Effects of a fire on a population of treefrogs (*Scinax* cf. *alter,* Lutz) in a restinga habitat in southern Brazil

Rocha, CFD., Ariani, CV., Menezes, VA. and Vrcibradic, D.*

Departamento de Ecologia, Universidade do Estado do Rio de Janeiro – UERJ,
Rua São Francisco Xavier, 524, CEP 20550-019, Rio de Janeiro, RJ, Brazil

*e-mail: cfdrocha@uerj.br

Received January 12, 2007 – Accepted June 21, 2007 – Distributed August 31, 2008

Abstract

The area of the Dunas da Joaquina, in Santa Catarina island, contains one of the most important remnants of restinga habitat in Santa Catarina State, southern Brazil. In December 2003, a fire occurred in a portion of this area, affecting most of the vegetation, including the bromeliad community. In this study, the density of individuals and the diet composition of the bromelicolous treefrog *Scinax* cf. *alter* were compared between the area affected by the fire and an adjacent unburned area. One-hundred-and-fifty-eight ground bromeliads (*Vriesea friburguensis*) were dissected and searched for the presence of treefrogs among their leaves. We found 30 frogs in 29.5% (23/78) of the bromeliads from the unburned site, with a mean of 1.3 frogs per rosette, and 15 frogs in 12.5% (10/80) of the bromeliads from the burned site, with a mean of 1.6 frogs per rosette. Eight (27%) of the frogs from the unburned site and eleven (73%) of those from the burned site had empty stomachs. Frogs from the burned site also contained less prey per stomach than those from the unburned site. The data suggest that the fire has negatively affected the local population of *Scinax* cf. *alter*, though it is possible that the population can recover.

Keywords: bromeliad, disturbance, fire, restinga, Anura, *Scinax* cf. *alter.*

Efeitos de uma queimada em uma população de pererecas (*Scinax* cf. *alter*) em um habitat de restinga no sul do Brasil

Resumo

A área das Dunas da Joaquina, na Ilha de Santa Catarina, contém um dos remanescentes mais importantes de habitat de restinga no Estado de Santa Catarina, no Sul do Brasil. Em dezembro de 2003, ocorreu uma queimada em uma porção desta área, afetando a maior parte da vegetação, incluindo a comunidade de bromélias. Neste estudo, comparamos a densidade de indivíduos e a composição da dieta da perereca bromelícola *Scinax* cf. *alter* entre a área afetada pelo fogo e a uma área adjacente que não foi afetada. Cento e cinqüenta e oito bromélias de chão (*Vriesea friburguensis*) foram dissecadas e examinadas quanto à presença de pererecas entre suas folhas. Foram encontradas 30 pererecas em 29,5% (23/78) das bromélias da área não-queimada, com uma média de 1,3 indivíduos por roseta; e 15 pererecas em 12,5% (10/80) das bromélias da área queimada, com uma média de 1,6 indivíduos por roseta. Oito (27%) dos animais da área não-queimada; e onze (73%) dos da área queimada estavam com o estômago vazio. As pererecas da área queimada também tiveram menos presas por estômago que as da área não-queimada. Os dados sugerem que o fogo afetou negativamente a população local de *Scinax* cf. *alter*, embora seja possível a sua recuperação.

Palavras-chave: bromélia, perturbação, fogo, restinga, Anura, *Scinax* cf. *alter*.

1. Introduction

Fire is the cause of considerable environmental disturbances, and might promote high mortality rates of local plant and animal communities and reduction of plant cover (Vogl, 1964). Fire alters soil moisture and temperature, vegetation structure, leaf-litter depth, nutrient availability, rates of erosion, and wetland hydroperiod (Cain et al., 1998). These environmental alterations are likely to severely affect many kinds of animals, especially those that are greatly sensitive to environmental disturbances, such as amphibians (Schurbon and Fauth, 2003). Nevertheless, data on the effects of fire (both direct and indirect) on amphibian populations and communities are still limited in the literature, and offer disparate results (Gillon, 1983; Friend, 1993; Kirkland et al., 1996; Giaretta et al., 1999; Russel et al., 1999; Papp and Papp, 2000; Schurbon and Fauth 2003).

Although amphibians are typically animals that depend on moisture, they are abundant in some xeric habi-

tats such as the restingas (coastal sand-dune habitats) of the eastern Brazilian coast (Carvalho-e-Silva et al., 2000). In those habitats, they depend on the water from permanent and temporary ponds as well as on the water stored on bromeliad rosettes (Peixoto, 1995; Carvalho-e-Silva et al., 2000). The use of water-storing (or "tank") bromeliads by amphibians as sites of vocalization, oviposition and tadpole development is well-known, with some species using the plants strictly as shelter and/or feeding grounds, whereas others use them during their entire life cycle (e.g., Hedges, 1987; Britto-Pereira et al., 1988; Krugel and Richter, 1995; Peixoto, 1995; Giaretta, 1996; Teixeira et al., 1997, 2002).

On the island of Santa Catarina, in southern Brazil, there is an extensive system of white sand dunes adjacent to the Joaquina beach, which stretches along ca. 3 km of coast. This area (known as the Dunas da Joaquina) contains a large portion of restinga habitat, where the treefrog *Scinax* cf. *alter* (Amphibia, Hylidae) occurs in high densities, being commonly found inside the ground bromeliad *Vriesea friburguensis* Mez. In December 2003, an arson fire burned a considerable portion (92 ha) of the restinga habitat of the Dunas da Joaquina, affecting most of the local vegetation, including bromeliads (Ariani et al., 2004). Considering the large quantity of *Vriesea friburguensis* individuals that have been burned in the area (see Ariani et al., 2004), we could predict a negative impact on the local population of *Scinax* cf. *alter* due to both mortality and loss of microhabitat by fire. Also, as a fire is supposed to reduce the availability of potential prey for the frogs through its negative effect on the local invertebrate fauna, we could expect a decrease of prey ingestion by the frogs found in the burned area. In the present study, we estimate the impact of the fire on *Scinax* cf. *alter*, by comparing data on the density and diet composition in the area affected by the fire and in an adjacent area that had not been burned. We aimed to answer the following specific questions: i) do the proportion of bromeliads containing frogs differ between the burned and unburned sites? ii) are there differences in the mean number of frogs per bromeliad between sites? and iii) do the mean number of prey in stomachs and the diet composition of *Scinax* cf. *alter* differ between the two sites?

2. Materials and Methods

1. Study area

The study area at the Dunas da Joaquina (27° 37' S and 48° 27' W) is located on the island of Santa Catarina, in the municipality of Florianópolis, and represents an important remnant of restinga habitat in the state of Santa Catarina, southern Brazil. Mean annual temperature in the area is 20.3 °C and mean annual rainfall is 1,544 mm (INMET 2005), with a warm and wet period from October to April and a cooler, drier period from May to September (Castellani et al., 1999). The study site is located within the 'wet lowlands' of the restinga (see Castellani et al., 1995), and constitutes a valley surrounded by sand dunes up to several meters high. This valley is covered by herbaceous and arbustive vegetation (Castellani et al., 1995), with a high density of ground bromeliads (Ariani et al., 2004).

2. Collecting methods and analysis

Fieldwork was carried out in December 2003, less than one week after the aforementioned fire that affected the study area. We estimated the occurrence and density of *Scinax* cf. *alter* found inside the rosettes of the bromeliad *Vriesea friburguensis* at the burned site and at an adjacent unburned site of the same restinga, approximately 300 m distant from it. All of the bromeliads at the burned site were charred and only the basal portions of the rosettes remained green, though often desiccated (see Ariani et al., 2004). To estimate frog density in each site, we dissected 80 rosettes of *Vriesea friburguensis* from the burned area and 78 rosettes of the same bromeliad species from the unburned area looking for frogs. The bromeliads were sampled arbitrarily, without following a specific sampling protocol. All frogs found were collected and subsequently euthanized by immersion in 50% ethanol solution and fixed in 10% formalin for posterior stomach content analysis.

To estimate if the fire affected the food intake and diet composition of the frogs, we analyzed the stomach contents of all frogs collected. Food items were identified and categorized to the taxonomic level of Order. Unidentified arthropod remains were grouped in a separate category, and were considered only for volumetric analyses. To estimate the volume (mm^3) of each prey, we used the ellipsoid formula, modified by Wiederhecker et al. (2002):

$$V = \frac{\pi W L^2}{6} \quad (1)$$

in which:

V = volume, W = width and L = length.

Differences in mean prey number and mean prey volume in stomachs between frogs from the burned and unburned areas were tested using the Mann-Whitney test.

3. Results

Of the 78 bromeliads examined from the unburned site, 23 (29.5%) had individuals of *Scinax* cf. *alter* inside their rosettes whereas only 10 of the 80 examined bromeliads from the burned site (12.5%) contained such frogs. We found a total of 30 frogs in rosettes from the unburned site and 15 frogs in rosettes from the burned site, with the mean number of frogs per rosette (considering only those bromeliads that contained frogs) being 1.3 ind/rosette (range 1-2) in the unburned site and 1.6 ind/rosette (range 1-3) in the burned site. When dissecting bromeliads from the burned site, we found that most of them still had water in their tanks and leaf axils.

Of the 30 frogs collected at the unburned site, only eight (27%) had empty stomachs, whereas 73% of the frogs (11/15) from the burned site had empty stomachs. Considering only the frogs with identifiable stomach contents, the mean number of prey per stomach was significantly higher for the unburned site (x = 2.8 ± 5.2; range 1-28) than for the burned site (x = 1.5 ± 0.7; range 1-2) (Mann-Whitney test: U = 136.50; P = 0.001). Also, the total prey volume ingested by frogs in the unburned site (985.7 mm^3) was greater than that of the burned site (92.7 mm^3). However, the mean prey volume per stomach found in the frogs from the unburned site (47.0 + 71.6 mm^3, n = 21, range 0.1-295.1 mm^3) did not differ significantly from that of the burned site (23.1 + 25.0 mm^3, n = 4, range 2.7-58.6 mm^3) (Mann-Whitney test: U = 46.000; P = 0.767). Among identifiable food items in the stomachs of frogs from the unburned site, the most abundant were Formicidae (59.8%), followed by insect eggs (16.4%), Diptera (9.1%) and Homoptera (6.7%) (Table 1). The remaining prey categories represented less than 5% each. Animals from the burned site had little identifiable prey in their stomachs with 66.6% being Formicidae and 33% being Aranae (Table 1). Most of the frogs from the burned site contained only unidentifiable arthropod remains in their stomachs, whereas the stomachs of frogs from the unburned site frequently contained intact prey (though a substantial portion of the total food volume ingested consisted of arthropod remains; Table 1).

4. Discussion

The data are consistent with the idea that the fire caused a negative impact on the *Scinax* cf. *alter* population of the burned site at the Dunas da Joaquina. The higher proportion of bromeliads having *Scinax* cf. *alter* in their rosettes at the unburned site suggested that the fire may have caused a reduction in the population size of that frog species in the burned site. Papp and Papp (2000) reported a populational decline of the bromelicolous hylid frog *Phyllodytes luteolus* (Wied-Neuwied) in another restinga habitat (the so-called Nativo do Paraju, in the state of Espírito Santo, southeastern Brazil) that had been affected by a fire. Those authors did not find any individual of *Phyllodytes* in 46 rosettes of *Vriesea neoglutinosa* Mez (the most abundant bromeliad in that area) examined four months after the fire, although this frog used to be commonly found and associated with this bromeliad in the area. A study carried out in the same area before the fire (Giaretta, 1996) showed that *P. luteolus* used to be relatively common locally, which led Papp and Papp (2000) to conclude that this frog's local population was severely affected by the fire, mainly due to its negative effect on the bromeliads. In our study, on the other hand, the presence of frogs in 12% of the bromeliads (with 1-3 frogs per bromeliad) from the burned site could suggest that the population of *Scinax* cf. *alter* at the Dunas da Joaquina had not been affected so severely by the fire. This could be partly explained by the biological differences between the two frog species. *Phyllodytes luteolus* is strongly dependent on bromeliads, where it reproduces and spends its entire life cycle, whereas *Scinax alter* uses bromeliads as shelter, but do not reproduce in them, using instead permanent or temporary ponds for spawning (Peixoto, 1995; Carvalho-e-Silva et al., 2000). Thus, we do not know to what extent the latter species could still be able to reproduce even after extensive destruction of local bromeliads by fire. Moreover, in the Nativo do Paraju, the fire affected practically the whole extension of restinga habitat (Rocha et al., 1996; Papp and Papp, 2000), whereas in the Joaquina restinga, a relatively large

Table 1. Absolute values and percentages for number, volume (in mm^3), and frequency of occurrence of each prey category found in stomachs of *Scinax* cf. *alter* from the unburned and burned sites at the Dunas da Joaquina, in Santa Catarina State, southern Brazil.

Prey category	Unburned site (n = 30)			Burned site (n =15)		
	N (%)	V (%)	F %	N (%)	V (%)	F %
ARACHNIDA						
Aranae	2 (2.2)	72.8 (7.4)	6.6	1 (33.3)	8.5 (9.0)	6.6
Acarina	1 (1.1)	0.006 (> 0.1)	3.3	-	-	-
INSECTA						
Orthoptera	1 (1.1)	22.1 (2.2)	3.3	-	-	-
Isoptera	4 (4.3)	7.5 (0.7)	1.1	-	-	-
Diptera	4 (4.3)	85.6 (8.7)	13.3	-	-	-
Coleoptera	3 (3.2)	10.5 (1.0)	10.0	-	-	-
Hymenoptera (ants)	55 (59.8)	40.4 (4.0)	36.6	2 (66.6)	2.7 (3.0)	6.6
Hymenoptera (other)	4 (4.3)	11.6 (1.2)	3.3	-	-	-
Homoptera	2 (2.2)	62.8 (6.4)	6.6	-	-	-
Lepidoptera	1 (1.1)	181.1 (18.4)	3.3	-	-	-
Insect eggs	15 (16.4)	0.02 (> 0.1)	6.6	-	-	-
Unidentified arthropod remains	-	490.9 (49.9)	26.6	-	81.5 (88.0)	13.3
Total	92	985.7		3	92.7	

area remained unaffected. This unburned area could, therefore, provide refuge for the frogs displaced by the fire as well as represent a source of recolonization for the adjacent affected area. Alternatively, considering the fact that the fire at the Dunas da Joaquina restinga had occurred less than one week before our study was carried out, we do not know if the surviving frogs would have lasted much longer at the burned area [by comparison, the study of Papp and Papp (2000) was carried out four months after the fire that ravaged the Nativo do Paraju].

The reduction in food intake observed for *Scinax* cf. *alter* at the burned site compared to the unburned one suggests that the fire may have had a negative effect on the arthropod fauna associated to bromeliads in the area, restricting the potential number of prey available for the frog. Studies carried out at the Nativo do Paraju restinga a few days after the fire that ravaged the whole area suggested that the invertebrate fauna associated with bromeliads was considerably affected (Rocha et al., 1996; Papp and Papp, 2000). Although Rocha et al. (1996) observed that 82% of the arthropods found in 15 examined rosettes of the bromeliad *Vriesea neoglutinosa* were alive, this was largely due to the presence of 108 live termites (comprising 89% of the live arthropods in the whole sample) in a single bromeliad, which obviously biased the results. In the present study, the ratio of individuals having empty stomachs was considerably higher in the burned site, suggesting that frogs in that site could be starving. The diet of frogs of the unburned site was composed of 11 types of prey, whereas that of the frogs from the burned site was composed of only two types of prey, indicating a considerable decrease in trophic diversity for the latter. Furthermore, the mean number of prey per stomach and the number of prey types in the stomachs decreased strongly from the frogs in the unburned site to the frogs in the burned site. The fact that most frogs from the burned site had only unidentifiable arthropod remains in their stomachs (suggesting that they had not eaten recently) may be indicative that after the fire, the frogs' prey sources in the burned site may have been depleted, resulting in a decrease in food consumption.

The water contained within the bromeliad tanks probably had an important role in the prevention of the complete burning of many individual plants during the fire (Ariani et al., 2004). Since much of the water is accumulated within the central tank of a bromeliad, where the plant's meristematic tissue is found, this may protect the central meristem from the fire, allowing survival and posterior recovering of the bromeliad and, consequently, the reestablishment of the bromeliad-associated fauna. Alves et al. (1996) showed that one year after the fire in the Nativo do Paraju restinga, a considerable portion of the bromeliad population has recovered, mostly due to re-growth from the live meristem of burned rosettes.

The results of the present study suggest that the fire in the study area affected the local population of the frog *Scinax* cf. *alter* through the charring of their main shelters (i.e. bromeliads) and through the probable negative impact on its main food source (i.e. invertebrates). Of course, the fire could have also impacted the frog population directly, by killing great numbers of frogs, though it was not possible for us to assess if this has occurred (we found no remains of dead frogs inside the bromeliads we examined). Nevertheless, recovery of the frog population seems likely, considering the potential for the bromeliad population to recover gradually from individuals that had survived the fire and the fact that the fire-affected area may be posteriorly re-colonized by frogs from the adjacent unaffected area.

Acknowledgements — This study was carried out as part of the project "The Ecology of Vertebrates of Eastern Brazil", of the Ecology Department, Universidade do Estado do Rio de Janeiro. We thank the Conselho Nacional do Desenvolvimento Científico e Tecnológico (CNPq) for the research grants (process n° 307653/2003-0 and 477715/2006-0 to CFDR), a PhD grant for VAM, and a scientific initiation grant to CVA. We thank Elton Leme and Carlos Eduardo V. B. de Siqueira who helped with the taxonomic identification of the bromeliad and José P. Pombal Jr. and Ivan Nunes who identified the frog species. The Instituto Biomas provided some logistic support for this study.

References

ALVES, MAS., ROCHA, CFD., and Van SLUYS, M., 1996. Population recovery rates in *Vriesea neoglutinosa* 15 months after a wild fire. *Bromélia,* vol. 3, no. 4, p. 3-8.

ARIANI, CV., MENEZES, VA., VRCIBRADIC, D. and ROCHA, CFD., 2004. The negative impact of fire on populations of three bromeliad species at a restinga habitat in the southern state of Santa Catarina, Brazil. *Vidalia,* vol. 2, no. 2, p. 44-49.

BRITTO-PEREIRA, MC., CERQUEIRA, R., SILVA, HR. and CARAMASHI, U., 1988. Utilização de *Neoregelia cruenta* (Bromeliaceae) como abrigo diurno por anfíbios anuros na Restinga de Maricá, Rio de Janeiro. In *Anais do VI Seminário Regional de Ecologia.* UFSCar: São Carlos, São Paulo. p. 307-318.

CAIN, MD., WIGLEY, TB. and REED, DJ., 1998. Prescribed fire effects on structure in uneven-aged stands of loblolly and shortleaf pines. *Wildl. Soc. Bulletin,* vol. 26, no. 2, p. 209-218.

CARVALHO-E-SILVA, SP., IZECHSOHN, E. and CARVALHO-E-SILVA, AMPT., 2000. Diversidade e ecologia de anfíbios em restingas do sudeste brasileiro. In Esteves, FA. and Lacerda, LD. (Eds.). *Ecologia de restingas e lagoas costeiras*. Macaé, Rio de Janeiro: NUPEM/UFRJ. p. 89-97.

CASTELLANI, TT., FOLCHINI, R. and SCHERER, KZ., 1995. Variação temporal da vegetação em um trecho de baixada úmida entre dunas, Praia da Joaquina, Florianópolis, SC. *Insula (Florianópolis),* vol. 24, no. 1, p. 37-72.

CASTELLANI, TT., CAUS, CA., and VIEIRA, S., 1999. Fenologia de uma comunidade de duna frontal no sul do Brasil. *Acta Bot. Bras.,* vol. 13, no. 1, p. 99-114.

FRIEND, GR., 1993. Impact of fire on small vertebrates in Mallee woodlands and heartlands of temperate Australia: a review. *Biol. Conserv.,* vol. 65, no. 2, p. 99-114.

GIARETTA, AA., 1996. Reproductive specializations of the bromeliad hylid frog *Phyllodytes luteolus. J. Herpetol.,* vol. 30, no. 1, p. 96-97.

GIARETTA, AA., FACURE, KG., SAWAYA R, J., MEYER, JHM. and CHEMIN, N., 1999. Diversity and abundance of litter frogs in a montane forest of southeastern Brazil: seasonal and altitudinal changes. *Biotropica,* vol. 31, no. 4, p. 669-674.

GILLON, D., 1983. The fire problem in tropical savannas. In Bourliere, F. (Eds.). *Ecosystems of the world. V. 13 Tropical savannas*. New York: Elsevier. p. 617-642.

HEDGES, SB., 1987. Vocalization and habitat preference of the Jamaican treefrog *Hyla marianae* (Anura: Hylidae). *Carib. J. Sci.,* vol. 23, no. 3-4, p. 380-384.

INMET, 2005. *Normais Climatológicas do INMET - 1961/1990*. Brasília: Instituto Nacional de Meteorologia.

KIRKLAND, GL., SNODDY, HW. and LAMSLER, T., 1996. Impact of fire on small mammals and amphibians in a Central appalachian deciduous forest. *Am. Midl. Nat.,* vol. 135, no. 2, p. 253-260.

KRUGEL, P. and RICHTER, S., 1995. *Syncope antenori* – a bromeliad frog with free-swimming, nonfeeding tadpoles (Anura: Microhylidae). *Copeia,* vol. 1995, no. 4, p. 955-963.

PAPP, MG. and PAPP, COG., 2000. Decline in a population of the treefrog *Phyllodytes luteolus* after fire. *Herpetol. Rev.,* vol. 31, no. 2, p. 93-95.

PEIXOTO, OL., 1995. Associação de anuros e bromeliáceas na Mata Atlântica. *Rev. Univ. Rural,* vol. 17, no. 2, p. 75-83.

ROCHA, CFD., VAN-SLUYS, M., ORNELLAS, AB., SIQUEIRA, AE., CONDE, CFV., BITTENCOURT, EB., OLIVEIRA, MGN., BARROS, MC. and MAGALHÃES, SAP., 1996. The effect of fire on natural populations of *Vriesea neoglutinosa* in a relict restinga of Espírito Santo State. *Bromélia,* vol. 3, no. 1, p. 16-26.

ROCHA, CFD., COGLIATTI-CARVALHO, L., NUNES-FREITAS, AF., ROCHA-PESSÔA, TC., DIAS, AS., ARIANI, CV. and MORGADO, LN., 2004. Conservando uma larga porção da diversidade biológica através da conservação de Bromeliaceae. *Vidalia,* vol. 2, no. 1, p. 52-72.

RUSSEL, KR., VAN LEAR, DH., and GUYNN, DC., 1999. Prescribed fire effects on herpetofauna: review and management implications. *Wildl. Soc. Bull.,* vol. 27, no. 2, p. 374-384.

SCHURBON, JM. and FAUTH, JE., 2003. Effects of prescribed burning on amphibian diversity in a southeastern U.S. national forest. *Conserv. Biol.,* vol. 17, no. 5, p. 1338-1349.

TEIXEIRA, RL., ZAMPROGNO, C., ALMEIDA, GI. and SCHINEIDER, JAP., 1997. Tópicos Ecológicos de *Phyllodytes luteolus* (Amphibia: Hylidae) da Restinga de Guriri, São Mateus, ES. *Rev. Brasil. Biol.,* vol. 57, no. 4, p. 647-654.

TEIXEIRA, RL., SCHINEIDER, JAP. and ALMEIDA, GI., 2002. The occurrence of amphibians in bromeliads from a southeastern Brazilian restinga habitat, with special reference to *Aparasphenodon brunoi* (Anura: Hylidae). *Rev. Bras. Biol. = Braz. J. Biol.,* vol. 62, no. 2, p. 263-268.

VOGL, RJ., 1964. The effects of the fire on the vegetational composition of bracken-grasslands. *Trans. Wisconsin Acad. Sci. Arts Lett.,* vol. 53, no. 1, p. 67-82.

WIEDERHECKER, HC., PINTO, ACS. and COLLI, GR., 2002. Reproductive ecology of *Tropidurus torquatus* (Squamata: Tropiduridae) in the highly seasonal Cerrado biome of central Brazil. *J. Herpetol.,* vol. 36, no. 1, p. 82-91.