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Short Communication

Ratio Between Growth and Tail Reduction in the Tadpoles of *Phyllomedusa nordestina* (Anura, Hylidae)

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ABSTRACT

Tadpoles have intra- and interspecific morphological plasticity that correlate them to their development habitat and environment occupation. Studies relating plasticity and development of tadpoles can agglutinate information for understanding basal and derivatives aspects of semaforontes. We evaluated the morphological development of tadpoles *Phyllomedusa nordestina* in transition between stages 45 and 46 of aiming at establishing a probable ratio between growth and metamorphosis. The biometry was composed of the segments body length, tail length, total length, and body mass. Individuals were measured every three hours and filmed twenty-four hours a day, with a camcorder of resolution Pal628x582; NTSC510x492, three lux lighting, 3.6 mm lens. The variables were subjected to multivariate allometry being the correlation between variables established by Pearson's correlation coefficient. The tail reduction shows positive allometry. The tail length reduces within 36 hours while the body length remains constant. It means that the tail presents an isogonic condition in relation to the body length. The relationship between body mass and tail reduction has a negative dependence ($r = -0.87$) with a nonlinear power regression ($y = 0.0573x^{-6.16}$. We conclude that the tadpoles' body at the end of the tail reduction presents its total length constant, however the body mass increases, which means that the body increases in volume without increasing its total length. This pattern is supposed to be related to the ecotonal dry environmental conditions of the municipality of Floriano, State of Piauí.

Key Words: Allometry; Amphibian; Biometry; Body Mass; Metamorphosis; Phyllomedusinae,

INTRODUCTION

Most anurans present a conspicuous condition of initially developing as tadpoles and only at stage 46, when they can be considered an imago; beginning their earthly or semiaquatic life (Duellman and Trueb 1994). Nevertheless, studies on tadpoles in Brazil until 2004 only covered up to 40% of biodiversity, being the remainder unknown (Andrade et al. 2007). Considering the 3300 frog species worldwide described until 1999, only 30% had a description of the larval stage (McDiarmid and Altig 1999).

The group of tadpoles called *Phyllomedusa hypochondrialis* (Daudin 1800) have been described by many researchers, whose main condition of study consists on grouping this genus of species. This grouping condition links the type of nest to the position related to the water and to the breeding season (Lutz and Lutz 1939, Cruz 1982, Caramaschi and Cruz 2002, Eterovick and Sazima 2004, Caramaschi 2006). Embryology and development of tadpoles of this genus were described by Cei (1980). The tadpole of *P. nordestina* Caramaschi 2006 was originally described as *Phyllomedusa hypocondrialis* by Cruz (1982), being described as a new species by

Caramaschi (2006), with areas of influence in the states of Piauí, Ceará, Rio Grande do Norte, Alagoas, Sergipe, Bahia and Minas Gerais (Caramaschi 2006).

Research efforts on tadpoles set some trends that are well described by McDiarmid and Altig (1999) as population structure and environment relationship and phenotypic plasticity. But the vast majority of examples do not apply to areas such as those ecotone between Cerrado and Caatinga, where abiotic conditions are punctual, sometimes extreme, with scarce rainfall.

Tadpoles have intra-and interspecific morphological plasticity that correlate them to their development habitat and environment occupation (Fatorelli and Rocha 2008). Studies relating plasticity and development of tadpoles can agglutinate information for understanding basal and derivatives aspects of semaforontes (Lima and Pederassi 2012), besides serving as a subsidy for conservation of this zoogroup.

In the present study we evaluated the morphological development of tadpoles in transitional stage between stages 45 and 46 of *Phyllomedusa nordestina* aiming at establishing a probable ratio between growth and metamorphosis.

MATERIAL AND METHODS

Phyllomedusa nordestina has its type locality in Maracas, State of Bahia, altimetry 960 m and distribution for the states of Bahia and Piauí (Caramaschi 2006). The records of the present study were made in the southern State of Piauí in ecotonal area of Floriano (06° 46' 01" S and 43° 01' 22" W), 140 meters above sea level, with morphoclimatic areas of the lowlands and transition on the border with the State of Maranhão; Caatinga with semiarid intermontanas and interplanaltic depressions on central west, inland tropical plains with savannah (Cerrado domain) and gallery forests on South (Ab'Sáber 2010). Climate characterized by high average temperature of 37.5°C, average relative humidity of 15.87%, reaching the minimum of 6% in August, September and October and averaging barometric pressure of 995.5 hPa (INMET 2012).

Classification and Development Stage

The tadpoles development begins with the zygote and ends on stage 46, when it is devoid of the tail and starts its earthly or semiaquatic life. We categorized the development stage of the tadpoles following Gosner (1960).

Morphometry

The biometry was composed of the following segments: body length (BL), tail length (TL), total length (TtL) and body mass (M) (Altig 2007). The measurements were taken using digital calipers, with 0.03 mm of accuracy and the mass was measured using a scale, digital accuracy of one gram.

Sample unit

The sampled tadpoles were divided into 10 randomized blocks of 10 *Phyllomedusa nordestina* frogs, between stages 42 and 46.

Management Condition

Right after the collection of tadpoles, they were put, in groups, in a 24 cm^2 aquaterrarium with water depth of 5 cm and boulder randomly arranged, totaling 10 aquaterrários. Individuals were measured every three hours and filmed twenty-four hours a day, with a camcorder of resolution Pal628x582, NTSC510x492, three lux lighting, 3.6 mm lens. This procedure was performed until the metamorphosis was completed.

Evaluation of Body Growth

Body variables were subjected to multivariate allometry, where the relationship between the body length (BL), tail length (TL), total length (TtL) and body mass (M) were adjusted to the allometric equation y = axb, where x = TtL, a and b are estimated by the least squares method (Vanzolini 1993). Predictive grip was the χ^2 for n - 1 degrees of freedom (DF) and $p < 0.0001$.

Growth allometric analysis

The isometric hypothesis of the body variables growth vector was assessed with the test: $ry = \sqrt{1/p}$ where p = number of variables with p-1 degrees of freedom. Where vector greater than $\sqrt{1/p}$ indicates positive allometry, and less than $\sqrt{1/p}$ indicates negative allometry (Mandarin-de-Lacerda 1995). Correlation between variables was established by Pearson's correlation coefficient (r).

Metamorphosis and Growth

The growth rate was measured by the dependence of development hours and metamorphosis through the boundary condition function (TL → 0; BL = a + b; a and b are constants M and TtL , respectively), being submitted to the growth equation and the correlation coefficient of Pearson.

Zoological collection

Each sample of tadpole species was kept in a batch and incorporated into the Coleção de História Natural da Universidade Federal do Piauí - CHNUFPI, Campus Amilcar Ferreira Sobral (G13, G37-39, G45-49, G51, G53-58, G69, and G241.).

RESULTS AND DISCUSSION

The *Phyllomedusa* genus and the description of its tadpoles were widely presented by Lutz and Lutz (1939), whose most conspicuous morphological condition is the vertical pupil. This condition is present since the early stage, which favors the minimization of questions regarding genus.

The diagnosis of the adult species is characterized by its average SVL (snout vent length) size from 32.1 to 42.1 mm for males and from 38.6 to 43.7 mm for females. Narrow or absent white band on the upper lip; vertical black bars on orange-red background on the hidden faces of flanks and locomotor members, broad green band over the entire length of the upper thigh, whitish band on the side part of body and on the posterior aspect of the tibia and no reticulated pattern drawing the eyelids, lips and lower parts of the body and locomotor members (Caramaschi 2006). All of these morphological features are present in the tadpole, from stage 45, except for size, where young have on average 15 mm.

According to the stages of development proposed by Gosner (1960), when the tadpole reaches stage 42, the arms have already emerged. In the following stages the mouth format is characteristic of the species, culminating, in stage 45, with its terminal portion exceeding the posterior margin of the eye. Finally, in stage 46, the tail disappears and the tadpole is in its imago condition. In this study, even after the arms having emerged, the tadpole remains with its front oral fission only, the tail remains present in its body and the tadpole moves outside the water with the characteristic displacement of Phyllomedusinae. The slightly twisted feet allow it to grab the substrate with a slow displacement (Caramaschi 2006). This displacement would be very characteristic of the imago, i.e., no tail, but we find this feature present even in tadpole with tail. Thus, we characterize the stage as 46, although the reduction in tail occurring after 36 hours of the onset of the displacement of the tadpole out of the water.

Morphometric condition at time zero (t_0) corresponded to the moment when the tadpole starts shifting out of water and tail regression process starts at (t_1) and ends in (t_n), with integral reduction of the tail. During this phase there is no food intake and tail reaches the final reduction condition after 36 hours (n = 100, x = 36 ± 1.67 h). When we submit the data to the scatter diagram we have a hyperbolic trend (Figure 1) and dependence between the reduction of the tail in mm and hours (r = 0.95).

When refuting the diagram to a geometric condition, the tail reduction shows positive allometry, which is, the tail length reduces within 36 hours while the body length remains constant (n = 100 , x = 15 ± 0.76 mm). So, tail presents an isogonic condition in relation to the body length, i.e., is kept the same angle of inclination of the tail length regarding the body length (b = 1, a > 1, r = 0.95) (Figure 2).

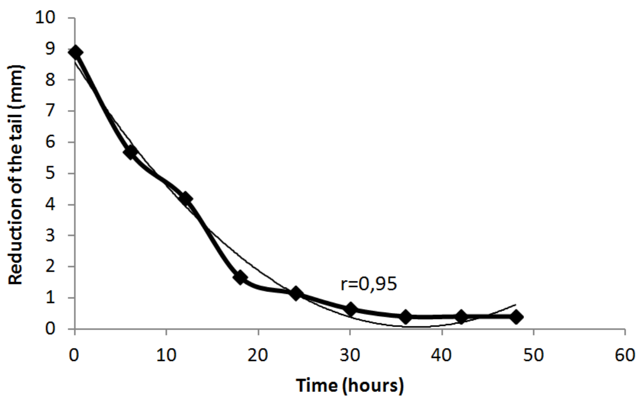

Figure 1. Hyperbolic dispersion between tail length reduction and time in in hours.

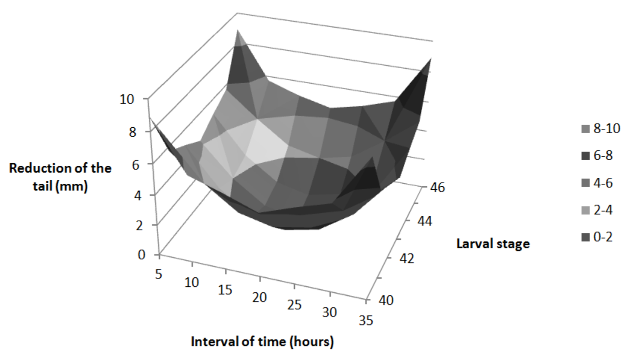

Figure 2. Model of the reduction ratio on tail length according to the interval (hours) and stage of development. Each color band represents the level of reduction in mm.

A multivariate allometry estimated by the least squares method (y = a + (b1)x + (b2)x^2) makes it possible to predict the ration between tail reduction and body constancy maintenance. The slope 0.9221 and the linear coefficient 17.04 for total length at t_0 demonstrate that the tail length tends to zero and equals to body length at *n* time (t_n).

When we submit the mathematical model to the χ^2 adhesion test (Table 1), we observe an adhesion and the differences between calculated and measured values are not significant ($\chi^2 = 0.45958$, DF = 49, $p < 0.0001$).

Table 1. Chi-square adhesion test in the mathematical model.

Interval of time	Measured value (TL)	Calculated value (TL)	Difference	χ^2 p<0.0001 49 GL
T_0 0	8.92	9.25	0.3454	0.45958
6	6.70	5.45	-0.2485	
12	4.20	3.86	-0.3310	
18	1.67	1.29	-0.37835	
24	1.15	0.96	-0.18575	
30	0.65	0.89	0.24675	
T_n 36	0.41	0.79	0.38795	

The relationship between body mass and tail reduction has a negative dependence, i.e., tail reduction and weight gain occur (r = -0.87) and when we submit it to the scatter plot we find a nonlinear power regression ($y = 0.0573x^{-6.16}$ as shown in Figure 3).

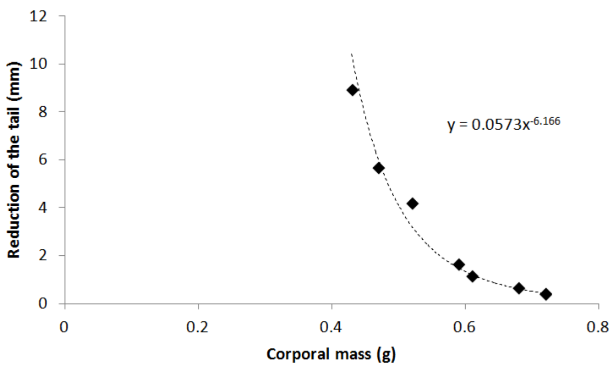

Figure 3. Scatter plot between tail reduction in mm and body mass in grams.

When comparing the measured values with those calculated by the equation of the χ^2 method, the equation is adherent and differences are not significant ($\chi^2 = 0.54$, DF = 49, $p < 0.001$).

The analysis of *P. nordestina* tangible parameters is characterized by the dependence of tail length to the time, while the body mass increases due to the tail and time reduction. Thus, we conclude that the body (BL) at the end of the tail reduction (TL) presents its total length constant (TtL), i.e., the body length is equal to total length when the total tail reduction occurs. However, body mass increases, which means, the body increases in volume without increasing its total length.

The morphological plasticity of tadpoles is a dependence condition to the environment. In this case, the body equivalence condition and metamorphosis dependence are linked to the ecotonal environment of Floriano/Piauí, which rainfall occurs during a short time period (November-March). The maximum rainfall of 211.52 mm for the 2011/2013 period corresponded to a scarce reproductive period, since the tadpoles species *P. nordestina* are dependent on water regime for its development.

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