Camila Vianello Bastazini

ANFÍBIOS DA RESTINGA DO MUNICÍPIO DE MATA DE SÃO JOÃO, BAHIA, BRASIL: QUE VARIÁVEIS AMBIENTAIS ESTÃO ASSOCIADAS À COMPOSIÇÃO DOS ANUROS?

Salvador – 2006

Camila Vianello Bastazini

ANFÍBIOS DA RESTINGA DO MUNICÍPIO DE MATA DE SÃO JOÃO, BAHIA, BRASIL: QUE VARIÁVEIS AMBIENTAIS ESTÃO ASSOCIADAS À COMPOSIÇÃO DOS ANUROS?

Dissertação apresentada ao Instituto de Biologia da Universidade Federal da Bahia, para a obtenção de Título de Mestre em Ecologia e Biomonitoramento. Orientador: Prof. Dr. Marcelo Felgueiras Napoli. Co-Orientador: Prof. Dr. Pedro Luís Bernardo da Rocha.

Salvador – 2006

Bastazini, Camila Vianello
Anfíbios da Restinga do Município de Mata de São João, Bahia, Brasil: que variáveis ambientais estão associadas à composição dos anuros?
58p.
Dissertação (Mestrado) – Instituto de Biologia da Universidade Federal da Bahia.

1. Restinga. 2. Anura. 3. Comunidade. I. Universidade Federal da Bahia. Instituto de Biologia.

Comissão Julgadora:

Prof.[a] Dr.[a] Flora Acuña Juncá

Prof. Dr. Carlos Frederico Duarte da Rocha

Prof. Dr. Marcelo Felgueiras Napoli (orientador)

Dedico essa dissertação aos meus pais, Estela e Roberto, e aos meus irmãos, Rafael e Simone, pois sem o amor e apoio financeiro a mim concedido este trabalho não teria chegado ao fim.

AGRADECIMENTOS

Ao Prof. Dr. Marcelo Felgueiras Napoli, pela orientação, amizade e paciência. Aprendi a respeitar e admirar essa pessoa, que sempre me ajudou muito e me fez obter grande crescimento profissional e pessoal.

À minha família, pois sem o apoio financeiro dos meus pais esse trabalho de mestrado não existiria. Agradeço o amor incondicional dos meus pais, Roberto e Estela, e dos meus amados irmãos Simone e Rafael, pois sem o apoio a mim concedido eu não teria chegado ao final desta longa e difícil jornada.

Ao meu tio Márcio Vianello e sua esposa Juliana que deram grande apoio financeiro e moral para minha família, para que eu pudesse continuar na Bahia.

Á minha querida avó Joaquina Vianello pelo carinho e por ter superado bem a saudade... e por dar um grande apoio à minha família sempre que preciso.

Ao Prof. Dr. Pedro Rocha pela co-orientação e por me ajudar na parte estatística e de delineamento amostral. Pelo tempo e paciência em que foi necessário ter comigo.

Aos amigos do AMPHIBIA que me ajudaram muito no trabalho de campo e na triagem do material em laboratório: Rafael Abreu, Tatiane Brandão, Agustín Camacho, Juliana Munduruca, Ariane Lima, Milena Camardelli, Thales dos Santos, Cinthia Macedo, André A. Mendonça e Wilton Fahning. Aproveito para agradecer ao Wilton pela grande ajuda com os gráficos e configurações. Agradeço em especial a minha amiga Patricia Fonseca, pois além de me ajudar nos trabalhos de campo muito me auxiliou nos momentos difíceis da vida com conversas e apoio, obrigada Pati!

Às minhas amigas “peixólogas” Angela Zanata e Priscila Camelier, pela amizade, conversas, almoços e companhia.

À Profa. Dr.ª Blandina Viana por nos emprestar seu carro nas coletas.

Ao Prof. Dr. Wilfried Klein pela revisão crítica do artigo.

Agradeço à amizade e apoio dos meus amigos baianos: Cristiano (Kiko), Ricardo e Aline, Breno, Rafa (Burger), Thiago Filadelfo, Diego Díaz, Lucas, Eva, Katarina, Jéssica, Mariana Vila Flor, Deise, Thiago Kinelli e Manuela.

Aos amigos mateiros Bil e Zé, que nos ajudaram muito desde a marcação das áreas até o último dia de coleta noturna.

Ao Adriano Paiva, por nos ter concedido a oportunidade de pesquisar na área da Restinga de Mata de São João.

Á Professora Josanídia Lima por ceder o Laboratório de Avaliação de Impactos em Ecossistemas Terrestres da Universidade Federal da Bahia (LAVIET) para análise de unidade do solo.

Ao Prof. Dr. Francisco Barros pela ajuda na parte de estatística.

À Jussara pela atenção e amizade, por estar sempre pronta para ajudar e avisar quando faltava algum documento ou assinatura.

À CAPES por ter me concedido bolsa no segundo ano de mestrado.

Ao IBAMA por ter cedido a licença de coleta.

ÍNDICE

I INTRODUÇÃO

Os estudos que versam sobre comunidades de anfíbios têm sido desiguais em suas abordagens e níveis de aprofundamento. Além disso, pesquisas que utilizaram os anuros como objetos de estudo têm se preocupado em investigar a totalidade das espécies da comunidade, mas com níveis de detalhamento inferiores aos empregados em estudos de urodelos (DUELLMAN & TRUEB, 1994). A maioria dos estudos em comunidades de anfíbios anuros (ver McCUNE & GRACE, 2002, para definição do conceito de comunidade concreta) tem se restringido a ambientes associados a corpos d'água no solo, como margens de rios, lagos ou alagados (p.ex., ROSSA-FERES & JIM, 1994; POMBAL, 1997; ARZABE *et al.*, 1998; ARZABE, 1999; BRASILEIRO *et al.*, 2005; VASCONCELOS & ROSSA-FERES, 2005), ou aqueles associados à presença de bromeliáceas (p.ex., PEIXOTO, 1995; SCHINEIDER & TEIXEIRA, 2001). Todavia, o entendimento sobre a ocupação de um determinado ecossistema por uma comunidade de anuros não deveria ficar limitado a uma determinada fisionomia do ambiente, como a áreas providas de corpos d'água no solo. Este procedimento acaba por enviesar os resultados, já que deixa de considerar a disponibilidade de outros recursos do ambiente. Além disso, o conhecimento dos padrões de distribuição espacial das comunidades de anuros e de como respondem aos recursos ambientais disponíveis não têm sido metodicamente explorados, limitando-se, via de regra, a aspectos descritivos, deixando-se de buscar assim os processos que norteiam a estruturação destas comunidades.

A caracterização inadequada e a falta de padronização dos estudos que versam sobre a composição de anfíbios em ecossistemas, não tem sido o único limitador do conhecimento sobre a estrutura de comunidades de anuros no Brasil. Determinados tipos de ambientes, como o de Restinga, foram pouco avaliados quanto à composição das populações e comunidades de anfíbios, assim como, e principalmente, quanto aos processos que norteiam sua estruturação. As restingas são ecossistemas característicos do bioma Mata Atlântica, localizadas nas baixadas litorâneas e constituídas por dunas e cordões arenosos. São ambientes abertos, com elevado aporte de iluminação solar que penetra entre os espaços da vegetação. O substrato arenoso implica em rápida percolação da água pluvial, o que limita a ocorrência de água livre, fundamental para os anfíbios, que são muito dependentes de balanço hídrico. De forma geral, nas restingas a água livre é encontrada apenas em alguns pontos de afloramento do lençol freático e no interior de bromélias-tanque, que possuem capacidade de reserva d'água em razão da disposição das folhas (CARVALHO-E-SILVA *et al.*, 2000; FREITAS *et al*, 2000; COGLIATTI-CARVALHO, 2001). As características físicas das restingas sugerem que as mesmas sejam consideradas ambientes hostis para organismos como anfíbios (VAN SLUYS *et al.*, 2004), já que a distribuição e abundância das espécies deste grupo, bem como a composição das comunidades, são limitadas por condições ambientais tais como umidade e temperatura, disponibilidade de nutrientes e estrutura física do habitat (BROWN *et al.*, 1995). Conclusões como esta acabam por acarretar o pouco conhecimento acumulado sobre comunidades de anuros em restingas no Brasil (CARAMASCHI e*t al.*, 1992; PEIXOTO, 1995; GIARETTA, 1996; CARVALHO-E-SILVA *et al.*, 2000; SCHINEIDER & TEIXEIRA, 2001; TEIXEIRA *et al.*, 2002; ROCHA *et al.*, 2003; ROCHA, *et al.*, 2004; VAN SLUYS *et al.*, 2004). Apenas para as restingas dos estados do Rio de Janeiro e Espírito Santo há listagens de espécies de anuros, sendo que a primeira é uma das poucas em que foi realizado esforço considerável de amostragem ao longo de ao menos um ano (ROCHA *et al.*, 2003). Há total ausência de estudos metódicos de cunho ecológico sobre anuros nas restingas do litoral norte baiano e pouco se sabe sobre a composição e estrutura destas comunidades. MUNDURUCA (2005) compôs o único trabalho conhecido que versa sobre a estrutura de anfíbios anuros no litoral norte baiano, investigando comunidades de anuros de um remanescente de Mata Atlântica. Este trabalho, além de ter sido pioneiro no litoral norte, utilizou delineamento amostral e procedimentos de análise inéditos no estudo de assembléias de anuros no Brasil. Vale ressaltar que o presente trabalho consiste no primeiro e único a ser realizado em ambiente de Restinga no litoral norte da Bahia versando sobre estrutura de comunidades de anuros.

As restingas brasileiras têm sofrido grande impacto devido à especulação imobiliária. O litoral norte da Bahia vem sofrendo intenso processo de ocupação decorrente da construção da Linha Verde (BA 099), o que acarretou na criação da área de proteção ambiental "APA Litoral Norte", criada pelo Decreto Estadual nº 1046 de 17/III/1992, devido à necessidade de conservar e preservar os remanescentes da Floresta Atlântica, associado a manguezais, áreas estuarinas, restingas, dunas e lagoas. A interferência humana tem sido clara no litoral norte da Bahia, onde *resorts* estão sendo construídos sem uma ação norteadora dos órgãos estaduais, ação esta que deveria estar fundamentada em estudos ecológicos metodicamente adequados sobre a fauna e flora da região.

O presente trabalho tem como objetivos: (1) determinar a composição e distribuição da comunidade de anuros em uma faixa de Restinga no litoral norte da Bahia, Brasil e (2) buscar por variáveis ambientais que estejam associadas à composição da comunidade de anuros.

II MANUSCRITO PARA APRECIAÇÃO

Este capítulo apresenta o manuscrito intitulado "**Which environmental variables explain better changes in anuran composition? A case study in the Restinga of Mata de São João, Bahia, Brazil**", que se destina à submissão para apreciação e publicação no periódico científico HERPETOLOGICA. Os resultados aqui discorridos, assim como a discussão e conclusões derivadas, decorrem do desenvolvimento da presente dissertação. Os critérios de redação e formatação seguem às normas deste periódico, as quais se encontram disponíveis na íntegra no ANEXO desta dissertação.

WHICH ENVIRONMENTAL VARIABLES EXPLAIN BETTER CHANGES IN ANURAN COMPOSITION? A CASE STUDY IN THE RESTINGA OF MATA DE SÃO JOÃO, BAHIA, BRAZIL

CAMILA V. BASTAZINI[1], JULIANA F. V. MUNDURUCA[1], PEDRO LUÍS B. ROCHA[1,2], AND MARCELO F. NAPOLI[1,2,3]

[1]*Programa de Pós-Graduação em Ecologia e Biomonitoramento, Instituto de Biologia, Universidade Federal da Bahia, Rua Barão de Geremoabo, Campus Universitário de Ondina, 40170-290 Salvador, Bahia, Brazil*

[2]*Departamento de Zoologia, Instituto de Biologia, Universidade Federal da Bahia, Rua Barão de Geremoabo, Campus Universitário de Ondina, 40170-290 Salvador, Bahia, Brazil*

[3]CORRESPONDENCE: e-mail, napoli@ufba.br

ABSTRACT: Studies of amphibian communities have been unbalanced in their approaches, field methods, meticulousness, and research designs. Most of them are descriptive and restricted to aquatic environments, such as breeding ponds and stream-side communities. Studies of entire tropical communities are rare, especially those focusing environmental processes that shape community structure. Moreover, some types of habitat-specific communities, like those of Restinga environment, are poorly studied. In Brazil, only restingas from the states of Rio de Janeiro and Espírito Santo have studies regarding anuran communities. The northern coastline of the State of Bahia harbors about 200 km of contiguous Restinga environments, but studies focusing the composition and structure of their anuran communities are virtually absent. The southern coastline of Bahia, on the other hand, has received much more attention, being considered as a hotspot of biodiversity. The present paper intended to fill out both gaps cited above. First, we aimed to determine which environmental variables, if any, were able to predict the main changes in anuran community composition, and secondly, to describe the composition and distribution of the anuran communities of the Restinga patch herein studied in the northern coastline of Bahia, Brazil. We sampled 30 plots (60 x 25 m) by active and passive methods in a continuous Restinga area in the Municipality of Mata de São João, State of Bahia, Brazil. Three sampling periods were carried out. In order to conduct the research at comparable times of the year, we distributed the sampling over two consecutive rainy seasons. We estimated environmental gradients potentially relevant to anuran species by measuring 20 primary environmental variables in each plot. We used the Nonmetric Multidimensional Scaling method (NMS) on the abundance matrix of species by plots in order to produce an axis that synthesizes changes in the anuran composition throughout the 30 plots. We used a principal component analysis (PCA) to synthesize the 20 environmental variables into a few orthogonal synthetic axes. In order to test the hypothesis of absence of association between the environmental synthetic axes and the NMS ordination axis, we used the multiple regression analysis. We sampled 737 anurans, belonging to 8 families, 17 genus, and 30 species. The NMS axis was able to express structure in the studied community, and ordered the anuran community through an environmental gradient that reflected the main physiognomies of the environment. The environmental variables that explained better the variation of the anuran communities were directly or indirectly linked to the vegetal stratification.

Key-words: Amphibia, Anuran composition, Environmental variables, Northern coastline of Bahia, Restinga.

INTRODUCTION

Studies on amphibian communities (see McCune and Grace, 2002 for definition of the concrete community concept) have been unbalanced in their approaches, field methods, meticulousness, and research designs (e.g., Bernarde and Kokobum, 1999; Eterovick and Sazima, 2000; Giaretta et al., 1999). Most investigations concerning anuran communities are restricted to sites with bodies of water on the ground, such as breeding ponds and stream-side communities (e.g., Arzabe, 1999; Arzabe et al., 1998; Brasileiro et al., 2005; Pombal, 1997; Rossa-Feres and Jim, 1994; Vasconcelos and Rossa-Feres, 2005) or focusing on anurans associated to bromeliads (e.g., Peixoto, 1995; Schineider and Teixeira, 2001). It is our understanding, however, that the knowledge about the structure of anuran communities in specific biomes should not be restricted to a specific environmental physiognomy, like breeding ponds in a forest floor. The restriction of researches to this microhabitat minimizes the understanding of structure and processes that shape the community, since a species also may occur, with distinct abundances, in other environmental physiognomies such as adjacent dry areas in the same forest floor. Despite of a notorious dependence of rainfall as the primary factor controlling breeding activity of anurans, which in turn regulates humidity and bodies of water, there is no concrete evidence that these variables really act as the main factors structuring anuran communities. Therefore, the restriction of community studies to breeding habitats is not justified.

The infrequent use of standard procedures (see Heyer et al., 1994 for standard procedures) by anuran community researches is a major problem in the study of community ecology, but it is not the only one. Anuran communities from specific Brazilian ecosystems, like that from the Restinga habitat, are poorly known and few studies on them have been done, as are the environmental processes that shape their communities (Van Sluys et al., 2004). The restingas are comprised in the Atlantic Forest Biome, and are coastal sand dune habitats, covered with herbaceous and shrubby vegetation, common along the Brazilian coast (Suguio and Tessler, 1984).

Although the Restinga ecosystem seems to be a hostile environment to an ectothermic vertebrate with permeable skin, anuran communities in restingas are relatively rich. Rocha et al. (2005) sampled 22 species of amphibians along two Restinga corridors (states of Rio de Janeiro, Espírito Santo, and southern Bahia). Among them, there are species endemic only to the Restinga ecosystem, like *Chaunus pygmaeus*, *Leptodactylus marambaiae*, *Scinax agilis*, *S. littorea*, and *Xenohyla truncata* (Rocha et al., 2005). Anurans from Restinga communities include scansorial, fossorial, and ground-dwelling species that are usually restricted to water bodies in open formations (e.g., *Chaunus granulosus*; *Dendropsophus branneri*; *Dermatonotus muelleri*; *Hypsiboas albomarginatus*; *Leptodactylus ocellatus*; *Pleurodema diplolister*; *Scinax alter*), but found also at forested areas in diverse microhabitats (e.g., *Chaunus crucifer*; *Eleutherodactylus ramagii*; *Itapotihyla langsdorfii*; *Proceratophrys boiei*; *Trachycephalus atlas*). Other species (e.g., *Aparasphenodon brunoi*; *Phyllodytes luteolus*; *Scinax perpusillus*; *Xenohyla truncata*) use only resources offered by terrestrial and epiphytic bromeliads (Peixoto, 1995; Schineider and Teixeira, 2001).

Detailed data on Brazilian Restinga communities are restricted to Maricá and Jurubatiba, in Rio de Janeiro State, and to Setiba, in Espírito Santo State (Rocha et al., 2003). The northern coast of the State of Bahia has approximately 200 km of contiguous Restinga environments, but studies focusing the composition and structure of anuran communities are virtually absent. Recently, Juncá (2006) published an amphibian inventory of three Atlantic Forest fragments in northern Bahia, but up to now, only Munduruca (2005) developed a detailed ecological research on anurans, investigating a large fragment of Atlantic Forest. Biodiversity studies in the northern coastline of Bahia are essential in order to subsidize conservation efforts. After the construction of the highway BA 099, the progressive conversion of restingas into resort areas led to loss of habitats. The "Reserva" Sapiranga (object of the present research) and "Reserva"

Camurujipe (research object of Munduruca, 2005) are among the rare forested landscapes that remain preserved in this region, both in private protected areas.

The goals of the present research are: (1) to determine the composition and distribution of the anuran community in a band of Restinga environment in the northern coastline of Bahia, Brazil, and (2) to analyze the environmental variables associated to the composition of the anuran community.

MATERIALS AND METHODS

Research Design and Field Methods

We distributed thirty sample units (SUs) (P01–P30), measuring 60 x 25 m each, in a contiguous Restinga landscape at Municipality of Mata de São João, State of Bahia, Brazil. We placed the sample units along trails, 50% with bodies of water (e.g., ponds, springs, rivers, and lakes) and 50% without them. The sampling areas included two private areas: "Reserva" Sapiranga and a property in Praia do Forte. The "Reserva" Sapiranga (12º 33' 59" S; 38º 02' 18" W, 12 m altitude) includes 500 hectares covered by arboreal vegetation, in which occur springs, streams, and rivers (P5, P13–P15), lakes and ponds (P1, P4, P21, P22, P25), areas without bodies of water and with less than 20 bromeliads in a SU (P4, P11, P12, P23, P24), and sandy areas (P2, P3) without bodies of water and with high density of bromeliads ($N \geq 100$ bromeliads in SUs). The Restinga from Praia do Forte (12º 34' 12" S; 38º 00' 04" W, sea level) is characterized for having sandy soil covered by many shrubs and bromeliads (> 100 bromeliads per SU) (P8–P10, P16–P18, P28–P30) and is continuous to a gallery forest that surrounds a lake formed by the fresh water river Timeantube (P6–P7, P19–P20, P26–P27), the latter filled with emergent vegetation. Both "Reserva" Sapiranga and Praia do Forte are included in the State environmental protected area "APA Litoral Norte".

We sampled SUs in 3 periods of consecutive rainy seasons (from April to September), as follows: 10 SUs from 06 to 13 September 2004, 10 SUs from 25 April to 02 May 2005, and 10

SUs from 16 to 23 August 2005. Each sampling period lasted seven days. The plots were considered as independent data, since they were not repeated. We placed nine SUs in sites with bodies of water, and six in areas without them. At Praia do Forte, nine SUs were placed in the arbustive vegetation (without bodies of water) and six in the gallery forest. We sampled anurans by active (manual) and passive methods (pitfall traps). In each SU, we installed 10 pitfall traps (20-liter plastic buckets) with 2-drift fence array (each fence, 5 m length and 50 cm height), totalizing 300 traps at the end of the research. In order to minimize the effect of environmental disturbance caused by the digging, the pitfall traps remained closed for 15 days. Only after this period we opened the pitfalls and started the sampling. We surveyed each SU for anurans during 40 minutes, between 1800 and 2400 h, totalizing four hours of active search per day. We covered the SUs with homogeneous effort with a team of four researches, which were not changed during the study. A pair of observers surveyed five SUs per night, and these pairs and the sequences of visitation to SUs were changed randomly during the sampling period.

We measured 20 environmental variables. (1) Soil moisture (SMO): ten soil samples were taken at random places in the SU, which were mixed and sealed in a plastic bag. The moisture was measured by the "Moisture at 65°C" analysis (Embrapa, 1997). (2) Air moisture (AMO) and (3) air temperature (TEM): both variables were measured every night in all sample units using a thermo-hygrometer Minipa MT 242. (4) Estimated percentage of water cover in the sample unit (WSU). (5) Kind of body of water in the SU (KBW). This is an ordinal variable to estimate the water flow: 0 – absence of body of water; 1 – pounds and lakes; 2 – rivers and streams. (6) Maximum width of the water body (MWB). (7) Maximum depth of the water body (MDB). The next six environmental variables were taken from 10 points chosen at random in the SU (Fig. 1), which were not changed during the study. In each point, a circle of 3 m diameter was signed around, and the following variables were measured: (8) percentage of leaf litter (PLL); (9–12) percentage of stratum volume covered by leaves (PSV): 0–5 m, 6–10 m, 11–15 m, and > 15 m; (13) density of trees (DTR) (point-quarter method; KREBS, 1999). (14) Number of terrestrial bromeliads (NBR): we counted up to 100 bromeliads in a SU; in plots with high densities of bromeliads (N > 100 bromeliads) we estimated this number by the rule of three from a quadrate of 10 x 10 m chosen at random. (15) Number of epiphytic bromeliads (NBE). The next five variables were measured using the maximum number of 20 bromeliads, chosen at random: (16) bromeliad mean height (HBR), (17) bromeliad mean diameter (BDI), (18) percentage of bromeliads filled with leaf litter (PBL), (19) percentage of bromeliads with water inside (PBW), and (20) percentage of terrestrial bromeliads with direct sunlight (PBS).

Specimens were caught under permissions of the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA), license numbers 02006.002336/03-26 and 0210.000812/05-84, and were deposited in the amphibian's collection of the Museu de Zoologia, Universidade Federal da Bahia (UFBA) (Appendix I). Names of the taxa used in the account followed Faivovich et al. (2005), Frost et al. (2006), and Grant et al. (2006).

Data treatment

For the purposes of analysis we produced three data matrices: (A) a 30 SUs (plots) vs. 30 anuran species (attributes) matrix, representing the dependent variable of the study, namely community composition. We used the "concrete community" concept of McCune and Grace (2002), characterized as the collection of organisms found at a specific place and time. In the matrix, each cell corresponded to the number of specimens of the related species in the SU; (B) a transformed abundance matrix, calculated from the matrix A by dividing each cell by the line sum, in a way that all sample units had the same weight in the analysis; and (C) a 30 SUs (plots) vs. 20 environmental variables (attributes) matrix, representing the independent variables of the analysis, each cell corresponding to the average value of the measured variable in the SU (for continuous variables), or a value from 0 to 2 for the ordinal variable KBW. We considered the relative number of collected specimens per species as an adequate comparative index of plot composition, since the sample effort was the same in the sample units.

We used linear models to test the null hypothesis of association between the dependent variable (anuran community composition; matrix B) and the independent variables (environmental variables; matrix C). We used the nonmetric multidimensional scaling method (NMS), an ordination technique, to seek and display the strongest anuran community structure, using only the anuran species data set (matrix B) (McCune and Grace, 2002). We selected only one dimension (ordination axis) to the NMS solution, and used the Sorensen distance measure. In order to avoid the local minima problem, we made 50 starting configurations to the real data, using as stability criteria the instability value of 0.0005, 20 iterations to evaluate the stability of the solution, and 500 as the maximum number of iterations. The Monte Carlo test (a randomization test) was used to evaluate whether NMS extracted a stronger axis than expected by chance. The proportion of variance represented by the NMS axis, based on the correlation between distance in the ordination space (Euclidian distance) and distance in the original space (Sorensen distance), was obtained by the standardized Mantel test (r). We used the principal component analysis (PCA) to reduce the environmental data set (matrix C) to a smaller number of orthogonal synthetic variables that represent most of the original information. The principal components were obtained from a correlation matrix among characters, and those with eigenvalues larger than 1.0 were rotated to a new varimax solution (McCune and Grace, 2002). The null hypothesis of absence of association between the environmental data set (principal components) and the anuran community composition (NMS axis) was tested by multiple regression analysis. The α-level of significance ($P \leq 0.05$) was Bonferroni corrected (Bland, 2004) for partial regression analyses developed with the same set of subjects.

RESULTS

Composition and Structure of Anuran Community

We sampled 737 anurans, belonging to 8 families, 17genus, and 30 species (number of species per genus in parenthesis): Bufonidae (2) – *Chaunus jimi*, *Rhinella* sp.; Brachycephalidae (1) – *Eleutherodactylus ramagii*; Cycloramphidae (1) – *Proceratophrys* aff. *boiei*; Dendrobatidae (1) – *Allobates alagoanus*; Hylidae (16) – *Dendropsophus branneri*, *D. minutus*, *D.* aff. *decipiens*, *Hypsiboas albomarginatus*, *H. pombali*, *H. semilineatus*, *Itapotihyla langsdorffii*, *Phyllodytes melanomystax*, S*cinax agilis*, *S. argyreornatus*, *S.* aff. *alter*, *S. auratus*, *S. eurydice*, *S.* aff. *similis*, *Sphaenorhynchus prasinus*, *Trachycephalus mesophaeus*; Leiuperidae (3) – *Physalaemus* gr. *cuvieri*, *P.* gr. *signifer*, *Pleurodema diplolister*; Leptodactylidae (4) – *Leptodactylus labyrinthicus*, *L. mystacinus*, *L. natalensis*, *L. ocellatus*; Microhylidae (2) – *Chiasmocleis* sp., *Dermatonotus muelleri*. Specimens of *Dendropsophus elegans*, *Hypsiboas faber*, *Leptodactylus troglodytes*, and *Trachycephalus atlas* were observed outside the SUs in “Reserva” Sapiranga but were not included in the analysis.

We considered the sampling methods used herein efficient, mainly when combined. Pitfall-traps were capable to sample litter frogs that would be hardly actively sampled at night (e.g., *D. muelleri, Chiasmocleis* sp.*, Proceratophrys boiei*, *Physalaemus cuvieri*, *P.* gr. *signifer,* and *Allobates alagoanus*, which were sampled only by this method). *Rhinella* sp. and *Pleurodema diplolister* were sampled by both methods. The other species were sampled only by active search at night.

The NMS axis was able to express structure in the studied community, as can be seen in Appendix II, where plots were arranged following NMS scores and species based on weighted averaging. Although stress associated with NMS axis was high (30.6), increase on sample units leads to a rise in stress, and the same occurs when the number of plots (objects) gets near to the number of species (attributes) (McCune and Grace, 2002), as is the case in our study (30 plots vs. 30 species). Thereby, it is not implied that the obtained stress leads to a low level of interpretation. The variance represented by the NMS axis explained 50% of the variance in the original multidimensional space (Mantel test: $r = 0.71$, $P = 0.001$). The Monte Carlo test resulted in a probability of 0.019, indicating that the NMS extracted a stronger axis than expected by chance. The NMS axis ordered the anuran community through an environmental gradient that reflects the following sequence of physiognomies (Appendix II): (1) beach zone, characterized by sandy soil covered by many shrubs and terrestrial bromeliads; (2) arboreal vegetation with temporary pounds and/or permanent lakes; (3) arboreal vegetation with rivers, springs or streams; and (4) arboreal vegetation without bodies of water on the ground.

Environmental Variables

The PCA applied on 20 environmental variables generated five principal components with eigenvalues larger than 1.0 (Table 1). They represented 79.4% of the entire variance after the Varimax solution. The first principal component accounted for 37.6% of the total variance, and presented high loadings (≥ 0.7) on the following variables, in decreasing order: "percentage of stratum volume covered by leaves 6–10 m", "percentage of leaf litter", "percentage of bromeliads with direct sunlight", "number of terrestrial bromeliads", and "soil moisture"; for PC2 (15.7%): "bromeliad height", "bromeliad diameter", and "maximum width of the body of water"; for PC3 (11.3%): "air temperature" and "percentage of bromeliads filled with leaf litter"; for PC4 (8.6%): "percentage of stratum volume covered by leaves 11–15 m" and "percentage of stratum volume covered by leaves >15 m"; for PC5 (6.1%): "percentage of stratum volume covered by leaves 0–5 m".

The projection of PC1 on PC2 discriminated three groups of SUs (dashed line, Fig. 2A): (1) SUs at Praia do Forte (beach zone; P8–P10, P16–P18, P28–P30), characterized by sandy soil covered by many shrubs and terrestrial bromeliads; (2) SUs at Praia do Forte and "Reserva" Sapiranga (P1–P7, P13, P15, P19–P22, P25–P27), covered by arboreal vegetation (density of trees ≥ 50% and leaves stratification above 10 m) with bodies of water on the ground and/or many terrestrial bromeliads (N > 100); (3) SUs at "Reserva" Sapiranga (P11–P12, P14, P23–P24), covered by arboreal vegetation with stratum higher than 5 m, with high percentage of leaf litter (90–100%), less than 20 terrestrial bromeliads, and without bodies of water (with the exception of P14, which was marginal to the brackish Pojuca river). The projection of PC3 on PC4 discriminated throughout the third axis a group formed by SUs P21–P25 (closed squares, Fig. 2B). These SUs belong to "Reserva" Sapiranga, have arboreal vegetation, and were sampled in August 2005, period we registered the lowest air temperatures in the study (21–22^{o}C; other combined SUs: 23–26^{o}C). The fourth axis denoted a trend in the increase of canopy stratification above ten meters high. Sample units at "Reserva" Sapiranga (closed squares and circles) were partially discriminated from the other SUs. The projection of PC5 on PC1 (not figured) resulted in a mosaic distribution of the SUs.

Anuran Community vs. Environmental Variables

We tested the null hypothesis of absence of association between the environmental data set (independent variables: principal components with eigenvalues ≥ 1.0) and the anuran community composition (dependent variable: NMS axis) using the multiple regression analysis, which was strongly significant (P < 0.0001). Nonetheless, out of five possible partial regressions, only PC1 vs. the NMS axis was significant (P < 0.005, Bonferroni corrected). The partial regression plot of PC1 on the NMS axis (Fig. 3A) accounted for 68% of the variation and clearly reflected an environmental gradient determined by the canopy stratification in the Restinga, that is, from shrub to arboreal environments.

DISCUSSION

The importance of the vegetal stratification to amphibians' communities is not new in the herpetological literature (e.g., Bernarde et al., 1999; Duellman and Trueb, 1994; Giaretta et al., 1999; Silvano and Pimenta, 2003), but has not been considered as the primary factor for the determination of the structure of anuran communities, as evidenced herein. Duellman and Trueb (1994) stated that spatial heterogeneity led to a higher amount of microhabitats, thereby increasing the number of anuran species, as they could occupy different parts of the mosaic. Tews et al. (2004) affirmed that in a good number of habitats plant communities determine the physical structure of the environment, and therefore, have an influence on the distributions and interactions of animal species. These statements seem to be confirmed by our data, as forested areas in the Restinga were noticeably more heterogeneous environments, with higher number of microhabitats, than areas with only shrubs and terrestrial bromeliads. Furthermore, the increase in vegetal stratification minimizes the effects of some limiting factors that act on the anuran microhabitats, such as direct sunlight, temperature elevation, and reduction of soil moisture. The relationship of these factors with vegetal stratification can easily be noticed in Fig. 2A, where the variable "percentage of terrestrial bromeliads with direct sunlight" varied in the opposite way to "percentage of stratum volume covered by leaves 5–10 m", "percentage of leaf litter", and "soil moisture", that is, more canopy stratification will result in the increase of leaf litter and decrease of direct sunlight on the ground, which combined will lead to increase the soil moisture. The importance of soil moisture in anuran communities was observed by Giaretta et al. (1997), who reported that soil moisture and leaf litter depth influence anuran composition and abundance. Toft (1982) pointed out that leaf litter amphibians are distributed in specific environments throughout moisture gradients. The combination of leaf litter and soil moisture was also noticeable in the present study, but both were under the dependence of the canopy stratification, that is, the measure of the latter variable will give to the researcher the leaf litter and soil moisture gradients, but with minor efforts. In this perspective, we also noticed the distribution of anurans throughout moisture gradients, which, in turn, followed the canopy stratification. Species restricted to environments with high soil moisture (≥ 50%) were *Proceratophrys* aff. *boiei*, *Physalaemus* aff. *cuvieri*, *P.* aff. *Signifier*, *Chiasmocleis* sp., *Allobates alagoanus*, and *Rhinella* sp.; species restricted to environments with low soil moisture (< 50%) (sandy SUs at Praia do Forte and "Reserva" Sapiranga) were *Pleurodema diplolister* and *Dermatonotus muelleri*. The influence of stratification on the anuran community is undeniably, also for species richness: arboreal areas presented 4–13 species and shrub environments, next to the beach zone, up to 7 species.

The bromeliads were among the environment variables that most explained the changes in the anuran composition in the Restinga. These plants are considered important ecological units in the Restinga ecosystem, being referred as shelter, breeding, and courtship sites for many zoological groups, as well as amphibians (Carvalho-e-Silva et al., 2000; Peixoto, 1995; Richardson, 1999; Shineider and Teixeira, 2001; Teixeira et al., 2002). The ecological attributes of bromeliads easily explain the strong contribution of variables related to them in PC1 and PC2 axes (Fig. 2A). Moreover, it is noticeable that canopy stratification and variables from terrestrial bromeliads (amount, percentage with direct sunlight, height and diameter) varied in an opposite way, the latter probably as a function of the former. This result suggests that environments with dense homogeneous canopy stratifications with humid soils will not lead to huge contributions of terrestrial bromeliads to the structure of anuran communities, as forested environments with damp soil tend to reduce the water and moisture dependence of anurans, and also provide numerous alternative microhabitats in substitution to bromeliads. Our argument can be confirmed by the study of Munduruca (2005). This author developed her master dissertation on anurans' composition at "Reserva" Camurujipe, an Atlantic Forest remnant ca. 10 km distance from "Reserva" Sapiranga, and employed the same research design and sampling methodology used herein. Bromeliad variables exhibited only a small contribution to the structure of the anuran community, whereas the variables that were mostly associated to the anuran composition were those of canopy stratification. Nevertheless, it is important to note that some frogs have their reproductive cycles associated with bromeliads (Peixoto, 1995). In these species, male reproductive activity might be related not only to macroclimatic patterns, but also to the availability of suitable microhabitats in bromeliads (Oliveira and Navas, 2004). For these anurans, bromeliads are essential, even though their contribution to the community structure may be small.

The anuran species found by us in the Restinga were not essentially different from that encountered by Munduruca (2005) for an Atlantic Forest remnant in the same Municipality (25 species in common). The Restinga habitat had six exclusive species (*Dermatonotus muelleri*, *Pleurodema diplolister*, *Scinax* aff. *alter*, *S.* aff. *similis*, *Phyllodytes melanomystax*, and *Leptodactylus mystacinus*), and the Atlantic Forest two exclusive species (*Dendropsophus* aff. *decipiens* and *Stereocyclops incrassatus*). Some of these taxa deserve special attention. *Dermatonotus muelleri* and *P. diplolister* are ordinary species of semiarid regions of Bahia (Santos et al., 2003), and their occurrence in sandy soils of the disjunct Atlantic Forest Domain appoint to other than ecologic similarity between Restinga and the Caatinga Domain (see Ab'Sáber, 1977 for definition of morphoclimatic domains), involving historic distribution patterns (Rodrigues, 2003). *Phyllodytes melanomystax* is a bromeligen treefrog (see Peixoto, 1995 for definition of bromeligen), commonly observed in terrestrial bromeliads at sand dunes, which explains its exclusivity to the Restinga habitat. *Stereocyclops incrassatus* is a leaf litter anuran and related to humid soils. However, at "Reserva" Sapiranga we encountered soils with similar ecological conditions to that of "Reserva" Camurujipe. The fact that this species has an explosive reproductive mode may explain its absence in dumpy forested areas in "Reserva" Sapiranga as an artifact of the sampling. *Scinax* aff. *alter*, *Scinax* aff. *similis*, and *L. mystacinus* are species that probably inhabit equivalent forest edges and/or internal lakes of "Reserva" Camurujipe. *Dendropsophus* aff. *decipiens* is usually associated with streams in forested areas, and also should occur in “Reserva” Sapiranga. The resemblance between anuran species from the Atlantic Forest and the Restinga was already observed by Carvalho-e-Silva et al. (2000) and Van Sluys et al. (2004), which stated that most of the anuran species found in restingas occur in the forests near the coast.

Although our study recognized the canopy stratification as the most important variable for the composition of the referred anuran community, there is an empiric trend to consider the presence/absence of bodies of water as the primary factor in anuran community compositions, which limited studies on anuran populations and communities to these habitats. This supposition is not supported herein, as the “water” variables not explained the changes in the anuran composition in the partial regression of PC1 on the NMS axis (the only significant partial regression). The second principal component, in which the “maximum width of the body of water” showed a high contribution, obtained a low level of significance (P = 0.335). Another important feature of our results is that the NMS axis explained only 50% of the original variation, which means that other variables, not measured herein, are also shaping the structure of the anuran community.

Complementary analyses should be considered in order to verify which most important variables obtained in the current research better explain the anuran community structure, mainly by removing their reciprocal influence.

RESUMO

Estudos que versam sobre comunidades de anfíbios têm sido desiguais em suas abordagens, métodos de coleta, aprofundamento e desenho amostral. A maioria das pesquisas sobre comunidades de anuros é descritiva e restrita a ambientes aquáticos, como poças utilizadas para reprodução e comunidades situadas ao longo de riachos. Estudos que versam sobre comunidades tropicais em sua totalidade são raros, especialmente aqueles focando processos ambientais responsáveis por sua estruturação. Além disso, alguns tipos de comunidades de

anuros, específicas a certos habitats, como aquelas localizadas em ambientes de Restinga, foram pouco estudadas. No Brasil, somente as restingas situadas nos estados do Rio de Janeiro e Espírito Santo apresentam estudos mais detalhados sobre as comunidades de anuros. O litoral norte do Estado da Bahia possui cerca de 200 km contíguos de Restinga, mas estudos que versem sobre a composição e estrutura das comunidades de anuros estão virtualmente ausentes. Já o litoral sul da Bahia tem recebido maior atenção, sendo considerado um "hotspot" em biodiversidade. O presente trabalho tem por objetivo preencher ambas as lacunas acima apontadas. Primeiramente, objetivamos determinar quais variáveis ambientais, se existirem, são capazes de prever as principais alterações na composição de comunidades de anuros e, secundariamente, descrever a composição e distribuição das comunidades de anuros na referida faixa de Restinga estudada no litoral norte da Bahia, Brasil. Nós investigamos 30 unidades amostrais (60 x 25 m) por métodos de amostragem ativo e passivo em áreas contíguas de Restinga no Município de Mata de São João, Estado da Bahia, Brasil. O estudo foi realizado em três momentos. A fim de desenvolver a pesquisa em períodos comparáveis do ano, nós distribuímos a amostragem em duas estações chuvosas consecutivas. Nós estimamos quais gradientes ambientais eram potencialmente relevantes para os anuros por meio de 20 variáveis ambientais primárias em cada unidade amostral. Utilizamos o método de escalonamento multidimensional não-métrico (NMS) em matriz de abundância de espécies de anuros por unidades amostrais a fim de gerar um eixo que sintetizasse as alterações na composição de anuros ao longo das 30 unidades amostrais. Usamos a análise dos componentes principais (PCA) para sintetizar as 20 variáveis ambientais em poucos eixos sintéticos ortogonais de variação. A fim de testar a hipótese de ausência de associação entre os componentes principais e o eixo NMS de ordenação dos anuros, utilizamos a análise de regressão múltipla. Nós coligimos 737 espécimes de anuros pertencentes a 8 famílias, 17 gêneros e 30 espécies. O eixo NMS foi capaz de expressar estruturação na comunidade estudada e ordenou a comunidade de anuros ao longo de um gradiente ambiental que refletiu as principais fisionomias do ambiente.

As variáveis ambientais que melhor explicaram a variação na comunidade de anuros estiveram direta ou indiretamente ligadas à estratificação vegetal.

Acknowledgments.—We are grateful to A. Camacho, A. Mendonça, A. L. Xavier, J. R. Bastazini, M. Camardelli, P. M. Fonseca, R. Abreu, T. Brandão, T. F. A. Santos, and W. Fahing for the excellent field assistance. To W. Klein, C. F. Rocha, and F. A. Juncá for the valuable comments on the manuscript. To Laboratório de Avaliação de Impactos em Ecossistemas Terrestres from Universidade Federal da Bahia (LAVIET) for collaboration with technical advice on the soil analysis. We acknowledge Fundação Garcia D´Ávila and A. A. Paiva for allowing us to access research areas under their care and for logistical assistance at Reserva Sapiranga and Praia do Forte; the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and the Coordenação de Aperfeiçoamento de Pessoal de Ensino Superior (CAPES) for fellowships to M. F. Napoli (proc. 302967/2003-6) and C. V. Bastazini, respectively; the Fundação de Amparo à Pesquisa do Estado da Bahia (FAPESB) for financial support (PRODOC) provided to M. F. Napoli; the Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) permitted collection of specimens (license numbers 02006.002336/03-26 and 0210.000812/05-84).

LITERATURE CITED

AB'SÁBER, A. N. 1977. Os domínios morfoclimáticos na América do Sul. Primeira aproximação. Geomorfologia 52:1–21.

ARZABE, C. 1999. Reproductive activity patterns of anurans in two different altitudinal sites within the Brazilian Caatinga. Revista Brasileira de Zoologia 16:851–864.

ARZABE, C., C. X. CARVALHO, AND M. A. G. COSTA. 1998. Anuran assemblages in Crasto forest ponds (Sergipe state, Brazil): comparative structure and calling activity patterns. Herpetological Journal 8:111–113.

BERNARDE, P. S., M. N. C. KOKUBUM, R. S. MACHADO, AND L. ANJOS. 1999. Uso de habitats naturais e antrópicos pelos anuros em uma localidade no Estado de Rondônia, Brasil (Amphibia: Anura). Acta Amazônica 29:555–562.

BERNARDE, P. S., AND M. N. C. KOKUBUM. 1999. Anurofauna do município de Guararapes, Estado de São Paulo, Brasil (Amphibia, Anura). Acta Biologica Leopoldensia 21:89–97.

BLAND, M. 2004. Multiple significance tests and the Bonferroni correction. Available at http://www-users.york.ac.uk/~mb55/intro/bonf.htm.

BRASILEIRO, C. A., R. J. SAWAYA, M. C. KIEFER, AND M. MARTINS. 2005. Amphibians of an open cerrado fragment in southeastern Brazil. Biota Neotropica 5:1–17.

CARVALHO-E-SILVA, S. P., E. IZECKSOHN, AND A. M. P. T. CARVALHO-E-SILVA. 2000. Diversidade e ecologia de anfíbios em restingas do sudeste brasileiro. Pp. 89–97. *In* F. A. ESTEVES, AND L. D. LACERDA (Eds.), Ecologia de restingas e lagoas costeiras. NUPEM/UFRJ, Macaé, Rio de Janeiro, Brazil.

DUELLMAN, W. E., AND L. TRUEB. 1994. Biology of Amphibians. The Johns Hopkins University Press, Baltimore, Maryland, USA.

EMBRAPA (EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA). 1997. Manual de Métodos de análises de solo. (2 ed). Embrapa, Rio de Janeiro, Brazil.

ETEROVICK, P. C. AND I. SAZIMA. 2000. Structure of an anuran community in a montane meadow in southeastern Brazil: effects of seasonality, habitat and predation. Amphibia-Reptilia 21:439–461.

FAIVOVICH, J., C. F. B. HADDAD, P. C. A. GARCIA, D. R. FROST, J. A. CAMPBELL, AND W. C. WHEELER. 2005. Systematic review of the frog family Hylidae, with special reference to Hylinae: phylogenetic analysis and taxonomic revision. Bulletin of the American Museum of Natural history 294:1–240.

FROST, D. R., T. GRANT, J. FAIVOVICH, R. H. BAIN, A. HAAS, C. F.B. HADDAD, R. O. DE SA´, A. CHANNING, M. WILKINSON, S. C. DONNELLAN, C. J. RAXWORTHY, J. A. CAMPBELL, B. L.

BLOTTO, P. MOLER, R. C. DREWES, R. A. NUSSBAUM, J. D. LYNCH, D. M. GREEN, AND W. C. WHEELER. 2006. The amphibian tree of life. Bulletin of the American Museum of Natural History 297:1–370.

GIARETTA, A. A., R. J. SAWAYA, G. MACHADO, M. S. ARAÚJO, K. G. FACURE, H. F. MEDEIROS, AND R. NUNES. 1997. Diversity and abundance of litter frogs at altitudinal sites at Serra do Japi, Southeastern Brazil. Revista Brasileira de Zoologia 14:341–346.

GIARETTA, A. A., K. G. FACURE, R. J. SAWAYA, J. H. M. MEYER, AND N. CHEMIN. 1999. Diversity and abundance of litter frogs in a montane forest of Southeastern Brazil: seasonal and altitudinal changes. Biotropica 31:669–674.

GRANT, T., D. R. FROST, J. P. CALDWELL, R. GAGLIARDO, C. F. B. HADDAD, P. J. R. KOK, B. D. MEANS, B. P. NOONAN, W. SCHARGEL AND W. C. WHEELER. 2006. Phylogenetic systematics of dart-poison frogs and their relatives (Anura: Athesphatanura: Dendrobatidae). Bulletin of the American Museum of Natural History 299: 1–262.

HEYER,W. R.; M. A. DONNELLY, R. W. MCDIARMID; L. C. HAYEK, and M. S. FOSTER. 1994. Measuring and Monitoring Biological Diversity, Standard Methods for Amphibians. Smithsonian Institution Press, Washington, U.S.A.

JUNCÁ, F. A. 2006. Diversidade e uso de hábitat por anfíbios anuros em duas localidades de Mata Atlântica, no norte do estado da Bahia. Biota Neotropica 6:1–17. Available at http://www.biotaneotropica.org.br/v6n2/pt/abstract?inventory+bn03006022006.

KREBS, C. J. 1999. Ecological Methodology. Benjamin/Cummings, Menlo Park, San Francisco, California, U.S.A.

MCCUNE, B., AND J. B. GRACE. 2002. Analysis of ecological communities. Gleneden Beach, Oregon, U.S.A.

MUNDURUCA, J. F. V. 2005. Gradientes ambientais e composição da comunidade de anuros da Reserva Camurujipe, Mata de São João, Bahia, Brasil. Master Dissertation, Universidade Federal da Bahia, Salvador, Bahia, Brazil.

OLIVEIRA, F. B. AND NAVAS, C. A., 2004. Plant selection and seasonal patterns of vocal activity in two populations of the bromeligen treefrog *Scinax perpusillus* (Anura, Hylidae). Journal of Herpetology 38:331–339.

PEIXOTO, O. L. 1995. Associação de anuros a bromeliáceas na Mata Atlântica. Revista da Universidade Rural, Série Ciência da Vida 17:75–83.

POMBAL, J. P. 1997. Distribuição espacial e temporal de anuros (Amphibia) em uma poça permanente na Serra de Paranapiacaba, sudeste do Brasil. Revista Brasileira de Biologia 57:583–594.

RICHARDSON, B. A. 1999. The bromeliad microcosm and the assessment of faunal diversity in a Neotropical Forest. Biotropica 31:321–336.

ROCHA, C. F. D., H. G. BERGALLO., M. A. S. ALVES, AND M. VAN SLUYS. 2003. A Biodiversidade nos grandes remanescentes florestados do Estado do Rio de Janeiro e nas restingas da Mata Atlântica. RiMa, São Carlos, São Paulo, Brazil.

ROCHA, C. F. D., M. VAN SLUYS, H. G. BERGALLO, AND M. A. S. ALVES. 2005. Endemic and threatened tetrapods in the restingas of the biodiversity corridors of Serra do Mar and of the central da Mata Atlântica in eastern Brazil. Brazilian Journal of Biology 65:159–168.

RODRIGUES, M. T. 2003. Herpetofauna da Caatinga. Pp. 181–236. *In* I. R. Leal, M. Tabarelli, and J. M. C. Silva (Eds.), Ecologia e Conservação da Caatinga. Editora Universitária da Universidade Federal de Pernambuco, Recife, Pernambuco, Brazil.

ROSSA-FERES, D. C., AND J. JIM. 1994. Distribuição sazonal em comunidades de anfíbios anuros na região de Botucatu, São Paulo. Revista Brasileira de Biologia 54:323–334.

SANTOS, J. W. A., R. P. DAMASCENO, AND P. L. B. ROCHA. 2003. Feeding habits of the frog *Pleurodema diplolister* (Anura, Leiuperidae) in Quaternary sand dunes of the Middle Rio São Francisco, Bahia, Brazil. Phyllomedusa 2:83–92.

SUGUIO, K., AND M. G. TESSLER. 1984. Planícies de cordões litorâneos quaternários do Brasil: origem e nomenclatura. Pp. 15–25. *In* L. D. Lacerda, D. S. D. Araújo, R. Cerqueira & B.

Turcq (Eds.), Restingas: Origem, Estrutura, Processos. Centro Editorial da UFF, Niterói, Rio de Janeiro, Brazil.

SCHINEIDER, J. A. P., AND R. L. TEIXEIRA. 2001. Relacionamento entre anfíbios anuros e bromélias da restinga de Regência, Linhares, Espírito Santo, Brasil. Iheringia, Série Zoológica 91:41–48.

SILVANO, D. L., AND B. V. S. PIMENTA. 2003. Diversidade e distribuição de anfíbios na Mata Atlântica do Sul da Bahia. *In* P. I. PRADO, E. C. LANDAU, R. T. MOURA, L. P. S. PINTO, G. A. B. FONSECA & K. ALGER (Eds.), Corredor de Biodiversidade na Mata Atlântica do Sul da Bahia. CD- ROOM, Ilhéus, IESB/CI/CABS/UFMG/UNICAMP.

TEIXEIRA, R. L., J. A. P SCHINEIDER, AND G. I. ALMEIDA. 2002. The occurrence of amphibians in bromeliads from a southeastern Brazilian Restinga habitat, with special reference to *Aparasphenodon brunoi* (Anura, Hylidae). Brazilian Journal of Biology 62:263–268.

TEWS, J., U. BROSE, V. GRIMM, K. TIELBORGER, M. C. WICHMANN, M. SCHWAGER, AND F. JELTSCH. 2004. Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. Journal of Biogeography 31:79–92.

TOFT, C. A. 1982. Community structure of litter anurans in a tropical forest, Makokov, Gabom: a preliminary analysis in the minor dry season. Terre et Vie 36:223–232.

VAN SLUYS, M., C. F. D. ROCHA, F. H. HATANO, L. BOQUIMPANI-FREITAS, AND R. V. MARRA. 2004. Anfíbios da Restinga de Jurubatiba: Composição e História Natural. Pp. 165–178. *In* C. F. D. ROCHA, F. A. ESTEVES & F. R. SCARANO, Pesquisas de longa duração da Restinga de Jurubatiba: Ecologia, História Natural e Conservação. RiMa, São Carlos, São Paulo, Brazil.

VASCONCELOS, T. S., AND D. C. ROSSA-FERES. 2005. Diversidade, distribuição espacial e temporal de anfíbios anuros (Amphibia, Anura) na Região Noroeste do Estado de São Paulo, Brasil. Biota Neotropica 5:1–14.

TABLE 1.—Standardized coefficients from principal component analysis (after Varimax rotation) for 20 environmental variables of 30 combined sample units from the Municipality of Mata de São João, State of Bahia, Brazil. Projection of component scores figured in Fig. 2. Variable codes follow those presented in Materials and Methods.

Environmental variables	PC1 (37.6%)	PC2 (15.7%)	PC3 (11.3%)	PC4 (8.6%)	PC5 (6.1%)
AMO	0.399	-0.042	-0.427	-0.463	-0.437
TEM	0.201	-0.070	0.910	-0.060	-0.069
SMO	0.811	0.299	-0.292	-0.014	-0.073
PSV 0-5m	0.146	0.373	-0.187	0.082	0.746
PSV 6-10	0.925	0.094	0.161	0.108	0.175
PSV 11-15	0.484	0.023	-0.070	0.702	0.188
PSV > 15	0.080	0.275	0.120	0.868	0.028
PLL	0.900	0.014	0.146	0.192	0.227
DTR	0.622	-0.168	0.052	0.092	0.600
BDI	0.182	0.871	0.102	0.043	0.204
HBR	-0.120	0.919	-0.012	0.180	0.049
NBR	-0.853	-0.200	0.021	-0.218	0.071
PBL	-0.236	0.141	0.821	0.175	0.006
PBW	-0.621	-0.068	0.262	-0.170	0.095
PBS	-0.878	-0.208	0.189	0.073	0.032
NBE	0.361	0.516	0.172	0.211	0.158
WSU	0.293	0.643	-0.143	0.481	-0.204
KBW	0.580	0.558	0.268	-0.214	-0.013

MWB	0.215	0.765	-0.230	0.288	-0.143
MDB	0.447	0.674	0.193	-0.201	0.310

FIGURE LEGENDS

FIG. 1.—Distribution map of 10 environmental sampling points chosen at random within a hypothetic sample unit. Six environmental variables were taken following this map: “percentage of leaf litter”, “percentage of leaves stratification: 0–5 m, 6–10 m, 11–15 m, and > 15 m”, and “density of trees”.

FIG. 2.—Projection of individual scores resulted from the principal component analysis for 20 environmental variables of the combined 30 sample units (SUs) used in the account in the space of (A) the first with the second and (B) the third with the fourth axes. Symbols represent types of environment: close triangle, shrubs with terrestrial bromeliads (Praia do Forte, beach zone); open square, arboreal with terrestrial bromeliads (“Reserva” Sapiranga); close square and open circle, arboreal and lentic (Praia do Forte and “Reserva” Sapiranga, respectively); open triangle, arboreal and lotic; close circle, arboreal without terrestrial bromeliads and aquatic environments (“Reserva” Sapiranga). Dashed lines represent three main physiognomic groups identified in the analysis (from left to right): sandy soil with shrubs and terrestrial bromeliads (Praia do Forte); arboreal vegetation with bodies of water on the ground and/or many terrestrial bromeliads (N ≥ 100) (Praia do Forte and “Reserva” Sapiranga); arboreal vegetation with high percentage of leaf litter (90–100%), less than 20 terrestrial bromeliads, and without bodies of water.

FIG. 3.—Partial regression plot of the first principal component axis (PC1; environmental variables) on the nonmetric multidimensional scaling axis (NMS; anuran species composition). Regression was significant ($P < 0.005$, Bonferroni corrected). See Fig. 2 for detailed meaning of symbols.

33

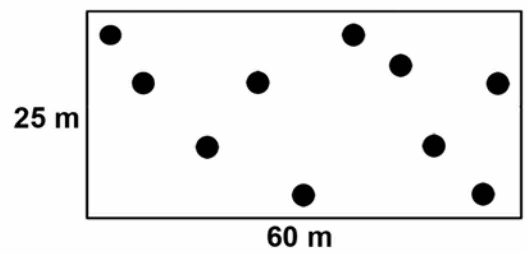
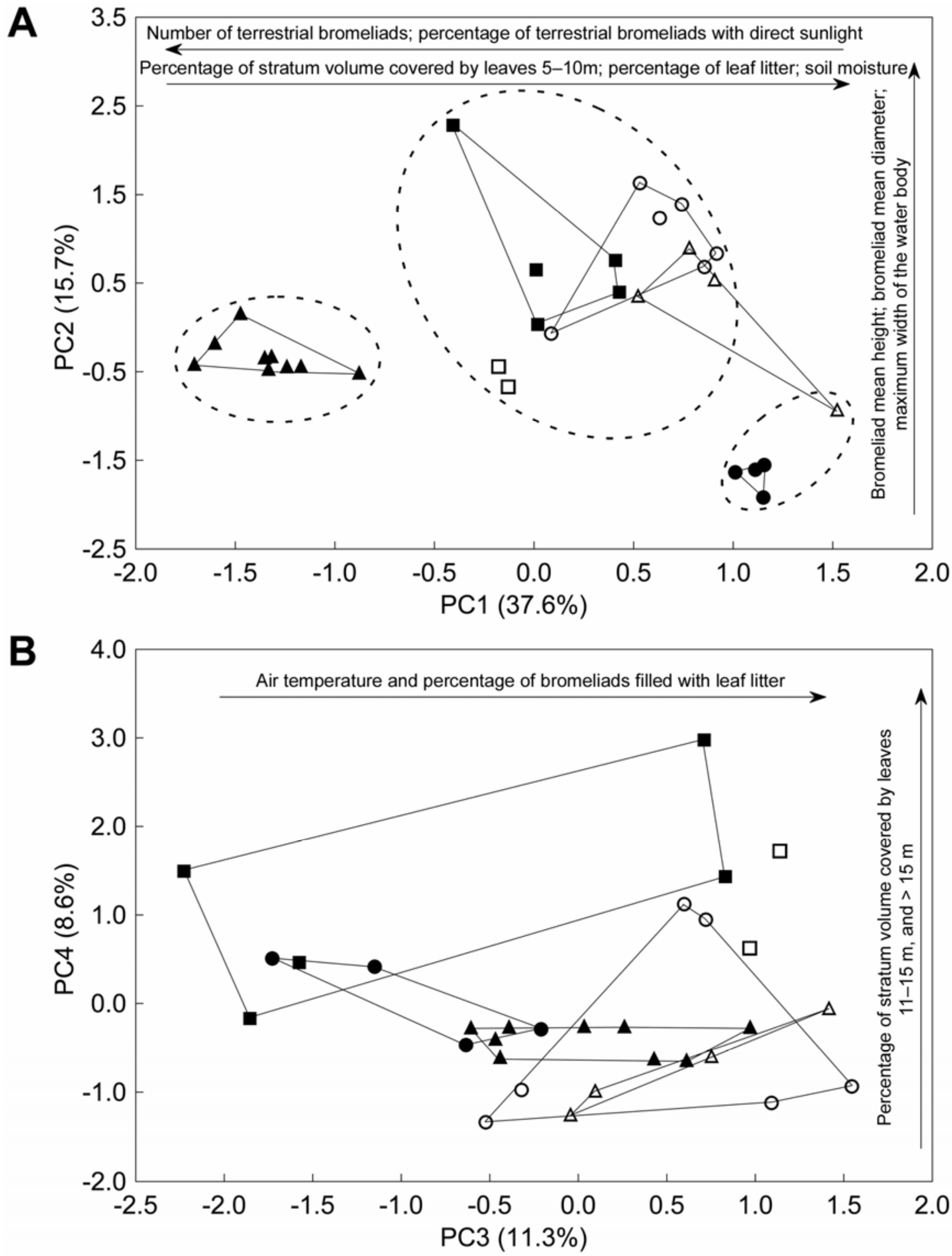


FIGURE 1



A
Number of terrestrial bromeliads; percentage of terrestrial bromeliads with direct sunlight
Percentage of stratum volume covered by leaves 5–10m; percentage of leaf litter; soil moisture
Bromeliad mean height; bromeliad mean diameter; maximum width of the water body
PC2 (15.7%)
PC1 (37.6%)
B
Air temperature and percentage of bromeliads filled with leaf litter
Percentage of stratum volume covered by leaves 11–15 m, and > 15 m
PC4 (8.6%)
PC3 (11.3%)

FIGURE 2

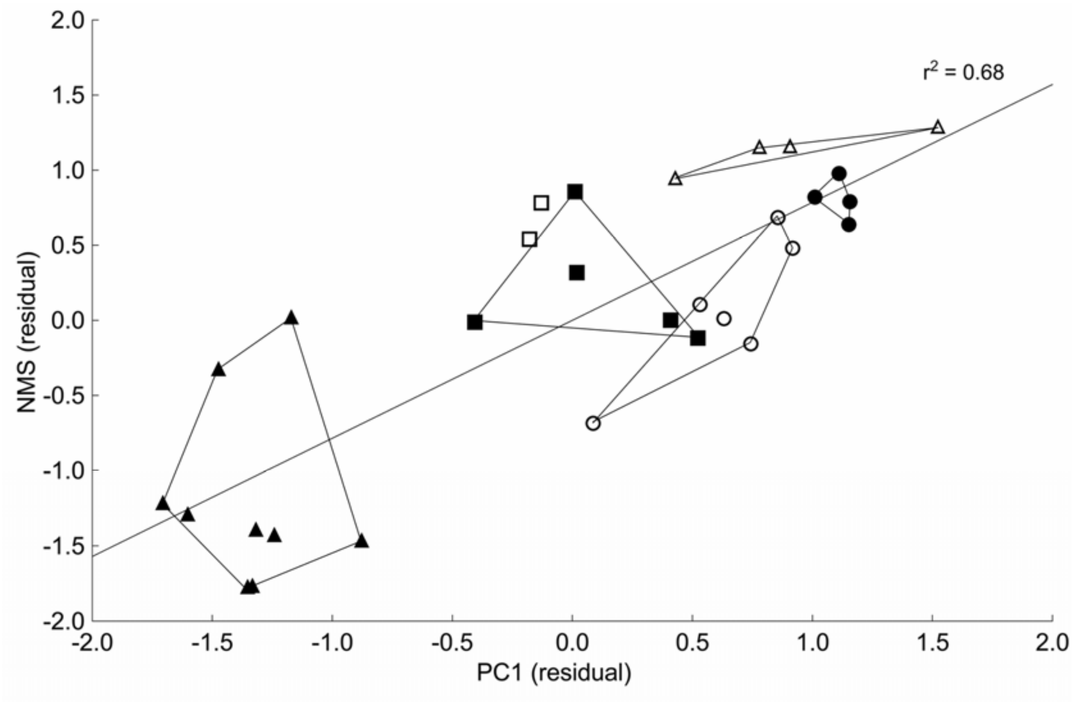

r² = 0.68
NMS (residual)
PC1 (residual)
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0

FIGURE 3

APPENDIX I

Specimens Examined in the Present Research

Chiasmocleis sp.: UFBA 4018–19, 4102–05, 4979–86, 5887; *Allobates alagoanus*: UFBA 3749, 5877; *Dendropsophus branneri*: UFBA 3826, 4998, 5857–67; *Dendropsophus* aff. *decipiens*: UFBA 3841, 4009–10, 4043–44, 5875–76; *Dendropsophus elegans*: UFBA 5868; *Dendropsophus minutus*: UFBA 4091–92, 4097–99, 5816–33; *Dermatonotus muelleri*: UFBA 5628; *Eleutherodactylus ramagii*: UFBA 3745–46, 3759–84, 3792–3811, 3816–19, 3823–24, 3832–39, 3842–52, 3856–62, 3879–80, 3893, 3898–3900, 3966–71, 3997–4007, 4021–22, 4030, 4033–36, 4048–55, 4059–69, 4802–10, 5020–23, 5632–36, 5638–60, 5834–40, 5846; *Hypsiboas albomarginatus*: UFBA 5716–79; *Hypsiboas pombali*: UFBA 3822, 3825, 3830, 3889–91, 4031, 4040, 5841; *Hypsiboas semilineatus*: UFBA 3884–85, 3892, 3896–97; *Itapotihyla langsdorffii*: UFBA 3742, 3744, 3877–78, 3883, 4916; *Leptodactylus labyrinthicus*: UFBA 3895, 4081–82, 5026–29, 5871–74, 5888; *Leptodactylus mystacinus*: UFBA 5815; *Leptodactylus natalensis*: UFBA 3853, 3865–66, 3972, 3993–96, 4011, 4015–16, 4023, 4038, 4058, 4070–72, 4974–75, 5847–52, 5854; *Leptodactylus ocellatus*: UFBA 3894, 4032, 4039, 5000, 5025, 5883, 5889; *Phyllodytes melanomystax*: UFBA 3785–91, 3813–15, 3881–82, 3887, 3963–65, 4012–13, 4028, 4041, 4075, 4078, 4083, 4911–15, 4918–28, 5590–5624; *Physalaemus cuvieri*: UFBA 5885, 5886; *Physalaemus* gr. *signifer*: UFBA 3867, 3875–76, 4970; *Pleurodema diplolister*: UFBA 4976–79, 5625–27, 5629–31; *Proceratophrys* aff. *boiei*: UFBA 5881; *Rhinella* sp.: UFBA 3752–58, 3812, 3820–21, 3863–64, 3868–74, 4079–80, 4972–73, 5024, 5878–80; *Scinax agilis*: UFBA 3973–92, 4008, 4014, 4020, 4076, 4084–89, 4093–96, 4929–65, 4999, 5661–5710, 5853; *Scinax argyreornatus*: UFBA 3747, 3827–29, 3831, 3840, 3854–55, 4037, 4056–57, 4077, 4100–01, 4971; *Scinax auratus*: UFBA 3743, 3750–51, 3888, 4026–27, 4042, 4917, 4966–69, 5842, 5844–45, 5855, 5869–70; *Scinax* *eurydice*: UFBA 4029, 4073, 4989–90; *Scinax* aff. *alter*: UFBA 5780–5814, 5843; *Scinax* aff. *similis*: UFBA 4024–25, 4074, 4090, 5882; *Sphaenorhynchus prasinus*: UFBA 4017; *Trachycephalus atlas*: UFBA 6187–88; *Trachycephalus mesophaeus*: UFBA 5884.

APPENDIX II

Abundances of anuran species in the sample units (P1-P30) used in the account. Sample units are ordered following NMS ordination scores and species based on weighted averaging. In each cell, the first and the second numbers represent the species abundances collected by pitfall-traps and by active search at night, respectively. Prevailing physiognomy of each plot is indicated by the numbers: (1) beach zone, characterized by sandy soil covered by many shrubs and terrestrial bromeliads; (2) arboreal vegetation with temporary pounds and/or permanent lakes; (3) arboreal vegetation with rivers, springs or streams; and (4) arboreal vegetation without bodies of water on the ground.

	P30	P10	P9	P17	P28	P8	P18	P27	P26	P29	P7	P25	P22	P16	P6	P20	P19	P21	P5	P13	P1	P2	P4	P15	P23	P11	P12	P24	P14	P3
Physiognomy	1	1	1	1	1	1	1	2	2	1	2	2	2	1	2	2	2	2	3	3	2	4	2	3	4	4	4	4	3	4
Dermatonotus muelleri					1;0																									
Pleurodema diplolister	3;1						2;0			2;1																				
Phyllodytes melanomystax	0;9	0;9	0;5	0;8	0;10	0;8	0;6			0;16	0;1			0;3																
Scinax aff. *alter*		0;1				0;1				0;4											0;4									
Scinax auratus			0;1	0;2	0;8				0;3		0;2	0;1	0;1	0;2	0;3	0;1			0;1											
Chaunus jimi									0;1								0;1													
Physalaemus aff. *cuvieri*												2;0																		
Hypsiboas albomarginatus												0;17	0;12																	

Dendropsophus branneri											0;11							0;1												
Scinax agilis						0;1	0;1		0;2	0;1	0;27	0;5	0;32		0;5	0;10	0;24	0;5												
Scinax aff. *similis*												0;1	0;34					0;1												
Dendropsophus minutus													0;18								0;1									
Dendropsophus aff. *decipiens*											0;1	0;2							0;5											
Leptodactylus ocellatus					1;0							0;1			0;1				0;2	0;1				0;1						
Leptodactylus natalensis									0;1		0;2	0;1	0;1				0;1		0;10	0;1	0;3	0;2								

APPENDIX II.—Continued.

	P30	P10	P9	P17	P28	P8	P18	P27	P26	P29	P7	P25	P22	P16	P6	P20	P19	P21	P5	P13	P1	P2	P4	P15	P23	P11	P12	P24	P14	P3
Physiognomy	1	1	1	1	1	1	1	2	2	1	2	2	2	1	2	2	2	2	3	3	2	4	2	3	4	4	4	4	3	4
Itapotihyla langsdorffii											0;1				0;2							0;1	0;1			0;1				
Leptodactylus mystacinus																		0;1												
Leptodactylus labyrinthicus												0;2	0;3		0;1					0;1			0;2			0;1			0;2	
Hypsiboas semilineatus																			0;5											
Sphaenorhynchus prasinus																			0;1											
Hypsiboas pombali																		0;1	0;5			0;1	0;1							
Rhinella sp.												1;0	1;0						5;0	1;0	10;2		5;0	1;0	1;0	1;0				
Allobates alagoanus																					1;0									
Eleutherodactylus ramagii										0;5	0;1		0;1	0;3	0;2	0;4	0;13	0;10	0;43	0;1	0;31	0;13	0;36	0;23	0;6	0;34	0;25	0;14	0;9	0;1
Scinax argyreornatus																			0;5			0;2	0;3			0;1				
Scinax eurydice																			0;5			0;1								
Physalaemus gr. *signifer*																					1;0	2;0		1;0						
Trachycephalus mesophaeus																									0;1					
Proceratophrys aff. *boiei*																									0;1					

Chiasmocleis sp.									1;0																				8;0	6;0

III Conclusão Geral

1. Há grande semelhança entre as anurofaunas do ambiente de Restinga e de Mata Atlântica.
2. A riqueza de espécies nas áreas florestadas foi sensivelmente maior do que em ambientes de cobertura arbustiva, próximos à zona de praia.
3. A comunidade de anfíbios anuros da área estudada apresentou uma ordenação forte e parte considerável desta variação está significativamente associada ao grau de estratificação da vegetação (dossel).
4. A umidade e temperatura do ar não se mostraram fortemente associadas à ordenação da assembléia de anuros.
5. Além das variáveis relativas à estratificação do dossel, outras variáveis ambientais estiveram igualmente associadas à composição da assembléia de anuros, já que obtiveram forte contribuição nos componentes principais (variáveis do ambiente) associados ao eixo de composição das espécies de anuros (NMS). Estas variáveis representaram a porcentagem de serapilheira, umidade do solo e variáveis associadas a bromélias terrestres.

IV Referências Bibliográficas

Arzabe, C. 1999. Reproductive activity patterns of anurans in two different altitudinal sites within the Brazilian Caatinga. Revista Brasileira de Zoologia 16:851–864.

Arzabe, C., C. X. Carvalho & M. A. G. Costa. 1998. Anuran assemblages in Crasto forest ponds (Sergipe state, Brazil): comparative structure and calling activity patterns. Herpetological Journal 8:111–113.

Brasileiro, C. A., R. J. Sawaya, M. C. Kiefer, & M. Martins. 2005. Amphibians of an open cerrado fragment in southeastern Brazil. Biota Neotropica 5:1–17.

Brown, J. H., D. W. Mehlman & G. C. Stevens. 1995. Spatial variation in abundance. Ecology 76:2028–2043.

Caramaschi, U., H. R. Silva & M. C. Brito-Pereira. 1992. A new species of *Phyllodytes* (Anura, Hylidae) from Southern Bahia, Brazil. Copeia (1992):187–191.

Carvalho-e-Silva, S. P., E. Izecksohn & A. M. P. T. Carvalho-e-Silva. 2000. Diversidade e ecologia de anfíbios em restingas do sudeste brasileiro. *In:* ESTEVES. F. A. & LACERDA, L. D. eds. Ecologia de restingas e lagoas costeiras. NUPEM/UFRJ, Macaé, Rio de Janeiro, Brasil. p. 89–97.

Cogliatti-Carvalho, L., A. F. N. Freitas, C. F. D. Rocha & M. Van Sluys. 2001. Variação na composição de Bromeliaceae em cinco zonas de vegetação de restinga no

Parque Nacional da Restinga de Jurubatiba, Macaé, RJ. Revista Brasileira de Botânica 24:1–9.

DUELLMAN, W. E & L. TRUEB. 1994. Biology of Amphibians. New York, McGraw-Hill. 670p.

FREITAS, A. F. N., L. COGLIATTI-CARVALHO, M. VAN SLUYS & C. F. D. ROCHA. 2000. Distribuição espacial de bromélias na restinga de Jurubatiba. Acta Botânica Brasileira 14:175–180**.**

GIARETTA, A. 1996. Reproductive specializations of the bromeliad hylid frog *Phyllodytes luteolus*. Journal of Herpetology 30:96–97.

MUNDURUCA, J. F. V. 2005. Gradientes Ambientais e Composição da Comunidade de Anuros da Reserva Camurujipe, Mata de São João, Bahia, Brasil. Master Dissertation, Universidade Federal da Bahia, Salvador, Bahia, Brazil.

PEIXOTO, O. L. 1995. Associação de anuros a bromeliáceas na Mata Atlântica. Revista Universitária Rural, Série Ciência da Vida 17:75–83.

POMBAL, J. P. 1997. Distribuição espacial e temporal de anuros (Amphibia) em uma poça permanente na Serra de Paranapiacaba, sudeste do Brasil. Revista Brasileira de Biologia 57:583–594.

ROCHA, C. F. D., H. G. BERGALLO., M. A. S. ALVES & M. VAN SLUYS. 2003. A Biodiversidade nos grandes remanescentes florestados do Estado do Rio de Janeiro e nas restingas da Mata Atlântica. São Carlos, RiMa, 160p.

ROCHA, C. F. D., M. VAN SLUYS, F. H. HATANO, L. BOQUIMPANI-FREITAS, R. V. MARRA & R. V. MARQUES. 2004. Relative efficiency of anuran sampling methods in a restinga habitat (Jurubatiba, Rio de Janeiro, Brasil). Brazilian Journal of Biology 64:879–884.

ROSSA-FERES, D. C. & J. JIM. 1994. Distribuição sazonal em comunidades de Anfíbios Anuros na região de Botucatu, São Paulo. Revista Brasileira de Biologia 54:323–334.

SCHINEIDER, J. A. P. & R. L. TEIXEIRA. 2001. Relacionamento entre anfíbios anuros e bromélias da restinga de Regência, Linhares, Espírito Santo, Brasil. Iheringia, Ser. Zool. 91:41–48.

TEIXEIRA, R. L., J. A. P. SCHINEIDER & G. I. ALMEIDA. 2002. The occurrence of amphibians in bromeliads from a southeastern brazilian restinga habitat, with special reference to *Aparasphenodon brunoi* (Anura, Hylidae). Brazilian Journal of Biology 62:263–268.

VAN SLUYS, M., C. F. D. ROCHA, F. H. HATANO, L. BOQUIMPANI-FREITAS & R. V. MARRA. 2004. Anfíbios da Restinga de Jurubatiba: Composição e História Natural. *In* Rocha, C. F. D.; Esteves, F. A. & Scarano, F. R.. Pesquisas de longa duração da Restinga de Jurubatiba: Ecologia, História Natural e Conservação. São Carlos: RiMa. p. 165–178.

VASCONCELOS, T. S. & D. C. ROSSA-FERES. 2005. Diversidade, distribuição espacial e temporal de anfíbios anuros (Amphibia, Anura) na Região Noroeste do Estado de São Paulo, Brasil. Biota Neotropica 5:1–14.

V Anexo

Normas para submissão de artigos a serem publicados no periódico Herpetologica, publicado por Herpetologists’League, cujo conceito Qualis/CAPES em 2006 é A nas áreas de Ecologia e Zoologia (disponível em: <http://www.inhs.uiuc.edu/cbd/HL/Inst-to-Cont.pdf>; capturado em 12 de maio de 2006).

INSTRUCTIONS FOR CONTRIBUTORS

General Information

Herpetologica and *Herpetological Monographs* publish original papers dealing largely or exclusively with the biology of amphibians and reptiles. Theoretical and primarily quantitative manuscripts are particularly encouraged, **with manuscripts organized around concept-driven hypotheses**. Authors submitting manuscripts to *Herpetologica* or *Herpetological Monographs* must be members of the Herpetologists' League before a paper may be accepted for publication, or they will be expected to pay full page charges. In the case of multi-authored papers, at least one coauthor must be a member of the Herpetologists' League. If a society member, payment of printing costs is voluntary and is not a condition for publication. Authors having access to funds for payment of printing costs are encouraged to contribute to the publication fund, especially if their articles exceed 15 printed pages. Authors are assessed costs for any special handling that may be required for their illustrations, such as color photographs.

Authors are accountable for the care and well being of the animals they study. Therefore, the corresponding author should indicate in the cover letter during submission or subsequent e-mail that the authors have observed appropriate ethical and legal guidelines and regulations: (1) for subjects of field studies (e.g., ASIH/HL/SSAR Guidelines for Use of Live Amphibians and Reptiles in Field Research); (2) when obtaining subjects, especially endangered species (e.g., proper collecting permits or use of reputable dealers); and (3) while subjects are in captivity (e.g., protocol approved by Institutional Animal Care and Use Committee). Submitted studies that obviously deviate from acceptable practices, when noted by the editorial staff, are subject to rejection.

Manuscripts should be **sent electronically** to the e-mail address of the Editor of *Herpetologica* or *Herpetological Monographs.* Text should be either in MS Word (*.doc), WordPerfect (*.wpd), or MS Word (*.doc), preferably for PC, and must include **line numbers**. Manuscripts will be assigned to appropriate Associate Editors, who in turn will seek two or three reviews of each submission. Manuscripts will be judged on the basis of their scientific merit. Authors should retain a paper copy and original artwork and photographs until the manuscript is accepted for publication; photocopies of both typescript and graphics are adequate for purposes of review. When the manuscript is accepted for publication, authors will be asked to provide original artwork and photographs, as well as updated electronic files that include a text file in MS Word (***.doc**) or WordPerfect (***.wpd**), preferably for PC, and relevant graphic files that are supported by the publisher (e.g., *.tif, *.eps, *.pdf, but not *.jpg or *.ppt: see allenpress.com); no figures should be embedded in text files.

The Manuscript

All manuscripts are to be in English, using U.S. spelling and grammar conventions. A second abstract, in any modern European language, may follow the Discussion. Use the active voice. Manuscripts should be typewritten on one side only of good quality bond of standard size (21.5 × 28 cm). The entire typescript should be double spaced, including literature citations, tables, and captions to figures, and should have 1-inch (2.4-cm) margins on all sides. Do not use the hyphenation function or the right justify function. For information on style of the manuscript, contributors should examine the most recent issue of *Herpetologica* or *Herpetological Monographs* and the *Council of Biology Editors Style Manual*, fifth edition.

Manuscripts should be arranged in the following order: title, author's name, author's address, abstract, key words, text, acknowledgments, literature cited, appendices, tables, legends to figures, figures. All pages, including tables and legends to figures, are labeled in the upper right-hand corner with the author's name and page number.

Title.—The title should be brief and informative. It should appear centered on the top of page 1 with all letters capitalized, e.g.,

PRIORITY USE OF CHEMICAL OVER VISUAL CUES FOR DETECTION OF PREDATORS BY GRAYBELLY SALAMANDERS

Author's name and address.—Following the title on page 1, the author's name should be centered, with capital and small capital letters. The address follows and is centered and italicized. Multiple author names should be matched to addresses by superscript numbers. The e-mail address of the corresponding author and any address changes should also be noted by superscript numbers, which should be indented from the left margin, e.g.,

CALEB R. HICKMAN[1,2], MATTHEW D. STONE[1,3] AND ALICIA MATHIS[1,4]

[1]*Department of Biology, Southwest Missouri State University, Springfield, MO 65804, USA*

[2]PRESENT ADDRESS: Department of Biology, University of New Mexico, 167 Castetter Hall, Albuquerque, NM 87131-1011, USA.

[3]PRESENT ADDRESS: Department of Zoology, Oklahoma State University, 430 Life Sciences West, Stillwater, OK 74078, USA.

[4]CORRESPONDENCE: e-mail, AliciaMathis@smsu.edu

Abstract.—The abstract follows the author's name and address and should begin on page 1. It should state the major points of the paper as clearly and concisely as possible without the need for reference to the text and without citation of references. The heading ABSTRACT should be indented, styled in capital and small capital letters, and followed by a colon, e.g.,

ABSTRACT: I performed an experiment to test the hypothesis that …

Key words.—Key words separate the abstract from the introduction. Indent the term and italicize both the term and its colon. The key words, which identify the major aspects of the manuscript, should appear in alphabetical order. Only the initial word in each term is capitalized, e.g.,

Key words: Anura; *Bufo americanus*; Predation; Predator avoidance

Text.—The text should begin after the key words. Most manuscripts are efficiently arranged in the order of introduction, methods, results, and discussion; however, some manuscripts profit by other arrangements of topics (e.g., by experimental conditions), so the author should use judgment in this matter. A recent issue of *Herpetologica* or *Herpetological Monographs* should be consulted for details of format. Italics should be used only for names of species and for appropriate leading terms (e.g., Key words) and headings (see below). Common foreign words are not italicized (e.g., et al., not et al). The text ends with the acknowledgments, which should be concise; use initials instead of first names for individuals, e.g.,

Acknowledgments.—I thank N. Windel for assistance in the field; S. and D. Broadhead for providing specimens; and D. Daugherty for critically reading the manuscript. The research was funded by…

Headings.—Three sets of headings are allowed. The MAJOR HEADING is centered with capital and small capital letters. A *Subheading* is centered and italicized, with each major word having an initial capital letter. A *Sub-subheading* is indented and italicized, with only the first letter of the first word capitalized; the sub-subheading is followed by a period and a dash. In any italicized subheadings, a species epithet is typed in roman type, e.g.,

MATERIALS AND METHODS

Experimental Condition 1: Bufo americanus

Collection and Maintenance. —We collected 50 adults of….

References.—In the text, references to papers by one or more authors are cited with surnames; papers with more than two authors are referenced by the first author's surname followed by "et al." Strings of references in the text should be placed in **alphabetical order**, e.g.,

Brodie and Formanowicz (1983) and Tilley et al. (1982) reported that …

…salamanders are excellent for studies of behavior (Arnold, 1976; David and Jaeger, 1981; Grant, 1955; Wrobel et al., 1980).

All references mentioned in the text must be listed in the Literature Cited, and vice versa. Check that dates and spelling match. Two or more references by the same author for the same year of publication are designated by lowercase, italicized letters, e.g., (Rand, 1967*a*,*b*).

The Literature Cited section follows the acknowledgments. **Spell out the names of all journals and book publishers**. References listed in the Literature Cited should be double spaced and in alphabetical order according to the author's surname. When there are several papers by the same senior author with various authors (cited as "et al." in the text), the papers should be listed in chronological order. A citation to a single author ("Smith, J. B., 2001") is listed before a citation to that author and a coauthor ("Smith, J. B., and M. T. Jones, 1999") and before any citation to the author with multiple coauthors ("Smith, J. B., M. T. Jones, and B. C. White, 2000"). A dash (3 em) is used for the author's name if it is identical to the previous entry; if multiple authors, all authors must be identical to the previous entry for the dash to be used. References should be in the following format (note spacing between initials and the use of capital and small capital letters in the author's name).

CARPENTER, C. C. 1986*a*. An inventory of the display-action-patterns in lizards. Smithsonian Herpetological Information Service No. 86:1–18.

—. 1986*b*. An inventory of combat rituals in snakes. Smithsonian Herpetological Information Service No. 87:1–18.

ETHERIDEGE, R. E. 1960. The Relationships of the Anoles (Reptilia:Sauria:Iguanidae): An
Interpretation Based on Skeletal Morphology. Ph.D. Dissertation, University of Michigan, Ann Arbor, Michigan, U.S.A.

FROST, D. R. 2004. Amphibian species of the world: an online reference. Available at http://research.amnh.org/herpetology/amphibia/index.html. American Museum of Natural History, New York, New York, U.S.A.

GANS, C., A. d'A. BELLAIRS, AND T. S. PARSONS (Eds.). 1969. Biology of the Reptiles, Volume 1, Morphology A. Academic Press, New York, New York, U.S.A.

MLBS (MOUNTAIN LAKE BIOLOGICAL STATION). 2005. Weather data collected and maintained by MLBS. Available at http://mlbs.org/weatherdata/weather.html University of Virginia, Charlottesville, Virginia, U.S.A.

REGALADO, R., AND O. H. GARRIDO. 1993. Diferencias en el comportamiento social de dos especies gemelas de anolinos Cubanos (Lacertilia: Iguanidae). Caribbean Journal of Science 29:18–23.

WILLIAMS, E. E. 1972. The origin of faunas. Evolution of lizard congeners in complex island faunas. A trial analysis. Pp. 47–89. *In* T. Dobzhansky, M. K. Hecht, and W. C. Steere (Eds.), Evolutionary Biology. Appleton-Century-Crofts, New York, New York, U.S.A.

USGS (UNITED STATES GEOLOGICAL SURVEY). 1998. National water quality assessment (NAWQA) program, water quality in the Ozark plateaus. Circular 1158. Available at http://water.usgs.gov/pubs/nawqasum/.

For references that are in the course of publication, cite "In press" in place of the page numbers; the complete name of the journal should be given. Manuscripts that are neither "In press" nor published should not be cited in the text or the Literature Cited.

Appendices.—Detailed information not essential to the text (such as "*Specimens Examined*") may be placed in appendices, which follow the Literature Cited and are headed with large and small caps as APPENDIX I, II, etc.

Tables.—Each table should be typed, double spaced, on a separate sheet. The legend for a table should follow the table number and should be on the same page as the table. Legends should not be indented, and should begin with the table number in large and small caps, followed by a period and an em dash, e.g.,

TABLE 1.—Seasonal differences in water and air temperatures…

Within the table, only the initial letter of the first word is capitalized (e.g., Grand average"). **Ruled lines on tables should be avoided** except to isolate the heading, legend, or the column labels, and where separate groups of columns require additional clarification. Footnotes (indented and indicated by symbols such as "*") may follow a table when detailed information is needed (such as levels of statistical significance).

Figures.—A computer file of each figure, or the photographic prints, should be sent to the **Editor** along with the revision of the manuscript. Dimensions of this artwork must not exceed 21.5 × 28 cm. Figures should be planned to accommodate reduction to a final width of one or two columns in *Herpetologica* or *Herpetological Monographs*. After reduction, lettering should be 1.5—2.0 mm high and decimals should be visible. Before submission, authors are encouraged to inspect figures for clarity after making a xerox reduction to the same scale as the journal print column. Include a scale of distance or dimension where appropriate. If a figure is to include more than one image, the prints should be arranged together in one electronic file, with adjacent figures butted together and separate prints identified by letters (A, B, C). If electronic versions of the prints are not possible, hard copies can be sent to the Editor, with multiple prints in the same figure mounted on Bristol board so that they are butted together; each should be lettered (A, B, C). If hard copies are sent, the back of each figure should be labeled with the author's name, the figure number, and the desired final printed size of the figure (one column or two columns are the only options). All axes of graphs should be labeled, with a larger font size used for major labels than for minor or quantitative labels. Legends should not appear on the figures, per se, but should be typed (double spaced) and grouped together on a separate sheet with three lines of space between legends. Legends should be indented, and should begin with the figure number in large and small caps, followed by a period and an em dash e.g.,

FIG. 1.—Correlation between Gosner stage and length of…

In the text, "Figure" should be abbreviated (e.g., Fig. 2) except when beginning a sentence. Abbreviations on figures (such as *n*, for sample size) should follow the conventions given below.

Footnotes.—Footnotes are discouraged except to clarify tables and to denote PRESENT ADDRESS of an author and CORRESPONDENCE as an e-mail address.

Numerals.—Numbers of 10 or larger should be typed as Arabic numerals except at the beginning of a sentence. Numbers one to nine should be spelled out unless they precede units of measurement (e.g., 4 mm), are designators (e.g., experiment 2), or are separated by a dash (e.g., 2–3 scutes). Only numbers with five or more digits are separated by a comma (e.g., 37,326, but not in 9427). The 24-hour clock is used to indicate times of day (e.g., 2200 h); dates are given by day, month, year (e.g., 13 January 1947). Decimals should not be naked (e.g., 0.5, not .5). In a series containing some numbers of 10 or more and some less than 10, use numerals for all (e.g., The 7 frogs, 9 salamanders, and 20 lizards were collected.).

Abbreviations.—Weights and measures should follow the International System of Units (SI), and such abbreviations should be used in the text, tables, and figures. Common abbreviations for *Herpetologica* and *Herpetological Monographs* follow.

> $\overline{X}$ (mean), *n* (sample size), N (chromosome number), no. (number), SVL (snout–vent length, but define this at first usage), yr (years), wk (weeks), d (days), h (hours), min (minutes), s (seconds), *P* (probability), df (degrees of freedom), SD and SE (standard deviation and standard error, respectively; give as 1 SD, 3 SE, etc.), NS (not significant), l (liter), g (gram), mm (millimeter), C (degrees Celsius, not °C).

Note that $\overline{X}$, *n*, and *P* are italicized, as are all statistical symbols of values (e.g., *t*-test, r^2, Mann-Whitney *U*). Greek letters (e.g., χ) are not italicized. Do not abbreviate "male" or "female," "personal communication," dates, or undefined terms.

Style for taxonomic descriptions.—The following outline is intended to standardize the overall style and format of species descriptions appearing in *Herpetologica*. In some cases, it may be preferable and necessary to vary from this format. In order to facilitate comparisons of species descriptions appearing in recent literature concerning the group being studied, authors are encouraged to match closely the style, sequence, and terminology of other recent and/or major works on that group. In studies where the discovery and description of the new species is based on a broad review of molecular and/or morphological variation in a group (e.g., revision of a species complex or analyses of variation in widespread species), it is preferable for such a review to be presented in the manuscript prior to the presentation of the formal species description(s). The justification for having the species description follow the analysis of variation is that, in many cases, the decision to name the species should first be justified. Manuscripts in *Herpetologica* generally follow the standard Introduction, Materials and Methods, Results, and Discussion format. In a paper following this format and including species descriptions, the Results should include the analysis of variation that justifies the recognition of new taxa, and the Discussion should explain this justification, including a clear statement of just which species concept is being invoked. The formal description(s) should follow the Discussion as a separate section, entitled Species Account(s).

MATERIALS AND METHODS

Include references to standardized or recently used measurements (e.g., formulae for anuran webbing and tadpole mouth parts), format, and terminology, as well as definitions of all museum acronyms used in text.

RESULTS

Data analyses (e.g., morphometric, morphological, molecular), if available, should be given here to support the following species description. Some manuscripts simply present a straightforward description of a new species and the Results section may not be needed.

DISCUSSION

As in the Results section, the Discussion section may be used in some cases or may not be appropriate.

SPECIES ACCOUNT(S)

Hyla ***abccc*** sp. nov.

List relevant synonymy information here.

Holotype.—Museum catalog number (and original field number, if available), sex, date, locality information, collector (Figure reference).

Paratypes. —May be organized by sex and/or geographical locality, whichever is most concise and clear.

Referred specimens.—List nontype specimens examined here, or in an Appendix if the list is lengthy.

Diagnosis.—Provide a concise summary of the salient characteristics of the species by which it may be referred to a particular genus, clade, and/or species group. Include short descriptions of the unique characteristics and/or a list of descriptions of characters commonly used in taxonomic treatments of that appropriate taxonomic group (e.g., ventral scales in snakes, costal grooves in salamanders). Include a section of explicit diagnostic comparisons to other species that will convince the reader of the unique nature of the new species. These may include diagnostic comparisons to other species to which the new species is (may be) closely related, sympatric, or with which it may be possibly confused. Diagnosis should be prepared using telegraphic style.

Description of holotype.—An explicit description of all aspects of the type specimen, following the features, level of detail, and general style and format of other recent, important literature relevant to the group (e.g., a description of a new species of *Eleutherodactylus* would do well to match the general format and terminology of Campbell and Savage, 2000, *Herpetological Monographs* 14:186—292). Descriptions should be prepared using telegraphic style. Include here (as per style for group being described): measurements of the holotype, color in preservative, and color in life (if known); in some cases, descriptions of color may be best presented in telegraphic style.

Variation.—A summary of evident variation among the type series and referred specimens, including reference to sexual dimorphism, geographic variation, and/or ontogenetic change. Morphometric variation is usually best summarized in a table.

Distribution and ecology.—Relevant commentary and summary of all known aspects of its life history, natural history, and distribution.

Tadpole (or larva).—Description of the larval stage (if known and relevant), following recent style and format for group being described.

Etymology.—Short description of the specific epithet.

Remarks.—Concise discussions relevant to the new species, such as taxonomy, variation, distribution, biogeography, natural history, evolution, and phylogenetic relationships.

APPENDIX I

Specimens Examined

Include here locality data (but not date of collection) and museum numbers of all specimens of both the new species and of comparative material used in the study and diagnoses.

Reprints, Proofs, and Revisions

Reprints or high-quality PDF files of articles may be purchased from Allen Press, using the forms provided, at the time page proofs are received. Authors may produce and distribute electronic (e.g. *.pdf) versions of any of their *Herpetologica* and *Herpetological Monographs* articles. Each author should check proofs carefully against the edited manuscript. Printer's errors are best detected when two persons read proof together—one reading aloud from the proofs, the other following on the typescript. The editorial staff of *Herpetologica* and *Herpetological Monographs* does not read proof on articles, so authors must assume full responsibility for detecting errors.

Both the edited manuscript and the corrected proofs should be returned to the **Editor** as soon as possible to prevent a delay in publication. Revisions should not be made in proofs; changes in proofs other than correction of printer's and editor's errors will be charged to authors at the rate of **$3.50/line**. Authors are invoiced for line charges; **until invoices are paid**, subsequent manuscripts from delinquent authors will not be considered for review.