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The leaf-litter frog community from Reserva Rio das Pedras, Mangaratiba, Rio de Janeiro State, Southeastern Brazil: species richness, composition and densities

Carlos Frederico Duarte ROCHA[1,*], Davor VRCIBRADIC[1,2], Mara Cintia KIEFER[1,3], Mauricio ALMEIDA-GOMES[1], Vitor Nelson Teixeira BORGES-JUNIOR[1], Vanderlaine Amaral MENEZES[1], Cristina Valente ARIANI[1], Jorge Antonio Lourenço PONTES[1], Pablo GOYANNES-ARAÚJO[1], Rodrigo Ventura MARRA[1,5], Diego Medeiros GUEDES[1], Carla da Costa SIQUEIRA[1,4] and Monique VAN SLUYS[1]

1. Departamento de Ecologia, Instituto de Biologia Roberto Alcântara Gomes, Universidade do Estado do Rio de Janeiro, R. São Francisco Xavier 524, CEP: 20550-013, Rio de Janeiro, RJ, Brazil.
2. Departamento de Zoologia, Universidade Federal do Estado do Rio de Janeiro. Av. Pasteur 458, Urca, 22240-290, Rio de Janeiro, RJ, Brazil.
3. Departamento de Biologia Geral, Instituto de Biologia, Universidade Federal Fluminense, Caixa Postal 100.436, Centro, 24020-971 Niterói, RJ, Brazil.
4. Universidade Federal do Rio de Janeiro, Programa de Pós-Graduação em Ecologia, Instituto de Biologia, Av. Carlos Chagas Filho 373 Bl. A, Cidade Universitária, 21941-902 Rio de Janeiro, RJ, Brazil.
5. Grupo de Apoio Técnico Especializado - Meio Ambiente, Ministério Público do Estado do Rio de Janeiro, Travessa do Ouvidor, 38, CEP 20040-040, Rio de Janeiro, RJ.
*Corresponding author, CF.D. Rocha, E-mail: cfdrocha@uerj.br

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Abstract. Data on community parameters of leaf-litter frogs are currently limited for most remnants within the Atlantic Rainforest Biome. In this study, we present data on the assemblage of leaf-litter frogs from Reserva Rio das Pedras (RERP), an Atlantic Forest remnant of the state of Rio de Janeiro, Brazil. Sampling was carried out during August 2005 at altitudes between 20 and 750 m a.s.l. We found six anuran species on the leaf-litter: *Brachycephalus didactylus*, *Ischnocnema parva*, *Ischnocnema guentheri*, *Haddadus binotatus*, *Zachaenus parvulus* and *Adenomera marmorata*, all endemic to the Atlantic Rainforest biome. The estimated overall frog density of the local leaf-litter frog assemblage was higher (10.1 frogs/100 m²) than those reported for most other areas of southeast Brazil. *Ischnocnema parva* (4.0 individuals/100 m²) and *Haddadus binotatus* (3.5 individuals /100 m²) had the highest densities in the area. *H. binotatus* (1413.1 g/ha) had the highest estimated mass per hectare, whereas *B. didactylus* had the lowest (8.4 g/ha). Both density and richness were lower at the lowermost site, which probably reflects the differences in habitat quality: at altitudes below 200 m the forest is sparser, whereas at higher altitudes it is denser and less disturbed.

Key words: Amphibia, Atlantic Forest, Brazil, density estimate, leaf-litter.

Introduction

The loss of forests around the world is continuously and worryingly increasing (Brooks et al. 2006). The remnants of the Brazilian Atlantic rainforest (one of the world´s biodiversity hotspots – Myers et al. 2000), which cover around 11% of its original area, support one of the highest levels of biological diversity and number of endemic species on the planet (Morellato & Haddad 2000, Rocha et al. 2003, Ribeiro et al. 2009, Jenkins et al. 2010). Some Atlantic rainforest remnants have special relevance not only due to their size and biological diversity, but also because of their strategic potential to link other remnants thus allowing a more effective conservation of the fauna and flora. This is the case of the Reserva Rio das Pedras, which is located between two of the largest forest remnants in the state of Rio de Janeiro (the Serra da Bocaina to the west and the Serra dos Órgãos to the east), being presently included in the Parque Estadual do Cunhambebe. Therefore, it potentially links the forests from the southwestern part of the state with those located in its central region (Rocha et al. 2003).

Current knowledge regarding the biodiversity of Reserva Rio das Pedras is represented by species lists of amphibians (Carvalho-e-Silva et al. 2008) and non-volant mammals (Pessôa et al. 2009). Carvalho-e-Silva et al. (2008) presented a checklist of the anuran species of the Reserve, emphasizing their association with specific habitats such as temporary ponds, bamboo thickets, bromeliads, tree canopy, wet rock surfaces, streams and leaf-litter. For the leaf-litter habitat in particular, Carvalho-e-Silva et al. (2008) listed the occur-

rence of six anuran species: *Brachycephalus didactylus*, *B. ephippium*, *Haddadus binotatus*, *Ischnocnema guentheri*, *I. parva* and *Adenomera marmorata*.

Data on community parameters of leaf-litter frogs (including estimated frog density and biomass per area) are currently limited for most forest remnants within the Atlantic Rainforest Biome, and published data are available for only seven areas, all in southeastern Brazil (Giaretta et al. 1997, 1999, Rocha et al. 2000, 2001, 2007, Van Sluys et al. 2007, Almeida-Gomes et al. 2008, 2010, Siqueira et al. 2009, Rocha et al. 2011). Because these organisms constitute important components of leaf-litter communities in tropical forests (e.g. Fauth et al. 1989, Allmon 1991, Vitt & Caldwell 1994) and are threatened by habitat fragmentation (Stuart et al. 2008), the shortage of data may hinder the development of conservation actions.

Here we present data on the assemblage of leaf-litter frogs at the Reserva Rio das Pedras, a rainforest area in southeastern Brazil, including species composition and richness, relative abundance, body size of individual species, and estimates of frog densities and biomass per hectare.

Materials and Methods

The study was carried out at the Reserva Rio das Pedras (hereafter RERP - 22° 59′ S, 44° 06′ W), a private reserve in the municipality of Mangaratiba, in the southwestern part of Rio de Janeiro State, Brazil. The reserve is crossed by the Grande and Borboleta rivers and their tributaries. It encompasses an area of *ca.* 1360 ha, with an altitudinal range from 20 to 1150 m a.s.l. (Mynssen & Windisch 2004). Mean annual temperature is *ca.* 22°C and mean annual rainfall is *ca.* 1900 mm; precipitation is most intense in the period between December and February (Mynssen & Windisch 2004, Carvalho-e-Silva et al. 2008). The predominant vegetation type in the study area is Evergreen Dense Forest (Radambrasil 1983), with trees ranging up to about 40 m in height and 45 cm DBH (diameter at breast height) (Mynssen & Windisch 2004).

Sampling was carried out during August 2005 at altitudes between 20 and 750 m a.s.l, using three sampling methods: plot sampling (Jaeger & Inger 1994), visual encounter surveys (Crump & Scott 1994), and pitfall traps with drift fences (Corn 1994).

For plot sampling, we set 30 quadrats of 5 × 5m on the forest floor, totaling 750 m² of forest floor sampled. Each quadrat was delimited by a flexible plastic fence *ca.* 50 cm high with corners fixed with wooden stakes and bottom pinned to the ground with stones and branches to prevent frogs from escaping. After sunset, five searchers using head lamps moved within each plot on hands and knees, side-by-side, carefully searching for frogs (usually with the aid of hand rakes) for about 30 minutes.

For the visual encounter surveys (hereafter VES), searchers walked along random transects at a slow walking pace, looking for frogs in all potentially available microhabitats. Surveys were carried out during the diurnal, crepuscular, and nocturnal periods, totaling 75 hours of sampling effort (25 hours per period).

We also established three pitfall trap systems that consisted of ten 30-liter buckets buried in the ground, each set at *ca.* 5 m apart from the next, with soft plastic drift fences about 50 cm high extended between them. Six of the buckets were set in line and the remaining four were placed at opposite ends of the fence (two at each side), perpendicularly to the main axis. Pitfalls remained open for a total of 16 days and were checked daily, always in the morning.

All frogs found by the three methodologies were collected and identified. Furthermore, individuals found during casual encounters (i.e. not using any methodology) were also collected, but those were included only for the calculation of mean values for snout-vent length (SVL) and body mass per species. After preservation in 10% formaline (and later in 70% alcohol), all frogs collected during the study had their snout-vent length (SVL, in mm) measured with digital calipers and their preserved body mass (in grams) taken with an electronic balance (precision of 0.001g). For estimates of density (expressed as frogs/100 m²) we considered only data obtained during plot sampling. We estimated density and overall mass of leaf-litter frogs per hectare (g/ha) for the whole sampled area of the RERP by dividing the total number and the pooled body mass of frogs found in the plots by the total area sampled. Individuals that were seen but eventually escaped collection during plot sampling were also considered for the estimates of frog density and (when the species could be determined) overall mass per hectare; in the latter case, mass of the uncollected frog was established as the mean mass for its species calculated based on all individuals collected during the study (regardless of methodology). Additionally, considering that our sampling spanned an altitudinal range of about 700 m, we also obtained estimates of density (in frogs/100 m²) separately for three altitudinal ranges in which the plot samplings were performed: 50-100 m; 350-500m and 700-750m a.s.l.

Results

We found six frog species associated to the leaf-litter habitat at the RERP (Table 1): *Brachycephalus didactylus* (Izeckshon 1971), *Ischnocnema parva* (Girard 1853), *Ischnocnema guentheri* (Steindachner 1864) (Brachycephalidae), *Haddadus binotatus* (Spix 1824) (Craugastoridae), *Zachaenus parvulus* (Girard 1853) (Cycloramphidae), and *Adenomera marmorata* Steindachner 1867 (Leptodactylidae).

We recorded five species during VES sampling (Table 1), of which *Ischnocnema parva* (N = 17, or 42.5% of individuals found) and *Haddadus*

Table 1 – Number of frogs found by the three sampling methods at the Reserva Rio das Pedras (RERP), Mangaratiba Municipality, Rio de Janeiro State, southeastern Brazil. Mean values (± one standard deviation) of snout-vent length (SVL, in mm) and body mass (in grams) are given for each species (sample sizes in parentheses). Overall mass (g/ha) and density (frogs/100m²) estimated for each species are based on data from plot sampling. VES = visual encounter surveys.

Species	Plots	VES	Pitfalls	SVL (N)	Body mass (N)	Overall mass (g/ha)	Density (ind/100 m²)
BRACHYCEPHALIDAE							
Brachycephalus didactylus	9	2		8.2 ± 1.3 (10)	0.07 ± 0.03 (10)	8.4	1.2
Ischnocnema guentheri	2	5		25.3 ± 10.4 (7)	2.6 ± 2.4 (7)	71.5	0.3
Ischnocnema parva	30	17	1	16.2 + 2.9 (55)	0.6 + 0.4 (55)	190.8	4.0
CRAUGASTORIDAE							
Haddadus binotatus	26	14		32.0 ± 13.3 (41)	4.6 ± 5.3 (41)	1413.1	3.5
CYCLORAMPHIDAE							
Zachaenus parvulus	4			24.3 ± 2.8 (4)	2.5 ± 0.9 (4)	131.9	0.5
LEPTODACTYLIDAE							
Adenomera marmorata	5	2		19.9 ± 3.1 (7)	0.8 ± 0.3 (7)	41.1	0.7
Total	76	40	1			1856.7	10.1

Table 2 – Number (N) and corresponding density (ind/100 m²) of frogs of each species sampled at the three altitudinal ranges (50-100m, 350-500m and 700-750m a.s.l.) in the Reserva Rio das Pedras (RERP), Mangaratiba Municipality, Rio de Janeiro State, southeastern Brazil.

Altitude (No. plots / sampled area)	Frog Species (N)	Density (ind/100 m²)
50–100 m (6 / 150 m²)	*Haddadus binotatus* (3)	2.0
	Adenomera marmorata (1)	0.7
350–500 m (12 / 300m²)	*Brachycephalus didactylus* (2)	0.7
	Haddadus binotatus (17)	5.7
	Ischnochnema parva (19)	6.3
	Adenomera marmorata (3)	1.0
	Zachaenus parvulus (3)	1.0
700–750 m (12 / 300m²)	*Brachycephalus didactylus* (7)	2.3
	Haddadus binotatus (6)	2.0
	Ischnochnema guentheri (2)	0.7
	Ischnochnema parva (11)	3.7
	Adenomera marmorata (1)	0.3
	Zachaenus parvulus (1)	0.3

binotatus (N = 14, or 35%) were the most frequently recorded. Most of the individuals were found during the nocturnal (N = 21, or 52.5% of the total) and crepuscular (N = 16, or 40%) samplings.

We recorded 76 individuals by plot sampling (Table 1), which gives an estimated overall density of 10.1 frogs/100 m². The number of frogs per plot ranged from zero (5/30 or 16.7% of all plots) to ten (1/30 or 3.3%) with a mean of 2.5 ± 2.2 frogs per plot. Considering each species individually, *Ischnocnema parva* had the highest density (4.0 individuals/100 m²) and comprised 39.5% of all frogs found in plots, followed by *Haddadus binotatus* (3.5 individuals /100 m²) which corresponded to 34.2% of the frogs found in plots.

Only one frog (an individual of *I. parva*) was captured in the pitfall traps (Table 1). Considering the combined methods, the most abundant species in the community were *Ischnocnema parva* and *Haddadus binotatus* which, together, comprised 75% of all frogs found in the study (Table 1).

The species with the highest estimated mass per hectare at the RERP was *H. binotatus* (1413.1 g/ha), whereas *B. didactylus* had the lowest (8.2 g/ha) (Table 1). The overall leaf-litter frog mass (pooled species) per hectare was 1856.7 g/ha (Table 1).

We found evidences of altitudinal variation in composition and density of leaf-litter frogs at the RERP. At lower elevations (50-100 m) we found only two frog species (*A. marmorata* and *H. binotatus*) and these were the only species occurring at all the three altitudinal ranges sampled (Table 2). The number of species found increased to five at 350-500 m and to six at 700-750 m (Table 2). *Ischnocnema parva* was the most abundant species occurring both at the 350-500m and 700-750m altitudinal belts (Table 2).

Discussion

All six species recorded in our study are endemic to the Atlantic Rainforest biome (Rocha et al. 2004, Frost 2010). The list of frog species associated with the leaf-litter habitat at the RERP recorded in our study was very similar to that of Carvalho-e-Silva et al. (2008), except that we did not record *Brachy-*

cephalus ephippium, but recorded *Zachaenus parvulus*. Our results thus indicate that our sampling effort for that short-term survey was adequate to represent the local leaf-litter frog assemblage.

Most species of frogs at the RERP were sampled with VES (five species) and plot (six species) methodologies. One species (*Z. parvulus*) was sampled only in plots and only one species (*I. parva*) was recorded using pitfall traps (with only one individual collected). This illustrates the importance of combining methodologies and, at the same time, the shortcomings of using pitfall traps for short-term inventories (e.g. Cechin & Martins 2000, Almeida-Gomes et al. 2008).

Most of the frogs sampled with the VES method were captured during the crepuscular and nocturnal periods (92.5% of individuals). Higher capture rates during these periods (compared to the daylight period) have been previously reported in studies with anuran assemblages from tropical forest areas in southeast Asia (Inger 1980) and the Neotropics (Rocha et al. 2000, 2007, Almeida-Gomes et al. 2008, 2010, Menin et al. 2008, Siqueira et al. 2009), indicating that anuran surveys should be preferentially carried out during and after sunset in order to maximize sampling efficiency.

The estimated overall frog density of the local leaf-litter frog assemblage was higher (10.1 frogs/100 m^2) than those reported for most other areas of southeast Brazil (based on surveys that employed similar-sized plots): the Serra do Japi (1.4 ind/100m^2, altitudes 850-1000 m a.s.l.; Giaretta et al. 1997) and the Parque Florestal do Itapetinga (4.6 ind/100m^2, altitudes 900-1250 m a.s.l.; Giaretta et al. 1999) in the state of São Paulo, and Ilha Grande (5.9 ind/100m^2, altitudes 220-230 m a.s.l.; Rocha et al. 2001), Reserva Ecológica de Guapiaçu (8.4 ind/100m^2, altitudes 100-400 m a.s.l.; Rocha et al. 2007), Morro São João (4.5 ind/100m^2, altitudes 0-320m a.s.l.; Almeida-Gomes et al. 2008), and Monte Verde (3.1 ind/100m^2, altitudes 100-650m a.s.l.; Almeida-Gomes et al. 2010) in the state of Rio de Janeiro. The only exception was a site within the Parque Estadual dos Três Picos (altitudes 500-800 m a.s.l.) in Rio de Janeiro State, for which the estimated density of leaf-litter frogs (17.1 ind/100m^2) was the highest one yet reported for Atlantic Rainforest areas (Siqueira et al. 2009). However, the estimated leaf-litter frog biomass at the RERP (1856.7 g/ha) was greater than those of other Atlantic Forest sites surveyed so far (476.6-1150 g/ha; Giaretta et al. 1999, Rocha et al. 2001, Siqueira et al. 2009). *Haddadus binotatus* comprised most of the frog biomass in the local leaf-litter community, due to their relatively large size and high abundance.

According to Scott (1976), species richness of tropical leaf-litter amphibians and reptiles tends to decrease with altitude, whereas overall density tends to increase (but see Fauth et al. 1989). Regarding the Atlantic Rainforest herpetofauna, particularly amphibians, little has been published about altitudinal variation in community parameters. Giaretta et al. (1997) compared two sites (at altitudes of 850 m and 1000 m a.s.l.) at the Serra do Japi, São Paulo State, and found higher litter frog densities at the higher elevation site. In another area, also in São Paulo State, Giaretta et al. (1999) compared three sites spanning an altitudinal range of only 350 m (with an altitudinal difference of 100 m or less among sites), but still found a much higher frog density at the uppermost site (located at 1200-1250 m a.s.l.). In neither of the two aforementioned studies was a decrease in species richness at higher altitudes observed. Results of two other studies carried out in two areas located only *ca.* 15 km apart and on the same mountain range (the Serra dos Órgãos, in Rio de Janeiro State), but at different altitudes (100-400 m a.s.l.– Rocha et al. 2007; 500-800 m a.s.l.– Siqueira et al. 2009) also evidence a similar trend: estimated frog density for the 500-800 m a.s.l. site was twice as high as for the 100-400 m a.s.l. site, though species richness was just slightly higher at the former. In the present study, we found both density and richness to be much lower at the lowermost site. This probably reflects the differences in habitat quality: at altitudes below 200 m at the RERP the forest is sparser, whereas at higher altitudes it is denser and less disturbed (Carvalho-e-Silva et al. 2008; pers. obs.). More studies are needed (including surveys at broader altitudinal gradients) to verify if the patterns of altitudinal variation in Atlantic Forest frog assemblages agree with Scott's (1976) hypothesis.

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References

Almeida-Gomes, M., Vrcibradic, D., Siqueira, C.C., Kiefer, M.C., Klaion, T., Almeida-Santos, P., Nascimento, D., Ariani, C.V., Borges-Junior, V.N.T., Freitas-Filho, R.F., Van Sluys, M., Rocha, C.F.D. (2008): Herpetofauna of an Atlantic Rainforest area (Morro São João) in Rio de Janeiro State, Brazil. Anais da Academia Brasileira de Ciências 80: 291-300.

Almeida-Gomes, M., Almeida-Santos, M, Goyannes-Araújo, P., Borges-Júnior, V.N.T., Vrcibradic, D., Siqueira, C.C., Ariani, C.V., Dias, A.S., Souza, V.V., Pinto, R.R., Van Sluys, M., Rocha, C.F.D. (2010): Anurofauna of an Atlantic Rainforest fragment and its surroundings in northern Rio de Janeiro State, Brazil. Brazilian Journal of Biology 70: 871-877.

Allmon, W.D. (1991): A plot study of forest floor litter frogs, Central Amazon, Brazil. Journal of Tropical Ecology 7: 503-22.

Radambrasil. (1983): Levantamento de recursos naturais, volume 32, folha S/ F. 23/ 24. Rio de Janeiro/Vitória. Rio de Janeiro, Ministério das Minas e Energia.

Brooks, T.M., Mittermeier, R.A., Fonseca, G.A.B., Gerlach, J., Hoffmann, M., Lamoreux, J.F., Mittermeier, C.G., Pilgrim, J.D., Rodrigues, A.S.L. (2006): Global biodiversity conservation priorities. Science 313: 58-61.

Carvalho-e-Silva, A.M.T., Silva, G.R., Carvalho-e-Silva, S.P. (2008): Anuros da Reserva Rio das Pedras, Mangaratiba, RJ, Brasil. Biota Neotropica 8: 199-209.

Cechin, S., Martins, M. (2000): Eficiência de armadilhas de queda (Pitfall traps) em amostragens de anfíbios e répteis no Brasil. Revista Brasileira de Zoologia 17: 729-740.

Corn, P.S. (1994): Straight-line drift fences and pitfall traps. pp. 109-117. In: Heyer, W.R., Doanelly, M.A., McDiarmid, R.W., Hayek, L.C., Foster, M.S. (eds.), Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press.

Crump, M.L., Scott, N.J. (1994): Visual encounter surveys. pp. 84-92. In: Heyer, W.R., Doanelly, M.A., McDiarmid, R.W., Hayek, L.C., Foster, M.S. (eds.), Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press.

Fauth, J.E., Crother, B.I., Slowinski, J.B. (1989): Elevational patterns of species richness, eveness and abundance of the Costa Rican leaf-litter herpetofauna. Biotropica 21: 178-85.

Frost, D. (2010): Amphibian Species of the World: an Online Reference. Version 5.4 (8 April 2010). American Museum of Natural History, New York, USA. <http://research.amnh.org/vz/herpetology/amphibia>, accessed at: 2010.07.29.

Giaretta, A.A., Sawaya, R.J., Machado, G., Araújo, M.S., Facure, K.G., Medeiros, H.F., Nunes, R. (1997): Diversity and abundance of litter frogs at altitudinal sites at Serra do Japi, Southesatern Brazil. Revista Brasileira de Zoologia 14: 341-346.

Giaretta, A.A., Facure, K.G., Sawaya, R.J., Meyer, J.H.D., Chemin, N. (1999): Diversity and abundance of litter frogs in a montane forest of southeastern Brazil: seasonal and altitudinal changes. Biotropica 31: 669-674.

Inger, R.F. (1980): Relative abundances of frogs and lizards in forests of Southeast Asia. Biotropica 12: 14-22.

Jaeger, R., Inger, R.F. (1994): Standard techniques for inventory and monitoring: Quadrat Sampling. pp. 97-102. In: Heyer, W.R., Doanelly, M.A., McDiarmid, R.W., Hayek, L.C., Foster, M.S. (eds.), Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press.

Jenkins, C.N., Alves, M.A.S. Pimm, S.L. (2010): Avian conservation priorities in a top-ranked biodiversity hotspot. Biological Conservation 143: 992–998.

Menin, M., Waldez, F., Lima, A.P. (2008): Temporal variation in the abundance and number of species of frogs in 10,000 ha of a forest in central Amazonia, Brazil. South American Journal of Herpetology 3: 68-81.

Morellato, L.P.C., Haddad, C.F.B. (2000): Introduction: The Brazilian Atlantic Forest. Biotropica 32: 786-792.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., Fonseca, G.A.B. (2000): Biodiversity hotspots for conservation priorities. Nature 403: 853-858.

Mynssen, C.M., Windisch, P.G. (2004): Pteridófitas da Reserva Rio das Pedras, Mangaratiba, RJ, Brasil. Rodriguésia 55: 125-156.

Pessôa, F.S., Modesto, T.C., Albuquerque, H.G., Attias, N., Bergallo, H.G. (2009): Non-volant mammals, Reserva Particular do Patrimonio Natural (RPPN) Rio das Pedras, municipality of Mangaratiba, state of Rio de Janeiro, Brazil. Check List 5: 577-586.

Ribeiro, M.C., Metzger, J.P., Martensen, A.C., Ponzoni, F.J. & Hirota, M.M. 2009. The Brazilian Atlantic Forest: How much is left, and how is the remaining forest distributed? Implications for conservation. Biological Conservation 142: 1141-1153.

Rocha, C.F.D., van Sluys, M., Alves, M.A.S., Bergallo, H.G., Vrcibradic, D. (2000): Activity of leaf-litter frogs: when should frogs be sampled? Journal of Herpetology 34: 285-287.

Rocha, C.F.D., Van Sluys, M., Alves, M.A.S., Bergallo, H.G., Vrcibradic, D. (2001): Estimates of forest floor litter frog communities: A comparison of two methods. Austral Ecology 26: 14-21.

Rocha, C.F.D., Bergallo, H.G., Van Sluys, M., Alves, M.A.S. (2003): A biodiversidade nos grandes remanescentes florestais do Estado do Rio de Janeiro e nas restingas da Mata Atlântica. Rima Editora, São Carlos.

Rocha, C.F.D., Bergallo, H.G., Pombal JR., J.P., Geise, L., Van Sluys, M., Fernandes, R., Caramaschi, U. (2004): Fauna de anfíbios, répteis e mamíferos do Estado do Rio de Janeiro, sudeste do Brasil. Publicações Avulsas do Museu Nacional 104: 3-23.

Rocha, C.F.D., Vrcibradic, D., Kiefer, M.C., Almeida-Gomes, M., Borges-Junior, V.N.T., Carneiro, P.C.F., Marra, R.V., Almeida-Santos, P.A., Siqueira, C.C., Goyannes-Araújo, P., Fernandes, C.G.A., Rubião, E.C.N., Van Sluys, M. (2007): A survey of the leaf-litter frog community from an Atlantic forest area (Reserva Ecológica de Guapiaçu) in Rio de Janeiro State, Brazil, with an estimate of frog densities. Tropical Zoology 20: 99-108.

Rocha, C.F.D., Vrcibradic, D., Kiefer, M.C., Siqueira, C.C., Almeida-Gomes, M., Borges-Junior, V.N.T., Hatano, F.H., Fontes, A.F., Pontes, J.A.L., Klaion, T., Gil, L.O., Van Sluys, M. (2011): Parameters from the community of leaf-litter frogs from Estação Ecológica Estadual Paraíso, Guapimirim, Rio de Janeiro State, southeastern Brazil. Anais da Academia Brasileira de Ciências 83(4): 1259-1268.

Scott jr., N.J. (1976): The abundance and diversity of the herpetofauna of tropical forest litter. Biotropica 8: 41-58.

Siqueira, C.C., Vrcibradic, D., Almeida-Gomes, M., Borges-Junior, V.N.T., Almeida-Santos, P., Almeida-Santos, M., Ariani, C.V., Guedes, D.M., Goyannes-Araújo, P., Dorigo, T.A., Van Sluys, M., Rocha, C.F.D. (2009): Density and richness of leaf litter frogs (Amphibia: Anura) of an Atlantic Rainforest area in the Serra dos Órgãos, Rio de Janeiro State, Brazil. Zoologia 26: 97-102.

Stuart, S.N., Hoffmann, V., Chanson, J.S., Cox, N.A., Berridge, N.J., Ramani, P., Young, B.E. (2008): Threatened amphibians of the world. Lynx Editions. Barcelona.

Van Sluys, M., Vrcibradic, D., Alves, M.A.S., Bergallo, H.G., Rocha, C.F.D. (2007): Ecological parameters of the leaf-litter frog community of an Atlantic Rainforest area at Ilha Grande, Rio de Janeiro State, Brazil. Austral Ecology 32: 254-260.

Vitt, L.J., Caldwell, J.P. (1994): Resource utilization and guild structure of small vertebrates in the Amazon forest leaf litter. Journal of Zoology 234: 463–476.