OCCUPATION DYNAMICS OF BROMELIADS BY *DENDROPHRYNISCUS BREVIPOLLICATUS* (ANURA: BUFONIDAE) IN A SANDY PLAIN AREA ON INSULAR ENVIRONMENT, RIO DE JANEIRO, BRAZIL

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ABSTRACT

Dendrophryniscus brevipollicatus is a bromeliad anuran that inhabits forests up to 900 meters in the southeastern coast of Brazil. We evaluated the occupation of *Neoregelia johannis* and *Aechmea* sp. bromeliads by this species, seeking to verify abiotic factors determining such a choice of occupation. The occurrence of anuran was assessed by the constancy of Bodenheimer (1955). A causal and occupational model was designed using Vensim® software. Seventeen frogs were found in bromeliads, being *N. johannis* constantly occupied (C = 76.47%) and *Aechmea* sp. accidentally occupied (C = 23.53%). The causal diagram was consolidated with 22 connectors and four streams connecting the systems, while the model indicated the incidence of light as an element for limiting the occupation of the bromeliad *Aechmea* sp. In addition to the criteria for bromeliad occupation by anurans, it was observed that *D. brevipollicatus* does not require, as advised, forests of slopes for its perpetuation, because the sampled population inhabits secondary forest on sandy plain, five meters from the sea level-implying a reclassification of the species regarding its ability for environmental occupation - and also making visible the need for protecting the sandy plain and its secondary vegetation.

KEYWORDS: *Aechmea*, bromeligen frog, causal diagram, *Neoregelia johannis*

1. INTRODUCTION

Dendrophryniscus brevipollicatus Jiménez de la Espada, 1870, is distributed among slopes and plains up to 900 m altitude between the states of Rio de Janeiro and mountain ranges surrounding São Paulo state (Frost, 2011; IUCN, 2012). Studies on its biology were initially published by Lutz (1932), Carvalho (1949) and Izecksohn and Cruz (1972) and more recently, works related to anurocenose report ecological interactions by this

species on bromeliads (Peixoto, 1995; Bertoluci et al., 2007; Moraes et al., 2007; Sluys et al., 2007). The relationship of the reproductive cycle of *D. brevipollicatus* with bromeliads has been analyzed since the thirties, when Lutz (1932) mentioned a possible preference for *Nidularium purpureum* Lindschau, 1933. Later, Peixoto (1977) classified the species as to their interaction with bromeliads, as bromeligen. Meanwhile, Izecksohn and

Carvalho-e-Silva (2001) reported that the slope forest conservation and their bromeliads are essential factors to the species' survival. In the present study, we investigated the distribution of this anuran in bromeliad *Aechmea* sp. and *Neoregelia johannis* five meters above the sea level in a sandy plain area, vegetated by Atlantic Forest, verifying which abiotic factors determine the constancy of *D. brevipollicatus* by bromeliad species. Our goal is to build the ecological model that best represents the dynamics of this system in a biological reserve called Reserva Biológica Estadual da Praia do Sul – which will be referenced as RBEPS in the present study.

2. MATERIAL AND METHODS

2.1. Study Area

RBEPS is located on the southern side of Ilha Grande, south coast of the state of Rio de Janeiro (Maciel et al., 1984). In the sandy plain of RBEPS, several roads were built in 1980 (Araújo et al., 1997), being later abandoned. This contributed to the vegetative composition of the area by secondary Atlantic Forest.

2.2. Unity and Sampling Period

For three rainy seasons in the month of January 2009, 2010 and 2011 a set of bromeliads comprising the perpendicular transect to the tidal zone, 200 meters from high tide line of syzygy (S 23 ° 10'47, 1 "WO 44 ° 18'36 , 8 ") was evaluated. And for each bromeliad inspected, the following was taken into consideration: the occupation by *D. brevipollicatus* in larval or adult form and the place of occupation. The bromeliads were separated by species and independent of hosting *D. brevipollicatus*, the quantity of leaves, leaf axils, the base width of longest leaf, length of leaf, as well as central height and diameter of the rosette were measured. The abiotic data measured in bromeliad microhabitat were: volume of accumulated water in the central region, axils cumulative volume (using 60 ml syringe, 1 ml accuracy, connected to a hose replacing the needle), water pH in the two cumulative areas (using Hanna® pH meter), relative humidity (% RH) through digital thermo-hygrometer Incoterm® precision ± 5% RH and ± 1 °C. Also, the degree of brightness to which each bromeliad was exposed to was measured using the light meter Instrutherm® LD300 accuracy of ± 5% rdg +10 Lux.

2.3. Statistical and ecological Analysis

The occupation of *D. brevipollicatus* in bromeliad species was evaluated by Constancy of Bodenheimer (1955) *Apud* Neto et al. (1976) being C = (p.100) / N, where p is the number of bromeliads containing the studied species, and N is the total sample. The presence of *D. brevipollicatus* per occupied bromeliad was considered: Constant> 50%; Accessory 25-50% and accidental <25%. It was also considered, as part of the anuran's occupation process, the water volume, the physical characteristics of the sampled plant (water volume in the leaf axils and on the center of the plant, number of leaves and leaf axils, base width and length of the largest leaf, largest diameter and height of the plant – from the base of the rosette to the apex of the top leaf). Those elements were submitted to ANOVA test: every time the differences were significant (α = 1%) the TUKEY test was applied. The temperature, pH and % RH were subjected to "t" test of Student for α = 1%.

2.4. Ecological Model

The proposed ecological model is based on the abiotic and biotic data collected during three rainy seasons. The model was developed using the Vensim® Software, on which we created the mathematical equations, algorithms and causal diagram.

3. RESULTS

The bromeliads that shelter anurans are divided in two species: *Aechmea* sp. Ruiz and Pav and *Neoregelia johannis* (Carrière) LB Smith. We verified 90 bromeliads, being *Aechmea* sp. (N = 24) and *N. johannis* (n = 66). *Aechmea* sp. is found in groups that may vary from 7 to 20 individuals, distributed in the ground substrate, while *N. johannis* is randomly distributed in the forest without forming clusters. This number of bromeliads remained the same for the three rainy seasons. We observed the occurrence of 17 individuals of *D. brevipollicatus* – being nine tadpoles and eight adults - associated with these two species of bromeliads. Among the occupied bromeliads, *N. johannis* demonstrated a greater constancy of occupancy (C = 76.47%), while

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Aechmea sp. constancy occupancy was C = 23.53%. Assessing the degree of occupation of *D. brevipollicatus*, based on the calculation of constancy of Bodenheimer, it appears that the anuran occupies the bromeliad *N. johannis* steadily while *Aechmea* sp. is randomly occupied. In order to identify possible morphological differences that may lead to bromeliads'

occupation in a constant and accidental manner, we submitted the physical characteristics of each bromeliad, by species, to the ANOVA test, which resulted in significant differences (F = 32.7, p <0.01). When differences were calculated by Tukey's test, it was observed that, among the organographical differences found (Table 1) only the rosette diameter was statistically significant.

Table 1
Organographical differences evaluated by the Tukey test. ns = not significant; s = significant for n-1 degrees of freedom.

Structure	Q	Difference	α = 1%
# of leafs	26.55	5	ns
# of axils	26.55	3	ns
Leaf lengh	26.27	14	ns
Rosette diameter	67.18	58	s

As for the variables – i.e. volume of water in the leaf axils and in the plant center; height of the plant from the rosette basis to the apex of the leaf - they presented differences among the two species, representing a lack of characters' homogeneity between the plants - the standard deviation (SD) was high among the sample set, which does not characterize homogeneity statistics for either species of bromeliads. The average pH was 6.96 (SD = 0.26) for the entire period, with no difference between the species of bromeliads in relation to the anuran's presence or absence. The relative humidity for *Aechmea* sp.

was 96.46% on average (SD = 0.77) and for *N. johannis* it was equal to 95.21% (SD = 0.68). When differences were submitted to Student's t test they presented no significance (t = 3.10, DF n-1, α = 1%). With regards to temperature, the average for the two species was 28.98 with SD = 1.17°C. The light incidence variation for the two species of resident bromeliads had statistically significant variations (t = 8.2, n-1 df, α = 1%): *Aechmea* sp. has a higher incidence and *N. johannis* showed a lower incidence of light (Table 2).

Table 2
light incidence per bromeliad species. SD= Standard Deviation.

Bromeliad	Average (Lux)	SD (Lux)
Aechmea sp.	147	10.03
N. johannis	108	4.67

The causal diagram included four key elements (simulated birth) considering the immature form; (bromeliads exposed to light) direct contact and physical count of the plants, (diameter of rosette) through direct measurement; (accumulation of water) water volume directly measured; and also the limiting element (photons of light) on the anuran. As part of the system inventory we took into consideration the (*D. brevipollicatus*) species and the distribution area of bromeliads *Aechmea* sp. and *N. johannis* distributed in the sandbank plain was also taken into consideration.

The diagram was consolidated with 22 connectors and four connecting flows between the systems (Figure 1). The graphs generated by the model have a limiting-element dynamic: the light photons, on which 10 to 20 bromeliads affect tadpoles exposed to 147 lux - this corresponds to a probable loss on the birth rate of six tadpoles, during the three rainy seasons being evaluated (Figure 2A). From 1.5 to 2 bromeliads are entirely exposed, affecting tadpoles development in *Aechmea* sp. (Figure 2B). The

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birth rate on the sampling period corresponded to   2-3 tadpoles (Figure 2C).
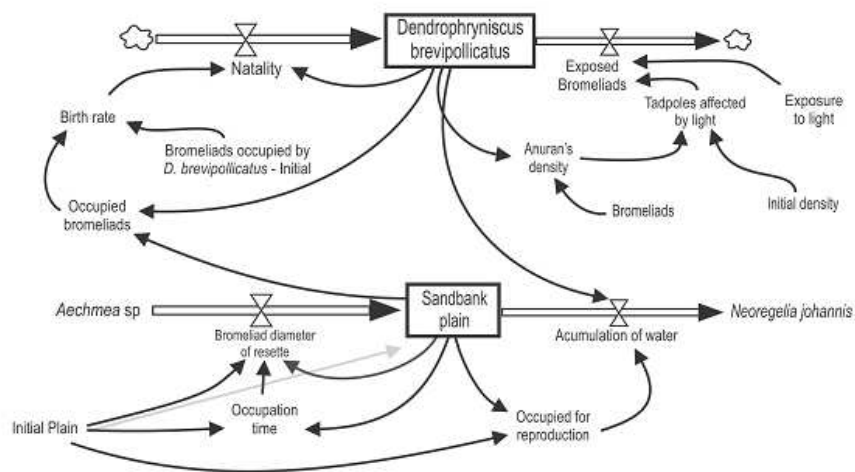
Figure 1
Causal diagram of the bromeliad occupation dynamics by D. brevipollicatus in sandy plain area.

Figure 2
(A) tadpoles affected by light which occupy Aechmea **sp.**
(B) bromeliads exposed to light,
(C) the birth rate for the sampling period - from 2009 to 2011.

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4. DISCUSSION

The probable fidelity of *D. brevipollicatus* for bromeliad of *Nidularium Purpureum* species mentioned by Lutz (1932) does not occur in RBEPS, not even the mandatory distribution on hills and slopes (Frost, 2011; IUCN, 2012) or the conservation of forest hillside occurs Izecksohn and Carvalho-e-Silva (2001). In RBEPS *D. brevipollicatus* is distributed by terrestrial bromeliads in secondary Atlantic Forest, five meters above the sea level. Only two bromeliads species shelter anurans and according to the calculations of Constancy of Bodenheimer (1955), apud Neto et al. (1976), *N. johannis* is a constant occupation bromeliad, while *Aechmea* sp. is randomly occupied. The organographies of both species, although different, do not statistically support the justifications for *D. brevipollicatus'* occupation, except for the central rosette diameter, which corresponds to a larger volume of accumulated water. However, given the heterogeneity of the sample, it was not possible to support this statistical hypothesis.

The light exposure degree in the current study identifies *Aechmea* sp. as the bromeliad with the greater exposure, which may justify the distribution of this Bromeliaceae species in groups, while *N. johannis* presented isolated distribution and reduced exposure to light. When comparing the occupation of these bromeliads by tadpoles, we verified that, from the nine tadpoles, eight were found occupying *N. johannis*, what once again proves an accidental occupation of *D. brevipollicatus* in *Aechmea* sp. The distribution of *D. brevipollicatus* on RBEPS proves that, although the development of their larval forms mandatorily occurs in bromeliads, these can be distributed along the rain forest and not necessarily in Montana Atlantic Forest (Izecksohn and Carvalho-e-Silva, 2001), this altimetric condition was firstly established by a list of type

locality, such as Corcovado in Rio de Janeiro, 710 m high (Bokermann, 1966). The altimetry quote estimated for this species is 900 m (IUCN, 2012), opposite from all mandatory altimetric predictions, *D. brevipollicatus* on RBEPS occurs and develops in the reproductive cycle five meters above the sea level, in plain antidunes. The species' fidelity for bromeliads is related to the bromeliad best combining favorable environmental conditions to the development of their larval forms. The present study consists on the observation of the distribution and occupation of the species in its larval and adult forms, pointing to accidental occupation when they occur in *Aechmea* sp. and constant occupation when dealing with *N. johannis*. This occupancy condition associated with the level of exposure to light (and the diameter of the rosettes) are unfavorable to the development of the *D. brevipollicatus* tadpole, differently to what happens in the occupation of constant bromeliads, which, in this study (in RBEPS), corresponded to *N. johannis* as less exposure to light and larger rosettes.

5. CONCLUSION

The modeled system dynamics corroborated the hypothesis of a limiting element for bromeliad occupancy with regards to light exposure. This element is also an abiotic aspect affecting bromeliads on their occupation in the study area. Regardless of the limiting factors, the new aspects as for the altimetric condition and low birth rate - considering the findings in RBEPS - imply a reclassification of the species as to its perpetuation and ability to occupy the environment. It also makes it essential to protect the sandy plain and its secondary vegetation.

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