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ANURAN NATURAL HISTORY FROM SERRA DONA FRANCISCA, AN ATLANTIC FOREST REMNANT IN SOUTHERN BRAZIL

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ABSTRACT

The Serra Dona Francisca is in the subtropical region of the Atlantic Forest and part of its area is protected by a sustainable use conservation unit. In the present study, we performed an anuran inventory at different elevations, providing information on natural history of each species. Field work was carried out from October 2012 to January 2014. We sampled the anuran by visual and auditory surveys and used three 50-meter pitfall lines composed of four 60L buckets with drift-fences at each elevation area. We registered 63 species belonging to 13 families: Brachycephalidae (4), Bufonidae (4), Centrolenidae (1), Craugastoridae (1), Cycloramphidae (2), Hemiphractidae (2), Hylidae (30), Hylodidae (2), Leptodactylidae (10), Microhylidae (2), Odontophrynidae (3), Phyllomedusidae (1), and Ranidae (1). We observed four new records for the northeastern region of the state of Santa Catarina: *Bokermannohyla luctuosa*, *Scinax aromothyella*, *Odontophrynus americanus*, and *Leptodactylus plaumanni*. We registered a higher number of species during the hot and wet months, with subsequent drop during the cold months. We found an increase of species richness at higher elevations. Considering that our results represent 50% of anuran richness of the state of Santa Catarina, this is an important region for conservation of biodiversity of southern Atlantic Forest.

Keywords: Subtropical, anura, conservation, inventory

RESUMEN

La Serra Dona Francisca está ubicada en la región subtropical de la Mata Atlántica y parte de su área está protegida por una unidad de conservación de uso sostenible. En el presente estudio, realizamos un inventario de anuros a diferentes elevaciones, proporcionando información sobre la historia natural de cada especie. El trabajo de campo se llevó a cabo desde octubre de 2012 hasta enero de 2014. Tomamos muestras de los anuros mediante búsqueda activa y utilizamos tres líneas de trampa de caída de 50 metros compuestas por cuatro baldes de 60 litros con cercas de deriva en cada área de elevación. Registramos 63 especies pertenecientes a 13 familias: Brachycephalidae (4), Bufonidae (4), Centrolenidae (1), Craugastoridae (1), Cycloramphidae (2), Hemiphractidae (2), Hylidae (30), Hylodidae (2), Leptodactylidae (10), Microhylidae (2), Odontophrynidae (3), Phyllomedusidae (1) y Ranidae (1). Observamos cuatro nuevos registros para la región nororiental del estado de Santa Catarina: *Bokermannohyla luctuosa, Scinax aromothyella, Odontophrynus americanus* y *Leptodactylus plaumanni*. Registramos un mayor número de especies durante los meses cálidos y húmedos, con la consiguiente disminución durante los meses fríos. Encontramos un aumento de la riqueza de especies en elevaciones más altas. Teniendo en cuenta nuestros resultados que representan el 50% de la riqueza de anuros del estado de Santa Catarina, esta es una región importante para la conservación de la biodiversidad de la Mata Atlántica Sur.

Palabras clave: Subtropical, anura, conservación, inventario

INTRODUCTION

The Serra Dona Francisca is a historic and natural area that has been of great scientific value since the XIX century, when a land glebe from the Santa Catarina province was given as a dowry to the prince of Joinville, François d'Orléans, with Princess Francisca Carolina, the sister of emperor Dom Pedro II (Ficker, 1965). This region was colonized for logging and development of agricultural activities, which were subsistence ways for

Fig. 1. SC-301 highway lookout located just up of Serra Dona Francisca showing an example of the exuberant Atlantic Forest region (Sub-Montane Ombrophilous Dense Forest - Lat -26.193884º Lon -49.035562).

the newly arrived European immigrants, especially Germans and Austrians (Ficker, 1965; Rodowicz-Oswiecimsky, 1992). The new Dona Francisca colony also attracted many European naturalists to explore its rich nature, which resulted in the description of new animal species for the south of Brazil. Regarding amphibians, George Albert Boulenger, from the British Natural History Museum, received many specimens in the late XIX century collected by Hr. Michäelis (Boulenger, 1888a). Boulenger listed 21 species for the Santa Catarina province and described four of them: *Scinax catharinae* (Boulenger, 1888a), *Vitreorana parvula* (Boulenger, 1894), *Physalaemus nanus* (Boulenger, 1888b), and *Chiasmocleis leucosticta* (Boulenger, 1888a). In the late XIX and early XX centuries, while living in the Hansa-Humbolt colony, adjacent to the Dona Francisca colony, Willhelm Ehrhardt collected 43 amphibian species (Gutsche, Kwet, Kucharzewski and Hallermann, 2007, Gutsche, Kwet, Kucharzewski, Lingnau and Güther, 2007). In subsequent studies made by Dr. Lorenz Müller, three new amphibian species were described for this region: *Adenomera nana* (Müller, 1922), *Vitreorana uranoscopa* (Müller, 1924) and *Aplastodiscus ehrhardti* (Müller, 1924). Furthermore, Müller listed 23 amphibian species for the colony and 38 species for Santa Catarina province (Müller, 1922).

Currently, amphibians (Lissamphibia) comprise more than 8400 species in the world (Frost, 2021), and Brazil harbors the highest diversity (1188 species, Segalla et al., 2021), with 625 species occurring in the Atlantic Forest (Rossa-Feres et al., 2017). According to Lucas (2008), there are 122 amphibian species in the state of Santa Catarina, 77 of which are known for the Serra Dona Francisca region, including São Bento do Sul, Campo Alegre, Joinville, and Corupá municipalities, north-eastern region of the state. This number represents 63% of all amphibian species found in the state, which emphasizes the value of this region for amphibian conservation. It is also worth noting that recent species records and anuran descriptions increased this number of species (e.g., Lucas and Garcia, 2011, Bruschi, Lucas, Garcia and Recco-Pimentel. 2014, Monteiro, Condez, Garcia, Comitti, Amaral, and Haddad, 2014, Bornschein et al. 2015, Condez et al. 2016, Monteiro, Comitti and Lingnau. 2014, Lourenço, Lingnau, Haddad and Faivovich, 2019). Although the Atlantic Forest has been greatly reduced and fragmented (Ribeiro, Metzger, Martensen, Ponzoni and Hirota, 2009), it harbors many endemic species, which characterizes the biome as a biodiversity hotspot (Myers, Mittermeier, Mittermeier, Fonseca and Kent, 2000). Therefore, studies focusing on tropical diversity are imperative to evaluate the conservation status of this environment and manage the regional species list (Verdade et al., 2012), that adds value to a preserved patrimony.

Given the historical importance of the Serra Dona Francisca and the lack of information for several areas in the Atlantic Forest biome, we performed an anuran inventory in the Serra Dona Francisca. We gathered data on natural history for each species recorded, describing their temporal and spatial distribution, especially along the elevational gradient. In addition, we compared the species composition with other anuran communities from subtropical Atlantic Forest

and provided comments on forest fragment conservation and preservation efforts in this sustainable use conservation unit.

MATERIAL AND METHODS

Study area

In the Serra Dona Francisca (Fig. 1) there is the "Área de Proteção Ambiental Serra Dona Francisca" (APA; Environmental Protection Area), a sustainable use conservation unit, with 41000 hectares under the environmental agency management FUNDEMA (Fundação Municipal do Meio Ambiente), from Joinville municipality, state of Santa Catarina, Brazil. The region is characterized by geological formations of Serra Geral and Serra do Mar mountain ranges, with the Cubatão River as the main watershed (Scheibe, 1986, Peluso Jr, 1991). There is no dry season in the region, but a period of higher rainfall intensity from spring to summer seasons was recorded (Klein, 1960). The historical mean amplitude of temperature is 12.3–24.5ºC, and mean amplitude of precipitation is 77.7–282.3 mm (INMET, for the nearest climatic stations, Porto União and São Francisco do Sul municipalities, from 1931 to 1990).

Sampling

We established four sampling localities at different elevations (100, 300, 700 and 1000 m) in the Serra Dona Francisca, within Joinville and Campo Alegre municipalities, with the highest elevation at 1200 m (Table 1, Fig. 2).

Field work was carried out in 16 months, totalling 68 sampling days. The first 12 campaigns occurred from October 2012 to March 2013, with two campaigns each month throughout the elevation gradient established, using the two methods described below. The following 10 campaigns were carried out from April 2013 to January 2014, in which we performed one campaign each month in the two categories of highest elevation (700 and 1000 m), Araucaria Forest and Montane Ombrophilous Forest, using only the surveys at breeding sites method. Such change in our sampling was due to logistic support that change through the monitoring.

We applied two sampling methods: (1) SBS - surveys at breeding sites, following Scott Jr and Woodward (1994), and (2) PT - pitfall traps (Corn, 1994). The SBS method consisted of visual and auditory surveys and counting the richness of anuran in breeding sites either in the forest interior, streams, swamps, or ponds. We selected at least five breeding sites at each elevation, totalling 34 breeding sites in all sampled area. In the forest and stream, we sampled 120 m transects, counting the anuran species that used these habitats for reproduction through visual and auditory surveys. Each elevation was visited for one night in each sampling, with activities starting at dusk, from 20:00 h to 24:00 h, totaling 272 person-hours of sampling. The PT method consisted of three lines of pitfall traps at each sampled elevation. The lines were built with four 60-liter plastic buckets, all connected with a 50 m-long and 1 m-high drift-fence. The buckets were open for four consecutive nights in each campaign, totalling 48 bucket-days and 4608 hours of total sampling effort. We checked the traps every morning while they were open, and we captured, identified, measured, and marked all anuran found in buckets. After these proceedings we released the animals next to the traps where they were first captured. This method was only applied in the first 12 campaigns of this study. Some vouchers were collected, and the specimens were deposited in the Zoology Scientific Collection at the Universidade Regional de Blumenau (FURB: 22166…22952) and in the Herpetological Collection of Ribeirão Preto (CHRP: 1387– 1390).

During fieldwork, we also obtained information on the anurans' breeding behaviour and spatial-temporal occupation in the environment: the habitat (forest interior, forest edge, open area, lentic, lotic), microhabitat (leaf litter, stream banks, shrubs, grasses, trees, bromeliads, rivers, ponds, marshes, aquatic vegetation, water), perch type at the reproductive activity (bromeliads, tree, shrub, grasses, herbaceous, soil, rocks), and activities (calling, foraging, amplecting). The reproduction period for all the species was categorized by the presence of ovigerous females, amplected couples, spawning and/or tadpoles and juveniles. We classified the species as continuous, prolonged, or explosive breeders as proposed by Crump (1974), Wells (1977) and Prado, Uetanabaro and Haddad (2004). According to Prado et al. (2004), continuous breeders are species with individuals that reproduce throughout the year; prolonged breeders are species with more than three months of reproduction and asynchronous arrival of females to breeding sites, with males showing territoriality behaviour; and explosive breeders present reproductive activity for only a few days or weeks with synchronous arrival of females and males. The reproductive modes were classified following Nunes-de-Almeida, Haddad and Toledo (2021).

For some species, we provide bioacoustics information to support taxonomic identification. We registered anuran calls using a Marantz PMD 661 digital recorder (sample rate 24000) with a YOGA HT-81 directional microphone. We analysed the recorded calls in the Audacity software (version 2.2.1).

Ecological analyses

We performed rarefaction/extrapolation curves based on incidence (samples in campaigns) for each method (SBS and PT) separately. We observed the

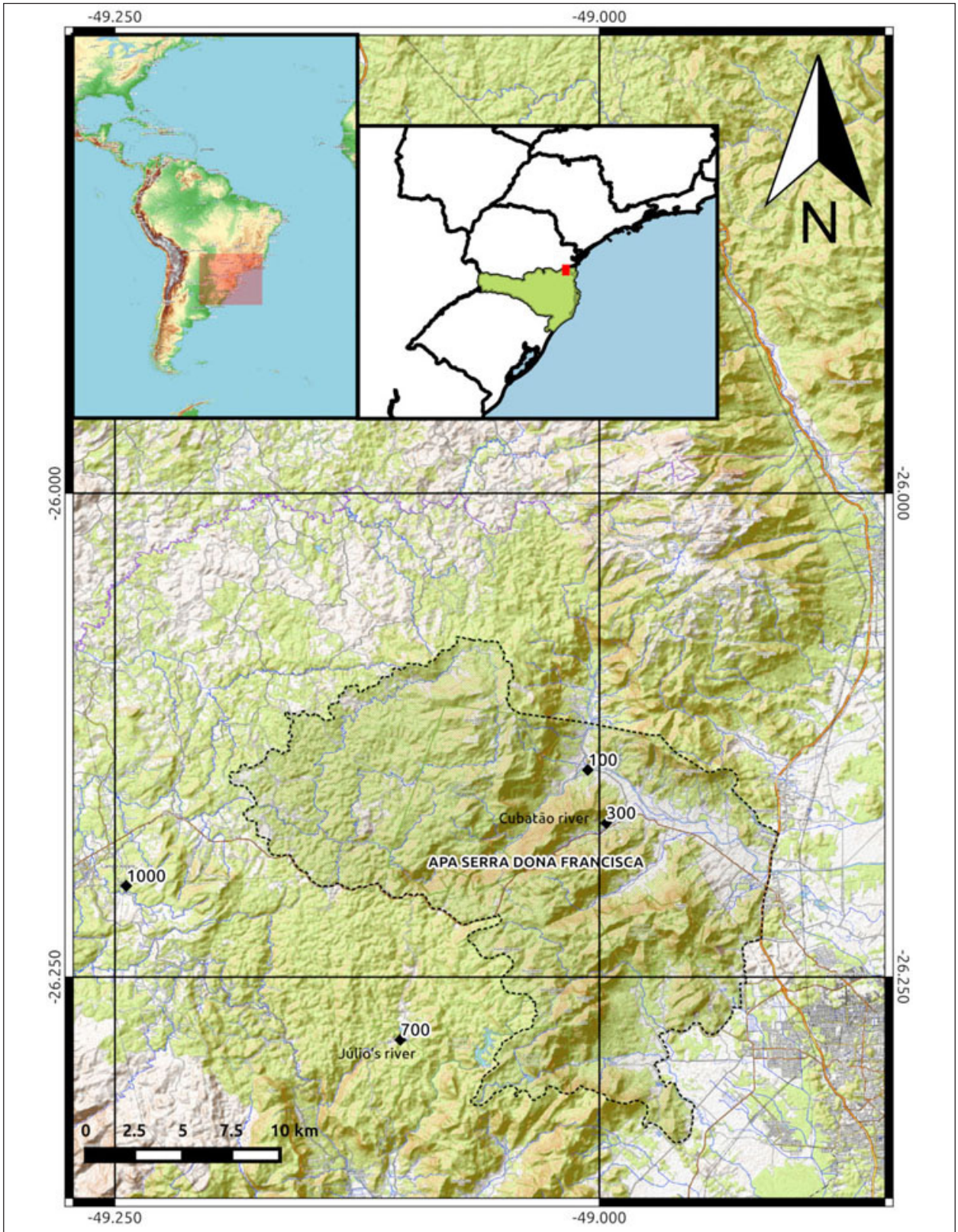


Fig. 2. Sampled points (black diamonds) in Serra Dona Francisca, Joinville municipality, Brazil. The shades area represents the contour line of the sustainable use environmental protection area (Serra Dona Francisca).

Table 1. Geographic coordinates (Datum: WGS 84), elevation, phytophysiognomies (Veloso et al. 2012) and relief of the four sampled localities and their sampled breeding sites (SBS) and pitfall traps (PT) of Serra Dona Francisca, Joinville and Campo Alegre, Santa Catarina, Brazil. Legends: DOSF - dense ombrophilous sub-montane forest, DMOF - ecotype between dense and mix ombrophilous forest, MOFS - ecotype between mix ombrophilous forest (Araucaria Forest) and steppe vegetation.

Sampled Locality					Vegetation	Relief
Sampled Point	Latitude	Longitude	elevation	Method	Type of Breeding Site/	Landscape
	1000				MOFS	upland
A15	26°12'10.56"	49°14'39.16"	970	SBS	lentic permanent/forest edge	
A16	26°12'11.05"	49°14'44.60"	960	SBS	lentic permanent/open land	
A17	26°12'8.91"	49°14'44.88"	963	SBS	lentic permanent/open land	
A21	26°12'57.40"	49°13'9.91"	1020	SBS	lentic permanent/forest edge	
A22	26°12'50.65"	49°13'13.11"1	022	SBS	lentic temporary/open land	
A23	26°12'47.14"	49°13'20.43"	984	SBS	lentic temporary/forest interior	
A24	26°13'7.05"	49°13'19.88"	917	SBS	lentic temporary/open land	
A25	26°12'45.81"	49°14'16.41"	1025	SBS	lentic temporary/open land	
A26	26°11'20.82"	49°15'3.10"	1029	SBS	lentic temporary/open land	
TF1000	26°12'41.19"	49°14'15.95"	992	SBS	forest interior	
TS1000	26°12'48.74"	49°13'18.68"	1014	SBS	lotic permanent/forest interior	
1000A	26°12'46.87"	49°13'14.86"1	020	PT	forest interior	
1000B	26°12'51.01"	49°13'11.72"	1036	PT	forest interior	
1000C	26°12'56.35"	49°13'9.04"	1033	PT	forest interior	
	700				DMOF	upland
B18	26°16'59.74"	49° 6'9.54"	636	SBS	lentic permanent/forest edge	
B19	26°16'56.81"	49° 6'9.87"	626	SBS	lentic temporary/forest interior	
B21	26°17'18.26"	49° 7'6.41"	613	SBS	lentic temporary/open land	
B22	26°17'20.82"	49° 7'4.97"	630	SBS	lentic permanent/open land	
B5	26°15'44.36"	49° 5'50.43"	651	SBS	lentic permanent/edge forest	
TF700	26°17'2.15"	49° 6'8.86"	649	SBS	forest interior	
TS700	26°17'0.96"	49° 6'8.28"	659	SBS	lotic permanent/forest interior	
700A	26°17'2.49"	49° 6'8.49"	639	PT	forest interior	
700B	26°17'0.21"	49° 6'9.04"	615	PT	forest interior	
700C	26°17'0.82"	49° 6'10.55"	626	PT	forest interior	
	300				DOSF	mountain climb
C43	26°10'13.58"48°	59'47.30"	118	SBS	lentic permanent/edge forest	
C48	26°10'40.78"	49° 0'22.17"	177	SBS	lentic temporary/edge forest	
C49	26°10'32.11"	49° 0'23.11"	165	SBS	lentic permanent/open land	
TF300	26°10'44.78"	49° 0'24.24"	148	SBS	forest interior	
TS300	26°10'48.69"	49° 0'20.24"	259	SBS	lotic permanent/forest interior	
300A	26°10'47.11"	49° 0'20.31"	219	PT	forest interior	
300B	26°10'52.50"	49° 0'20.03"	242	PT	forest interior	
300C	26°10'55.45"	49° 0'18.27"	262	PT	forest interior	
	100				DOSF	lowland
C1	26° 8'34.76"	49° 0'21.68"	85	SBS	lentic permanent/edge forest	
C24	26° 8'59.50"	48°59'33.91"	74	SBS	lentic temporary/edge forest	
C25	26° 8'58.92"	48°59'32.13"	72	SBS	lentic permanent/open land	
C28	26° 9'5.08"	48°59'27.88"	75	SBS	lentic permanent/open land	
C29	26° 9'2.85"	48°59'27.07"	77	SBS	lentic temporary/open land	

Table 1. Cont.

Sampled Point	Sampled Locality Latitude	Longitude	elevation	Method	Vegetation Type of Breeding	Relief Site/ Landscape
C30	26° 9'2.59"	48°59'30.09"	73	SBS	lentic temporary/edge	forest
TF100	26° 9'12.26"	48°59'36.87"	99	SBS	forest	interior
TS100	26° 9'8.83"	48°59'36.02"	100	SBS	lotic permanent/forest	interior
100A	26° 9'8.93"	48°59'32.63"	97	PT	forest	interior
100B	26° 9'10.31"	48°59'34.13"	100	PT	forest	interior
100C	26° 9'10.89"	48°59'35.88"	100	PT	forest	interior

asymptote of the curves (Chao's richness index) comparing the observed richness and estimated richness by Hill numbers (order q=0) (the endpoint of both methods for extrapolation was 40 campaigns) (Hsieh, Ma and Chao, 2016). To compare the species diversity among sampled localities (100, 300, 700 and 1000 m) per method (SBS and PT), we estimated the richness (Hill number q=0), Shannon diversity (Hill number q=1) and Simpson diversity (Hill number q=2) using rarefaction/extrapolation curves based on abundance (the standard function remained, which was twice the sample size). Only for SBS method, we used, as the value of abundance, the sum of the higher abundance recorded for each species in each breeding site during sampling campaigns (Table 2). Since the differences of sampling efforts (number of breeding sites) among sampled localities might influence the species diversity comparisons, we plotted sample completeness curves, which is a comparison of point diversities for some sample size using the same rarefaction/extrapolation curves described above. We used the iNEXT package in R environment for such analyses (Hsieh et al., 2016, R Core Team, 2020).

We compared the species composition of anuran communities of Serra Dona Francisca with other anuran communities from subtropical Atlantic Forest (see Table 1 in Suppl. Info. 1) using cluster analysis. We generated a similarity matrix of species composition for each locality through the Jaccard index (presence-absence) using vegan package (Oksanen et al., 2019). To check whether the geographical distance influenced species composition, we search for spatial autocorrelation between species composition (the same similarity matrix used in the cluster analysis) and geographical distance matrix between samples (matrix of latitudinal and longitudinal coordinates of each sampled locality) using the Mantel test (vegan package, Oksanen et al., 2019). All analyses were performed using the R language (R Core Team, 2020).

RESULTS AND DISCUSSION

1. Anuran Commented List

We found 63 anuran species sampled by both SBS and PT methods, in all four elevational localities (Table 2, Fig. 3–8). These species belong to 13 families (number of species in parenthesis): Brachycephalidae (4), Bufonidae (4), Centrolenidae (1), Craugastoridae (1), Cycloramphidae (2), Hemiphractidae (2), Hylidae (30), Hylodidae (2), Leptodactylidae (10), Microhylidae (2), Odontophrynidae (3), Phyllomedusidae (1), and Ranidae (1).

Family Brachycephalidae

Brachycephalus sulfuratus

Condez, Monteiro, Comitti, Garcia, Amaral and Haddad, 2016

(Fig. 3A)

Vouchers - FURB 22950, 22952

Taxonomy and distribution - This is a recently described species endemic to the Atlantic Forest (Condez et al., 2016). *Brachycephalus sulfuratus* belongs to the *B. didactylus* species group and occurs in São Paulo, Paraná, and Santa Catarina states. It is apparently widely distributed, occurring from the sea level up to 1000 m (Condez et al., 2016).

Ecology - We did not observe any behavior of this species in the field, once two individuals were captured by PT and only one individual was collected on a shrub in the forest interior during the SBS, all at 700 m altitude. The *Brachycephalus*' species present endotrophic and direct development of their eggs (Hedges, Duellman and Heinicke, 2008). They deposit the eggs in the leaf litter, tree barks and on the soil (reproductive mode 27 – Nunes-de-Almeida et al., 2021). Condez et al. (2016) observed this species calling under the leaf-litter on rainy days with reproductive activity throughout the year.

Table 2. Amphibians' species and abundance registered in the four elevation localities of Serra Dona Francisca, Brazil. The two sampling methods: SBS - survey at breeding sites - from October 2012 to January 2014, and PT - pitfall traps - from October 2012 to March 2013.

Taxa/Elevation localities/Methods	100		300		700		1000	
	SBS	PT	SBS	PT	SBS	PT	SBS	PT
Class Amphibia - Order Anura								
Brachycephalidae (2 genera, 4 species)								
Brachycephalus sulfuratus Condez, Monteiro, Comitti, Garcia, Amaral and Haddad, 2016	-	-	-	-	1	2	-	-
Ischnocnema sp. (gr. *guentheri*)	1	-	8	-	-	-	-	-
Ischnocnema henselii (Peters, 1872)	-	-	-	-	10	1	6	-
Ischnocnema sp. *(I. lactae* species series)	-	-	8	-	-	-	-	-
Bufonidae (3 genera, 4 species)								
Dendrophryniscus berthalutzae Izecksohn, 1994	-	-	-	-	11	-	-	-
Rhinella ornata (Spix, 1824)	5	39	48	28	24	17	9	4
Rhinella icterica (Spix, 1824)	2	1	-	-	20	1	66	18
Melanophryniscus xanthostomus Baldo, Bornschein, Pie, Ribeiro, Firkowski and Morato, 2015	-	-	-	-	-	-	4	-
Centrolenidae (1 genus, 1 species)								
Vitreorana uranoscopa (Müller, 1924)	-	-	-	-	4	-	15	-
Craugastoridae (1 genus, 1 species)								
Haddadus binotatus (Spix, 1824)	-	-	2	-	-	-	-	-
Cycloramphidae (1 genera, 2 species)								
Cycloramphus bolitoglossus (Werner, 1897)	-	-	-	-	1	3	1	-
Cycloramphus izecksohni Heyer, 1983	-	-	9	-	-	-	-	-
Hemiphractidae (1 genus, 2 species)								
Fritziana mitus Walker, Wachlevski, Nogueira-Costa, Garcia and Haddad, 201811-45-60---*Fritziana* sp.	-	-	-	-	-	-	17	-
Hylidae (8 genera, 30 species)								
Aplastodiscus sp.	-	-	-	-	29	-	41	-
Aplastodiscus ehrhardti (Müller, 1924)	-	-	-	-	9	-	-	-
Aplastodiscus perviridis A. Lutz in B. Lutz, 1950	-	-	-	-	-	-	20	-
Boana albomarginata (Spix, 1824)	10	-	-	-	7	-	-	-
Boana albopunctata (Spix, 1824)	-	-	-	-	-	-	59	-
Boana bischoffi (Boulenger, 1887)	-	-	8	-	86	-	101	-
Boana faber (Wied-Neuwied, 1821)	9	-	3	-	23	-	58	-
Boana semilineata (Spix, 1824)	15	-	1	-	-	-	-	-
Boana semiguttata (Lutz, 1925)	-	-	-	-	-	-	10	-
Bokermannohyla hylax (Heyer, 1985)	6	-	7	-	12	-	-	-
Bokermannohyla luctuosa Pombal and Haddad, 1993	-	-	-	-	17	-	14	-
Dendropsophus berthalutzae (Bokermann, 1962)	-	-	20	-	-	-	-	-
Dendropsophus elegans (Wied-Neuwied, 1824)	79	-	13	-	-	-	-	-
Dedropsophus microps (Peter, 1872)	-	-	-	-	14	-	11	-
Dendropsophus minutus (Peters, 1872)	-	-	1	-	16	-	465	-
Dendropsophus nahdereri (B. Lutz and Bokermann, 1963)	-	-	-	-	22	-	20	-
Dendropsophus werneri (Cochran, 1952)	66	-	19	-	29	-	-	-
Scinax aromothyella Faivovich, 2005	-	-	-	-	-	-	30	-
Scinax catharinae (Boulenger, 1888)	-	-	-	-	-	-	2	-

Table 2. Cont.

Taxa/Elevation localities/Methods	100		300		700		1000	
	SBS	PT	SBS	PT	SBS	PT	SBS	PT
Scinax aff. *perpusillus*	-	-	1	-	9	-	-	-
Scinax litorallis (Pombal and Gordo, 1991)	19	-	7	-	-	-	-	-
Scinax rizibilis (Bokermann, 1964)	2	-	1	-	9	-	3	-
Scinax fuscovarius (A. Lutz, 1925)	19	-	-	-	14	-	1	-
Scinax granulatus (Peters, 1871)	-	-	-	-	-	-	38	-
Scinax imbegue Nunes, Kwet and Pombal, 2012	110	-	25	-	54	-	-	-
Scinax perereca Pombal, Haddad and Kasahara, 1995	13	-	22	-	65	-	101	-
Scinax squalirostris (A. Lutz, 1925)	-	-	-	-	-	-	30	-
Scinax tymbamirim Nunes, Kwet and Pombal, 2012	53	-	-	-	-	-	-	-
Sphaenorhynchus surdus (Cochran, 1953)	-	-	-	-	-	-	112	-
Trachycephalus mesophaeus (Hensel, 1867)	27	-	4	-	9	-	-	-
Hylodidae (2 genera, 2 species)								
Crossodactylus sp.	-	-	-	-	36	-	-	-
Hylodes perplicatus (Miranda-Ribeiro, 1926)	-	-	7	6	1	6	-	-
Leptodactylidae (4 genera, 10 species)								
Adenomera araucaria (Kwet and Angulo, 2002)	-	-	-	-	15	-	19	6
Adenomera nana Müller, 1922	7	12	4	25	27	23	22	-
Leptodactylus paranaru Magalhães, Lyra, Carvalho, Baldo, Brusquetti, Burella, Colli, Gehara, Giaretta, Haddad, Langone, López, Napoli, Santana, Sá and Garda, 2020	11	-	2	-	15	-	31	5
Leptodactylus notoaktites Heyer, 1978	21	9	8	2	16	2	7	-
Leptodactylus plaumanni Ahl, 1936	-	-	-	-	-	-	26	2
Physalaemus aff. *gracilis*	-	-	-	-	-	-	50	13
Physalaemus cuvieri Fitzinger, 1826	22	4	-	-	2	-	42	8
Physalaemus lateristriga (Steindachner, 1864)	1	-	-	5	36	156	50	393
Physalaemus nanus (Boulenger, 1888)	-	-	-	-	-	-	17	4
Scythrophrys sawayae (Cochran, 1953)	-	-	-	1	17	61	-	-
Microhylidae (2 genera, 2 species)								
Chiasmocleis leucosticta (Boulenger, 1888)	3	26	1	1	-	2	4	-
Elachistocleis bicolor (Valenciennes in Guérin-Menéville, 1838)	33	1	-	-	-	-	22	1
Odontophrynidae (2 genera, 3 species)								
Odontophrynus americanus (Duméril and Bibron, 1841)	-	-	-	-	-	-	4	-
Proceratophrys boiei (Wied-Neuwied, 1825)	-	1	5	9	49	79	13	2
Proceratophrys subguttata Izecksohn, Cruz and Peixoto, 1999	-	-	-	-	-	2	-	-
Phyllomedusidae (1 genus, 1 species)								
Phyllomedusa disticta A. Lutz in B. Lutz, 1950	-	-	-	-	2	-	4	-
Ranidae (1 genus, 1 species)								
Lithobates catesbeianus (Shaw, 1802)	-	1	-	-	-	-	-	-
Total Richness	**24**	**9**	**27**	**8**	**37**	**14**	**38**	**11**

Fig. 3. Some amphibians registered in Serra Dona Francisca: (A) *Brachycephalus sulfuratus,* (B) *Ischnocnema henselii,* (C) *Ischnocnema* sp. (gr. *Guentheri*), (D) *Ischnocnema* sp. (*I. lactae species* series), I *Dendrophryniscus berthalutzae*, (F) *Rhinella ornata,* (G) *Rhinella icterica,* (H) *Melanophryniscus xanthostomus,* (I) *Vitreorana uranoscopa,* (J) *Haddadus binotatus,* (K) *Cycloramphus bolitoglossus*, and (L) *Cycloramphus izecksohni*.

Ischnocnema henselii
(Peters, 1870)
(Fig. 3B)
Vouchers - FURB 22375, 22390, 22719, 22730, 22738, 22739

Taxonomy and distribution - This species was recently placed within the *Ischnocnema guentheri* species group, and it is widely distributed in the south portion of Atlantic Forest in the São Paulo, Paraná, Santa Catarina, and Rio Grande do Sul states, and in the northeast of Argentina (Conte et al., 2010, Gehara, Canedo, Haddad and Vences, 2013).

Ecology - We registered males of *I. henselii* at the altitude levels of 700 m and 1000 m, foraging and calling in the leaf litter or on vegetation such as shrubs, grasses, or trees, in the forest interior and in stream banks. We observed males emitting advertisement calls from October 2012 to January 2013 and September 2013 to December 2013, and registered ovigerous females in March 2013, December 2013 and January 2014. Species of the genus *Ischnocnema* have reproductive mode 27, with direct development of the terrestrial eggs (Nunes-de-Almeida et al., 2021).

***Ischnocnema* sp. (gr. *guentheri*)**
(Fig. 3C)
Vouchers - FURB 22283, 22374, 22380, 22795, 22812, 22913

Taxonomy and distribution - This species is part of the *I. guentheri* species complex, cited as Candidate Species 1 (CS1) in Gehara et al. (2013), which was delimited by using molecular markers and bioacoustics data. This putative species occurs from the states of São Paulo to Santa Catarina (Gehara et al., 2013). The calls (n=6 from two males) have similar acoustic parameters if compared with Gehara et al. (2013), as follows: dominant frequency 2325–2497 Hz (2403.833 ± 63.294), call duration 1.880–2.440 s (2.118 ± 0.184) and notes per call 29–35 (31.5 ± 1.974).

Ecology - We registered this species only at low elevations (100 and 300 m). We observed calling males in the leaf litter, at the stream banks or on the vegetation in the forest interior, from October 2012 to March 2013; we registered ovigerous females during November and December 2012, and from January to March 2013. Species of the genus *Ischnocnema* have reproductive mode 27 (Nunes-de-Almeida et al., 2021).

***Ischnocnema* sp. (*I. lactea* species series)**
(Fig. 3D)
Vouchers - FURB 22748, 22758, 22907, 22929

Taxonomy and distribution - This species was assigned as part of the *I. lactea* species series based on external morphology. There are three species belonging to this species series occurring close of the studied region: *I. paranaensis*, *I. manezinho* and *I. sambaqui.* The collected individuals (adults, males) differ from *I. paranaensis* by their larger size (SVL 21.3–21.8 mm in *Ischnocnema* sp.; 17.7 mm in *I. paranaensis*, Langone and Segalla, 1996) and by the presence of external tympanum (indistinct in *I. paranaensis*). *Ischnocnema* sp. presents variegated dorsal coloration that varies from brown to yellow; thigh, shank and forearms with black stripes on dorsal surfaces. The snout is round from dorsal view and acuminate in profile. Because of the presence of the internal tarsal tubercle, collected individuals are similar to *I. sambaqui*, and differs from *I. manezinho* (internal tarsal tubercle absent) (Garcia, 1996, Castanho et al., 2000). The advertisement calls (n = 12, two males) have duration of 0.140–0.270 s (0.207 ± 0.029), with 3.000–5.000 notes per call (3.916 ± 0.288), note duration of 0.008–0.010 s (0.010 ± 0.001), and only one pulse per note. The dominant frequency is 3014.000–3100.000 Hz (3071.333 ± 38.167), Fmin 1765.000–2282.000 Hz (2095.583 ± 130.311), and Fmax 3875.000–4392.000 Hz (4083.750 ± 150.020). The advertisement call of *I. paranaensis* is not described, hampering any comparisons. However, we observed differences in the call duration and number of notes in comparison with *I. manezinho* (respectively, 0.79–0.97 s and 11–13 number of notes, Florianópolis municipality, Santa Catarina state, approximately 160 km from Serra Dona Francisca, Castanho et al. 2000) and *I. sambaqui* (respectively, 0.50–0.63 s and 6.0–8.0 number of notes, Guaraqueçaba municipality, Paraná state, approximately 130 km from Serra Dona Francisca, Castanho et al. 2000). Therefore, because of the reasons explained above, we were not able to assign the collected individuals to any of these three species.

Ecology - We observed males of *Ischnocnema* sp. calling during November 2013 in the forest interior, only at 300 m of elevation level. Males of this species use large rocks (more than 1 m from the soil) as calling sites, besides trunks wrapped by mosses and bryophytes. Species of the *Ischnocnema* genus have the reproductive mode 27 (Nunes-de-Almeida et al., 2021).

Family Bufonidae
Dendrophryniscus berthalutzae
Izecksohn, 1994
(Fig. 3E)
Vouchers - FURB 22282, 22474, 22720, 22901, 22908

Taxonomy and distribution - This species occurs in coastal forests in the Paraná and Santa Catarina states (Fusinatto, Cruz and Garcia, 2008) and belongs to the *D. brevipollicatus* species group (Izecksohn, 1993).

Ecology - We registered *D. berthalutzae* only at the elevation level of 700 m, foraging on the vegetation and rocks in the forest interior. We observed calling males on shrubs in the streams (1.5 m high), only in November 2012, but we found females during all the survey, and juveniles only in February 2013. This species is usually found in bromeliads, where the eggs are laid (reproductive mode 4 – Peixoto, 1995, Nunes-de-Almeida et al., 2021).

Rhinella ornata
(Spix, 1824)
(Fig. 3F)
Vouchers - FURB 22166-22168, 22170-22175

Taxonomy and distribution - This species is widely distributed from the south of Minas Gerais and Rio de Janeiro states to the south of the state of Santa Catarina, and from the east littoral to the west in Argentina. It belongs to the *R. crucifer* species group (Pereyra et al., 2021).

Ecology - We found individuals of *R. ornata* at all elevation levels and within all sampled habitats: open areas, forest edges and in the forest interior. We observed calling males from October 2012 to January 2013 and from August to October 2013 in open areas and forest edges. We captured ovigerous females during the period of vocalization. We registered amplected couples only at the end of October 2012. Out of the breeding period, we captured mostly females and juveniles in the forest interior (PT method), from October 2012 to March 2013. This species presents the reproductive mode 1, with eggs and exotrophic tadpoles in lentic habitats (Nunes-de-Almeida et al., 2021).

Rhinella icterica
(Spix, 1824)
(Fig. 3G)
Vouchers - FURB 22176, 22177, 22201, CHRP 1387, 1388

Taxonomy and distribution - The cururu toad is widely distributed in the Atlantic Forest of the south and southeast of Brazil and belongs to the *R. marina* species group (Pereyra et al., 2021).

Ecology - We found *R. icterica* at all elevation levels and observed this species in breeding activity in open areas and in forest edges, but we also collected some individuals in the forest interior (PT and SBS). We observed calling males and adult females from October 2012 to January 2013, and amplected couples only at the end of October 2012. We captured some juveniles from October 2012 to March 2013. This species presents the reproductive mode 1 (Nunes-de-Almeida et al., 2021).

Melanophryniscus xanthostomus
Baldo, Bornschein, Pie, Ribeiro, Firkowski and Morato, 2015
(Fig. 3H)
Vouchers - FURB 22713, 22714, 22822, 22851

Taxonomy and distribution - *Melanophryniscus xanthostomus* is a recently described species and it is not assigned to any species group (Bornschein et al., 2015). This species is distributed on top of mountains of northeaster of the state of Santa Catarina (Bornschein et al., 2015).

Ecology - We observed calling males inside terrestrial bromeliads in the forest interior from November 2013 to January 2014, only at the elevation level of 1000 m. We found eggs, tadpoles and one female near a pitfall trap fence in November 2013. As well as reported for other species of *Melanophryniscus* with this breeding behaviour, this species has the reproductive mode 4 (Nunes-de-Almeida et al., 2021).

Family Centrolenidae
Vitreorana uranoscopa
(Müller, 1924)
(Fig. 3I)
Vouchers - FURB 22462, 22813

Taxonomy and distribution - This species inhabits streams of the Atlantic Forest from the southeast to the south of Brazil (Heyer, 1985a, Machado et al., 2010). *Vitreorana uranoscopa* represents a species complex with several distinct lineages (Paz et al., 2018). Bokermann (1966) assigned Corupá municipality, state of Santa Catarina, as the type locality of this species, and given the proximity of the studied area (less than 15 km of airline distance from Serra Dona Francisca), we considered this population as the nominal species (the green dot lineage from Paz et al., 2018).

Ecology - We collected this species at the elevation levels of 700 m and 1000 m. We observed calling males on *xaxins* (*Dicksonia sellowiana*), palms and other shrub leaves (up to 1 m high) in streams of the forest interior, from November 2012 to February 2013, and from September 2013 to January 2014; we registered spawning on leaves pending above streams during December 2013. This species has reproductive mode 22, with arboreal eggs hatching into exotrophic tadpoles that drop in lotic water (Nunes-de-Almeida et al., 2021).

Family Craugastoridae
Haddadus binotatus
(Spix, 1824)
(Fig. 3J)
Vouchers - FURB 22235, 22487, 22253

Taxonomy and distribution - This species is widely distributed throughout the Atlantic Forest, from the south of Bahia to Rio Grande do Sul states (Kwet, Lingnau and Di-Bernardo, 2010, Dias, Lourenço-de-Moraes and Solé, 2012). There is a record for Mata de São João, state of Bahia (Brazil), that could be the northern record for this species (Amaro, Nunes, Canedo, Napoli and Juncá, 2013, Napoli, Menezes and Abreu, 2017). However, individuals of *H. binotatus* present some morphological differences that can indicate a possible species complex (Amaro et al., 2013, Napoli et al., 2017).

Ecology - We found this species only at the elevation level of 300 m, during the SBS in the forest interior. We have not observed individuals calling or breeding, only in foraging activity. *Haddadus binotatus* presents direct development and deposits the eggs on the leaf litter in the forest (reproductive mode 27,

Hedges, Duellman and Heinicke, 2008, Nunes-de-Almeida et al., 2021).

Family Cycloramphidae
Cycloramphus bolitoglossus
(Werner, 1897)
(Fig. 3K)
Vouchers - FURB 22244, 22765, 22870

Taxonomy and distribution - This species occurs in the Atlantic Forest of Paraná and Santa Catarina states (Heyer, 1983, Conte and Rossa-Feres, 2007), and belongs to the *C. bolitoglossus* species group (Lingnau, Solé, Dallacorte and Kwet, 2008).

Ecology - We found this species at the elevation levels of 700 m and 1000 m. We observed several calling males after an intense rainfall in November 2013. We also found calling males in October and November 2012, always under the leaf litter in the forest edge and in the forest interior. *Cycloramphus bolitoglossus* breeds in the humid forest soil (Lingnau et al. 2008). There are some controversies about the breeding behavior of this species (see Heyer, 1983); however, it is supposed that its reproductive mode is similar to *C. stejnegeri* (Noble, 1924), which consists to terrestrial non-froth eggs laid in constructed burrow (reproductive mode 41, Lingnau et al. 2008, Nunes-de-Almeida et al., 2021).

Cycloramphus izecksohni
Heyer, 1983
(Fig. 3L)
Vouchers - FURB 22646, 22712, 22882

Taxonomy and distribution - This species occurs in Serra do Mar mountain range throughout the states of São Paulo, Paraná and Santa Catarina (Frost, 2021), and it is included in the *C. fuliginosus* species group (Verdade, 2005).

Ecology - We found *C. izecksohni* in hillside streams in the forest interior all over the region at the elevation level of 300 m. We observed calling males on rocks, trunks, and on the soil at the stream banks, from November 2012 to March 2013, and juveniles from January to March 2013; females were not recorded. Lingnau et al. (2008) reported the presence of some females with eggs in December 2004 and January 2006, and tadpoles in the small waterfalls at the same locality of the present study. This species has reproductive mode 17 (Nunes-de-Almeida et al., 2021), which is non-froth eggs laid on rock nest in lotic water.

Family Hemiphractidae
Fritziana mitus
Walker, Wachlevski, Nogueira-Costa, Garcia and Haddad, 2018
(Fig. 4A)
Vouchers - FURB 22489, 22922

Taxonomy and distribution - This genus is endemic to the Atlantic Forest, and the species are popularly named marsupial treefrogs, because females carry fertilized eggs in the dorsum (Duellman, Jungfer and Blackburn, 2011). *Fritziana mitus* is distributed along the Atlantic Forest, from northern of the state of São Paulo state to northern of the state of Rio Grande do Sul (Walker et al., 2018).

Ecology - We observed calling males calling in the canopy and understory in the forest interior, on bromeliads and epiphytic plants, at the elevation levels of 100 m to 700 m. The period of vocalization comprised the rainy season, from October 2012 to March 2013, June 2013 and October 2013 to January 2014. We have not found female carrying eggs of this species; however, it is known that females carry the eggs in a dorsal pouch, and after hatching, the tadpoles are deposited in the water-filled axils of bromeliads (reproductive mode 67, Nunes-de-Almeida et al., 2021).

***Fritziana* sp.**
(Fig. 4B)
Vouchers - FURB 22749, 22881, 22926

Taxonomy and distribution - We found specimens of *Fritziana* sp. only in the Araucaria Forest, which represents the first record of the genus in this vegetation type. We cannot relate these specimens to any other *Fritziana* species because of differences in body size and colour patterns, as follows: individuals of *Fritziana* sp. are larger (SVL 23.4–25.3 mm) than *Fritziana mitus* (SVL 16.2–23.7 mm, Walker et al., 2018), presents a subovoid snout in dorsal view and slightly acute in profile, and yellowish light orange background with dark spots evenly distributed on dorsum.

Ecology - We observed calling males calling from the canopy to the ground, on bromeliads and epiphytic plants in the forest interior, only at the elevation level of 1000 m. We highlight that there is an allopatric distribution between *F. mitus*, distributed only in sub-montane and montane ombrophilous Atlantic Forest, and *Fritziana* sp., occurring only in Araucaria Forest. This pattern may be related to climatic conditions associated to altitudinal gradient. The period of vocalization occurred in November and December 2013. Females of this genus carry the eggs in a dorsal pouch and after hatching, the tadpoles are deposited in the water-filled axils of bromeliads (reproductive mode 67, Peixoto 1995, Nunes-de-Almeida et al., 2021); we did not find any female carrying eggs.

Family Hylidae
***Aplastodiscus* sp.**
(Fig. 4C)
Vouchers - FURB 22306, 22461, 22463, 22478, 22818

Taxonomy and distribution - The canebrake treefrogs are distributed mostly in the Atlantic Forest, from São Paulo to Santa Catarina states (Berneck et al., 2016). The collected individuals belong to the *A. albosignatus* species group, and the last available

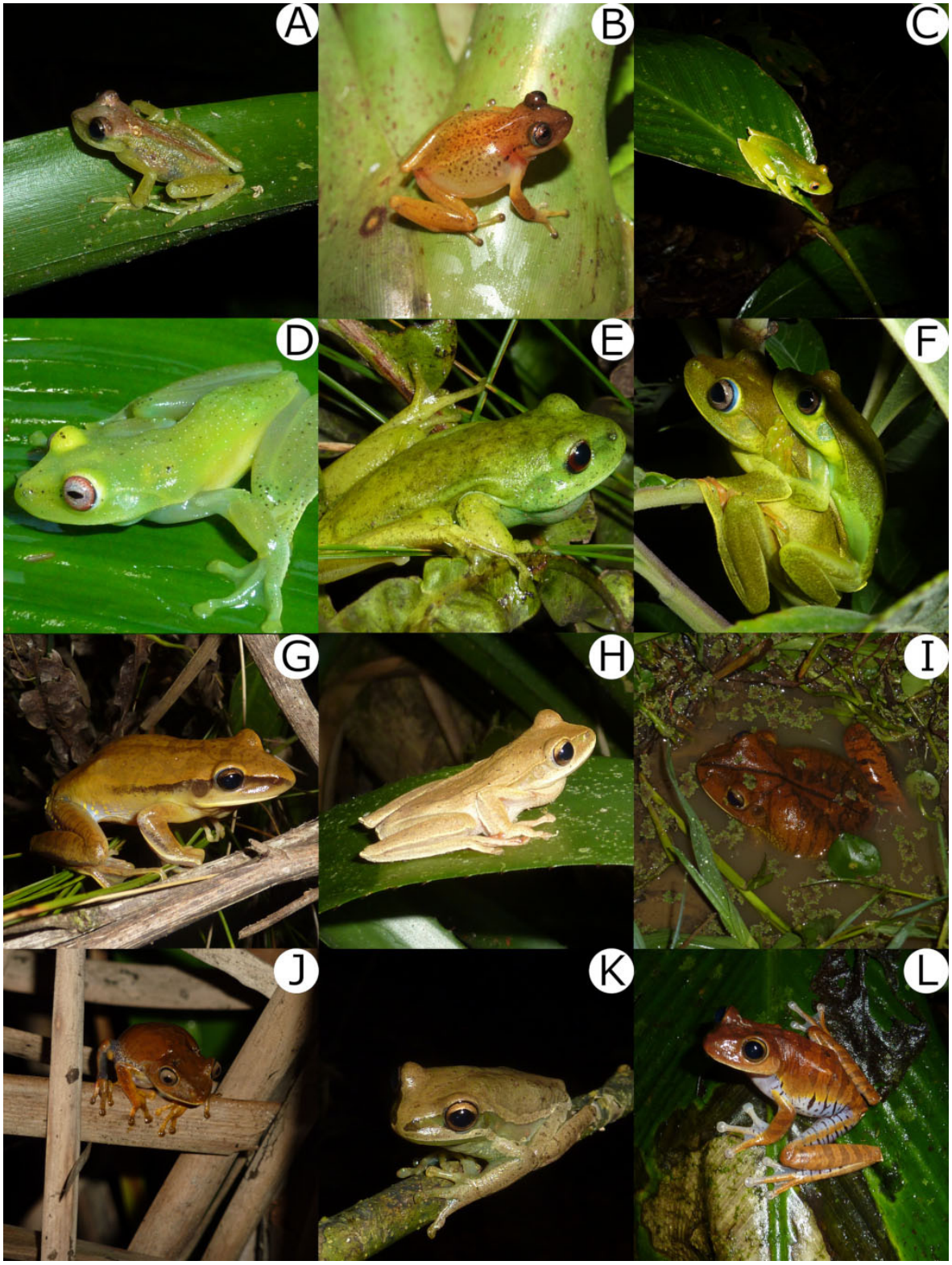


Fig. 4. Some amphibians registered in Serra Dona Francisca: (A) *Fritziana mitus,* (B) *Fritziana* sp. (photo by Carlos Eduardo Conte), (C) *Aplastodiscus* sp., (D) *Aplastodiscus erhardti,* (E) *Aplastodiscus perviridis,* (F) *Boana albomarginata,* (G) *Boana albopunctata,* (H) *Boana bischoffi,* (I) *Boana faber,* (J) *Boana semilineata,* (K) *Boana semiguttata,* and (L) *Bokermannohyla hylax*.

phylogenetic hypothesis divided this species group under six clades, in which the population recorded in the present study was recognized as an undescribed species (*Aplastodiscus* sp. 5, Berneck et al., 2016).

Ecology - We observed males calling from October 2012 to April 2013, and from July 2013 to January 2014, in the swamps at the forest edges and in the forest interior, at the elevation level of 700 m. We did not observe spawning of *Aplastodiscus* sp. but species of this genus lay their eggs in underground cavities, and after developed, tadpoles head towards a body of water (reproductive mode 10, Nunes-de-Almeida et al., 2021).

Aplastodiscus ehrhardti
(Müller, 1924)
(Fig. 4D)
Vouchers - FURB 22248, 22645

Taxonomy and distribution - This species occurs from the south of the state of São Paulo, in the municipality of Paranapiacaba, to the south coast of the state of Santa Catarina (Conte, Lingnau and Kwet, 2005, Conte and Rossa-Feres, 2006). It belongs to the *A. albofrenatus* species group (Berneck et al., 2016).

Ecology - We observed males calling from October 2012 to January 2013 and July 2013 to January 2014, only in the forest interior, on *taquaras*, bromeliads and *cipós*, at the elevation level of 700 m. We did not find ovigerous females and amplected couples. As mentioned for *Aplastodiscus* sp. this genus usually presents the reproductive mode 10 (Nunes-de-Almeida et al., 2021).

Aplastodiscus perviridis
Lutz, 1950
(Fig. 4E)
Vouchers - FURB 22236, 22285, 22307

Taxonomy and distribution - This species is widely distributed, occurring from southeastern Brazil to the state of Rio Grande do Sul, and north-eastern Argentina (Frost, 2021). It is part of the *A. perviridis* species group (Berneck et al., 2016).

Ecology - We recorded individuals of *A. perviridis* only at the elevation level of 1000 m. We observed males calling in open swamps and dams at the forest edge, from October 2012 to February 2013, and from November 2013 to January 2014. We did not find ovigerous females or amplected couples. *Aplastodiscus perviridis* reproduces in swamps or streams and deposits the eggs in underground cavities; after reaching advanced stages, the tadpoles follow to adjacent water bodies (reproductive mode 10, Nunes-de-Almeida et al., 2021).

Boana albomarginata
(Spix, 1824)
(Fig. 4G)
Voucher - FURB 22250

Taxonomy and distribution - This species occurs in the Atlantic Forest of eastern Brazil, from state of Paraíba to state of Santa Catarina (Frost, 2021), and belongs to the *B. faber* species group (Faivovich et al., 2005).

Ecology - We found *B. albomarginata* at the elevation levels of 100 m and 700 m, occupying herbaceous and shrubby vegetation of dams and swamps in open areas and forest edges. We observed males calling from October 2012 to March 2013 and December 2013, and amplected couples in December 2012. This species deposits its eggs on the water surface; the tadpoles are exotrophic (reproductive mode 1, Giasson and Haddad, 2007, Nunes-de-Almeida et al., 2021).

Boana albopunctata
(Spix, 1824)
(Fig. 4G)
Voucher - FURB 22240

Taxonomy and distribution - This species is widely distributed in open areas in the midwest and south of Brazil (Frost, 2021), and belongs to the *B. albopunctata* species group (Faivovich et al., 2005).

Ecology - We found this species only in dams in open areas or in the edge of the forest, at the elevation level of 1000 m. We observed males calling perched on grasses at the edge or inside the water body, from October 2012 to February 2013, and from December 2013 to January 2014. We did not observe females or spawning of *B. albopunctata*. This species lays eggs directly on the water surface (reproductive mode 1 - Muniz et al., 2008, Nunes-de-Almeida et al., 2021).

Boana bischoffi
(Boulenger, 1887)
(Fig. 4H)
Vouchers - FURB 22247, 22254, 22247,22464, 22480, 22745, 22861

Taxonomy and distribution - This species is widely distributed in the Atlantic Forest, from the state of São Paulo to the state of Rio Grande do Sul (Cochran, 1955, Kwet et al., 2010), and belongs to the *B. pulchella* species group (Faivovich et al., 2021).

Ecology - We found individuals of *B. bischoffi* foraging in both lotic and lentic environments, and males calling only in lentic water, in dams from open areas or on forest edges, at all elevation levels. Calling males were observed during all the survey (specially call type 1 - *Hyla multilineata* - *sensu* Heyer et al., 1990), except in May 2013. Males emitted the call type 2 (*sensu* Heyer et al., 1990) only during the hotter months from October 2012 to March 2013, when we also found ovigerous females. We observed juveniles some weeks after the beginning of the reproductive period, at the end of November. We recorded individuals laying their eggs on the water surface of lentic environments. This species presents exotrophic tadpoles (reproductive mode 1, Kwet et al., 2010, Nunes-de-Almeida et al., 2021).

Boana faber
(Wied-Neuwied, 1821)
(Fig. 4I)
Vouchers - FURB 22178, 22179, 22180

Taxonomy and distribution - This species is widely distributed in Brazil and occurs mainly in the Atlantic Forest, from the state of Rio Grande do Norte to the state of Rio Grande do Sul. It also occurs in adjacent formations, such as the Cerrado, and in Paraguay and Argentina (Lavilla, Aquino, Kwet and Baldo, 2010). The species belongs to the *Boana faber* species group (Faivovich et al., 2005).

Ecology - We found individuals reproducing in dams and swamps in open areas and forest edges at all sampled elevation levels. We observed males calling from October 2012 to March 2013, and from September to December 2013; the reproduction events occurred in the same period as the calling, once we observed clay nests with spawns in the breeding sites (reproductive mode 12, Nunes-de-Almeida et al., 2021). In December 2012 and January 2013, and in the same period of 2013 and 2014, we observed many females and amplected couples; juveniles were observed some weeks later.

Boana semilineata
(Spix, 1824)
(Fig. 4J)
Vouchers - FURB 22234, 22300, 22302, 22760

Taxonomy and distribution - This species occurs in the Atlantic Forest from the state of Pernambuco to the state of Santa Catarina (Van Sluys and Rocha, 2010), and belongs to the *B. semilineata* species group (Faivovich et al., 2005).

Ecology - We found *B. semilineata* in dams and swamps in open areas and forest edges at the elevation levels of 100 m and 300 m. We observed males calling from October 2012 to January 2013, using *taboa* as vocalization site. We did not find females, juveniles, or spawning. However, it is known that this species deposits its eggs on the water surface of lentic and lotic environments; the tadpoles are exotrophic (reproductive mode 16, Nunes-de-Almeida et al., 2021).

Boana semiguttata
(Lutz, 1925)
(Fig. 4K)
Vouchers - FURB 22313, 22479, 22880

Taxonomy and distribution - This species belongs to the *Boana pulchella* species group. Since populations from Joinville and São Bento do Sul municipalities were previously assigned as *B. semiguttata* (Faivovich et al., 2020), we identified the population from Campo Alegre municipality as *B. semiguttata.*

Ecology - We found males of *B. semiguttata* calling only in December 2012 and September 2013 to January 2014 in streams at forest edge at the elevation level of 1000 m; some individuals were observed foraging during other periods. We did not observe ovigerous or spawning. The species of the *B. pulchella* group deposit their eggs on the water surface, and present exotrophic tadpoles (reproductive mode 16, Garcia, Faivovich and Haddad, 2007, Kwet, 2008, Nunes-de-Almeida et al., 2021).

Bokermannohyla hylax
(Heyer, 1985)
(Fig. 4L)
Vouchers - FURB 22241, CHRP 1389, 1390

Taxonomy and distribution - The forest treefrog *B. hylax* occurs from the south of the state of Rio de Janeiro (Napoli and Pimenta, 2009) to the south of the state of Santa Catarina (Napoli and Pimenta, 2009), restricted to the coast region and the mountain range (Armstrong and Conte, 2010, Lucas, 2008). This species belongs to the *B. circumdata* species group (Heyer, 1985b).

Ecology - We found *B. hylax* at the elevation levels of 100 m, 300 m, and 700 m, in swamps and rivulets in the interior of the forest. We observed males calling from October 2012 to March 2013, and from September 2013 to January 2014. We did not observe any reproductive behaviour other than calling males. This species reproduces in streams, lays eggs on the water surface, and presents exotrophic tadpoles (reproductive modes 12, Nunes-de-Almeida et al., 2021).

Bokermannohyla luctuosa
Pombal and Haddad, 1993
(Fig. 5A)
Vouchers - FURB 22274, 22275, 22189, 22190

Taxonomy and distribution - *Bokermannohyla luctuosa* occurs in south-eastern Brazil (Napoli, 2005). This is the first record of this species in southern Brazil. Despite the very similar morphology between *B. circumdata* and *B. luctuosa*, we were able to see the subtle difference in the tubercle of finger IV, which differ these two species (Fig. 9) (Pombal and Haddad, 1993).

Ecology - We found males of this species on the edge and inside the forest, at the elevation levels of 700 m and 1000 m, calling from November 2012 to January 2013, and from October 2013 to January 2014. In December 2012 we registered one female and observed some agonistic interactions among males placed at a small water body on the ground. *Bokermannohyla luctuosa* presents the reproductive mode 12 (Pombal and Haddad, 1993, Nunes-de-Almeida et al., 2021).

Dendropsophus berthalutzae
(Bokermann, 1962)
(Fig. 5B)
Vouchers - FURB 22754, 22897, 22899

Taxonomy and distribution - *Dendropsophus berthalutzae* occurs in the Atlantic Forest from the state of Espírito Santo to the state of Paraná, with a record in

the state of Minas Gerais (Moura, Lacerda and Feio, 2012, Comitti, 2017). This species belongs to the *D. decipiens* species group (Orrico et al., 2021).

Ecology - We found individuals of *D. berthalutzae* at the elevation level of 300 m, on the herbaceous vegetation in the forest edge. Calling males were observed from October 2012 to March 2013. This species laid eggs in the hanging foliage over a lentic breeding site in February 2013 (reproductive mode 22, Nunes-de-Almeida et al., 2021).

Dendropsophus elegans
(Wied-Neuwied, 1824)
(Fig. 5D)
Vouchers - FURB 22715, 22716, 22889, 22925

Taxonomy and distribution - This species occurs in the Serra do Mar mountain range, from northern Bahia (Canelas and Bertoluci, 2007; Gondim-Silva et al., 2016) to the state of Santa Catarina (Lucas and Garcia, 2011). It belongs to the *D. leucophyllatus* species group (Orrico et al., 2021).

Ecology - We found this species at elevation levels of 100 m and 300 m, in swamps and dams in open areas. Calling males were observed from October 2012 to February 2013, perched on herbaceous vegetation and on the grass. We did not observe females and spawning of *D. elegans*. This species lays its eggs in the water surface (reproductive mode 1, Bastos and Haddad, 1996, Nunes-de-Almeida et al., 2021).

Dendropsophus microps
(Peters, 1872)
(Fig. 5E)
Vouchers - FURB 22395

Taxonomy and distribution - This species is widely distributed in the south and southeast of Brazil (Maffei et al., 2009), and belongs to the *D. parviceps* species group (Orrico et al., 2021).

Ecology - We found *D. microps* only at elevation levels of 700 m and 1000 m. Calling males were observed from October 2012 to January 2013 and in the same period in 2013 and 2014, perched in herbaceous and grassy vegetation in swamps and ponds at the edge of the forest. We did not observe females and spawning of *D. microps*. This species lays its eggs in the water surface and presents exotrophic tadpoles (reproductive mode 1, Nunes-de-Almeida et al., 2021).

Dendropsophus minutus
(Peters, 1872)
(Fig. 5F)
Vouchers – FURB 22237, 22381, 22860, 22879, 22898

Taxonomy and distribution – This species is widely distributed all over the South America (Frost, 2021), and belongs to the *D. minutus* species group (Orrico et al., 2021). Despite its wide distribution, there are several lineages within this nominal species (Gehara et al., 2014).

Ecology - We found *D. minutus* at all elevation levels, occupying swamps, dams, and streams in open areas and in the forest edge areas. Calling males were observed from October 2012 to March 2013, and from August 2013 to January 2014, using herbaceous vegetation and bushes as calling sites. We found ovigerous females and amplected couples during November and December 2012 and 2013. This species lays its eggs on the water surface, and presents exotrophic tadpoles (reproductive mode 1, Nunes-de-Almeida et al., 2021).

Dendropsophus nahdereri
(Lutz and Bokermann, 1963)
(Fig. 5G)
Vouchers - FURB 22471, 22472

Taxonomy and distribution - This species is restricted to the south of Brazil, mostly recorded in the state of Santa Catarina (Conte et al., 2010), and belongs to the *D. marmoratus* species group (Orrico et al., 2021).

Ecology - We found *D. nahdereri* in open areas and in the forest edge at elevation levels of 700 m and 1000 m. Calling males were observed on the ground, perched on herbaceous vegetation or in trees near water bodies, from October 2012 to January 2013, and from July 2013 to January 2014. We observed amplected couples only in November 2012. This species lays its eggs in lentic environments, and presents exotrophic tadpoles (reproductive mode 1, Haddad et al., 2013, Nunes-de-Almeida et al., 2021).

Dendropsophus werneri
(Cochran, 1952)
(Fig. 5C)
Vouchers - FURB 22382, 22392, 22797, 22800, 22940

Taxonomy and distribution - This species occurs in the Serra do Mar mountain range, from Rio de the state of Janeiro to the state of Rio Grande do Sul (Pombal and Bastos, 1998; Freire et al., 2016), and belongs to the *D. microcephalus* species group (Orrico et al., 2021).

Ecology - We found individuals of *D. werneri* in herbaceous vegetation of dams and swamps in open areas and on the edge of the forest at elevations of 100 m, 300 m, and 700 m, sometimes syntopically to *D. berthalutzae*. We observed calling males from October 2012 to March 2013, and from November 2013 to January 2014. Some females were sporadically observed close to males, but we did not observe spawning of this species. *Dendropsophus werneri* lays its eggs on the water surface in lentic environments and presents exotrophic tadpoles (reproductive mode 1, Nunes-de-Almeida et al., 2021).

Phyllomedusa distincta
Lutz, 1950
(Fig. 8A)
Vouchers - FURB 22243, 22245

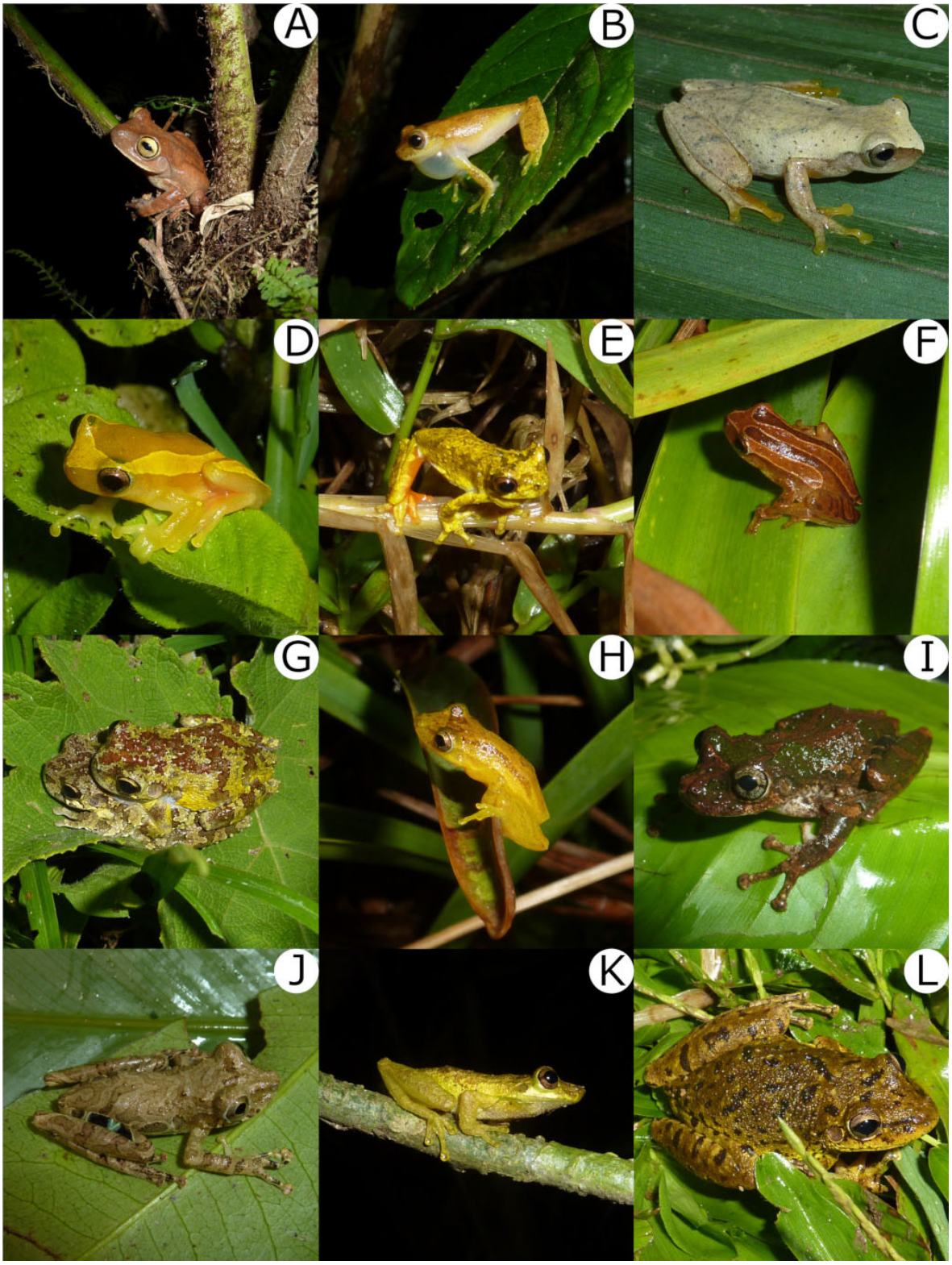


Fig. 5. Some amphibians registered in Serra Dona Francisca: (A) *Bokermannohyla luctuosa,* (B) *Dendropsophus berthalutzae,* (C) *Dendropsophus werneri,* (D) *Dendropsophus elegans,* (E) *Dendropsophus microps,* (F) *Dendropsophus minutus,* (G) *Dendropsophus nahdereri,* (H) *Scinax aromothynella,* (I) *Scinax catharinae,* (J) *Scinax littoralis,* (K) *Scinax rizibilis,* and (L) *Scinax fuscovarius*.

Taxonomy and distribution - This species occurs from south of São Paulo to north of Rio Grande do Sul states (Kwet et al., 2010), and belongs to the *P. burmeisteri* species group (Pombal and Haddad, 1992; Faivovich et al., 2010).

Ecology - We found individuals of *P. distincta* foraging at the elevation level of 1000 m, and males calling in a swamp at the elevation level of 700 m, all at the edges of the forest, only in October 2012. We did not observe females or spawning, but this species lays its eggs in foliage hanging over lentic breeding sites (reproductive mode 37, Nunes-de-Almeida et al., 2021).

Scinax aromothyella
Faivovich, 2005
(Fig. 5H)
Vouchers - FURB 22259, 22314, 22647, 22772, 22723, 22891, 22944.

Taxonomy and distribution - This species occurs in Uruguay, Argentina, and Brazil in the state of Paraná (Pereyra et al., 2012).

Ecology - We found *S. aromothyella* in temporary swamps from only in open areas, at elevation level of 1000 m. Calling males were observed in herbaceous vegetation, in February, November and December 2013, and January 2014. We recorded ovigerous females in the same period and in September 2013. We did not observe the reproductive mode of this species, which remains unknown.

Scinax catharinae
(Boulenger, 1888)
(Fig. 5I)
Vouchers - FURB 22239, 22281, 22311,22746

Taxonomy and distribution - This species occurs in the mountain regions of the state of Santa Catarina and Rio Grande do Sul (Lutz, 1973). There are some records in the interior of Santa Catarina (Lucas and Fortes, 2008) and Paraná states (Machado and Bernarde, 2002, Crivelari et al., 2014), but in some of these records the identification is uncertain (*Scinax* cf. *catharinae*). The type locality of the species is imprecise (*Sierra do Catharina,* Boulenger, 1888a), but Lutz (1973) suggested that it is probably the mountains of northern of the state of Santa Catarina, where the German immigrants settled.

Ecology - We found individuals foraging in a stream at the edge of the forest, only at the elevation level of 1000 m, from November 2012 to March 2013, and October 2013. We did not observe the reproductive behaviour, which species remains unknown.

Scinax littoralis
(Pombal and Gordo, 1991)
(Fig. 5J)
Vouchers - FURB 22278, 22280, 22711

Taxonomy and distribution - This species occurs from São Paulo (Pombal and Gordo, 1991) to state of Santa Catarina (Lucas and Garcia, 2011), and belongs to the *Scinax catharinae* group (Faivovich et al., 2005).

Ecology - We found individuals of *S. littoralis* in swamps and streams at the edge of the forest, at elevation levels of 100 m and 300 m. Calling males were observed on the shrubby vegetation, from October 2012 to March 2013; only one female was found in February 2013. This species presents the reproductive mode 7, with eggs and tadpoles in bromeliad axils (Toledo et al., 2012) and reproductive modes 1 or 2, with exotrophic eggs and tadpoles in lentic or lotic water breeding sites (Pombal and Gordo, 1991, Nunes-de-Almeida et al., 2021).

Scinax rizibilis
(Bokermann, 1964)
(Fig. 5K)
Vouchers - FURB 22371, 22372, 22391, 22473, 22869

Taxonomy and distribution - This species occurs from the state of São Paulo (Bokermann, 1964) to the state of Rio Grande do Sul (Kwet et al., 2010) and belongs to the *S. catharinae* species group (Faivovich et al., 2005).

Ecology - We found *S. rizibilis* in lentic environments, such as swamps and dams at the forest edge and in the forest interior, at all sampled elevation levels. Calling males were observed on the shrubby vegetation from October 2012 to March 2013, and we found only one female, in October 2012. We did not observe spawning. This species lays its eggs on the water surface (Bokermann, 1964) and uses foam nests to protect the eggs (reproductive mode 65, Haddad, Pombal and Gordo, 1990, Nunes-de-Almeida et al., 2021).

Scinax* sp. (gr. *perpusillus)
Vouchers - no vouchers

Taxonomy and distribution – This species is morphologically and ecologically similar to the species belonging to the Scinax *perpusillus* group*,* which are distributed from the state of Espírito Santo to the state of Paraná (Faivovich et al. 2005). Despite Bertha Lutz (1973), in her book "Brazilian Species of *Hyla*" (1973) provided the species occurrence for Guaramirin and Joinville municipalities, state of Santa Catarina, Brazil, we did not collect individuals, hampering further comparisons. The advertisement calls (n = 9, one male) have the following parameters: Fmin 3617.000–3789.000 Hz (3707.777 ± 50.166), Fmax 4608.000–4780.000 Hz (4732.222 ± 58.661), Fdom 4134.000–4177.000 Hz (4167.444 ± 18.961), call duration 0.205–0.278 s (0.249 ± 0.026), 3–4 notes per call (3.777 ± 0.440), note duration 0.029–0.046 s (0.034 ± 0.003), 7–12 pulses per note (9.527 ± 1.922). *Scinax* aff. *perpusillus* differs from *S. perpusillus* by the lower dominant frequency (4134–4177 Hz), longer duration (0.200–0.270 s), and higher number of pulses (7–12 pulses/note) (4554–4856 Hz, 0.007–0.018 s, 3–5 pulses/note, Rio de Janeiro municipality, Rio de

Janeiro state, 700 km from Serra Dona Francisca, Pombal and Bastos 2003). Nevertheless, we kept the population of the study area as *S.* aff. *perpusillus*.

Ecology - We did not observe individuals of this species, but we heard several males calling in the epiphytic bromeliads occurring one to two meters from the ground, at the edge of the forest and in the forest interior. We recorded this species at altitude levels of 300 m and 700 m, from October to December 2012, and from December 2013 to January 2014. Is worth to note that species belonging to the *Scinax perpusillus* group are bromeligenous that lays their eggs in the accumulated water of tank bromeliads (reproductive mode 4, Peixoto, 1995, Nunes-de-Almeida et al., 2021).

Scinax fuscovarius
(Lutz, 1925)
(Fig. 5L)
Vouchers - FURB 22258, 22299

Taxonomy and distribution - This species is widely distributed in the eastern Brazil from Alagoas to Rio Grande do Sul states, and in the northern Argentina, northern and eastern Paraguay, and Bolivia, from 150 to 1800 m elevation (Frost, 2021), and belongs to the *S. ruber* species group (Faivovich et al., 2005).

Ecology - We found individuals of *S. fuscovarius* at elevation levels of 100 m, 700 m, and 1000 m, in temporary or permanent lentic environments in open areas and in forest edges areas. We observed males calling in herbaceous vegetation and grasses, from October 2012 to February 2013, and from November 2013 to January 2014. We did not find females or spawning. This species lays its eggs on the water surface and presents exotrophic tadpoles (reproductive mode 1, Kwet et al. 2010, Nunes-de-Almeida et al., 2021).

Scinax granulatus
(Peters, 1871)
(Fig. 6A)
Vouchers - FURB 22648, 22710, 22764, 22771

Taxonomy and distribution - This species is widely distributed south of South America, occurring in north-eastern Argentina, Uruguay, in the Brazilian states of Paraná, Santa Catarina, and Rio Grande do Sul, and in south-eastern Paraguay (Conte et al., 2010; Frost, 2021), and belongs to the *S. ruber* species group (Faivovich et al., 2005).

Ecology - We found *S. granulatus* only at elevation level of 1000 m. Calling males were observed in temporary or permanent lentic environments, perched on herbaceous vegetation at open areas, from November 2012 to April 2013, and from August 2013 to January 2014. We did not find females or spawning. This species presents the reproductive mode 1 (Nunes-de-Almeida et al., 2021), and presents exotrophic tadpoles (Kwet et al. 2010, Nunes-de-Almeida et al., 2021).

Scinax imbegue
Nunes, Kwet and Pombal, 2012
(Fig. 6B)
Vouchers - FURB 22284, 22823, 22921

Taxonomy and distribution - This species is widely distributed in the south and southeast of Brazil (Frost, 2021) and it is endemic to the Atlantic Forest (Nunes, Kwet and Pombal, 2012). *Scinax imbegue* belongs to the *S. ruber* species group (Nunes et al., 2012).

Ecology - We found *S. imbegue* in temporary and permanent lentic environments in open areas and in forest edges, at elevation levels from 100 m to 700 m. We observed males calling in herbaceous vegetation and grasses, from October 2012 to March 2013, and from September 2013 to January 2014; we found amplected couples in October and December 2012. This species has its nest absent, with non-froth floating eggs laid in lentic water (reproductive mode 1; Nunes et al. 2012, Nunes-de-Almeida et al., 2021).

Scinax perereca
Pombal, Haddad and Kasahara, 1995
(Fig. 6C)
Vouchers - FURB 22238, 22386, 22482, 22488, 22824

Taxonomy and distribution - *Scinax perereca* is known only from a few localities in the states of São Paulo to Rio Grande do Sul states in Brazil, and Misiones Province in north-eastern Argentina; likely in south-eastern Paraguay (Frost, 2021). This species belongs to the *S. ruber* group (Pombal, Haddad and Kasahara, 1995; Faivovich et al., 2005).

Ecology - We found *S. perereca* in temporary and permanent lentic environments in open areas and in forest edge areas, at all sampled elevation levels. We observed calling males on herbaceous vegetation or in underground cavities, from October 2012 to March 2013, and from September 2013 to January 2014. We also observed this species in forested areas, calling on tree trunks up to 60 cm from the ground, and did not find spawns or females. This species presents the reproductive mode 1 (Nunes-de-Almeida et al., 2021), with spawning laid in lentic environments and with exotrophic tadpoles (Kwet et al. 2010).

Scinax tymbamirim
Nunes, Kwet and Pombal, 2012
(Fig. 6D)
Vouchers - FURB 22257, 22722, 22896, 22903, 22946

Taxonomy and distribution - This species is widely distributed in the south and southeast of Brazil (Frost, 2021), endemic to the Atlantic Forest (Nunes et al., 2012). It belongs to the *S. ruber* species group (Nunes et al., 2012).

Ecology - We found *S. tymbamirim* in temporary and permanent lentic environments in open areas, only at elevation level of 100 m, with males calling from October 2012 to March 2013. We observed females and amplected couples in October 2012. This species

Fig. 6. Some amphibians registered in Serra Dona Francisca: (A) *Scinax granulatus,* (B) *Scinax imbegue,* (C) *Scinax pereireca,* (D) *Scinax tymbamirim,* (E) *Scinax squalirostris,* (F) *Sphaenorhynchus surdus,* (G) *Trachycephalus mesophaeus,* (H) *Crossodactylus* sp., (I) *Hylodes perplicatus,* (J) *Adenomera araucaria,* (K) *Adenomera nana*, and (L) *Leptodactylus paranaru*.

occurred syntopically with *S. imbegue* and *S. perereca*. It presents the reproductive mode 1 (Nunes-de-Almeida et al., 2021), with spawning laid in lentic environments and with exotrophic tadpoles (Nunes et al., 2012).

Scinax squalirostris
(Lutz, 1925)
(Fig. 6E)
Vouchers - FURB 22369, 22729, 22755

Taxonomy and distribution - This species is widely distributed in the south, southeast and midwest of Brazil (Frost, 2021), and belongs to the *S. ruber* species group (Faivovich et al., 2005).

Ecology - We found *S. squalirostris* only in temporary swamps in open areas at elevation level of 1000 m. Several calling males were observed from October 2012 to March 2013, and from May to December 2013. This species occurred syntopically with *S. fuscovarius*, *S. perereca* and *S. granulatus*. *Scinax squalirostris* presents the reproductive mode 1 (Nunes-de-Almeida et al., 2021), with spawning laid in lentic environments and with exotrophic tadpoles (Kwet et al. 2010).

Sphaenorhynchus surdus
(Cochran, 1953)
(Fig. 6F)
Vouchers - FURB 22370, 22246, 22475

Taxonomy and distribution - This species is restricted to the south of Brazil, in Araucaria Forest and in transitional areas between other associated physiognomies (Toledo et al., 2007).

Ecology - We found *S. surdus* only at elevation level of 1000 m, in lentic environments, using herbaceous vegetation, grasses and macrophytes as vocalization sites in open areas and in forest edge areas. We observed males calling from October 2012 to March 2013, and from August 2013 to January 2014. We did not find females and spawning. This species lays its eggs in lentic environments and presents exotrophic tadpoles (reproductive mode 3; Nunes-de-Almeida et al., 2021).

Trachycephalus mesophaeus
(Hensel, 1867)
(Fig. 6G)
Vouchers - FURB 22191, 22192

Taxonomy and distribution - This species occurs along the coast from the state of Rio Grande do Sul to the state of Pernambuco (Santana et al., 2016).

Ecology - We found *T. mesophaeus* in temporary swamps in open areas, forest edges and forest interior, at elevation levels from 100 m to 700 m. We observed several individuals, including males and females, after heavy rains in October, November, and December 2012. We found amplected couples laying the eggs on the surface of the water (reproductive mode 1, Nunes-de-Almeida et al., 2021); five weeks after the first reproductive event we found froglets of this species. Lutz (1973) observed the larval development of this species under laboratory conditions, and the total duration until metamorphosis was two to three months.

Family Hylodidae
***Crossodactylus* sp.**
(Fig. 6H)
Vouchers - FURB 22725, 22747, 22763

Taxonomy and distribution - The occurrence of *C. caramaschii* Bastos and Pombal, 1995 has already been reported for the study area (Pimenta, 2008). However, based on external morphology, such as the presence of a gland under the tympanum, as a discreet crest in *C. caramaschii*, very distinct in the *vouchers*, we were not able to associate this population to *C. caramaschii* or to any valid nominal species within the genus.

Ecology - We found individuals of *Crossodactylus* sp. in streams in the interior of the forest, only at elevation level of 700 m. Calling males were observed from October 2012 to January 2013, and in March 2013; we did not observe females or spawning. In January and February 2013, we found individuals foraging in streams, and two juveniles were captured by pitfall traps. Species of the genus *Crossodactylus* present the reproductive mode 18 (Nunes-de-Almeida et al., 2021), with spawning and tadpoles in early stages sheltered in burrows on the banks of the stream; after development, the exotrophic tadpoles move to water.

Hylodes perplicatus
(Miranda-Ribeiro, 1926)
(Fig. 6I)
Vouchers - FURB 22252, 22273, 22863

Taxonomy and distribution – This species is known only from few localities in the municipalities of São Bento do Sul, Corupá and Joinville, northen of the state of Santa Catarina, Brazil. Its type locality, Colônia Hansa-Humboldt (Miranda-Ribeiro, 1926), current Corupá and São Bento do Sul municipalities, state of Santa Catarina (Frost, 2021). The advertisement calls (n = 7 calls from one male) have the following parameters: dominant frequency 3445.000–3617.000 Hz (3524.857 ± 62.945), call duration 0.904–1.235 s (1.114 ± 0.114), notes per call 18–24 (21.571 ± 2.070), and note duration 0.026–0.044 (0.037 ± 0.006). These calls match with the description of the advertisement call available for *H. perplicatus* in this same locality (Monteiro, Comitti and Lingnau, 2014).

Ecology - We found *H. perplicatus* in streams in the interior of the forest, only at elevation levels of 300 m and 700 m. Calling males were observed from November 2012 to March 2013. We observed only one female in February 2013, and juveniles captured, mostly by pitfall traps, from November 2012 to

February 2013. This species has reproductive modes 14 and 18 and presents exotrophic tadpoles (Nunes-de-Almeida et al., 2021).

Family Leptodactylidae

Adenomera araucaria

Kwet and Angulo, 2002

(Fig. 6J)

Vouchers - FURB 22376, 22704, 22717, 22728, 22796, 22828, 22936

Taxonomy and distribution - This species is distributed in the south of Brazil, occurring in western Paraná state, and reaching the southern coast of the state of Santa Catarina (Conte et al., 2010; Fouquet et al., 2014).

Ecology - We found individuals of *A. araucaria* at elevation levels of 700 m and 1000 m. We observed males calling in the leaf litter at the edge and the interior of the forest, from October 2012 to January 2013, and from November 2013 to January 2014. From October 2012 to January 2013, we captured females with pitfall traps, and ovigerous females during December 2012 and January 2013. In January and February 2013, we captured two juveniles. This species lays its eggs in underground cavities or in leaf litter, in foam nests, and presents endotrophic tadpoles (reproductive mode 62, Kwet et al. 2010, Nunes-de-Almeida et al., 2021).

Adenomera nana

(Müller, 1922)

(Fig. 6K)

Vouchers - FURB 22260, 22261, 22262, 22264, 22276, 22295, 22296, 22316, 22317, 22318, 22385, 22393, 22476, 22718, 22744, 22768, 22825, 22892, 22893, 22931, 22945

Taxonomy and distribution - This species occurs in Santa Catarina and Paraná states, southern Brazil (Kwet, 2007, Conte et al., 2010, Fouquet et al., 2014).

Ecology - We found individuals of *A. nana* in all sampled elevation levels. We observed males calling in the leaf litter at the edge and the interior of the forest, from October 2012 to March 2013, and from September 2013 to January 2014. We captured females in the pitfall traps from October 2012 to January 2013, and ovigerous females during December 2012 and January 2013. This species lays its eggs in underground cavities or in leaf litter, in foam nests, and presents endotrophic tadpoles (reproductive mode 62, Heyer, 1973, Kwet et al. 2010, Nunes-de-Almeida et al., 2021).

Leptodactylus paranaru

Magalhães, Lyra, Carvalho, Baldo, Brusquetti, Burella, Colli, Gehara, Giaretta, Haddad, Langone, López, Napoli, Santana, Sá and Garda, 2020.

(Fig. 6L)

Vouchers - FURB 22187, 22188

Taxonomy and distribution - This species belongs to the *Leptodactylus latrans* group (Magalhães et al., 2020), and represents a recently described species, which was removed from the synonymy of *L. latrans* (Magalhães et al., 2020). The Southern-butter-frog is distributed in the south-eastern coastal region of the Atlantic Forest, from Santos municipality, in the state of São Paulo, to the northeastern state of Rio Grande do Sul, located east of the Serra do Mar mountain range (Magalhães et al., 2020).

Ecology - We found this species at all sampled elevation levels, in lentic environments (temporary or permanent swamps and dams) in open areas and on forest edges. Calling males were observed from October 2012 to March 2013, and from October 2013 to January 2014, but we also found individuals foraging in April, August, and September 2013. We observed females and tadpoles from November 2012 to March 2013, and juveniles were captured with pitfall traps in January and March 2013. Tadpoles form schools that receive adult parental care. This species lays its eggs in foam nests in lentic environments, and presents exotrophic tadpoles (reproductive mode 45, Nunes-de-Almeida et al., 2021).

Leptodactylus notoaktites

Heyer, 1978

(Fig. 7A)

Vouchers - FURB 22193, 22251, 22255, 22256, 22292, 22303, 22367, 22816, 22895

Taxonomy and distribution - This species occurs from the state of São Paulo to the state of Santa Catarina (Heyer, 1978; Figueiredo et al., 2018) and belongs to the *L. fuscus* species group (Sá et al., 2014).

Ecology - We found *L. notoaktites* at all elevation levels in temporary ponds in open areas and on forest edges, where we observed males calling from October 2012 to March 2013, and from October 2013 to January 2014. We did not find females; we captured juveniles in pitfall traps, from December 2012 to March 2013. As usually observed for species of the *L. fuscus* group, *L. notoaktites* lays its eggs in foam nests in underground cavities, and presents exotrophic tadpoles (reproductive mode 64, Nunes-de-Almeida et al., 2021).

Leptodactylus plaumanni

Ahl, 1936

(Fig. 7B)

Vouchers - FURB 22467, 22366, 22483

Taxonomy and distribution - This species is distributed in north-eastern Misiones Province, Argentina, and in the Brazilian states of Rio Grande do Sul, Paraná, and Santa Catarina, likely into adjacent Paraguay (Kwet, Di-Bernardo and Garcia, 2001; Frost, 2021), and belongs to the *L. fuscus* species group (Sá et al., 2014).

Ecology - We found individuals of *L. plaumanni* at elevation level of 1000 m, in temporary swamps in open areas. We observed males calling from October 2012 to January 2013, and from September 2013 to January 2014; only one juvenile was captured in March 2013, by

Fig. 7. Some amphibians registered in Serra Dona Francisca: (A) *Leptodactylus notoaktites,* (B) *Leptodactylus plaumanni,* (C) *Physalaemus aff. gracilis,* (D) *Physalaemus cuvieri,* (E) *Physalaemus lateristriga,* (F) *Physalaemus nanus,* (G) *Scythrophrys sawayae,* (H) *Chiasmocleis leucosticta,* (I) *Elachistocleis bicolor,* (J) *Odontophrynus americanus,* (K) *Proceratophrys boiei,* and (L) *Proceratophrys subguttata*.

pitfall trap. *Leptodactylus plaumanni* lays its eggs in foam nests in underground cavities, and presents exotrophic tadpoles (reproductive mode 64, Nunes-de-Almeida et al., 2021).

Physalaemus* aff. *gracilis
(Fig. 7C)
Vouchers - FURB 22287, 22731, 22853, 22854, 22934

Taxonomy and distribution - Species of the *P. gracilis* group are distributed in the south of Brazil, Uruguay, Paraguay, and Argentina, occupying areas above 600 m a.s.l., except *P. gracilis* (Nascimento, Caramaschi and Cruz, 2005) which occurs at lower elevations. Because we recorded individuals only at the elevation level of 1000 m and based on acoustic data and taxonomic remarks by Kwet et al., 2010, we believe that specimens from Serra Dona Francisca are not conspecific with *P. gracilis*. The advertisement calls (n=32 from four males) have the following parameters: dominant frequency 2454–2928 Hz (2823.066 ± 145.361), call duration 0.986–1.328 s (1.114 ± 0.123), one note per call and seven harmonics.

Ecology - We registered *Physalaemus* aff. *gracilis* at elevation level of 1000 m, in lentic environments (permanent or temporary) in open areas and in forest edges areas. We observed males calling from October 2012 to February 2013, and from July 2013 to January 2014. Females were captured in pitfall traps from October 2012 to March 2013; only one juvenile was captured in January 2013. Species of the genus *Physalaemus* presents reproductive mode 45 (Nunes-de-Almeida et al., 2021), laying their eggs in floating foam nests, and present exotrophic tadpoles in ponds.

Physalaemus cuvieri
Fitzinger, 1826
(Fig. 7D)
Vouchers - FURB 22468, 22733, 22757, 22817, 22862, 22920, 22943

Taxonomy and distribution - This species is widely distributed in South America (Frost, 2021) and belongs to the *P. cuvieri* clade (Lourenço et al., 2015).

Ecology - We found individuals of *P. cuvieri* at all sampled elevation levels, in temporary or permanent lentic environments in open areas and in forest edges areas. We observed males calling from October 2012 to March 2013, and from June 2013 to January 2014. Females were captured by pitfall traps in November 2012. This species presents reproductive mode 45, laying their eggs in foam nests in lentic environments, and presents exotrophic tadpoles (Nunes-de-Almeida et al., 2021).

Physalaemus lateristriga
(Steindachner, 1864)
(Fig. 7E)
Vouchers - FURB 22305, 22368, 22378, 22394, 22481, 22709, 22819, 22820, 22821, 22865, 22890

Taxonomy and distribution - This species occurs from south-eastern state of São Paulo to north-eastern state of Santa Catarina and belongs to the *P. olfersii* species group (Cassini, Cruz and Caramaschi., 2010).

Ecology - We recorded one individual of *P. lateristriga* foraging at the elevation level of 100 m and several individuals at the elevation levels of 700 m and 1000 m, all at the edges of the forest. We observed males calling from October 2012 to March 2013, and from October 2013 to January 2014. During this same period, we captured females with pitfall traps; we captured juveniles from October 2012 to February 2013. This species presents reproductive mode 45 (Nunes-de-Almeida et al., 2021).

Physalaemus nanus
(Boulenger, 1888)
(Fig. 7F)
Vouchers - FURB 22319, 22384, 22930

Taxonomy and distribution - This species occurs from the north of the state of Rio Grande do Sul (Kwet et al., 2010) to the north state of Santa Catarina (Bokermann, 1962), extending mostly through the west of the state of Santa Catarina (Lingnau, 2009). *Physalaemus nanus* belongs to the *P. signifer* clade (Lourenço et al., 2015).

Ecology - We found *P. nanus* only at the elevation level of 1000 m, with males calling in temporary ponds in the forest interior, and in a swamp at the edge of the forest, from November 2012 to January 2013, and from September 2013 to January 2014. Only one female was captured in November 2013, by pitfall trap. As known for other species of the genus *Physalaemus*, *P. nanus* presents reproductive modes 45 and 59, producing foam nests in lentic environments, and presents exotrophic tadpoles (Nunes-de-Almeida et al., 2021).

Scythrophrys sawayae
(Cochran, 1953)
(Fig. 7G)
Vouchers - FURB 22727, 22815, 22827, 22872, 22888

Taxonomy and distribution - This species occurs from the south of the state of Paraná to the south of the state of Santa Catarina (Santos et al., 2020).

Ecology - We registered this species with pitfall traps at the elevation level 300 m, and in high abundance at the elevation level of 700 m (see Table 2). During the hot and rainy season, we captured males and females by pitfall traps, and found individuals in calling activity from October to November 2012 and 2013. We observed some amplected couples inside pitfall traps from October 2012 to January 2013. *Scythrophrys sawayae* uses temporary ponds as reproduction sites, where we found males calling at the edge of the forest and in the forest interior. Some spawning was observed in the cover of pitfall traps with accumulated water (reproductive mode 1, Nunes-de-Almeida et al., 2021).

Fig. 8. Some amphibians registered in Serra Dona Francisca: *Phyllomedusa distincta*.

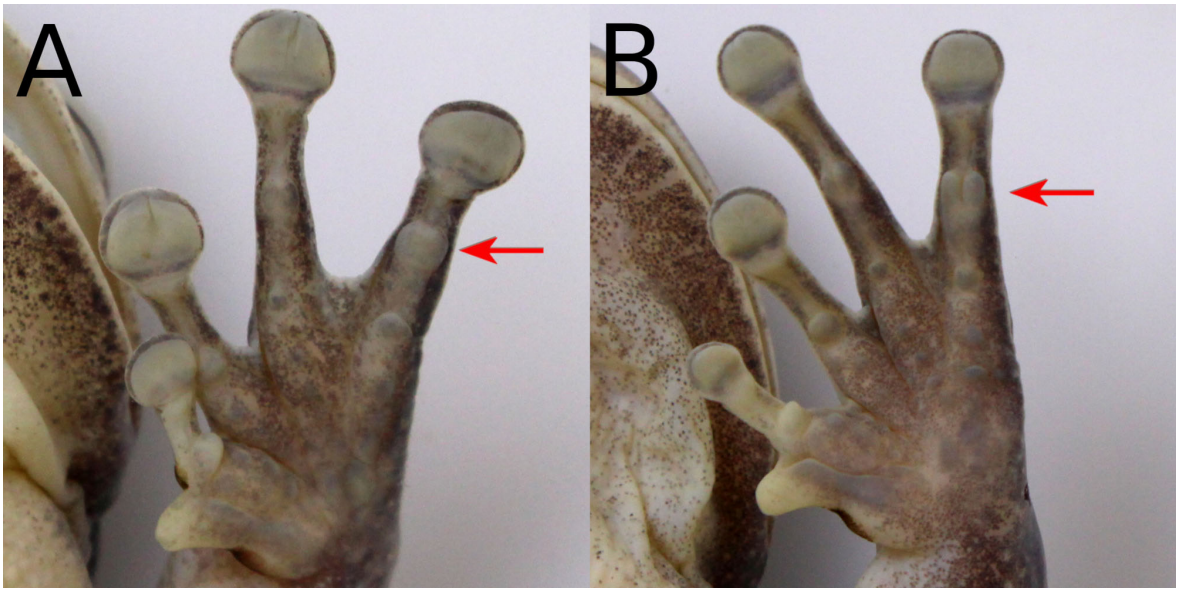


Fig. 9. Hands of two adult males of (A) *Bokermannohyla luctuosa,* from Campo Alegre municipality, state of Santa Catarina, and (B) *B. circumdata,* from Doutor Pedrinho municipality, state of Santa Catarina. The red arrows indicate the differences (bilobed in B) of the tubercles of finger IV.

Family Microhylidae
Chiasmocleis leucosticta
(Boulenger, 1888)
(Fig. 7H)
Vouchers - FURB 22388, 22484, 22485, 22750, 22769, 22866, 22905

Taxonomy and distribution - This species occurs from the states of São Paulo to Rio Grande do Sul (Cruz, Caramaschi and Izecksohn, 1997; Freire et al., 2016) and it is not assigned to any species group (Sá et al., 2012).

Ecology - We registered individuals of *C. leucosticta* in the forest at the elevation levels from 100 m to 700 m. We observed intense vocalization activity after heavy rains and captured numerous ovigerous females and amplected couples in pitfall traps, in October 2012. Besides this explosive episode, we also captured this species in abundance in pitfall traps during the summer (from October 2012 to February 2013). *Chiasmocleis leucosticta* builds foam nests in temporary swamps in the forest interior, and presents exotrophic tadpoles (reproductive mode 65, Haddad and Hödl, 1997, Nunes-de-Almeida et al., 2021).

Elachistocleis bicolor
(Guérin-Méneville, 1838)
(Fig. 7I)
Vouchers - FURB 22387, 22887, 22928

Taxonomy and distribution - This species occurs from the state of São Paulo to Rio Grande do Sul, with records in Paraguay, Uruguay, and Argentina (Caramaschi, 2010).

Ecology - We found *E. bicolor* only in the elevation levels of 100 m and 1000 m, with males calling in lentic and temporary environments at open areas. The vocalization period lasted from October 2012 to February 2013, and in November and December 2013. No females and juveniles were captured by pitfall traps. *Elachistocelis bicolor* lays its eggs directly on the surface of the water (reproductive mode 1, Rodrigues, Lopes and Uetanabaro, 2003, Nunes-de-Almeida et al., 2021).

Family Odontophrynidae
Odontophrynus americanus
(Duméril and Bibron, 1841)
(Fig. 7J)
Vouchers - FURB 22286, 22466, 22477

Taxonomy and distribution - This species is widely distributed, occurring from the south of the state of Minas Gerais to the state of Rio Grande do Sul, Paraguay, Argentina, and Uruguay, and belongs to the *O. americanus* species group (Rosset et al., 2006).

Ecology - We found this species in February 2012 and November 2013, in only one reproductive site, a temporary swamp in an open area, at the elevation level of 1000 m. We did not find spawning of *O. americanus* during fieldwork, but it is known that this species presents reproductive mode 2, laying its eggs in lentic environments, and presents exotrophic tadpoles (Nunes-de-Almeida et al., 2021).

Proceratophrys boiei
(Wied-Neuwied, 1824)
(Fig. 7K)
Vouchers - FURB 22195, 22196, 22197, 22198, 22199, 22200, 22242, 22469, 22470

Taxonomy and distribution - This species is widely distributed in Brazil, occurring from the state of Espírito Santo to Santa Catarina, in the Atlantic Forest domain, extending to the Cerrado domain in São Paulo and Minas Gerais states, and belongs to the *P. boiei* species group (Prado and Pombal, 2008).

Ecology - We found individuals of *P. boiei* at all sampled elevation levels. Calling activity was observed in swamps in the forest interior during the spring and summer periods from 2012 to 2014. We captured females and juveniles by pitfall traps, from October 2012 to January 2013, and from October 2012 to March 2013, respectively. We did not observe individuals reproducing, but this species presents reproductive modes 2 and 16 (Nunes-de-Almeida et al., 2021).

Proceratophrys subguttata
Izecksohn, Cruz and Peixoto, 1999
(Fig. 7L)
Vouchers - FURB 22193, 22194, 22290

Taxonomy and distribution - This species is restricted to south of the state of Paraná and northeast of the state of Santa Catarina and belongs to the *P. appendiculata* species complex (Prado and Pombal, 2008).

Ecology - Three individuals were captured by pitfall traps, and three juveniles were observed in the forest in October 2012, only at the elevation level of 700 m. We did not find males in calling activity, nor do we observe individuals reproducing. The reproductive mode of this species is 16 (Nunes-de-Almeida et al., 2021).

Family Ranidae
Lithobates catesbeianus
(Shaw, 1802)

Taxonomy and distribution - Widely introduced throughout the globe, including in several regions in Brazil (Both et al., 2011), this species is native from eastern North America and some adjacent areas in Central America (Frost, 2021).
Vouchers - FURB 22924
Only one juvenile was captured at the elevation level of 100 m, by pitfall trap. We did not find males in calling activity during fieldwork. This is an exotic and invasive species, distributed in the south, southeast, middle-west and northeast of Brazil (Both et al. 2011), with some records in Argentina (Akmentins and Cardozo, 2010), Uruguay (Laufer et al., 2008), Colombia, Ecuador, and Venezuela (IUCN SSC 2015).

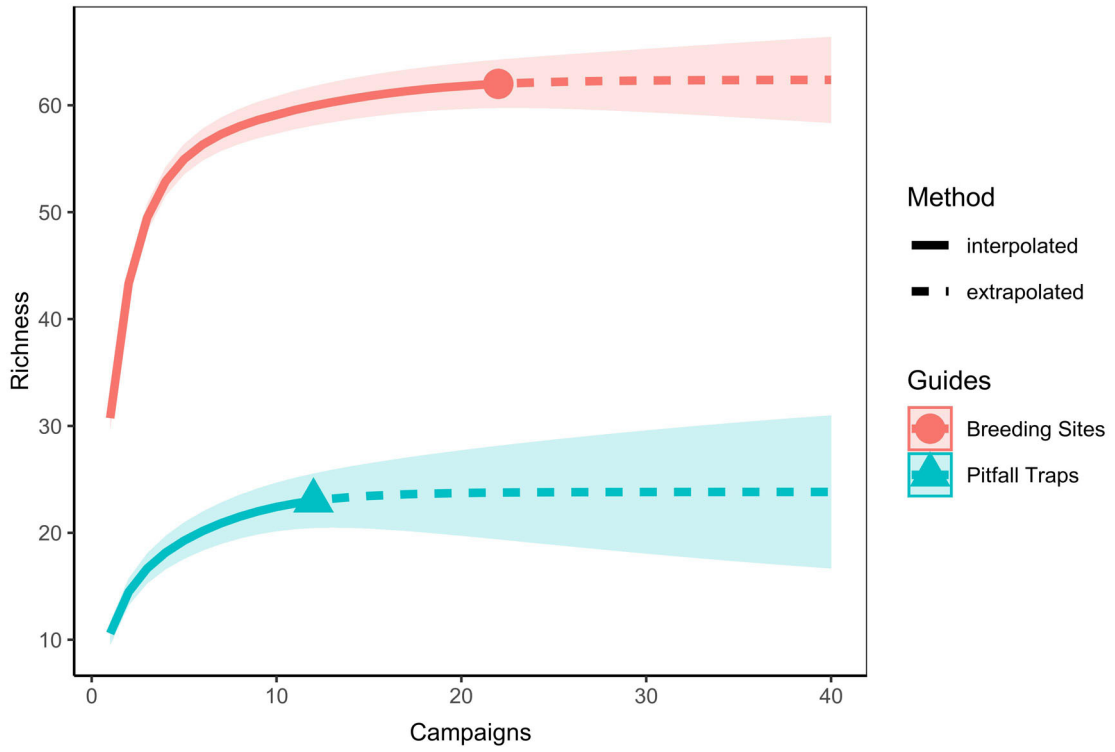


Fig. 10. Rarefaction curves for the Surveys at Breeding Sites (SBS) and Pitfall Traps (PT) sampling methods showing the interpolation curve (continuum line) with the observed richness (dot) and the extrapolation curve (dashed line) representing the estimated richness. Shaded areas represent the 95% confidence interval.

2. Species Richness and Species Composition

The rarefaction/extrapolation curves for the SBS (observed richness=62, estimated richness=62.382 ± 0.838) and PT (observed richness=23, estimated richness=23.825 ± 1.367) methods reached the asymptote, with no differences between the observed and estimated species richness (Hill numbers of order q=0) (Fig. 10). The sample completeness curves did not show differences among the sampled localities for each sampling method (Fig. 11). The high species richness (63 species) found in Serra Dona Francisca is probably related to the heterogeneous landscape of the region. The elevation gradient presents streams, ponds, and permanent and temporary swamps within the phytophysiognomies of the Atlantic Forest: lowlands, sub-montane and montane ombrophilous dense forests, mixed ombrophilous forest (or Araucaria Forest) and steppes (Veloso et al., 2012).

We found the greatest species richness at the highest elevations (Fig. 12), within areas with montane ombrophilous dense forest, mixed ombrophilous forest and steppes. The richness is the same for interpolated species curves between 1000 m and 700 m, as the same for 300 m and 100 m. The richness difference is in the interpolated species richness curves between these groups (1000 and 700 are different from 300 and 100), and in the extrapolated species richness curve of 300 m level had a light overlap of confidence interval with the 700 m and 1000 m elevation levels (Fig. 12 - Hill numbers q=0). For the SBS method, the elevation level 1000 m registered the highest species richness (observed=38.000, estimated=39.999 ± 3.739), followed by 700 m (observed=36.000, estimated=38.247 ± 3.392), 300 m (observed=26.000, estimated=32.228 ± 7.526) and 100 m (observed=24.000, estimated=24.998 ± 1.868). Only the elevation level of 300 m showed differences between observed and estimated species richness (Table 3). For the PT method, the interpolated and extrapolated curves had no differences among the elevation levels for species richness (Fig. 13 - Hill numbers q=0). The highest species richness was registered at the 700 m elevation level (observed=14.000, estimated=14.665 ± 1.303),

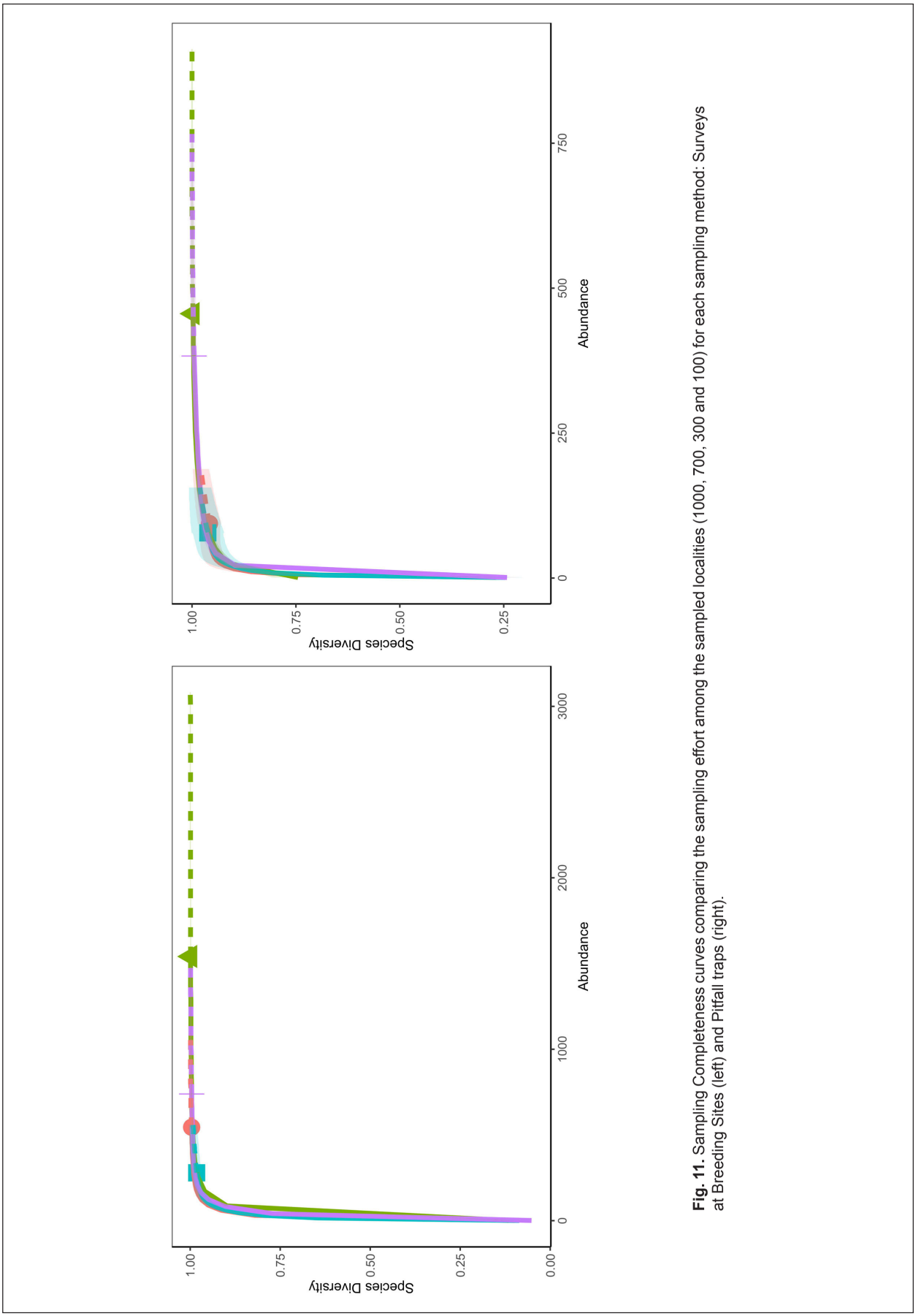


Fig. 11. Sampling Completeness curves comparing the sampling effort among the sampled localities (1000, 700, 300 and 100) for each sampling method: Surveys at Breeding Sites (left) and Pitfall traps (right).

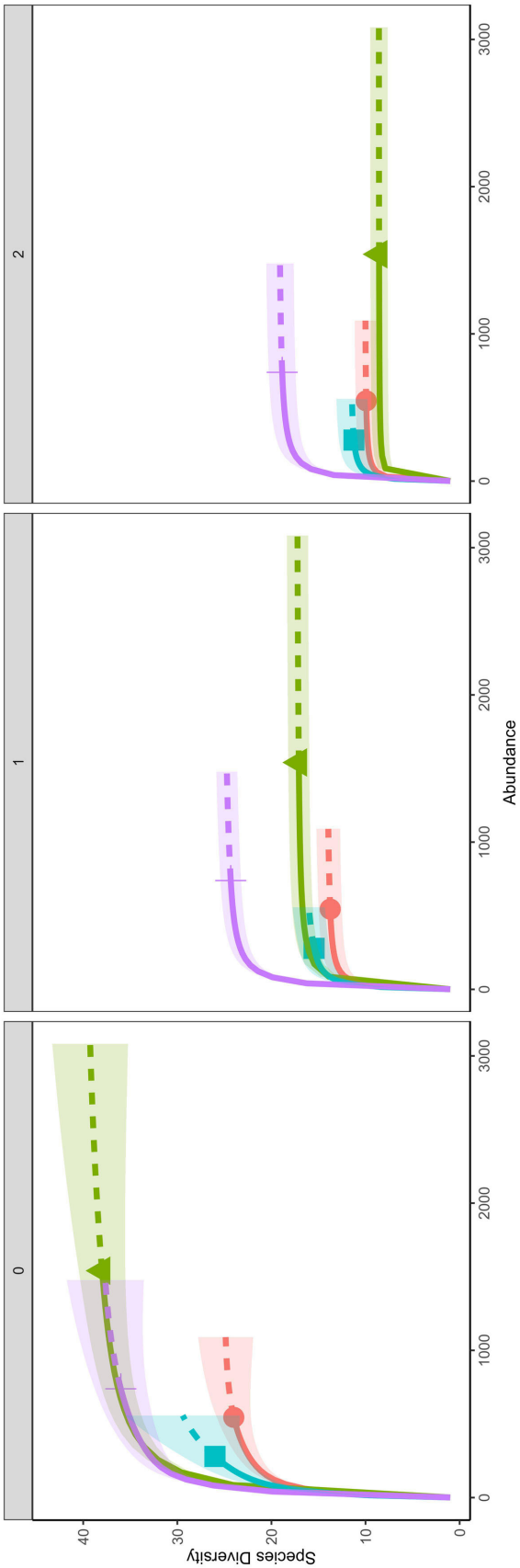


Fig. 12. Rarefaction curves for the Surveys at Breeding Sites (SBS) sampling method showing the interpolation curve (continuum line) and the extrapolation curve (dashed line) representing the richness (Hill number=0), Shannon diversity (Hill number=1) and Simpson diversity (Hill number=2) with twice the sample size, for each sampled locality (1000 - green; 700 - purple; 300 - blue; 100 - red). Shaded areas represent the 95% confidence interval.

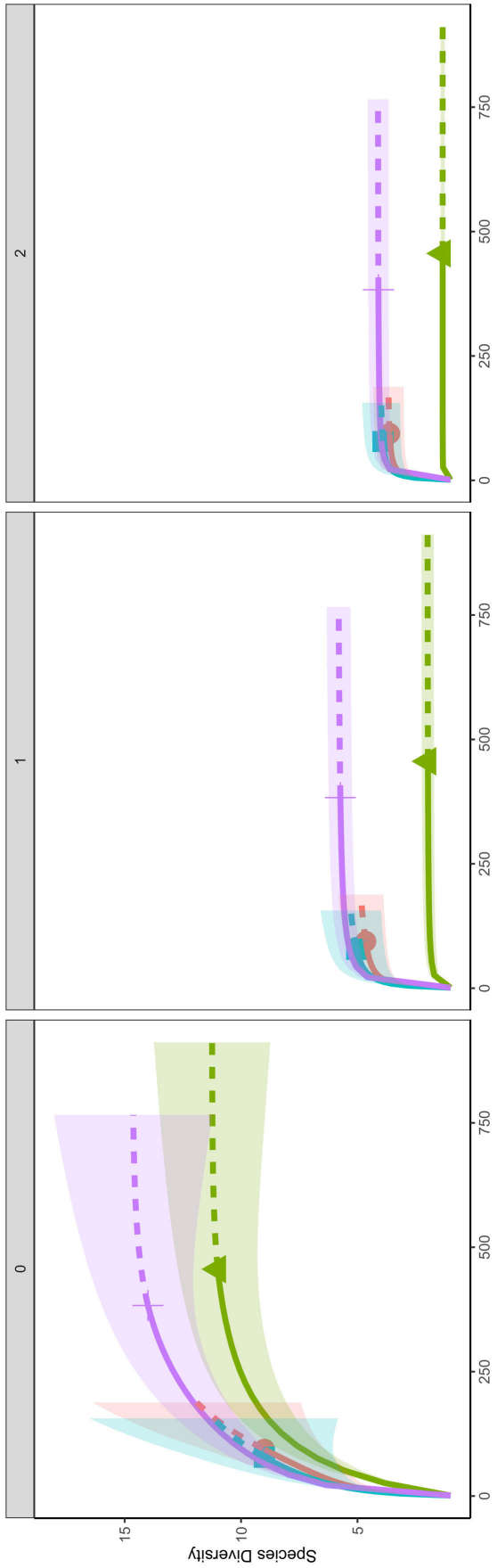


Fig. 13. Rarefaction curves for the Pitfall Traps (PT) sampling method showing the interpolation curve (continuum line) and the extrapolation curve (dashed line) representing the richness (Hill number=0), Shannon diversity (Hill number=1) and Simpson diversity (Hill number=2) with twice the sample size, for each sampled locality (1000 - green; 700 - purple; 300 - blue; 100 - red). Shaded areas represent the 95% confidence interval.

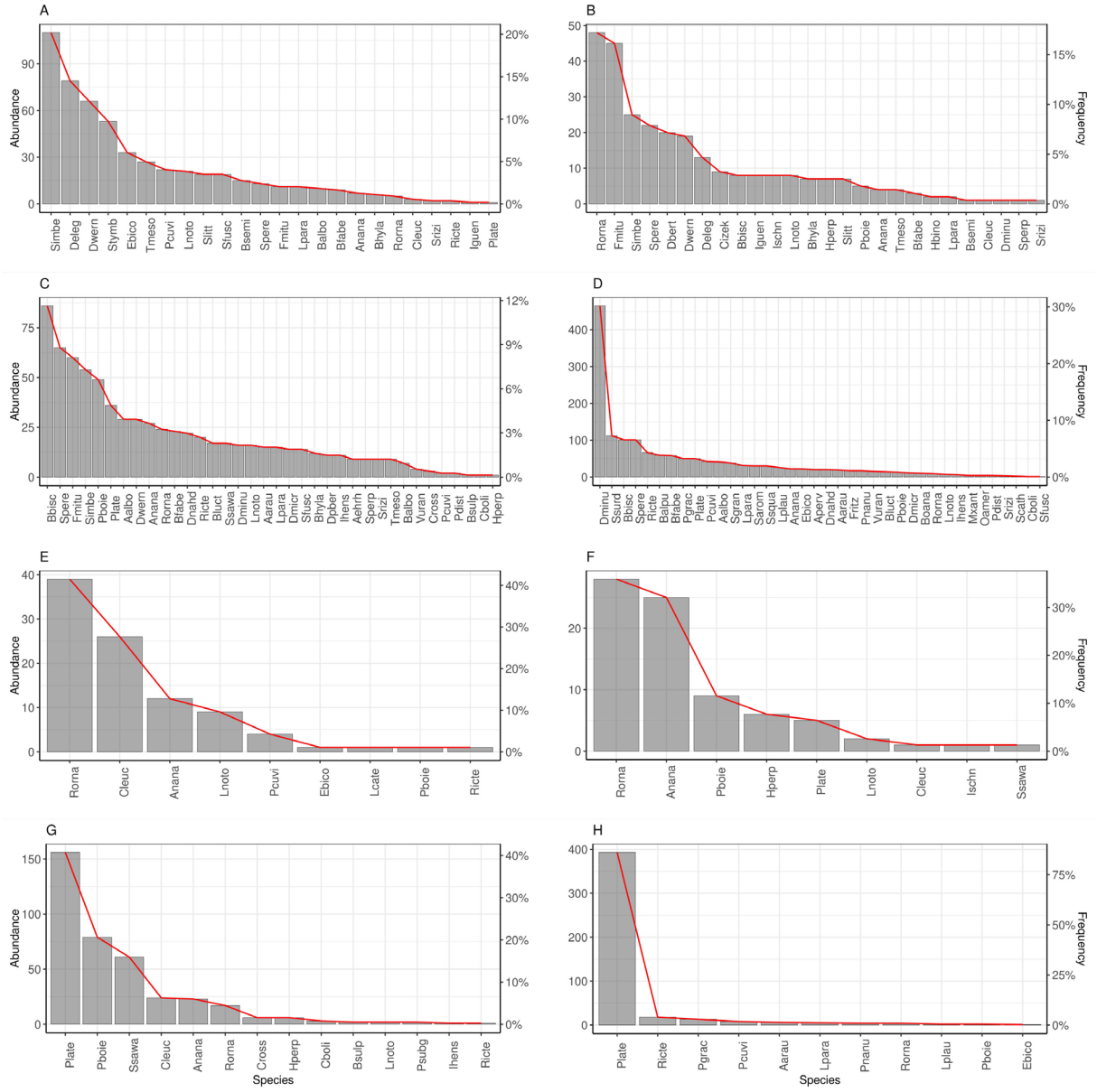


Fig. 14. Abundance distribution of the anuran species registered for each sampled locality (100 - A, E; 300 - B, F; 700 - C, G; 1000 - D, H) and sampling method (Surveys at Breeding Sites - A-D; Pitfall traps - E-H). Grey bars – relative (SBS) and total (PT) abundances (left axis); Red line - percentage of abundance (right axis). Aalbo - *Aplastodiscus albomarginatus,* Aarau - *Adenomera araucaria,* Aehrh - *Aplastodiscus ehrhardti,* Anana - A*denomera nana,* Aperv - *Aplastodiscus perviridis,* Balbo - *Boana albomarginata,* Balpu - *Boana albopunctata,* Bbisc - *Boana bischoffi,* Bfabe - *Boana faber,* Bhyla - *Bokermanohyla hylax,* Bluct - *Bokermanohyla luctuosa,* Boana - *Boana semiguttata,* Bsemi - *Boana semilineata,* Bsulp - *Brachycephalus sulfuratus,* Cboli - *Cycloramphus bolitoglossus,* Cizek - *Cycloramphus izecksohni,* Cleuc - *Chiasmocleis leucosticta,* Cross - *Crossodactylus* sp., Dbert - *Dendropsophus berthalutzae,* Deleg - *Dendropsophus elegans,* Dmicr - *Dendropsophus microps,* Dminu - *Dendropsophus minutus,* Dnahd - *Dendropsophus nahdereri*, Dpber - *Dendrophryniscus berthalutzae,* Dwern - *Dendropsophus werneri,* Ebico - *Elachistocleis bicolor,* Fmitu - *Fritziana mitus,* Fritz - *Fritziana* sp., Hbino - *Haddadus binotatus,* Hperp - *Hylodes perplicatus,* Lcate - *Lithobates catesbeianus,* Iguen - *Ischnocnema* sp. (gr. *guentheri*), Ihens - *Ischnocnema henselii,* Ischn - *Ischnocnema* sp. (*I. lactea* species series), Llatr - *Leptodactylus paranaru,* Lnoto - *Leptodactylus notoaktites,* Lplau - *Leptodactylus plaumanni,* Mxant - *Melanophryniscus xanthostomus,* Oamer - *Odontophrynus americanus,* Sarom - *Scinax aromothyella,* Scath - *Scinax catharinae,* Slitt - *Scinax littoralis,* Sperp - *Scinax* aff. *perpusillus,* Srizi - *Scinax rizibilis,* Pboie - *Proceratophrys boiei,* Pcuvi - *Physalaemus cuvieri,* Pdist - *Phyllomedusa distincta,* Pgrac - *Physalaemus* aff. *gracilis,* Plate - P*hysalaemus lateristriga,* Pnanu - *Physalaemus nanus,* Psubg - *Proceratophrys subguttata,* Rorna - *Rhinella ornata,* Ricte - *Rhinella icterica,* Sfusc - *Scinax fuscovarius,* Sgran - *Scinax granulatus,* Simbe - *Scinax imbegue,* Spere - *Scinax perereca,* Ssawa - *Scythophrys sawayae,* Ssqua - *Scinax squalirostris,* Ssurd - *Sphaenorhynchus surdus,* Stymb - *Scinax tymbamirim,* Tmeso - *Trachycephalus mesophaeus,* Vuran - *Vitreorana uranoscopa*.

Table 3. Results from asymptotic analysis comparing the Species richness (Chao Richness), Shannon diversity (Chao Shannon) and Simpson diversity (Chao Simpson) among sampled localities: 1000, 700, 300 and 100; for each sampling method: SBS - Sampling at Breeding Sites and PT - pitfall traps. S.E. - Standard Error, CI - confidence interval.

Method	Sampled Locality	Diversity index	Observed	Estimator	S.E.	Lower CI	Upper CI
SBS	1000	Species richness	38,000	39,999	3,739	38,181	60,115
		Shannon diversity	17,089	17,314	0,536	17,089	18,363
		Simpson diversity	8,559	8,601	0,485	8,559	9,551
	700	Species richness	36,000	38,247	3,392	36,266	55,016
		Shannon diversity	24,322	24,972	0,706	24,322	26,356
		Simpson diversity	18,857	19,325	0,932	18,857	21,152
	300	Species richness	26,000	32,228	7,526	26,976	5,996
		Shannon diversity	15,457	16,406	0,968	15,457	18,304
		Simpson diversity	11,231	11,66	0,861	11,231	13,348
	100	Species richness	24,000	24,998	1,868	24,093	5,048
		Shannon diversity	13,752	14,073	0,541	13,752	15,135
		Simpson diversity	9,928	10,094	0,602	9,928	11,274
PT	1000	Species richness	9,000	14,936	7,05	9,944	46,32
		Shannon diversity	4,644	5,026	0,504	4,644	6,014
		Simpson diversity	3,618	3,723	0,379	3,618	4,465
	700	Species richness	9,000	13,442	7,106	9,488	49,421
		Shannon diversity	5,036	5,483	0,67	5,036	6,797
		Simpson diversity	3,905	4,058	0,466	3,905	4,972
	300	Species richness	14,000	14,665	1,303	14,057	21,789
		Shannon diversity	5,734	5,845	0,302	5,734	6,437
		Simpson diversity	4,099	4,132	0,249	4,099	4,62
	100	Species richness	11,000	11,249	0,728	11,013	15,725
		Shannon diversity	1,971	1,995	0,128	1,971	2,246
		Simpson diversity	1,341	1,342	0,049	1,341	1,437

followed by the 1000 m elevation level (observed=11.000, estimated=11.249 ± 0.728) and by the elevation levels of 100 m (observed=9.000, estimated=14.936 ± 7.050) and 300 m (observed=9.000, estimated=13.442 ± 7.106). The elevation levels of 100 m and 300 m had the same species richness and were the only ones to show differences between observed and estimated species richness (Table 3).

Compared to some studies on anuran in elevation gradients (*e.g.,* Fauth, Crother and Slowinski, 1989, Lescano et al., 2015), we found an inverted pattern of species richness, with an increase in the number of species toward higher elevations. Such pattern, however, has already been reported for other anuran communities (Heyer, 1967; Naniwadekar and Vasudevan, 2007). The Shannon and Simpson indexes are two measurements that show the heterogeneity of diversity and the evenness of some community (Krebs, 1999). While the Shannon index focuses more on equitability between species, Simpson focuses more on dominance between common and rare species (Magurran, 2011). The elevation levels of 300 m and 100 m showed lower Shannon and Simpson diversity indexes for the SBS method, with the Simpson diversity index of the 300 m altitude level being higher than that of the 1000 m level (Fig. 12 - Hill numbers q=1 and 2). For the SBS method, *S. imbegue* was the dominant species at 100 m elevation (Fig. 14 A) and *R. ornata* at 300 m elevation (Fig. 14 B). Even with lower species richness for the PT method, the sampled elevations 100 m and 300 m had similar values of Shannon and Simpson indexes with the elevation level 700 m (Fig. 13 - Hill numbers q=1 and 2), being *R. ornata* the dominant species in both elevation levels (Fig. 14 E, F). The elevation level 700 m had the highest Shannon and Simpson diversity indexes, with differences from all sampled elevation levels for SBS and only from 1000 m for PT method (Fig. 12 and 13 -

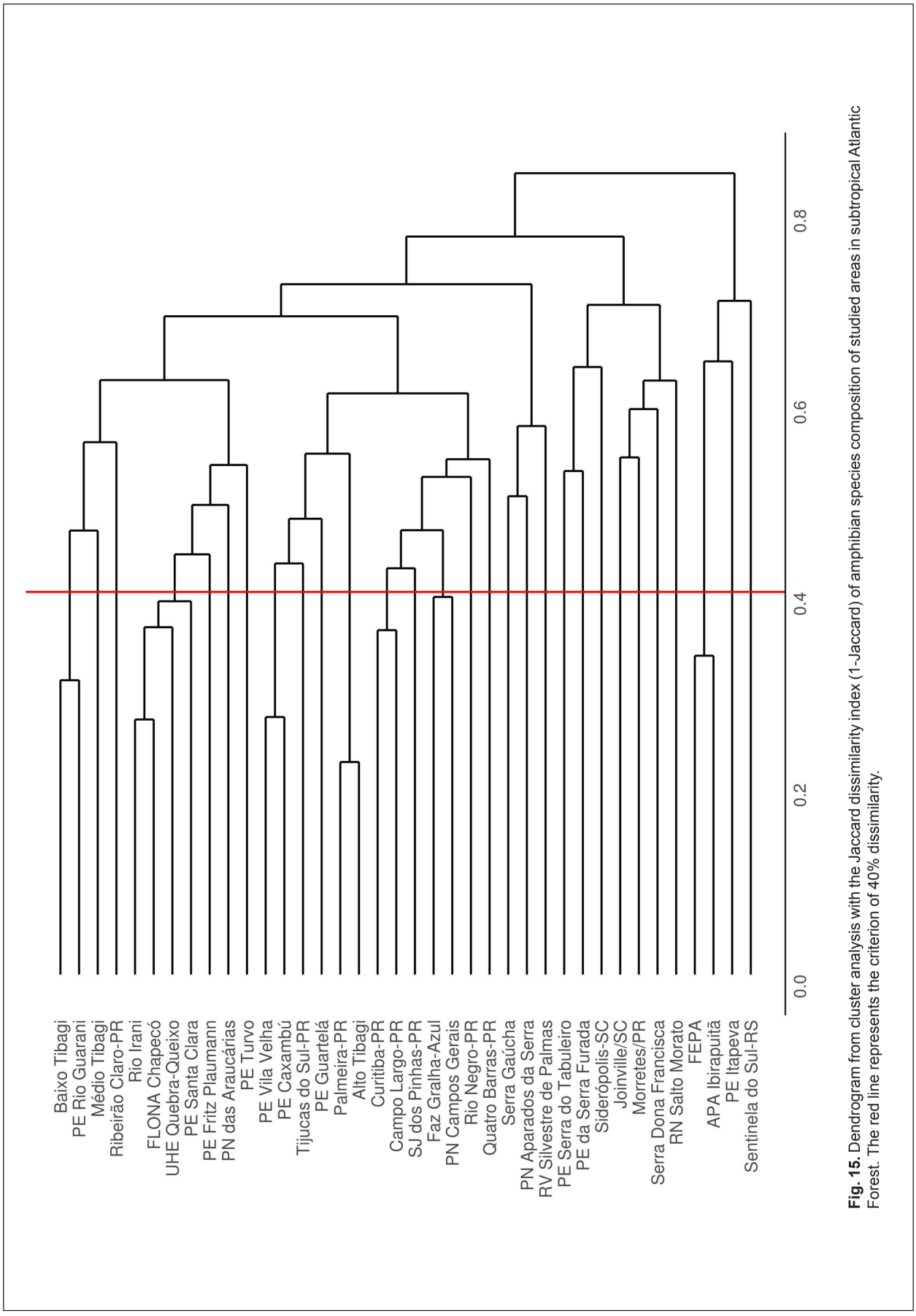


Fig. 15. Dendrogram from cluster analysis with the Jaccard dissimilarity index (1-Jaccard) of amphibian species composition of studied areas in subtropical Atlantic Forest. The red line represents the criterion of 40% dissimilarity.

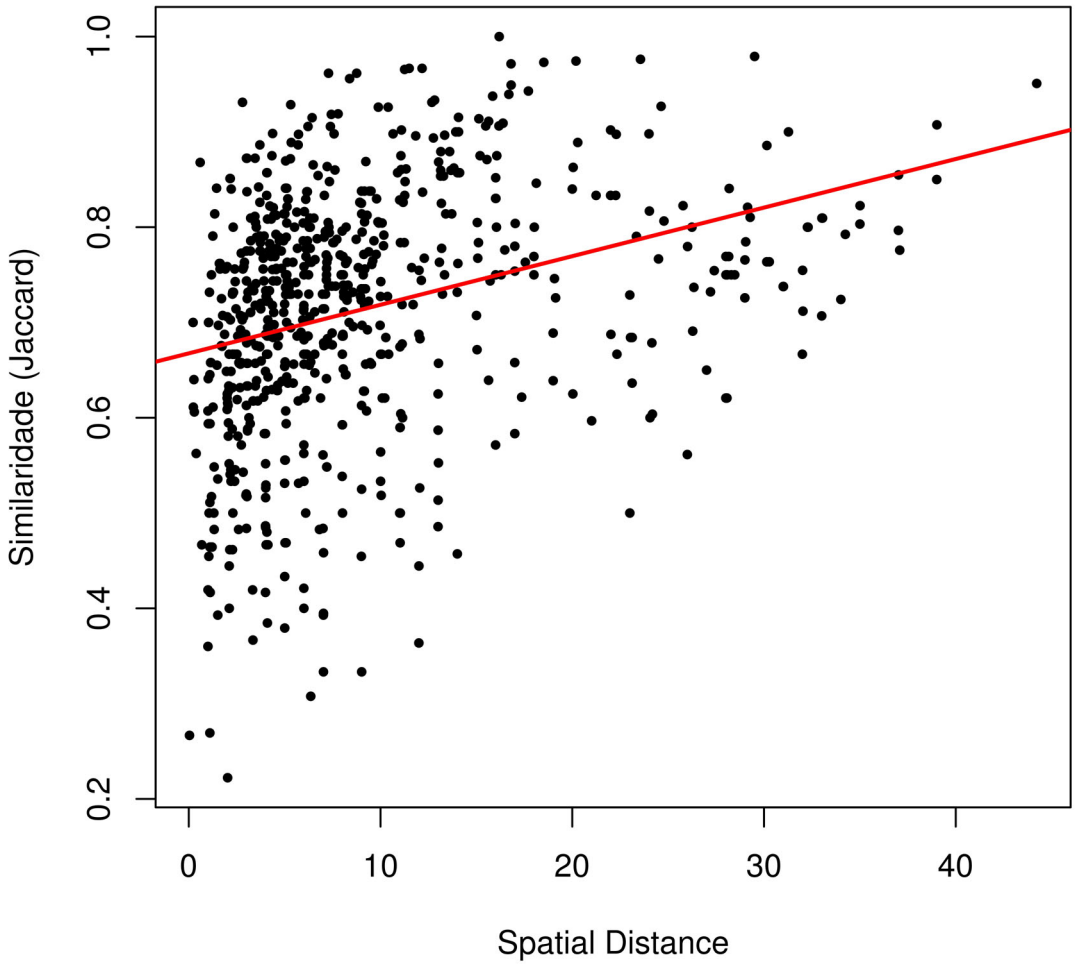


Fig. 16. Regression of the similarity matrix of amphibian species compositions (Jaccard index) with the spatial distance matrix (latitudinal and longitudinal coordinates) of communities from subtropical Atlantic Forest. (Mantel Test - r=0.312, p=0.004).

Hill numbers q=1 and 2) due to the high uniformity of species abundance distribution (Fig. 14 C, G). Even with higher species richness, the sampled elevation level 1000 m had lower Shannon and Simpson indexes (Fig.s 12 and 13 - Hill numbers q=1 e 2) due to the high dominance of *D. minutus* (SBS method) and *P. lateristriga* (PT method) (Fig. 14 D, H). These results may be related to the quality of the environment, as the elevation level 1000 m has some negative environmental impacts (see below).

Even if Serra Dona Francisca is characterized by formations of Serra Geral and Serra do Mar mountain ranges (Scheibe, 1986, Peluso, 1991), this locality grouped (Fig. 15) with Joinville municipality (state of Santa Catarina), Reserva Natural Salto Morato and Morretes municipality (both in the state of Paraná), all of which are characterized by sub-montane and montane ombrophilous dense forest (Straube and Urben-Filho, 2005, Armstrong and Conte, 2010, Garey and Hartmann, 2012, Comitti, 2017). Even with high dissimilarity in the cluster analysis (Fig. 15), the anuran species composition of Serra Dona Francisca is closer to north-eastern Serra do Mar mountain range than to any other area in the south-eastern region of the state of Santa Catarina (in Serra Geral mountain range, such as Parque Estadual Serra do

Fig. 17. Maps from Google Earth showing the advance of exploitation kaolin mining (red circle) in the region 1000 meters of the Serra Dona Francisca. (A) Image from 9th February 2014 of sampling site A21 and (B) image from 7th September 2018 of the same site.

Tabuleiro, Parque Estadual Serra Furada and Siderópolis, see Table 1 of Suppl. Info. 1 for additional information on these localities). Other nearby localities, such as Fazenda Gralha-Azul (Fazenda Rio Grande municipality), São José dos Pinhais, Curitiba and Campo Largo municipalities, all in state of Paraná, are characterized by mixed ombrophilous forest (Araucaria Forest) and steppe vegetation, but these localities were grouped with regions of the same vegetation type in the state of Paraná. Finally, the species composition of anuran communities in the subtropical Atlantic Forest is influenced by geographical distance (Mantel Test - r = 0.312, p = 0.004) (Fig. 16), that is, more distant locations present more dissimilar species compositions, a pattern evidenced in previous studies on anuran communities (*e.g.,* Bertoluci et al., 2007, Iop et al., 2011).

3. New Distribution Records

We provided four new records for the region: *Bokermannohyla luctuosa* - distribution extended 385 km from the nearest record (São Paulo municipality, state of São Paulo, Pombal and Haddad, 1993); *Scinax aromothyella* - distribution extended 70 km from the nearest record (Rio Negro municipality, state of Paraná, Santos and Conte, 2014); *Odontophrynus americanus* - distribution extended 65 km from the nearest record (Fazenda Rio Grande municipality, state of Paraná, Conte and Rossa-Feres, 2006); and *Leptodactylus plaumanni* - distribution extended 200 km from the nearest record (Caçador municipality, state of Santa Catarina, Lucas, 2008).

4. Spatial and Temporal Distribution

Out of the 14 exclusive anuran species at the elevation level of 1000 m (Table 2), only four are usually associated with vegetation in open areas (grasses and shrub vegetation with few trees): *S. aromothyella* (Faivovich, 2005), *S. squalirostris* (Gallardo, 1961), *L. plaumanni* (Kwet et al., 2001) and *O. americanus* (Savage and Cei, 1965); the other ten species are usually associated with highland landscapes (Garcia, Caramaschi and Kwet, 2001, Araújo, Bocchiglieri and Holmes, 2007, Toledo et al. 2007, Lucas, 2008), although *Scinax granulatus* and *Physalaemus nanus* present a wider and more generalized distribution (Conte et al., 2010, Kwet et al., 2010). Breeding sites in grassland vegetation have a lower number of available microhabitats compared to breeding sites in forest due to the vertical stratification of the latter. Furthermore, the highlands of Serra Dona Francisca present different climatic conditions, with lower temperatures, more lentic and less lotic breeding sites, compared to the rugged terrain of the mountain climb.

We also registered exclusive species at the remaining elevations levels (Table 2), characterized mainly by forest and stream environments: five species at the elevation level of 700 m - *B. sulfuratus*, *P. subguttata, Crossodactylus* sp., *A. ehrhardti* and *Dendrophryniscus berthalutzae*; four species at the elevation level of 300 m elevation - *Ischnocnema* sp. (gr. *lactea*), *H. binotatus, C. izecksohni* and *Dendropsophus berthalutzae*; and two species at the elevation level of 100 m elevation - *S. tymbamirim* and *L. catesbeianus*. Furthermore, we registered five other species exclusive to these three elevation levels, which are not usually registered in the Araucaria Forest: *F. mitus, B. hylax, D. werneri, S. imbegue* and *C. leucosticta* (Conte, 2010).

Ten anuran species were registered at all elevation levels (Table 2): *R. ornata, R. icterica, B. faber, O. rizibilis, S. perereca, A. nana, L. paranaru, L. notoaktites, P. lateristriga* and *P. boiei* (Table 2). *Elachistocleis bicolor* was registered at the 100 m and 1000 m levels, with a distribution gap of 300 to 700 m levels (Table 2). This result may be due to differences in forest vegetation types, anthropic disturbance along the entire elevation gradient, and the rugged landscape from 300 m to 700 m elevation levels, which is markedly different from lowlands (100 m) and highlands (1000 m).

Out of the 74 known reproductive modes among all amphibian species (*sensu* Nunes-de-Almeida et al., 2021), we registered 21 modes for the species found in Serra Dona Francisca, with predominance of mode 1, which is the most common type among anuran species (Duellman and Trueb, 1994). This result can be explained by the fact that the frogs in the study area are mainly inhabitants of lentic environments. We detected 46 anuran species in lentic environments, 22 species in lotic environments and 17 species with breeding activity in the forest.

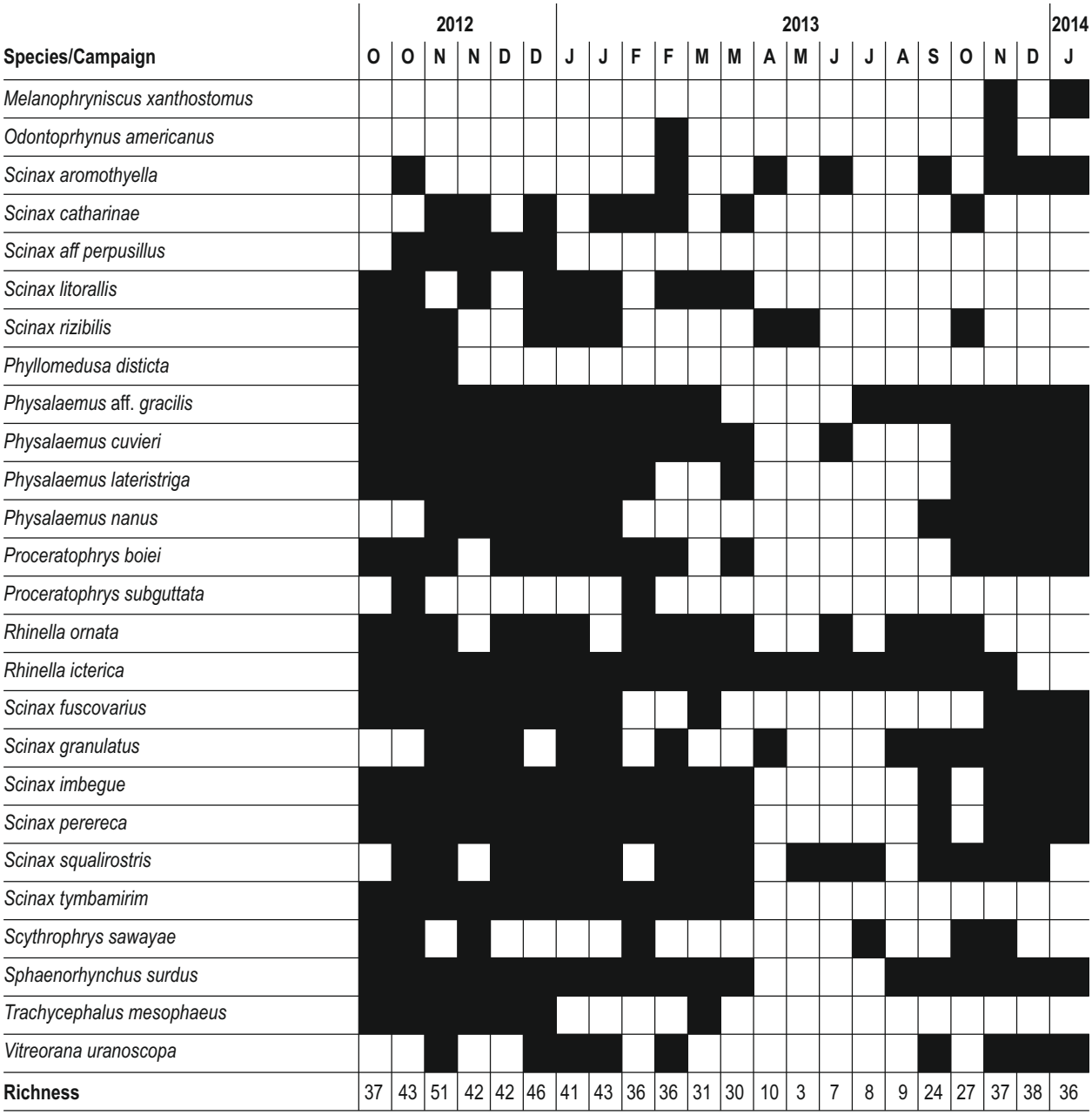
Most hylid species were found occupying open areas and forest edges habitats, except for *Aplastodiscus* sp., *A. ehrhardti* and *Bokermannohyla* spp., which were found in forest interior habitats. Even with the arboreal habits, the breeding sites of the hylid species were in lentic environments, most of them located in forest edges or open areas. Several anuran species registered in the forest interior present reproductive modes associated with the forest floor, streams, or epiphyte vegetation (e.g., Brachycephalidae spp., Hylodidae spp., Cycloramphidae spp., Hemiphractidae spp., *Adenomera* spp., *Proceratophrys* spp., *Vitreorana uranoscopa, Chiasmocleis leucosticta, Dendrophryniscus berthalutzae, Haddadus binotatus,* and *Melanophryniscus xanthostomus*). Only four species occupied all habitats: *Rhinella* spp., *Trachycephalus mesophaeus* and *Scinax perereca.*

There are 19 forest-dependent species, 13 open-area-dependent species, four generalist species, and the remaining 27 species have some association with forest or open areas. Therefore, it is relevant for the amphibians to preserve both landscape matrixes (Foerster and Conte, 2018), even with some anthropic

Table 4. Temporal distribution of amphibian species of Serra Dona Francisca, Joinville and Campo Alegre municipalities, state of Santa Catarina, Brazil, between October 2012 and January 2014. Shades are the campaigns where we recorded the amphibians foraging, calling or any other behaviour.

	2012						2013															2014
Species/Campaign	O	O	N	N	D	D	J	J	F	F	M	M	A	M	J	J	A	S	O	N	D	J
Adenomera araucaria		■	■	■		■	■	■												■	■	■
Adenomera nana	■	■	■	■	■	■	■	■	■	■	■	■						■	■	■	■	■
Aplastodiscus sp.	■	■	■	■	■	■	■	■	■	■	■		■			■		■	■	■	■	■
Aplastodiscus ehrhardti		■	■	■	■		■	■								■	■	■	■	■	■	■
Aplastodiscus perviridis	■		■	■	■	■	■	■	■	■										■	■	■
Boana albomarginata		■	■	■	■	■	■	■	■	■	■										■	
Boana albopunctata	■		■	■	■	■	■	■	■	■										■	■	■
Boana bischoffi	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■
Boana faber	■	■	■	■	■	■	■	■	■	■	■	■						■		■	■	■
Boana semilineata	■	■	■	■	■	■	■	■														
Boana sp.*(*gr. *pulchella)*																		■	■			■
Bokermannohyla hylax	■	■	■	■	■	■	■	■	■	■	■	■						■	■		■	■
Bokermannohyla luctuosa													■						■		■	■
Brachycephalus sulphuratus																					■	■
Chiasmocleis leucosticta			■	■				■													■	■
Crossodactylus sp.	■	■						■				■	■							■	■	■
Cycloramphus bolitoglossus			■																	■		
Cycloramphus izecksohni			■		■	■	■	■	■	■	■	■										
Dendrophryniscus berthalutzae				■	■	■	■	■	■	■	■	■	■	■				■		■	■	■
Dendropsophus elegans		■	■	■	■	■	■	■	■	■	■											
Dendropsophus microp	■	■	■	■	■	■	■		■		■	■							■		■	■
Dendropsophus berthalutzae	■	■	■			■	■	■	■	■	■	■										
Dendropsophus minutus	■	■	■	■	■	■	■	■	■	■	■	■					■	■	■	■	■	■
Dendropsophus nahdereri	■	■	■	■	■	■	■									■		■			■	■
Dendropsophus werneri	■	■	■	■	■	■	■	■	■	■	■	■								■	■	■
Elachistocleis bicolor	■	■	■			■		■		■	■									■	■	
Fritziana mitus	■	■	■	■	■	■	■	■	■	■	■	■			■				■	■	■	■
Fritziana sp.			■	■	■															■	■	
Haddadus binotatus									■			■										
Hylodes perplicatus			■	■		■		■	■	■	■	■										
Ischnocnema henselii	■	■	■					■				■						■	■	■	■	■
Ischnocnema sp. *(guentheri* group*)*	■	■	■		■	■	■	■		■	■	■								■		
Ischnocnema sp. *(I. lactae* species series*)*																				■		
Leptodactylus cf. *latrans*	■	■	■	■	■	■	■	■	■	■	■	■	■				■	■	■	■	■	■
Leptodactylus notoaktites	■	■	■	■	■	■	■	■	■	■	■	■							■	■	■	■
Leptodactylus plaumanni		■	■	■	■	■	■	■										■	■		■	■
																				■		■

Table 4. Cont.



influence (Mendenhall et al., 2014).

Regarding the calling activity, we observed an increase in the number of species during spring and summer, and a decrease during autumn and winter, an evident pattern of temporal distribution for the subtropical Atlantic Forest (Conte and Machado, 2005, Conte and Rossa-Feres, 2007, Santos and Conte, 2014). Nevertheless, six species showed some activity (foraging or calling) during autumn: *B. luctuosa, Crossodactylus* sp.*, Dendrophryniscus berthalutzae, F. mitus, S. aromothyella, P. cuvieri;* eight species during winter: *A. ehrhardti, B. faber, D. minutus, D. nahdereri, R. icterica, S. imbegue, S. sawayae* and *S. surdus;* and three species only during spring: *Brachycephalus sulfuratus*, *Ischnocnema* sp. (gr. *lactae*) and *P. distincta* (Table 4). Usually in seasonal environments, the rainy season is the main abiotic factor associated with amphibian's reproduction (Arzabe, 1999, Prado et al., 2004). Even without a dry season, the subtropical Atlantic Forest present lower temperatures during autumn and winter, with lower precipitation in autumn (Conte and Machado, 2005, Conte and Rossa-Feres, 2007, Santos and Conte, 2014). This evidence

reinforces the temperature as the main abiotic factor structuring amphibian communities in subtropical environments (Ceron et al., 2020).

Classifying the anuran species as continuous, prolonged, or explosive breeders is not an easy task. Many studies have used the calling behaviour of males to identify the period of breeding activity (Bertoluci and Rodrigues, 2002, Prado et al., 2004, Conte and Rossa-Ferres, 2007). However, the reproduction event, when males mate with ovigerous females and lay their clutch eggs in the environment or when tadpoles or juveniles are present, is more restrict to a few days or months. Unlike seasonal environments such as the Caatinga (Arzabe, 1999) or the Pantanal (Prado et al., 2004) with many explosive breeding species, in Serra Dona Francisca we found only five explosive breeders: *M. xanthostomus, S. sawayae, S. aromothyella, T. mesophaeus* and *C. leucosticta.* Only *B. bischoffi* presented continuous breeding behaviour considering the male's annual calling period (except May 2013). However, if we consider only the period in which we observed ovigerous females, *B. bischoffi* is a prolonged breeder with the reproductive period restricted to hot and rainy months (October 2012 to March 2013). We identified eight species as prolonged breeders, with reproduction activity for only four to six months during the hot and wet months: *R. ornata, B. faber, A. nana, A. araucaria, Leptodactylus paranaru, L. notoaktites, P. lateristriga,* and *P. boiei*. Another 25 species presented four to six months of calling activity, but direct evidences of reproduction (presence of females, amplected couples, spawning, tadpoles or juveniles) were restricted to one or two months: *Aplastodiscus* sp., *A. ehrhardti, A. perviridis, B. albomarginata, B. albopunctata, B. semilineata, B. hylax, B. luctuosa, C. izecksohni, Dendrophryniscus berthalutzae, D. elegans, D. microps, D. berthalutzae, D. minutus, D. nahdereri, D. werneri, E. bicolor, F. mitus, I. henselii, Ischnocnema* sp. (gr. *guentheri*), *L. plaumanni, S. rizibilis, P. cuvieri, Physalaemus* aff. *gracilis,* and *R. icterica*.

5. Conservation of Serra Dona Francisca

Considering the field records and literature data, the Serra Dona Francisca region, which covers the Corupá, Campo Alegre, São Bento do Sul, Joinville and Schroeder municipalities, has the highest anuran diversity in the state of Santa Catarina, and one of the greatest species richness of the subtropical Atlantic Forest (total of 87 species, considering our results and literature data; Lucas, 2008, Conte et al., 2010), highlighting the paramount importance of this region for anuran conservation. There are many sustainable conservation units in the region (e.g., Área de Preservação Ambiental Serra Dona Francisca, Área de Relevante Interesse Ecológico Morro do Iriri, Parque Natural Municipal da Caieira, and Reserva do Desenvolvimento Sustentável da Ilha do Morro do Amaral, all in Joinville municipality, and Área de Preservação Ambiental Estadual de Guaratuba, in Guaratuba municipality) that contribute to the conservation of the area, especially by the inclusion of the local population in sustainable economic activities, such as hotels, inns, restaurants and recreational activities focusing on ecotourism.

We observed some illegal activities in Serra Dona Francisca, including hunting and palm heart exploitation, and an activity that causes great impacts to the environment: kaolin mining. A visual impact of the mining activity is the suppression of the grassland, a steppe phytophysiognomy used by anurans as breeding sites, which affects all species that occupy open landscapes. This activity culminates in the deposition of sediments and suppression of breeding sites. Observing Google images for five years (2012-2017), we notice an increase in mining activities in the vicinity of the breeding sites (Fig. 17). In Serra Dona Francisca, most of the sampled environments have some associated human activity such as farmlands or small pastures. However, the intensity of human activities associated with these environments should be investigated, as it can negatively impact amphibian communities, especially with chemical inputs on agricultural lands (Mendenhall et al., 2014) or chemical residuals from some types of activities (De Lucca et al., 2017).

We believe that the creation of an integral protection conservation unit in the region would help to stop mining exploitation but keeping the local population in a sustainable conservation unit and investing in environmental education might be the best conservation actions for the region.

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Authors' Contributions

Lucas Ribeiro Mariotto. Substantial contribution in

the concept and design of the study; Contribution to data collection; Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Sarah Mângia. Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Diego José Santana. Contribution to data analysis and interpretation; Contribution to manuscript preparation; Contribution to critical revision, adding intellectual content.

Conflicts of Interest

"The author(s) declare(s) that they have no conflict of interest related to the publication of this manuscript"

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