 1982, Bartlow and Agosta 2021) such as those formed in bromeliads.

Bromeliads (Bromeliaceae) are nearly endemic to the Neotropical region (Benzing 1990, Ulloa Ulloa *et al.* 2017) and possess complex foliar structures with overlapping leaves that collect rainwater and form phytotelmata (Zotz and Thomas 1999). Phytotelmata are aquatic micro-ecosystems formed in plant structures, sustaining microenvironments suitable

Received 07 July 2023
Accepted 23 October 2023
Distributed December 2023

for the occurrence of specialized aquatic communities (Kaehler *et al.* 2005). Among bromeliad inhabitants, ostracods of the genus *Elpidium* Müller, 1880 are aquatic microcrustaceans that live almost exclusively in this environment (Müller 1880, Pereira *et al.* 2023). Because they do not have structures for terrestrial locomotion, they are not capable of colonizing new bromeliads by themselves (Müller 1880). Instead, they rely on a passive dispersal mode (Kneitel 2018), attaching themselves to larger animals that use bromeliads. Confirmed records as host organisms exist only for amphibians and reptiles (Müller 1880, Binns 1982, Seidel 1989, Lopez *et al.* 1999).

The occurrence of *Elpidium* ostracods in Brazil has been confirmed for several localities in the south, southeast, and northeast regions, all within the Atlantic Forest (Pinto and Purper 1970, Lantyer-Silva *et al.* 2016, Malfatti *et al.* 2022, Pereira *et al.* 2022, 2023). In other localities, ostracods identified only to class have been reported from bromeliads (Mestre *et al.* 2001). Even though these specimens were not identified to genus, they likely correspond to *Elpidium,* because no records of other ostracods in the phytotelms of bromeliads have been reported (Lopez *et al.* 2009). Although the distribution of *Elpidium* in Brazil has been confirmed only in the Atlantic Forest, the genus could potentially occur in bromeliads and other phytotelms in other biomes (Müller 1880, Pinto and Jocqué 2013).

The many anurans that inhabit bromeliads in the Atlantic Forest can be divided into two categories: bromelicolous and bromeligenous (Peixoto 1995). Bromelicolous species do not reproduce in bromeliads, whereas bromeligenous species utilize bromeliads for reproduction (Peixoto 1995). Many species of anurans are known to transport *Elpidium* (Lopez *et al.* 2005, Colombo *et al.* 2008, Sabagh *et al.* 2011, 2014, Lantyer-Silva *et al.* 2016, Araújo *et al.* 2019, 2020, Moroti *et al.* 2019, Guarabyra *et al.* 2021).

This type of phoresy has been recorded in the south (Colombo *et al.* 2008), southeast (Lopez *et al.* 1999), and northeast (Lantyer-Silva *et al.* 2016) regions of Brazil. Despite this broad geographic area, the records are from few localities with large gaps in-between. It is likely that the interaction also occurs within these gaps and remains unnoticed because of the small size of *Elpidium* and the lack of research on these ostracods, even though the phoresy can be easily visualized in the field. So far, 21 species of anurans have been listed as dispersal hosts in the review of Moroti *et al.* (2019); one additional species was added to the list by Araújo *et al.* (2020).

Herein we report new records of the phoresy of *Elpidium* by anurans, including new species as dispersal hosts and new localities of occurrence. We provide a review of the relationship and an updated version of the list compiled by Moroti *et al.* (2019). Additionally, we map the geographical distribution of this phoresy, and highlight areas that lack records of this relationship.

Our new records were found during careful inspections of bromeliads around anuran vocalization sites; further, we examined whether anurans in these areas had ostracods adhered to them. Most of our observations occurred in Reserva Biológica Estadual Mata Paludosa, municipality of Itati, state of Rio Grande do Sul, Brazil, a protected area at the southern limit of the Atlantic forest. We extensively sampled this reserve from 2015 to 2022 as part of an amphibian monitoring project. We also sampled bromeliads from 2005 to 2022 at other localities throughout the Atlantic forest. Nomenclature for amphibian species follows Frost (2023). Ostracods were identified only to the generic level because diversity of the genus is understudied; most likely several undescribed and endemic species occur throughout the study area (Pereira *et al.* 2023). Characteristics used to identify *Elpidium* included having a larger width than height and a flat ventral surface; in addition, this genus is the only one currently associated with bromeliads (Pereira *et al.* 2022). To create a distribution map, we combined our records with

those from the literature to visualize the spatial pattern of phoretic records in the Neotropical region.

We found 19 new anuran species as dispersal hosts of *Elpidium* sp., including the families Hylidae (15 spp.), Centrolenidae (2), and Bufonidae (2) (Figure 1; Table 1). The new records are from 10 Brazilian localities, seven in the south and three in the southeast regions (Figure 2; Table 1). Ten of the dispersal hosts were recorded in Reserva Biológica Estadual Mata Paludosa: *Boana bischoffi, B. guentheri, Dendropsophus microps, Itapotihyla langsdorffii, Ololygon catharinae, O. rizibilis, Phyllomedusa distincta, S. perereca, S. tymbamirim,* and *Trachycephalus mesophaeus*. With the exception of *S. perereca* and *S. tymbamirim,* which were found in other localities, these interactions were found exclusively at this locality.

Four other anuran species carrying *Elpidium* were recorded at Parque Estadual da Serra do Mar, state of São Paulo, Brazil: *Bokermannohyla astartea, B. circumdata, Scinax hayii,* and *Dendrophryniscus imitator*. In all other localities only one species was found as a dispersal host (Table 1). In Reserva Biológica Estadual Mata Paludosa we also found *Fritziana mitus* carrying ostracods, a species first reported as a dispersal host in the state of São Paulo (Moroti *et al.* 2019). In Reserva Particular do Patrimônio Natural Caruara, state of Rio de Janeiro, Brazil, we found *Nyctimantis brunoi* carrying ostracods, a new locality north of its previous records (Lopez *et al.* 1999, 2005). Most of the records are from adult anurans, although some juveniles of *Dendropsophus microps* were recorded as dispersal hosts.

We report the first record for the family Centrolenidae and for the genera *Bokermannohyla, Itapotihyla,* and *Trachycephalus.* In addition, we report the first records for the states of Santa Catarina, the farthest inland at approximately 180 km from the coast, and Espírito Santo, the locality with the highest altitude (1600 m a.s.l.). We also report the first non-adult amphibian as a dispersal host.

With the addition of our records, Brazil has 40 anuran species known as phoretic hosts, 10 of which are bromeligenous, and 30 bromelicolous. They are from 23 localities, with the majority of records close to coastal regions of the Atlantic Forest (Figure 2). Even with the addition of our records, the distribution map of this phoresy shows large geographical gaps (Figure 2). These gaps likely represent a lack of sampling rather than a non-occurrence of the relationship. In the southeast, several gaps are within "restinga," an ecoregion with abundant bromeliads where several amphibian communities have been studied (Schineider and Teixeira 2001, Oliveira and Rocha 2015, Martins *et al.* 2019). The coast of the Santa Catarina State, likewise, still lacks phoretic records, even though several individuals of *Elpidium* were sampled and described for the region (Pinto and Purper 1970). The largest sampling gap is in northeastern Brazil, with phoretic records in only two localities, despite several anurans sampled from bromeliads throughout the region (Gondim-Silva *et al.* 2016, Dubeux *et al.* 2020).

The greatest diversity of anurans as dispersal hosts in the Atlantic Forest was found in Reserva Biológica Estadual Mata Paludosa, where 11 anuran species carry *Elpidium*. Bromeliads are abundant at this locality, and 14 of 18 treefrog species in this area use these plants. A few other localities have been searched for phoretic Elpidium, resulting in finding between five and 10 species of anurans as hosts (Lopez *et al.* 2005, Sabagh and Rocha 2014, Araújo *et al.* 2020). The large number of records from this locality may be related to our intense sampling efforts and to a larger number of anurans that use bromeliads in this particular area. In any case, a detailed comparative study would be necessary to draw further conclusions. The other new localities presented here, despite having fewer current records, are likely to have other dispersal hosts if sampling efforts are increased.

Bromelicolous anurans, despite having a facultative association with bromeliads, form the majority of hosts for *Elpidium* dispersion.

Figure 1. New records of anurans as dispersal hosts of *Elpidium*. (**A**) *Boana bischoffi*, (**B**) *Boana guentheri*, (**C**) *Bokermannohyla astartea*, (**D**) *Bokermannohyla circumdata*, (**E**) *Dendrophryniscus imitator*, (**F**) *Dendrophryniscus krausae*, (**G**) *Dendropsophus sanborni*, (**H**) *Fritziana mitus*, (**I**) *Vitreorana uranoscopa*, (**J**) *Vitreorana eurygnatha*, (**K**) *Itapotihyla langsdorffii*, (**L**) *Phyllomedusa distincta*, (**M**) *Trachycephalus mesophaeus*, (**N**) *Ololygon catharinae*, (**O**) *Scinax hayii*, (**P**) *Scinax perereca*, (**Q**) *Ololygon rizibilis*, (**R**) *Scinax tymbamirim*.

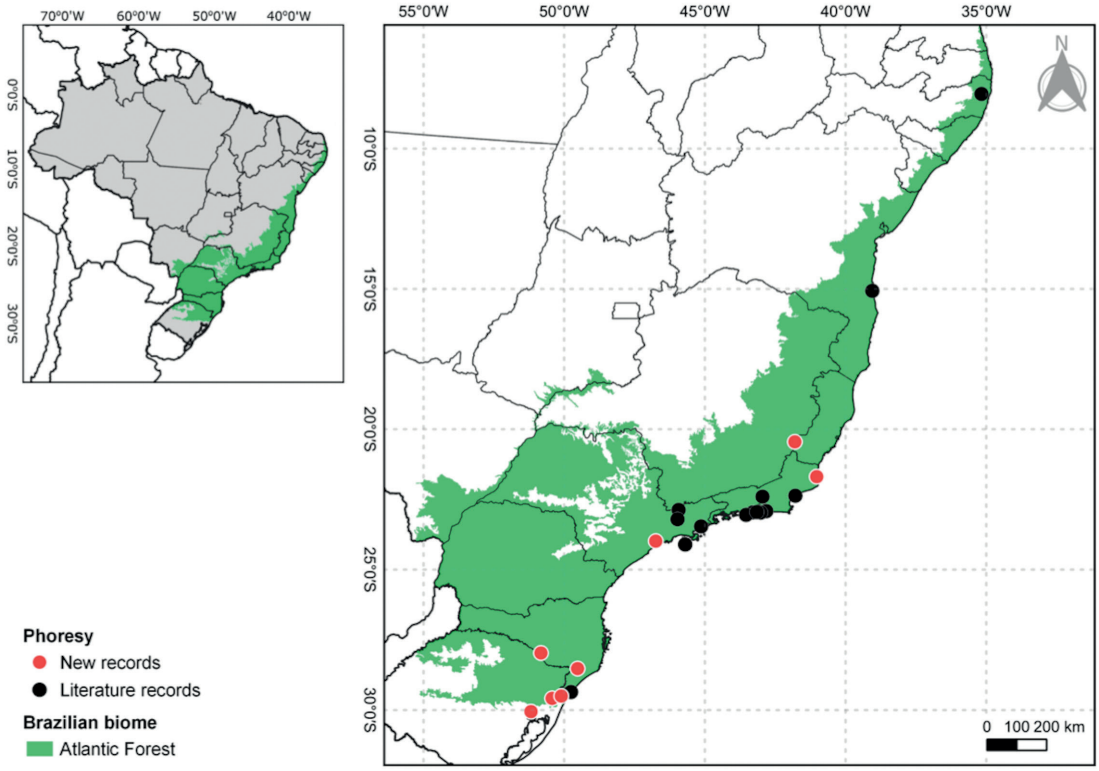

Figure 2. Distribution map of the phoresy between anurans and *Elpidium*. In black, records obtained from the literature, and in red, localities of records added by this work. The area of the Brazilian Atlantic Forest is shown in green. Even though the southernmost record appears not to be within the limits of the Atlantic Forest, the locality contains vegetation remnants related to the Atlantic Forest.

Bromelicolous frogs may move around more than bromeligenous species and provide more opportunities for dispersion of *Elpidium*. Differences in dispersal potential for *Elpidium* also exist among sexes within species, such as in *B. astartea,* in which males remain at particular bromeliads but females move among bromeliads (Malagoli *et al.* 2021). Our observations revealed that resident males had fewer attached ostracods than females. The diversity of bromelicolous species recorded as phoretic hosts may occur because they are relatively more abundant, widespread, and better studied.

The skin of many amphibians has glands that produce efficient chemical defenses (Daly *et al.* 2005, Jeckel *et al.* 2015). The proximity of *Elpidium* with some of these anurans suggests that these microcrustaceans might, on some level, avoid or be resistant to the wide diversity of chemicals secreted by anurans. We highlight *Elpidium* adhesion to *T. mesophaeus* and *P. distincta,* species well-known for their skin toxicity. The genus *Phyllomedusa* has skin components that, in mammals, can induce physiopathological alterations (Conceição *et al.* 2007) and lead to sedation and catalepsy (Toledo and Jared 1995).

The phoresy between anurans and *Elpidium* is, for now, restricted to the Atlantic Forest at several Brazilian localities, frequently those with

Table 1. Compilation of all the phoretic records between anurans and *Elpidium*, including the new records added by this work. Legend to Brazilian states: BA = Bahia, ES = Espírito Santo, PE = Pernambuco, SP = São Paulo, RJ = Rio de Janeiro, RS = Rio Grande do Sul, SC = Santa Catarina.

Taxa	Relation with bromeliads	Locality	State	Coordinates	Elevation (m a.s.l.)	References
Bufonidae						
Dendrophryniscus brevipollicatus Jiménez de la Espada, 1870	Bromeligenous	Projeto Dacnis, Ubatuba	SP	23°27'45" S, 45°07'58" W	37	Moroti *et al.* 2019
Dendrophryniscus imitator (Miranda-Ribeiro, 1920)	Bromeligenous	Núcleo Curucutu, Parque Estadual da Serra do Mar	SP	23°59'1.88" S, 46°44'8.40" W	795	This work
Dendrophryniscus krausae Cruz and Fusinatto, 2008	Bromeligenous	Reserva Biológica da Serra Geral	RS	29°35' S, 50°10' W	600	This work
Centrolenidae						
Vitreorana eurygnatha (Lutz, 1925)	Bromelicolous	Parque Nacional do Caparaó	ES	20°26'53" S, 41°48'02" W	1900	This work
Vitreorana uranoscopa (Müller, 1924)	Bromelicolous	Cascata do Chuvisqueiro, Riozinho	RS	29°34'54.90" S, 50°25'34.20" W	130	This work
Cycloramphidae						
Thoropa miliaris (Spix, 1824)	Bromelicolous	Costão de Itacoatiara, Parque Estadual Serra da Tiririca	RJ	22°58' S, 43°01' W	145	Sabagh and Rocha 2014
		MoNa Morro da Urca e Pão de Açúcar, Rio de Janeiro	RJ	22°57' S, 43°09' W	-	Sabagh and Rocha 2014
Hemiphractidae						
Fritziana goeldii (Boulenger, 1895)	Bromeligenous	Parque Nacional da Serra dos Órgãos	RJ	22°24' S, 42°57' W	963	Lopez *et al.* 2005
		Floresta da Tijuca, Parque Nacional da Tijuca	RJ	23º35'15.89" S, 43º28'58.59" W	-	Guarabyra *et al.* 2021
Fritziana mitus Walker, Wachlevski, Nogueira da Costa, Nogueira-Costa, Garcia, and Haddad, 2018	Bromeligenous	Projeto Dacnis, Ubatuba	SP	23°27'45" S, 45°07'58" W	37	Moroti *et al.* 2019
		Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work
Hylidae						
Aplastodiscus arildae (Cruz and Peixoto, 1987)	Bromelicolous	Parque Nacional da Serra dos Órgãos	RJ	22°24' S, 42°57' W	963	Lopez *et al.* 2005
Boana albomarginata (Spix, 1824)	Bromelicolous	Grumari, Rio de Janeiro	RJ	23°03' S, 43°32' W	10	Sabagh *et al.* 2011
Boana bischoffi (Boulenger, 1887)	Bromelicolous	Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work

Table 1. *Continued.*

Taxa	Relation with bromeliads	Locality	State	Coordinates	Elevation (m a.s.l.)	References
Boana guentheri (Boulenger, 1886)	Bromelicolous	Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work
Boana semilineata (Spix, 1824)	Bromelicolous	Parque Nacional de Jurubatiba, Macaé	RJ	22°22' S, 41°47' W	9	Lopez *et al.* 2005
Bokermannohyla astartea (Bokermann, 1967)	Bromeligenous	Núcleo Curucutu, Parque Estadual da Serra do Mar	SP	23°59'8.29" S, 46°44'37.11" W	800	This work
Bokermannohyla circumdata (Cope, 1871)	Bromelicolous	Núcleo Curucutu, Parque Estadual da Serra do Mar	SP	23°59'53.60" S, 46°44'47.09" W	830	This work
Dendropsophus decipiens (Lutz, 1925)	Bromelicolous	Alto da Buchada, São Lourenço da Mata	PE	08°03' S, 35°10' W	200	Araújo *et al.* 2019
Dendropsophus microps (Peters, 1872)	Bromelicolous	Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work
Dendropsophus minutus (Peters, 1872)	Bromelicolous	Parque Estadual de Itapeva, Torres	RS	29°21'20" S, 49°45'19" W	7	This work
Dendropsophus sanborni (Schmidt, 1944)	Bromelicolous	Florestal Gateados, Campo Belo do Sul	SC	27°58'2.19" S, 50°49'22.66" W	960	This work
Itapotihyla langsdorffii (Duméril and Bibron, 1841)	Bromelicolous	Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work
Nyctimantis arapapa (Pimenta, Napoli, and Haddad, 2009)	Bromeligenous	Reserva Natural Boa União, Ilhéus	BA	15°03'59" S, 39°03'00" W	95	Lantyer-Silva *et al.* 2016
Nyctimantis brunoi (Miranda-Ribeiro, 1920)	Bromelicolous	Barra de Maricá, Rio de Janeiro	RJ	22°55' S, 42°49' W	6	Lopez *et al.* 1999, 2005
		Parque Nacional de Jurubatiba, Macaé	RJ	22°22' S, 41°47' W	9	Lopez *et al.* 2005
		Reserva Particular do Patrimônio Natural Caruara, São João da Barra	RJ	21°41'13.60" S, 41°1'28.29" W	0	This work
Ololygon catharinae (Boulenger. 1888)	Bromelicolous	Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work
Ololygon rizibilis (Bokermann, 1964)	Bromelicolous	Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work
Phyllomedusa distincta Lutz, 1950	Bromelicolous	Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work
Scinax alcatraz (Lutz, 1973)	Bromeligenous	Ilha dos Alcatrazes, São Sebastião	SP	24°06'18" S, 45°41'50" W	134	Moroti *et al.* 2019
Scinax auratus (Wied-Neuwied, 1821)	Bromelicolous	Alto da Buchada, São Lourenço da Mata	PE	08°03' S, 35°10' W	200	Araújo *et al.* 2019, 2020

Table 1. *Continued.*

Taxa	Relation with bromeliads	Locality	State	Coordinates	Elevation (m a.s.l.)	References
Scinax crospedospilus (Lutz, 1925)	Bromelicolous	Projeto Dacnis, São Francisco Xavier	SP	22°52'27" S, 45°55'50" W	884	Moroti *et al.* 2019
		Universidade do Vale do Paraíba, São José dos Campos	SP	23°12'30" S, 45°58'12" W	591	Moroti *et al.* 2019
Scinax cuspidatus (Lutz, 1925)	Bromelicolous	Costão de Itacoatiara, Parque Estadual Serra da Tiririca	RJ	22°58' S, 43°01' W	145	Sabagh and Rocha 2014
Scinax hayii (Barbour, 1909)	Bromelicolous	Núcleo Curucutu, Parque Estadual da Serra do Mar	SP	23°59'57.48" S, 46°44'14.90" W	750	This work
Scinax littoreus (Peixoto, 1988)	Bromeligenous	Costão de Itacoatiara, Parque Estadual Serra da Tiririca	RJ	22°58' S, 43°01' W	145	Sabagh *et al.* 2011, Sabagh and Rocha 2014
Scinax pachycrus (Miranda-Ribeiro, 1937)	Bromelicolous	Alto da Buchada, São Lourenço da Mata	PE	08°03' S, 35°10' W	200	Araújo *et al.* 2019, 2020
Scinax perereca Pombal, Haddad, and Kasahara, 1995	Bromelicolous	Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work
		Treviso	SC	28°31'20" S, 49°31'16" W	276	This work
Scinax perpusillus (Lutz and Lutz, 1939)	Bromeligenous	MoNa Morro da Urca e Pão de Açúcar, Rio de Janeiro	RJ	22°57' S, 43°09' W	-	Sabagh *et al.* 2011, Sabagh and Rocha 2014
Scinax tymbamirim Nunes, Kwet, and Pombal, 2012	Bromelicolous	Jardim Botânico de Porto Alegre	RS	30°03'7.05" S, 51°10'36.29" W	48	This work
		Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work
		Treviso	SC	28°31'20" S, 49°31'16" W	276	This work
Scinax x-signatus (Spix, 1824)	Bromelicolous	Alto da Buchada, São Lourenço da Mata	PE	08°03' S, 35°10' W	200	Araújo *et al.* 2019, 2020
Sphaenorhynchus caramaschii Toledo, Garcia, Lingnau, and Haddad, 2007	Bromelicolous	Parque Estadual de Itapeva, Torres	RS	29°21'20" S, 49°45'19" W	33	Colombo *et al.* 2008
Trachycephalus mesophaeus (Hensel, 1867)	Bromelicolous	Reserva Biológica Estadual Mata Paludosa, Itati	RS	29°30' S, 50°06' W	250	This work
Xenohyla truncata (Izecksohn, 1959)	Bromelicolous	Barra de Maricá, Rio de Janeiro	RJ	22°55' S, 42°49' W	6	Lopez *et al.* 1999, 2005
Strabomantidae						
Pristimantis ramagii (Boulenger, 1888)	Bromelicolous	Alto da Buchada, São Lourenço da Mata	PE	08°03' S, 35°10' W	200	Araújo *et al.* 2020

abundant bromeliads. Other phytotelmata, such as in the family Eriocaulaceae, also have records of *Elpidium* occurring in them (Pereira *et al.* 2023). We suggest that expanding the study of geographical regions and dispersal hosts can provide additional information about this complex relationship.

Acknowledgments.—MEB Cunha thanks Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) (grant 8887.500282/2020-00) and BR Campanher, D Heiermann, and C Zank for field support. TS Soares thanks Fundação de Amparo à Pesquisa e Inovação do Espírito Santo (grant #437/2021). LR Malagoli thanks Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) (grant #141259/2014-0). For financial support, we thank São Paulo Research Foundation (FAPESP) (grants #2008/54472-2, #2008/50928-1, #2013/50741-7, #2014/50342-8, #2014/23677-9, #2022/10081-7, #2022/11096-8). LR Malagoli also thanks Fundação para a Conservação e a produção Florestal do Estado de São Paulo, VS Nascimento, M Alonso, T Schmidt, and MJ Gonçalves for logistical support at the Núcleo Curucutu from Parque Estadual da Serra do Mar. We thank CH Nogueira for his contributions and RPPN Caruara for permission to enter and sample. Thanks to "Herpeto Capixaba" project for logistical and financial support.

References

Araújo, A. P., C. M. Bastos, R. V. I. Santos, G. J. B. Moura, M. Melo-Júnior, and M. S. Tinoco. 2019. Novel records of phoresy among microcrustaceans and bromeliad treefrogs in the Atlantic Rainforest of Northeast Brazil. *Herpetology Notes 12:* 531–535.

Araújo, A.P., A. H. C. Marques, A. P. Dantas, M. Melo-Junior, G. J. B. Moura, and M. S. Tinoco. 2020. Assisted phoresy of invertebrates by anurans in tank bromeliads. *Aquatic Sciences 82:* 64.

Bartlow, A. W. and S. J. Agosta. 2021. Phoresy in animals: review and synthesis of a common but understudied mode of dispersal. *Biological Reviews 96:* 223–246.

Benzing, D. H. 1990. *Vascular Epiphytes. General Biology and Related Biota.* Cambridge. Cambridge University Press. 376 pp.

Binns, E. S. 1982. Phoresy as migration - some functional aspects of phoresy in mites. *Biological Reviews 57:* 571–620.

Colombo, P., A. Kindel, G. Vinciprova, and L. Krause. 2008. Composição e ameaças à conservação dos anfíbios anuros do Parque Estadual de Itapeva, município de Torres, Rio Grande do Sul, Brasil. *Biota Neotropica 8:* 229–240.

Conceição, K., F. M. Bruni, M. M. Antoniazzi, C. Jared, A. C. M. Camargo, M. Lopes-Ferreira, and D. C. Pimenta. 2007. Major biological effects induced by the skin secretion of the tree frog *Phyllomedusa hypochondrialis*. *Toxicon 49:* 1054–1062.

Daly, J. W., T. F. Spande, and H. M. Garraffo. 2005. Alkaloids from amphibian skin: A tabulation of over eight hundred compounds. *Journal of Natural Products 68:* 1556–1575.

Dubeux, M. J. M., U. Gonçalves, F. A. C. Nascimento, and T. Mott. 2020. Anuran amphibians of a protected area in the northern Atlantic Forest with comments on topotypic and endangered populations. *Herpetology Notes 13:* 61–74.

Frost, D. R. 2023. Amphibian Species of the World: An Online Reference. Version 6.1. Electronic Database accessible at https://amphibiansoftheworld.amnh.org/index.php. American Museum of Natural History, New York, USA.

Gondim-Silva, F. A. T., A. R. S. Andrade, R. O. Abreu, J. S. Nascimento, G. P. Corrêa, L. Menezes, C. C. Trevisan, S. S. Camargo, and M. F. Napoli. 2016. Composition and diversity of anurans in the restinga of the Conde municipality, northern coast of the state of Bahia, northeastern Brazil. *Biota Neotropica 16:* e20160157.

Guarabyra, B., A. M. Bezerra, A. F. Antunes, and S. P. Carvalho-e-Silva. 2021. Diet, reproductive biology, and ecological interactions of *Fritziana goeldii* (Anura: Hemiphractidae). *Phyllomedusa 20:* 37–52.

Houck, M. A. and B. M. O'Connor. 1991. Ecological and evolutionary significance of phoresy in the Astigmata. *Annual Review of Entomology 36:* 611–636.

Kaehler, M., I. G. Varassin, and R. Goldenberg. 2005. Pollination of a bromeliad community in the high montane Atlantic rain forest in Paraná state, Brazil. *Brazilian Journal of Botany 28:* 219–228.

Kneitel, J. M. 2018. Occupancy and environmental responses of habitat specialists and generalists depend on dispersal traits. *Ecosphere 9:* e02143.

Jeckel, A. M., R. A. Saporito, and T. Grant. 2015. The relationship between poison frog chemical defenses and age, body size, and sex. *Frontiers in Zoology 12:* 1–8.

Lantyer-Silva, A. S. F., C. C. Souza, I. M. J. Barreiro, and M. Solé. 2016. *Aparasphenodon arapapa* (Bahia's Broad-snout Casqueheaded Treefrog). Phoretic ostracods. *Herpetological Review 47:* 106.

Lopez, L. C. S., R. R. D. N. Alves, and R. I. Rios. 2009. Micro-environmental factors and the endemism of bromeliad aquatic fauna. *Hydrobiologia 625:* 151–156.

Lopez, L. C. S., P. J. F. P. Rodrigues, and R. I. Rios. 1999. Frogs and snakes as phoretic dispersal agents of bromeliad ostracods (Limnocytheridae: *Elpidium*) and annelids (Naididae: *Dero*). *Biotropica 31:* 705–708.

Lopez, L. C. S., B. Filizola, I. Deiss, and R. I. Rios. 2005. Phoretic behaviour of bromeliad annelids (*Dero*) and ostracods (*Elpidium*) using frogs and lizards as dispersal vectors. *Hydrobiologia 594:* 15–22.

Malagoli, L. R., T. L. Pezzuti, D. L. Bang, J. Faivovich, M. L. Lyra, J. G. R. Giovanelli, P. C. A. Garcia, R. J. Sawaya, and C. F. B. Haddad. 2021. A new reproductive mode in anurans: Natural history of *Bokermannohyla astartea* (Anura: Hylidae), with the description of its tadpole and vocal repertoire. *PLoS ONE 16:* e0246401.

Malfatti, E., E. C. G. Couto, P. M. A. Ferreira, and L. R. P. Utz. 2022. "Hitchhicking with invertebrates": two reports of epibiosis by peritrich ciliates on ostracods and hydrachnid mites in tanks of epiphytic bromeliads from south Brazil. *Anais da Academia Brasileira de Ciências 94:* e20210894.

Martins, A., R. Pontes, C. Mattedi, R. A. Murta-Fonseca, J. Frarani, L. O. Ramos, A. L. R. Brandão, D. B. Maciel, and R. R. Pinto. 2019. Herpetofauna community from coastal restinga remnants in Northeast Rio de Janeiro state, Brazil. *Journal of Coastal Conservation 23:* 1019–1037.

Mestre, L. A. M., J. M. R. Aranha, and M. L. P. Esper. 2001. Macroinvertebrate fauna associated to the bromeliad *Vriesea inflata* of the Atlantic Forest (Paraná State, Southern Brazil). *Brazilian Archives of Biology and Technology 44:* 89–94.

Moroti, M. T., E. Muscat, M. Pedrozo, I. F. Machado, L. T. Sabagh, and D. J. Santana. 2019. Interaction between ostracods and anurans: A review and new records in Brazil. *Phyllomedusa 18:* 269–275.

Müller, F. 1880. Descrição do *Elpidium bromeliarum* crustáceo da família dos Cytherídeos. *Archivos do Museu Nacional, Rio de Janeiro 4:* 27–34.

Oliveira, J. C. F. and C. F. D. Rocha. 2015. Journal of coastal conservation: A review on the anuran fauna of Brazil's sandy coastal plains. How much do we know about it? *Journal of Coastal Conservation 19:* 35–49.

Peixoto, O. L. 1995. Associação de anuros a bromeliáceas na Mata Atlântica. *Revista de Ciências da Vida 17:* 75–83.

Pereira, J. S., C. E. F. Rocha, R. L. Pinto, and M. B. Silva. 2022. A new species of *Elpidium* (Crustacea: Ostracoda: Limnocytheridae) from Brazil and a morphological phylogenetic proposal for the genus. *Zoological Studies 61:* 27.

Pereira, J. S., C. E. F. Rocha, K. Martens, R. L. Pinto, and M. B. Silva. 2023. Six new species of *Elpidium* Müller, 1880 (Podocopida: Limnocytheridae) from Eastern Brazil. *Zootaxa 5258:* 1–38.

Pinto, R. L. and M. Jocqué. 2013. A new species of *Elpidium* (Crustacea, Ostracoda) from bromeliads in Cusuco National Park, Honduras. *ZooKeys 313:* 45–59.

Pinto, I. D. and I. Purper. 1970. A neotype for *Elpidium bromeliarum* Müller, 1879 (type species for the genus) and a revision of the genus *Elpidium* (Ostracoda). *Escola de Geologia, Universidade Federal do Rio Grande do Sul, Publicação Especial 19:* 1–23.

Sabagh, L. T. and C. F. D. Rocha. 2014. Bromeliad treefrogs as phoretic hosts of ostracods. *Naturwissenschaften 101:* 493–497.

Sabagh, L. T., R. J. P. Dias, C. W. C. Branco, and C. F. D. Rocha. 2011. News records of phoresy and hyperphoresy among treefrogs, ostracods, and ciliates in bromeliad of Atlantic forest. *Biodiversity and Conservation 20:* 1837–1841.

Schineider, J. A. P. and R. L. Teixeira. 2001. Relationship between anuran amphibians and bromeliads of the sandy coastal plain of Regência, Linhares, Espírito Santo, Brazil. *Iheringia, Série Zoologia 91:* 41–48.

Seidel, B. 1989. Phoresis of *Cyclocypris ovum* (Jurine) (Ostracoda, Podocopida, Cyprididae) on *Bombina variegata variegata* (L.) (Anura, Amphibia) and *Triturus vulgaris* (L.) (Urodela, Amphibia). *Crustaceana 57:* 171–176.

Toledo, R. C. and C. Jared. 1995. Cutaneous granular glands and amphibian venoms. *Comparative Biochemistry and Physiology 111A:* 1–29.

Ulloa Ulloa, C., P. Acevedo-Rodríguez, S. Beck, M. J. Belgrano, R. Bernal, P. E. Berry, L. Brako, M. Celis, G. Davidse, R. C. Forzza, S. R. Gradstein, O. Hokche, B. León, S. León-Yánez, R. E. Magill, D. A. Neill, M. Nee, P. H. Raven, H. Stimmel, M. T. Strong, J. L. Villaseñor, J. L. Zarucchi, F. O. Zuloaga, and P. M. Jorgensen. 2017. An integrated assessment of the vascular plant species of the Americas. *Science 358:* 1614–1617.

Zotz, G. and V. Thomas. 1999. How much water is in the tank? Model calculations for two epiphytic bromeliads. *Annals of Botany 83:* 183–192.

Editor: Antoine Fouquet