RELATIVE EFFICIENCY OF ANURAN SAMPLING METHODS IN A RESTINGA HABITAT (JURUBATIBA, RIO DE JANEIRO, BRAZIL)

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ABSTRACT

Studies on anurans in restinga habitats are few and, as a result, there is little information on which methods are more efficient for sampling them in this environment. Ten methods are usually used for sampling anuran communities in tropical and sub-tropical areas. In this study we evaluate which methods are more appropriate for this purpose in the restinga environment of Parque Nacional da Restinga de Jurubatiba. We analyzed six methods among those usually used for anuran samplings. For each method, we recorded the total amount of time spent (in min.), the number of researchers involved, and the number of species captured. We calculated a capture efficiency index (time necessary for a researcher to capture an individual frog) in order to make comparable the data obtained. Of the methods analyzed, the species inventory (9.7 min/searcher /ind.- MSI; richness = 6; abundance = 23) and the breeding site survey (9.5 MSI; richness = 4; abundance = 22) were the most efficient. The visual encounter inventory (45.0 MSI) and patch sampling (65.0 MSI) methods were of comparatively lower efficiency restinga, whereas the plot sampling and the pit-fall traps with drift-fence methods resulted in no frog capture. We conclude that there is a considerable difference in efficiency of methods used in the restinga environment and that the complete species inventory method is highly efficient for sampling frogs in the restinga studied and may be so in other restinga environments. Methods that are usually efficient in forested areas seem to be of little value in open restinga habitats.

Key words: Anura, restinga habitat, Anuran sampling methods, Restinga de Jurubatiba, species richness.

RESUMO

Ediciência relativa de métodos de amostragem de anuros em um habitat de restinga (Jurubatiba, Rio de Janeiro, Brasil)

São escassos os estudos sobre anuros em áreas de restinga e, conseqüentemente, há pouca informação sobre os métodos mais eficientes de amostragem nesse habitat. De forma geral, são utilizados dez métodos de amostragem em comunidades de anuros em áreas tropicais e subtropicais. Neste estudo, avaliamos quais seriam os métodos mais eficientes para amostrar a comunidade de anfíbios na restinga do Parque Nacional da Restinga de Jurubatiba, norte do Estado do Rio de Janeiro. Analisamos seis métodos usualmente utilizados para a amostragem de anuros. Registramos, para cada método, o tempo total dispendido (em min), o número de pesquisadores envolvidos e o número de espécies e de anuros capturados. Calculamos, então, um índice de eficiência de captura (tempo necessário para um pesquisador capturar um animal), de forma a tornar comparáveis os dados obtidos, e estimamos a riqueza e a abundância totais obtidas com cada método. Dos métodos avaliados, os mais eficientes foram Inventário completo de espécies (9,7 min/amostrador/indivíduo-MAI, com riqueza = 6 e abundância = 23) e Transectos em sítios reprodutivos (9,5 MAI, com riqueza = 4 e abundância = 22). Os métodos Levantamento por encontros visuais (45,0 MAI) e Amostragem em manchas (65,0 MAI) apresentaram eficiência consideravelmente menor, enquanto Amostragem em parcelas (*plots*) e Armadilhas de queda com direcionadores (*Pit-falls*) não capturaram nenhum indivíduo. Concluímos, portanto, que há considerável diferença na eficiência dos métodos em ambiente de restinga e que os métodos Inventário completo de espécies e Transectos em sítios reprodutivos foram os mais eficientes para a amostragem de anuros na restinga estudada e, supostamente, em outros ambientes de restinga. Os dados mostram a importância da procura ativa pelos anuros nos microhabitats durante as amostragens nesse ambiente. Alguns métodos usualmente eficientes em áreas florestadas (como *pit-falls* e *plots*) apresentaram baixa eficiência no habitat estudado de restinga aberta.

Palavras-chave: Anura, restinga, métodos de amostragem de anuros, Restinga de Jurubatiba, riqueza de espécies.

INTRODUCTION

Anuran communities from restinga habitats in Brazil are poorly known and few studies on them have been done (e.g., Britto-Pereira *et al*., 1988; Giaretta, 1996; Peixoto, 1995; Carvalho-e-Silva *et al*., 2000; Caramaschi *et al*., 1992). In different parts of the world, various methods have generally been used to sample these communities (see a review in Heyer *et al*., 1994): 1. complete species inventories; 2. visual encounter surveys; 3. patch sampling; 4. pit-fall traps with drift fences; 5. plot sampling; 6. surveys at breeding sites; 7. transect sampling; 8. drift fences encircling breeding sites; 9. audio strip transects; and 10. quantitative sampling of amphibian larvae. When deciding which method (or methods) should be used in a particular area it is also important to consider the habits of the species under study (e.g., aquatic, fossorial, or arboreal); time, economic resources, and personnel available; and nature of the habitat (e.g., habitat complexity), local faunal diversity, and size of the area to be studied. As a result, method efficiency can vary greatly and depends on habitat (Heyer *et al*., 1994). Although the efficiency of many of these methods is well known in forested habitats (Heyer *et al*., 1994; Cechin & Martins, 2000; Rocha *et al*., 2000, 2001), at the present time this is not the case for any of these methods in sampling anurans in restinga habitats.

In this study we evaluate the relative efficiency for anuran inventories in a restinga habitat of six common anuran sampling methods in order to identify which should be considered more appropriate.

MATERIAL AND METHODS

Study area

The study was carried out in the restinga habitat of Jurubatiba (currently a National Park), which is situated between 22º and 22º23'S and 41º15' and 41º45'W and encompasses three municipalities (Macaé, Carapebus, and Quissamã) in northern Rio de Janeiro State, Brazil. Jurubatiba is a typical sandbar plain ecosystem occupying ca. 6,000 km² of coastal plain, which makes it the largest continuous area of this type of ecosystem in the State (Araújo & Henriques, 1984). Annual rainfall in the area averages 1164 mm, and is highly seasonal, with mean monthly totals ranging from 41 mm during winter to 189 mm during summer (Henriques *et al*., 1986). Mean temperature varies monthly from 29.7ºC in January to 20ºC in July, and the annual average is 22.6ºC (Henriques *et al*., 1986). The area is characterized predominantly by shrubby and herbaceous xerophilic vegetation in which the families Clusiaceae, Myrtaceae, Erythroxylacea, Leguminoseae, Cactaceae, and Bromeliaceae dominate. For a comprehensive description of area vegetation, see Henriques *et al*. (1986), Araújo *et al*. (1998), and Zaluar & Scarano (2000).

The area in the restinga in which the study was carried out is adjacent to the Cabiúnas Lagoon (22º16'S; 41º41'W), corresponding to a sub-area called "open *Clusia* formation" (Henriques *et al*., 1986; Araújo *et al*., 1998). The arbustive-arboreal vegetation is dominated by species of Clusiaceae, Myrtaceae, Erythroxylaceae, and Burseraceae, with abundant bromeliads and cacti and a high density of the trunkless dwarf sand palm or *guriri*, *Alagoptera arenaria* (Aceraceae) (Henriques *et al*., 1986; Araújo *et al*., 1998).

Sampling methods

The study was made during April 2001, which in that area corresponds to the end of the wet season. For the methods applied we followed procedures described in Heyer *et al*. (1994) and adapted by us to the local conditions of the restinga environment. The following methods were tested: 1. complete species inventory, in which observers walked at a regular pace along the restinga, actively and carefully searching (e.g., looking under leaves or branches of shrubs, stirring leaf-litter, and overturning logs and branches) out all microhabitats suitable for frogs presence; 2. visual encounter surveys, a method relatively similar to the previous one but involving only visual searching with no microhabitat interference; 3. patch sampling with "patch" signifying any portion of the environment with increased probability of life and occurrence of some frog species (Heyer *et al*., 1994). The patches considered in this study were of bromeliads, inside of which frogs were carefully searched for by dissecting individual bromeliads. Using this method, the two most abundant bromeliad species at the study site (*Aechmea nudicaulis* and *Vriesea neoglutinosa*) were sampled; 4. pit-fall traps with drift fences, by which were established ten pit-fall trap systems inside thickets dominated by scrub of *Clusia* spp. Each pit-fall system consisted of four 20-liter buckets with drift fences (1.5 m x 0.5 m) forming a "Y" on the ground (Jones, 1981). These systems remained in place during five days, being checked each morning (from 7:30 to 8:30 h) for presence of captured frogs. The systems were installed inside the thickets to protect captured frogs from exposure to high temperatures; 5. plot sampling, by which, after measuring the greatest length and width of the thicket (to the nearest cm), four of the members (of the same team maintained throughout the study) positioned side-by-side along the edge of the thicket crawled to the center of the plot while carefully searching for frogs. All leaves, logs, wood, and fallen branches inside the plot were overturned and spaces between tree roots and bromeliads were checked for frogs. Each plot was searched by the crew for 30-40 minutes; 6. transect sampling in reproductive sites, an association of two usual methods (surveys at breeding sites and transect sampling) by which 2 m-wide transects were established along an important Jurubatiba restinga reproductive site: the Cabiúnas lagoon vegetative border. The observer would move along the reproductive site at a regular walking pace, carefully searching out all available microhabitats within the transect. So as to make the results comparable, we calculated an index of capture efficiency (the time necessary to find a frog). We estimated by each method the richness and total abundance.

Due to their specific characteristics, the time spent on each sampling method varied. To make comparable the relative efficiencies, we standardized frog abundance by expressing the data in terms of individuals found/observer/minute for each method. For all of the sampling methods used, we recorded total time spent searching for frogs (in minutes), habitats sampled, species found, and number of individuals found.

Except for the pit-fall trap and patch sampling methods, we start recording at dusk (approximately 18:00 h). Time spent on sampling totaled 225 min in the complete species inventory, 209 min in the transects-in-breeding-sites method, and 90 min in the visual encounter survey method. All habitats along the study area were sampled. We started each sampling day with a different method, in order to minimize the effect of time in the samplings.

RESULTS

We found six frog species during the study, all of them hylids (*Aparasphenodon brunoi*, *Hyla meridiana, Hyla semilineata*, *Scinax alter*, *Scinax cuspidatus*, and *Scinax* sp. (Table 1). The highest species richness (N = 6) and total abundance (N = 23) of frogs was obtained when sampling using the complete species inventory (Table 1). This method sampled all frog species recorded during the present study and an average of only 9.7 minutes were necessary to find a frog (independent of species) (Table 1).

The method that sampled the second highest number of frog species and abundance was transects in reproductive sites by which we sampled 22 individuals of four frog species. This method required an average of 9.5 minutes to find a frog (Table 1).

The other methods used seemed comparatively less efficient for sampling frogs in the restinga habitat studied. Patch sampling (bromeliads), despite requiring much more time (260 minutes/observer) than the two previous methods, yielded only four individuals belonging to a single species (*Scinax cuspidatus*). Using visual encounter surveys we found two species, each represented by only one individual, for which an average of 45 minutes were necessary to find a frog. The plot sampling and pit-fall trap with drift fence methods produced no frogs, despite the considerable amount of time spent on surveys (i.e., the former took 121 min/observer and the latter, 5220 min/observer).

TABLE 1
Effort in terms of time spent on each sampling method (in minutes/observer), species richness, total abundance, species found, and time necessary for an observer to find an individual frog (MSI – minutes/observer/individual), using six anuran sampling methods in the Restinga de Jurubatiba, Macaé, Rio de Janeiro State. The number following each species name indicates the species-specific abundance found.

Sampling method	Effort (minutes/ observer)	Species richness	Total abundance	Species	MSI
1. Complete species inventory	225	6	23	*Aparasphenodon brunoi* – 1 *Hyla meridiana* – 5 *Hyla semilineata* – 2 *Scinax alter* – 6 *Scinax cuspidatus* – 6 *Scinax* sp. – 3	9.7
2. Visual encounter inventory	90	2	2	*Hyla meridiana* – 1 *Scinax cuspidatus* – 1	45.0
3. Transects in reproductive sites	209	4	22	*Hyla meridiana* – 3 *Hyla semilineata* – 5 *Scinax alter* – 3 *Scinax* sp. – 11	9.5
4. Plot sampling	121	0	0	No species sampled	0
5. Sampling in patches	260	1	4	*Scinax cuspidatus* – 4	65.0
6. Pit-fall traps with drift fences	5220	0	0	No species sampled	0

DISCUSSION

There are few studies evaluating the relative eficiency of different sampling methods for herpetofauna (Heyer *et al.*, 1994; Parris *et al.*, 1999; Rocha *et al.*, 2001) and among them none focuses on restinga environments. As a step in filling that gap, the data presented here show that efficiency of, and effort required, by the methods analyzed for sampling anurans in a restinga habitat varied greatly.

The two most efficient methods were the complete species inventory and the transects in reproductive sites not only in terms of anuran species richness recorded but also in anuran abundance and, consequently, in time spent, which was nearly the same for both methods, in finding a particular individual. By using the complete species inventory we were able to sample all of the anuran species recorded in using all methods combined. Furthermore, this one has the advantage of actively searching all restinga microhabitats available (both horizontally and vertically). Because this method involves moving or turning over some elements of the microhabitat, the probability of finding a frog is greatly increased. Similarly, transects in reproductive sites also proved highly efficient for sampling anurans in the restinga. However, the efficiency of this method, which limits sampling to humid habitats (reproductive sites) was expected. In relatively dry habitats such as restingas, many anuran species would tend to gather in humid portions of the environment (or microhabitats), allowing reproduction and larvae development.

The visual encounter survey and the complete species inventory methods produced relatively similar results; however, they differed markedly in sampling efficiency. Most of the differences resulted from the kind of search employed in each method (Heyer *et al.*, 1994). While for the complete species inventory, the observer actively searches all microhabitats, in visual encounter surveys the observer records only the individuals sighted, without actively searching out microhabitats. As a result, a considerable difference appeared among these methods in the time necessary to find each frog in the restinga (9.7 minutes by complete species inventory and 45 minutes in the visual encounter survey), which indicates the importance of actively searching out microhabitats when sampling restinga environments.

Patch-sampling efficiency was relatively restricted, resulting in locating only four individuals of one frog species (*Scinax cuspidatus*). This may be because in Jurubatiba this method was used to sample only one kind of microhabitat (bromeliad interiors), which may not be used by some species of the local anuran assemblage. Curiously, no specimens of *Aparasphenodon brunoi* and *Scinax alter* were recorded by this method, even though these species are commonly found inside bromeliads (Britto-Pereira *et al*., 1988). Patch sampling may be more efficient for studies restricted to a particular bromelicolous frog species, e.g., *Scinax cuspidatus*.

Pit-fall traps with drift fences and plot sampling, which are well-known methods for efficiently sampling anurans in densely forested areas (Lloyd *et al.*, 1968; Scott, 1976, 1982; Allmon, 1991; Heyer *et al*., 1994; Gascon, 1996; Cechin & Martins, 2000; Rocha *et al*., 2000, 2001) proved inefficient in the restinga habitat studied. We believe that this may result from differences between the restinga environment (an open sandy habitat) and dense forest habitat, and because these methods efficiently sample frogs primarily moving on the ground. Most tropical forested areas have a deep, humid, leaf-litter layer spread along all the forest floor, which harbours a rich and abundant anuran fauna (Lloyd *et al.*, 1968; Scott, 1976, 1982; Allmon, 1991; Heyer *et al*., 1994; Gascon, 1996; Cechin & Martins, 2000; Rocha *et al*., 2000, 2001). Therefore, in these habitats methods of sampling anuran species on leaf litter enjoy a great probability of success. On the other hand, in restinga habitats the normally thin and dry leaf-litter layer is restricted to the ground in the interior of thickets. Most of the ground where thickets grow is open dry sand and may reach high temperatures during the day (Franco *et al*., 1984; Rocha, 1988). As a result, most frogs in restinga habitats are usually associated with microhabitats inside thickets and tend to show some degree of arboreality compared to their relationship with the comparatively less-explored terrestrial habitat. As a result, since only a small fraction of anurans in open restinga habitats seems to move on the ground, as was observed in this study during collections (pers. obs.), low frog-sampling efficiency would be expected in both the pit-fall trap and plot sampling methods.

Our results show a considerable difference in efficiency of the methods used in the restinga environment, the complete species inventory (sensu Heyer *et al*., 1994) proving superior for frog sampling in the restinga studied. Methods usually efficient in forested areas seem to be of little value in open restinga habitats. Also, our study shows the importance of actively searching out microhabitats when sampling in restinga environments.

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