

Composition, temporal distribution and vocalisation microhabitats of frogs at Sumaúma State Park, Manaus, Amazonas, Brazil

André de Lima Barros^{1,*}, Gislaíne Oliveira², Julianny Pantoja², Rodrigo Taveira²
and Maria Clara Silva-Forsberg²

Abstract. We investigated the number of species, the temporal distribution and vocalization microhabitats used by frogs in a forest fragment inserted in a highly populated urban environment in Central Amazon. Monthly sampling was carried out from May to October 2013 and from April to May 2016 using visual and acoustic surveys. We recorded 14 species of frogs that belong to six families: Aromobatidae (2), Bufonidae (2), Craugastoridae (1), Hylidae (5), Leptodactylidae (3) and Microhylidae (1). There was a difference between the number of species and the number of individuals recorded in the months of sampling. We found 10 types of vocalisation microhabitats used by frogs in the Park. The number of species recorded in this study, although low compared to other lists available for the Manaus area, demonstrates the importance such forest remnant as shelter for these animals. In addition, we describe the occurrence of some reptile species (three snakes, three lizards and one caiman) found in the Park during field research.

Keywords: Anurans, Conservation, Forest remnant, Urban Park

Introduction

Habitats loss has been identified as a major cause for the decline of many amphibian populations (Delis et al., 1996; Becker et al., 2007; Bernarde and Macedo 2008; Rodrigues et al., 2008), as well as infection caused by fungi and pathogens in the environment (Daszak et al., 1999; La Marca et al., 2005; Skerratt et al., 2007). Due to the rapid growth of urban areas, continuous forest areas are reduced to fragments gradually surrounded by cities. These forest remnants are refuges for wildlife, which, in this context, are generally only represented by species that are more tolerant to environmental changes (Viana and Pinheiro, 1998; Rambaldi and Oliveira, 2003; Telles and Dias, 2010).

Although some species can colonise degraded areas, various amphibian assemblages, in number of species, have been found in areas with increased availability of reproductive sites, since most species depend on water for oviposition and larval development (Haddad and Prado, 2005; Pombal Jr and Haddad, 2005; Koop et al., 2010). Thus, investigating remaining amphibian assemblages in forest fragments helps us understand the human impacts on biodiversity.

In this study we present data on the distribution, composition and use of vocalisation microhabitats by frogs at Sumaúma State Park, an urban forest fragment located in Manaus, Amazonas, Brazil.

Material and Methods

Study area.—The study was conducted at Sumaúma State Park (3°2'10"S 59°58'51"W), located in a densely populated area in the city of Manaus, state of Amazonas (Figure 1), and is one of the few protected forest remnants, immersed in the urban context. The Park has 5300 km² area and your original vegetation was named dense ombrophilous forest, but is currently characterised as a secondary forest (Pinheiro et al., 2010). Altitudes ranged from 45 to 90 m (Cavalcante et al., 2010)

¹ Departamento de Ecologia, Instituto Nacional de Pesquisas da Amazônia – INPA, Campus V8, AV. Efigênio Sales, 2239, 69060-020, Manaus, Amazonas, Brazil.

² Laboratório de Ecologia Aplicada, Universidade do Estado do Amazonas, Av. Djalma Batista, 2470, Chapada, 69050-010, Manaus, Amazonas, Brazil

* Corresponding author. E-mail: andrelima1701@gmail.com

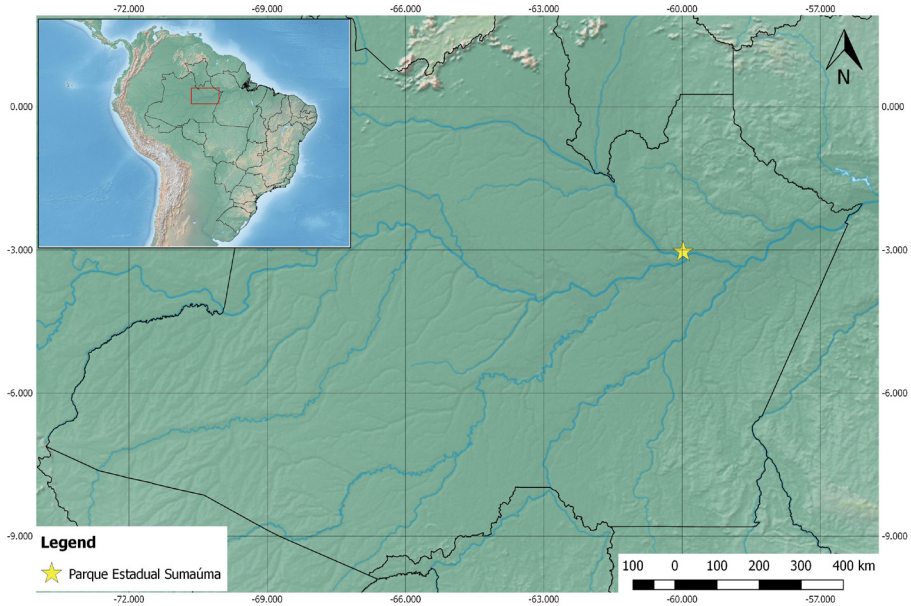


Figure 1. Localization of Sumaúma State Park in Manaus, Amazonas, Brazil.

Data collection.—Sampling was conducted from May to October 2013 and from April to May 2016. We visited sites during four days in each sampling month (two consecutive days, every 15 days in all months). No sampling between November and March was conducted thus some species active in these months were not registered. We sampled frogs by means of the time-limited active search method, standardised at eight hours per day, in two intervals: i) in the mornings from 9 AM to 1 PM; ii) at night from 6 PM to 10 PM. These two rounds were established to cover species with diurnal and nocturnal habits.

The searches were conducted by two observers. The search for frogs was conducted in four 500 meters-long x 20 meters-wide transects. Third-two visits (32) were carried out in all transects, totalling 512 hours of sampling effort. The transects are approximately 300 meters from one another.

Microhabitats used for vocalisation were categorised according to the substrate where individuals were found at the time of observation. Dominance in transects was estimated by means of the Berger-Parker Index (Magurran, 1988), by way of formula $D = N_{\max} / N_T$, where N_{\max} is the number of individuals of the most abundant species and N_T is the total number of individuals in the sample.

The Dajoz Index (Dajoz, 1983) was used to test the frequency of encounter of each species in the sample area, by way of formula $C = i \times 100 / L$; where C is the occurrence constant, i is the number of days in which the species was found, and L is the total number of days sampling took place. C values lower than 25 % correspond to occasional species; ranging from 25 and 50 %, to common species; and greater than 50 %, to common species.

Results

A total of 493 frog specimens were recorded in the four transects, distributed into five families, 11 genera and 14 species (Table 1, Figure 2). Hylidae (Rafinesque, 1815) was the most species rich family ($N = 5$), followed by Leptodactylidae (Werner, 1896) ($N = 3$), Aromobatidae (Grant, Frost, Caldwell, Gagliardo, Haddad, Kok, Means, Noonan, Schargel and Wheeler, 2006) and Bufonidae (Gray, 1825), both with two species, and Craugastoridae (Hedges, Duellman and Heinicke, 2008) and Microhylidae (Günther, 1858), with one species each.

Amongst 14 recorded species, eight were found in all transects. *Rhinella major* was only found at headquarter of the Park, outside the sampling transects, reason for which it was only recorded in the results regarding the

Table 1. Composition, number and relative abundance of amphibians found in four sampling transects at Sumaúma State Park, Manaus, Amazonas, Brazil

Species	Transect 1		Transect 2		Transect 3		Transect 4	
	N	%	N	%	N	%	N	%
Aromobatidae								
<i>Allobates sumtuosus</i> (Morales 2002)	1	1.42	5	3.44	1	1.31	5	2.48
<i>Anomaloglossus stepheni</i> (Martins 1989)	-	-	-	-	-	-	2	0.99
Bufoidea								
<i>Amazophrynella manaoas</i> (Rojas et al. 2014)	27	38.57	42	28.96	5	6.57	10	4.97
Craugastoridae								
<i>Pristimantis</i> gr. <i>fenestratus</i> (Steindachner 1864)	9	12.85	25	17.24	19	25	30	14.92
Hylidae								
<i>Boana cinerascens</i> (Spix 1824)	-	-	17	11.72	4	5.26	25	12.43
<i>Boana lanciformis</i> (Cope 1871)	9	12.85	23	15.86	3	3.94	29	14.42
<i>Osteocephalus oophagus</i> (Jungfer and Schiesari 1995)	-	-	5	3.44	2	2.63	6	2.98
<i>Osteocephalus taurinus</i> (Steindachner 1862)	2	2.85	4	2.75	9	11.84	13	6.46
<i>Scinax ruber</i> (Laurenti 1768)	-	-	-	-	-	-	5	2.48
Leptodactylidae								
<i>Adenomera andreae</i> (Müller 1923)	13	18.57	10	6.89	17	22.36	26	12.93
<i>Adenomera hylaedactyla</i> (Cope 1868)	7	10	7	4.82	11	14.47	27	13.43
<i>Leptodactylus pentadactylus</i> (Laurenti 1768)	2	2.85	6	4.13	5	6.57	19	9.45
Microhylidae								
<i>Synapturanus mirandaribeiroi</i> (Nelson and Lescure 1975)	-	-	1	0.68	-	-	4	1.99
TOTAL	70		145		76		201	

Table 2. Time distribution and number of frogs recorded during the campaign at Sumaúma State Park.

Family / Species	Months							
	2013					2016		
	MAY	JUN	JUL	AUG	SEP	OCT	APR	MAY
Aromobatidae								
<i>Allobates sumtuosus</i> (Morales 2002)	-	-	-	-	6	4	1	1
<i>Anomaloglossus stepheni</i> (Martins 1989)	-	-	-	-	1	-	-	2
Bufoidea								
<i>Amazophrynella manaoas</i> (Rojas et al. 2014)	2	-	38	3	22	8	9	2
<i>Rhinella major</i> (Müller and Hellmich 1936)	1	-	-	-	-	-	-	-
Craugastoridae								
<i>Pristimantis</i> gr. <i>fenestratus</i> (Steindachner 1864)	-	2	2	3	13	9	34	20
Hylidae								
<i>Boana cinerascens</i> (Spix 1824)	-	-	-	-	-	7	20	19
<i>Boana lanciformis</i> (Cope 1871)	5	7	3	2	5	2	30	10
<i>Osteocephalus oophagus</i> (Jungfer and Schiesari 1995)	-	4	-	3	-	1	3	2
<i>Osteocephalus taurinus</i> (Steindachner 1862)	1	4	-	2	7	-	9	5
<i>Scinax ruber</i> (Laurenti 1768)	-	-	-	-	-	1	4	-
Leptodactylidae								
<i>Adenomera andreae</i> (Müller 1923)	2	-	1	4	3	13	32	11
<i>Adenomera hylaedactyla</i> (Cope 1868)	1	-	8	3	19	4	12	5
<i>Leptodactylus pentadactylus</i> (Laurenti 1768)	1	1	-	3	1	7	11	08
Microhylidae								
<i>Synapturanus mirandaribeiroi</i> (Nelson and Lescure 1975)	-	-	-	-	-	-	4	-
Number of species	7	5	5	8	9	10	12	11
Number of individuals	13	18	52	23	77	56	169	85
Total number of individuals	493							



Figure 2. Anurans of Sumaúma State Park, Manaus, Amazonas, Brazil: A) *Allobates sumtuosus*; B) *Anomaloglossus stepheni*; C) *Amazophrynella manaos*; D) *Rhinella major*; E) *Boana lanciformis*; F) *Boana cinerascens*; G) *Osteocephalus oophagus*; H) *Osteocephalus taurinus*; I) *Scinax ruber*; J) *Adenomera andreae*; K) *Adenomera hylaedactyla*; L) *Leptodactylus pentadactylus*; M) *Synapturanus mirandaribeiroi*; N) *Pristimantis* gr. *fenestratus*. Photos by: A. de Lima Barros (D, E, I, N), A. Silva (B, C), A. Lima (G, M), L. Veras (A, F, K) and D. Meneghelli (H, J, L).

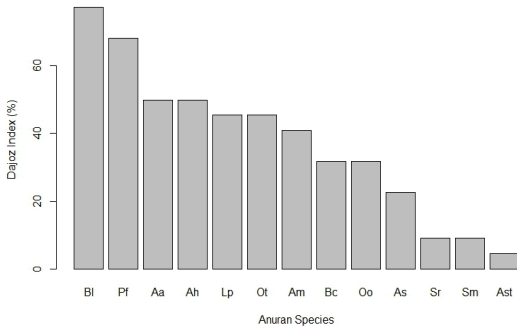


Figure 3. Dajoz Index Values (%) for the frog species recorded in the four sampling transects at Sumaúma State Park. Key: Aa = *Adenomera andreae*; Ah = *Adenomera hylaedactyla*; Am = *Amazophrynella manaos*; As = *Anomaloglossus stephenie*; Ast = *Allobates sumtuosus*; Bc = *Boana cinerascens*; BI = *Boana lanciformis*; Lp = *Leptodactylus pentadactylus*; Oo = *Osteocephalus oophagus*; Ot = *Osteocephalus taurinus*; Pf = *Pristimantis gr. fenestratus*; Sm = *Synapturanus mirandaribeiroi*; Sr = *Scinax ruber*.

in other research on frog communities, which, in turn, may be linked to the increased number of breeding sites (Moreira and Lima, 1991; Haddad and Prado, 2005).

The number of frog species recorded in this study can be considered low compared to other studies on frogs conducted in larger fragments in the Manaus region. Lima *et al.* (2008), for example, found 53 species of anurans in the Adolpho Ducke Reserve, another fragment located in the urban perimeter of Manaus and that presents approximately 10,000 km² of area. Likewise, Tsujii-Nikishido and Menin (2011), found a total of 17 species of anurans in riparian areas in the Campus of the Federal University of Amazonas, whose extension is about 600 ha. On the other hand, Silva *et al.* (2011), found a higher number of species of anurans (18 species), than the found in this study, in a smaller forest fragment. It is possible that, since it is known that the Sumaúma Park presents high anthropic impact, including of enterprises in its surroundings, the quality of environment for anurans may be lower here. Although the Park is located in an urban area, and isolated from other forest fragments, it is suggested that frog assemblies are more strongly affected by the size of the area than by isolation (Lima *et al.*, 2015), which would explain the low number of species found in this study. The fact that we did not record frog species commonly found in disturbed areas, such as *Leptodactylus fuscus* and *Rhinella marina*, suggests the need for further studies to be conducted to test whether the conditions of the Park may limit the

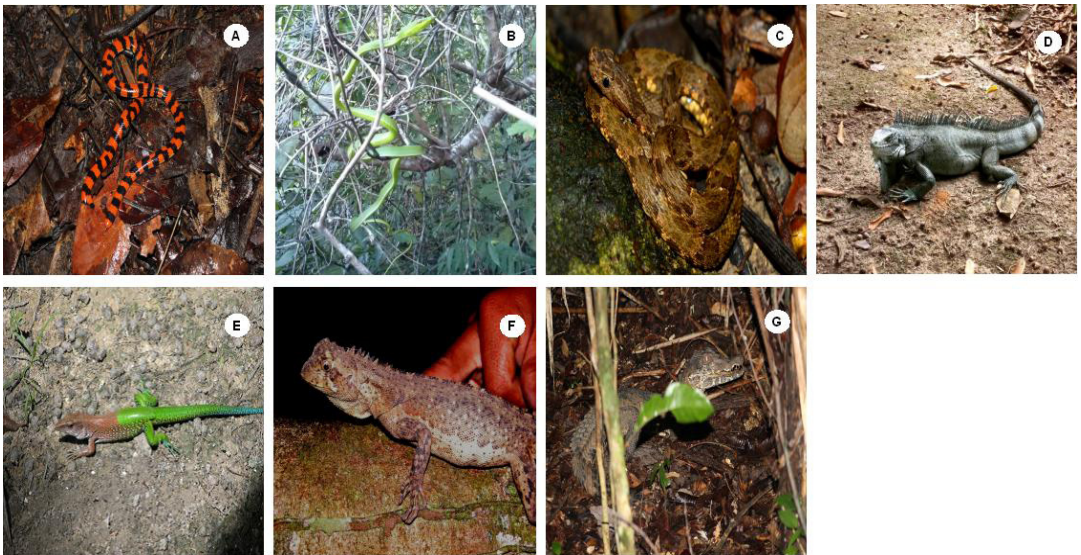


Figure 4. Species of reptiles found at Sumaúma State Park, Manaus, Amazonas, Brazil: A) *Anilius scytale*; B) *Oxybelis fulgidus*; C) *Bothrops atrox*; D) *Iguana iguana*; E) *Ameiva ameiva*; F) *Uranoscodon superciliosus*; G) *Paleosuchus trigonatus*. Photos by: A. De Lima Barros (B, D), A. Lima (E, F), L. Veras (A, G), V. Gama (C).

Table 4. Number of individuals and species of reptiles found at Sumaúma State Park.

Family	Species	No. of observed individuals
Aniliidae	<i>Anilius scytale</i> (Linnaeus 1758)	1
Colubridae	<i>Oxybelis fulgidus</i> (Daudin 1803)	2
Viperidae	<i>Bothrops atrox</i> (Linnaeus 1758)	3
Teiidae	<i>Ameiva ameiva</i> (Linnaeus 1758)	2
Tropiduridae	<i>Uranoscodon superciliosus</i> (Linnaeus 1758)	2
Iguanidae	<i>Iguana iguana</i> (Linnaeus 1758)	1
Alligatoridae	<i>Paleosuchus trigonatus</i> (Schneider 1801)	5

capacity for colonisation by other frog populations, mostly those typically found in edge environments. The *Allobates sumtuosus* and *Amazophrynella manaos* species recorded in this study have little knowledge about the ecological and natural history aspects (IUCN, 2017; Rojas et al., 2014). In addition, *A. manaos*, is a newly described species of anuran (Rojas et al., 2014), demonstrating the importance of maintaining this urban fragment for populations of anurans that are scarce data, and can serve as a sampling site for future studies on these species. Our results, despite the low number of species, show that the conservation of forest remnants located in the urban area are important to the local herpetofauna, and that further studies about the impacts on ecological aspects and about the history of life of urban frogs are necessary.

In addition to the frogs, we occasionally recorded some species of reptiles during the campaign, corresponding to snakes (N=3), lizards (N=3) and one species of caiman (Table 4, Fig. 5). There are no studies on the composition of the general herpetofauna in the Park, so we observed, in addition to the importance of this fragment as a shelter for local frogs, the need for further studies on other taxonomic groups.

Acknowledgements. We thank the Amazonas State Research Foundation (FAPEAM) for the resources made available through the Jovem Cientista Amazônico Program (JCA-AP), NOTICE 004/2012; and Program for the Support of Scientific Article Publication, NOTICE N. 015/2014 - PAPAC. The Department of Climate Change and Protected Areas Management (DEMUC) and the Amazonas State Secretariat of Environment (SEMA) for authorizing our research at the Sumaúma State Park (No. 16/2016). Biologist Mr. José Luciano Thiago for his support in our fieldwork. Diego Meneghelli, Lucian Veras, Andréia Ferreira, Vanessa Gama and Prof. Dr. Albertina Lima for the photos; and Prof. Dr. Rafael Fraga for his suggestions on our manuscript.

References

- Becker, C.G., Fonseca, C.R., Haddad, C.F.B., Batista, R.F., Prado, P.I. (2007): Habitat split and the global decline of amphibians. *Science* **18**: 1775–1777.
- Bernarde, P.S., Macedo, L.C. (2008): Impacto do desmatamento e formação de pastagem sobre a anurofauna de serapilheira em Rondônia. *Iheringia, Série Zoologia, Porto Alegre* **98**: 454–459.
- Cavalcante, D.G., Pinheiro, E.S., Macedo, M.A., Martinot, J.F., Nascimento, A.Z.A., Marques, J.P.C. (2010): Análise da vulnerabilidade ambiental de um fragmento florestal urbano na Amazônia: Parque Estadual Sumaúma. *Sociedade & Natureza, Uberlândia* **22**: 391–403.
- Dajoz, R. (1983): *Ecologia geral*. Petrópolis, Brazil, Editora Vozes.
- Daszak, P., Berger, L., Cunningham, A.A., Hyatt, A.D., Green, D.E., Speare, R. (1999): Emerging infectious diseases and amphibian population declines. *Emerging Infectious Diseases* **5**: 735–748.
- Delis, P.R., Mushinsky, H.R., McCoy, E.D. (1996): Decline of some west-central Florida anuran populations in response to habitat degradation. *Biodiversity and Conservation* **5**: 1579–1595.
- Haddad, C.F.B., Prado, C.P.A. (2005): Reproductive modes in frogs and their unexpected diversity in the atlantic forest of Brazil. *BioScience* **55**: 207–217.
- IUCN 2017. The IUCN Red List of Threatened Species. Version 2017-3. <<http://www.iucnredlist.org>>. Downloaded on 11 January 2018.
- Knispel, S.R., Barros, F.B. (2009): Anfíbios anuros da região urbana de Altamira (Amazônia Oriental), Pará, Brasil. *Biotemas* **22**: 191–194.
- Koop, K., Signorelli, L., Bastos, R.P. (2010): Distribuição temporal e diversidade de modos reprodutivos de anfíbios anuros no Parque Nacional das Emas e entorno, estados de Goiás, Brasil. *Iheringia, Série Zoologia, Porto Alegre* **100**: 192–200.
- La Marca, E., Lips, K.R., Lötters, S., Puschendorf, R., Ibáñez, R., Rueda-Almonacid, J.V., Schulte, R., Marty, C., Castro, F., Manzanilla-Puppo, J., García-Pérez, J.E., Bolaños, F., Chaves, G., Pounds, J.A., Toral, E., Young, B.E. (2005): Catastrophic population declines and extinctions in neotropical harlequin frogs (Bufonidae: *Atelopus*). *Biotropica* **37**: 190–201.
- Lima, A. P., Magnusson, W.E., Menin, M., Erdtmann, L.K., Rodrigues, D.J., Keller, C., Hödl, W. (2008): *Guia de Sapos*

- da Reserva Adolpho Ducke: Amazônia Central, 2nd Edition. Manaus, Brazil, Attema Design Editorial Ltda.
- Lima, J.R., Galatij, U., Lima, C.J., Fáveri, S.B., Vasconcelos, H.L., Neckel-Oliveira S. (2015): Amphibians on amazonian land-bridge islands are affected more by area than isolation. *Biotropica* **47**: 369–376.
- Magurran, A.E. (1988): Ecological diversity and its measurement. Princeton, USA, Princeton University Press.
- Moreira, G., Lima, A.P. (1991): Seasonal patterns of juvenile recruitment and reproduction in four species of leaf litter frogs in central Amazonia. *Herpetologica* **47**: 295–300.
- Pinheiro, E.S., Martinot, J.F., Cavalcante, D.G., Macedo, M.A., Nascimento, A.Z.A., Marques, J.P.C. (2010). Paisagem, estrutura e composição florística de um parque urbano em Manaus, Amazonas, Brasil. *Rodriguésia* **61**: 531–549.
- Pombal Jr, J.P., Haddad, C.F.B. (2005): Estratégias e modos reprodutivos em anuros (Amphibia) em uma poça permanente na Serra de Paranapiacaba, Sudeste do Brasil. *Papéis Avulsos de Zoologia* **45**: 201–213.
- Rambaldi, D.M., Oliveira, D.A.S. (2003): Fragmentação de ecossistemas: causas, efeitos sobre a biodiversidade e recomendações de políticas públicas, 1st Edition. Brasília, Brasil, Ministério do Meio Ambiente.
- Rodrigues, R.G., Machado, I.F., Christoff, A.U. (2008): Anurofauna em uma área antropizada no Campus Ulbra, Canoas, Rio Grande do Sul, Brasil. *Biodiversidade Pampeana*, PUCRS, Uruguaiiana **6**: 39–43.
- Rojas, R.R., Carvalho, V.T., Gordo, M., Ávila, R.W., Farias, I.P., Hrbek, T. (2014): A new species of *Amazophrynella* (Anura: Bufonidae) from the southwestern part of the Brazilian Guiana Shield. *Zootaxa* **3753**: 79–95.
- Silva, E.P., Mendes-Pinto, T.J., Júnior, L.H.C., Sales, M.E.P. (2011): Riqueza de espécies de anfíbios anuros em um fragmento florestal na área urbana de Manaus, Amazonas, Brasil. *Revista de Biologia e Farmácia, Campina Grande*, **5**: 1983–4209.
- Silva-Soares, T., Scherrer, P.V. (2013): Amphibians of Parque Estadual do Forno Grande, State of Espírito Santo, Southeastern Brazil: Species composition and conservation. *North-Western Journal of Zoology* **9**: 113–120.
- Skerratt, L.F., Berger, L., Speare, R., Cashins, S., McDonald, K.R., Phillott, A.D., Hines, H.B., Kenyon, N. (2007): Spread of chytridiomycosis has caused the rapid global decline and extinction of frogs. *EcoHealth* **4**: 127–134.
- Telles, M., Dias, M.M. (2010). Bird communities in two fragments of Cerrado in Itirapina, Brazil. *Brazilian Journal of Biology* **70**: 537–550.
- Tsujii-Nikishido, B.M., Menin, M. (2011): Distribution of frogs in riparian areas of an urban forest fragment in Central Amazonia. *Biota Neotropica* **11**: 63–70.
- Viana, V.M., Pinheiro, L.A.F. (1998): Conservação da biodiversidade em fragmentos florestais. *Série Técnica IPEF* **12**: 25–42.