DIVERSITY AND ABUNDANCE OF LITTER FROGS AT ALTITUDINAL SITES AT SERRA DO JAPI, SOUTHEASTERN BRAZIL

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ABSTRACT. It was sampled the litter frogs at altitudinal sites of a semideciduous mesophytic forest located at Serra do Japi (Jundiaí, São Paulo, 23°17'S, 47°00'W, 800-1300m altitude, 1500mm rain/year). Forty two plots of 8x8m were sampled in the dry/cold season of 1995: 21 at a Higher Site (HS) (1000m) and 21 at a Lower Site (LS) (850m). The plots were evenly located near, mid-distance, and far from the stream-bed. It was found a total of five species, three at each site. *Eleutherodactylus guentheri* comprised 83% of the individuals at HS and *E. juipoca* 67% at LS. The density of individuals was higher at HS and near the stream. The greater density at HS may be due to greater humidity there, provided by mist. The frogs may aggregate in wetter places (stream edges) in the dry/cold season. The studied sites represent harsh and early successional environments and both these factors may be acting together to produce the low observed diversity.
KEY WORDS. *Brachycephalus*, *Eleutherodactylus*, *Hyla*, litter frogs, diversity, Southeastern Brazil

Species composition and abundance of litter frogs are influenced by local environmental conditions such litter depth and humidity (SCOTT 1976; TOFT 1980) in addition to historical factors such as human disturbance (LIEBERMAN 1986; HEINEN 1992). The Serra do Japi is a group of low mountains in the Mantiqueira range in Southeastern Brazil mostly covered by a seasonally dry semideciduous mesophytic forest (LEITÃO-FILHO & MORELLATO 1997). On its west face, in a 300m altitudinal range (850-1170m), different vegetational types are found (RODRIGUES & SHEPHERD 1992). It was sampled the litter frogs at two altitudinal sites on this west face, in the altitudinal extremes where an accessible forest stream is found. Specifically it was asked: 1) Do the litter frog diversity and abundance differ between the sites?; and 2) Do the abundance vary with distance from the stream?

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MATERIAL AND METHODS

This study was carried out at the Serra do Japi (around 23°17'S, 47°00'W, 800-1300m altitude, 1500mm rain/year), municipality of Jundiaí, State of São Paulo, Brazil. It was sampled two altitudinal sites on the west face of the mountain. The Higher Site (HS) is at an elevation of about 1000 m, and the Lower Site (LS) at about 850m, below the "Represa do Departamento de Águas e Esgotos". These two sites are about 2000 m apart. The main stream is about 1.5m wide at HS and 4.5m at LS; it has clear water and rocky/sandy bed; waterfalls are common. In the region, the climate is seasonal with a dry/cold season from April to September (with occasional frosts in June-July) and a wet/warm season from October to March (MORELLATO 1992). Field work was done in the dry/cold season, from mid-July to early August 1995. At the study sites, it seems that trees have been slashed and burned for coal in the past, as indicated by old roads and coal-pits inside the forest. A burnt trunk at the lower site is evidence of a recent fire. Buttress trees and tank bromeliads were not found at the study sites.

A total of 42 plots of 8x8m were sampled: 21 at HS and 21 at LS, following the methodology in JAEGER & INGER (1994). At both sites, plots were evenly located near (lower border at 2m), mid-distance (10m), and far (18-50m) from the stream-bed. In each site, the plots were randomly distributed along a 1000m transect. The plot perimeter was delimited by ropes and ground strips cleaned of litter, about 30cm wide. The plots were examined once during the day time, usually by the authors. The litter was stirred on hand and knees, with tridents. To each plot it was considered the following environmental variables: the mean litter and root mat layer depth (1.5m from each corner and at the center); air moisture, using a psychrometer; and the temperature at the ground level. Holes in the ground were examined superficially with flash-lights and tree trunks were rolled, looking for frogs. In the lab all frogs were weighed to the nearest 0.01g. Individuals that were lost before identification were used only for calculations of density and biomass (estimates according to size). Differences in density, biomass and environmental characteristics among samples were tested by nonparametric ANOVA (ZAR 1974); the level of statistical significance was chosen *a priori* as 0.05. The diversity index (Shannon-Wiener) and the significance of the differences between their values were determined as in MAGURRAN (1988). The coefficient of dispersion (variance-mean ratio) was calculated for each altitudinal site. Voucher frog specimens are housed at the Museu de História Natural da Universidade Estadual de Campinas (ZUEC).

RESULTS

In the litter samples from the Serra do Japi it was found 37 frog individuals. The 35 for which identification was possible belong to five species in three families (Tab. I). Three species were found at each site (Tab. I). The abundance of individuals and biomass were higher at HS (2.3 and 5.4g/100m^2) than at LS (0.4 and 2.7g/100m^2) (Tab. II). The densities of individuals were greater at plots near the stream and the biomass showed a similar trend (Tab. III). At HS, the dominant species was *Eleutherodactylus guentheri* (Steindachner, 1864) (83% of the indivi-

duals); whereas at LS *Eleutherodactylus juipoca* Sazima & Cardoso, 1978 dominated (67%). Direct developing species comprise 85.8% of the sampled frogs; juveniles 28.6% and adults of species with aquatic larval phase 8.6%. The HS can be characterized as having deeper litter and root mat than the LS (Tab. II). No difference in humidity and temperature was found between altitudinal sites (Tab. II) and distances from the water (P>0.10). Values of species diversity index in nits and evennes were, respectively, 0.546/0.162 to HS; 0.868/0.484 to LS; and 0.939/0.264 to the pooled sample (42 plots). The values of the species diversity do not differed significantly between altitudinal sites (P>0.10). At HS the frogs showed an aggregated pattern, with a coefficient of dispersion of 2.5; at LS this value was 1.1, a random distribution.

Table I. Species of frogs found in litter plots at the Serra do Japi (Jundiaí, São Paulo) and its percentual contribution at two altitudinal sites and different distances from the stream. N=21 plots at each site and seven at each water distance. Higher site around 1000m; lower site around 850m; (Ne) near (2m); (Md) mid-distance (10m); (Fa) far (18-50m) from the stream-bed.

Family and specie	Higher site			Lower site			Total (%)
	Ne	Md	Fa	Ne	Md	Fa	
Brachycephalidae							
Brachycephalus ephippium [1]	0.0	0.0	2.9				2.9
Hylidae							
Hyla faber				0.0	2.8	0.0	2.8
Hyla luctuosa [2]	5.8	2.8	2.8				11.4
Leptodactylidae							
Eleutherodactylus guentheri [1]	48.7	11.4	8.6	2.8	0.0	0.0	71.5
Eleutherodactylus juipoca [1]				8.6	0.0	2.8	11.4

1) Species that undergoes direct development; 2) found at the lower site, but outside of plots. See HADDAD & SAZIMA (1992) for color pictures of the species.

Table II. Values of some environmental variables and abundance indicators of the litter frog assemblage at two altitudinal sites at Serra do Japi (Jundiaí, São Paulo). N=21 plots at each site. Higher site around 1000m; lower site around 850m; (**Me**) median; (**Max**) maximal and (**Min**) minimal observed values; (**U**) values of the Mann-Whitney test; (**P**) probability.

Variables	Higher site			Lower site			U	P
	Me	Max	Min	Me	Max	Min		
Litter depth (cm)	3.7	5.1	2.0	2.3	6.0	1.4	336	0.004
Root mat (cm)	4.1	7.9	0.8	1.6	4.5	0.0	372	<0.001
Relative humidity (%)	90.0	100.0	75.0	90.0	100.0	75.0	208	0.759
Temperature (ºC)	17.0	20.0	10.0	17.0	24.0	13.0	205	0.143
Frogs/plot	1.0	6.0	0.0	0.0	2.0	0.0	308	0.013
Biomass (g)/plot	0.6	23.6	0.0	0.0	30.2	0.0	533	0.021

Table III. Values of abundance indicators of the litter frog assemblage in the Serra do Japi (Jundiaí, São Paulo) in relation to distance from stream-bed. N=14 plots at each distance. Unequal exponents indicate differences between groups. (**Me**) median; (**Max**) maximal observed value; all minimal values were zero.

Distance from the stream-bed	Nember of inviduals		Biomass (g)	
	Me	Max	Me	Max
Near (2m)	1 [a]	6	2.0	23.6
Mid-distance (10m)	0 [b]	3	0.0	30.2
Far (18-50m)	0 [b]	3	0.0	2.6
Values of the Kruskal-Wallis test (H)	6.600		5.630	
Probability	0.037		0.060	

DISCUSSION

The five frog species found in the plots comprise 45% of the known litter frog fauna in the Serra do Japi (HADDAD & SAZIMA 1992), which may include, at least, *Bufo crucifer*, *B. ictericus*, *Scinax hiemalis*, *Eleutherodactylus parvus*, *E. binotatus* and *Proceratophrys boiei*. The observed diversity was similar at the two altitudinal sites, with three species each, being one of them highly dominant; differences are related to species composition, dominant species, and abundance. Although some important environmental differences were found between the sites, such as litter and root mat depth, we believe that the main reason for the differences in the species composition and abundance is related to the lower humidity at the LS. Even though we were unable to show differences in moisture (rains fell during the sampling), the LS, as well as plots far from the water, are expected to represent drier places. GIARETTA *et al.* (in preparation) found that higher sites at the Serra do Itapetinga (Atibaia, São Paulo), a close locality, also in the Mantiqueira range, have wetter litter than lower sites during the dry/cold season. The sporadic occurrence of mist at higher sites in the Serra do Itapetinga and Serra do Japi may be the proximal cause of the greater litter moisture during the dry/cold season. The dominant species at LS, *E. juipoca*, is also found in the drier peripheral grassland areas and may be a drought resistant species whereas *E. guentheri*, dominant at HS, is a typical forest dweller and probably a more wet dependent species.

The higher density of frogs found near the water can not be attributed to reproductive aggregation since most of the frog individuals belong to direct developing species or are sub-adults. Greater densities of frogs near the water edge, certainly a wetter place, in drier months was also demonstrated for Panamanian sites by TOFT (1980). At the sampled areas in the Serra do Japi the individuals may aggregate by moving to, or having higher survivor rates, near the streams; plots in the wet/warm season may confirm the first hypothesis.

Low diversity, as indicated by a great dominance of a few species, is characteristic of harsh or early successional environments (GILLER 1984). At the studied sites in the Serra do Japi, both these factors may be acting together to produce the low observed diversity. Some disturbed areas in Central America still show great richness, although of high dominance, of litter frogs and the proximity of primary

forest favors the faunal recomposition (LIEBERMAN 1986; HEINEN 1992). Summer plots at the studied sites may reveal additional species, as found by GIARETTA *et al.* (in preparation) in the Serra do Itapetinga, but the high dominance pattern is expected to be maintained.

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