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Death feigning in *Physalaemus kroyeri* (Reinhardt and Lütken, 1862) (Anura, Leiuperidae)

Michelly Gally[1]*, Amanda Santiago Ferreira Lantyer Silva[2] and Juliana Zina[1]

Abstract. Herein we report and describe a new kind of thanatosis behaviour observed in a Brazilian native frog species, *Physalaemus kroyeri*. Death feigning is very common amongst anurans and it is considered to be dependent on abiotic and individual physiological conditions.

Keywords. Defensive behaviour, Tanathosis, *Physalaemus cuvieri* group, SVL.

Introduction

Modulated by selective predation pressure, defensive behaviours exhibited by anurans can be: (1) passive (e.g. colouring, chemical and mechanical defences) or (2) active and postural (this category includes actions such as the choice of a site for reproductive activities to the execution of behaviours in the presence of a potential predator) (Duellman and Trueb, 1986; Sazima and Caramaschi, 1986; Wells, 2007). Thanatosis, crouching, and deimatic behaviour are some of the most common postural defences in many species of frogs (Duellman and Trueb, 1986; Toledo, Sazima and Haddad, 2010) which minimize the chances of attack by predators and increase the likelihood of not being attacked in the future (Gallup et al., 1971; Gerald, 2007). The direction of the stimulus, as well as extrinsic abiotic factors and intrinsic physiological factors, may be responsible for the expression or intensity of thanatosis (Gomes, Bevier and Navas, 2002). Despite the potential importance for adult survival and, ultimately, for maintaining the dynamics of an anuran population, there is still little information about the influences of extrinsic factors on the execution of death feigning behaviour, as well as its frequency and duration.

In this study we describe thanatosis of *Physalaemus kroyeri*, a species which has a restricted geographical distribution within the states of Bahia, Minas Gerais, Piauí, and Paraiba, Brazil and is associated with open formations of the Cerrado and Caatinga (Nascimento, Caramaschi and Cruz, 2005; Frost, 2011). We also evaluated whether morphometric measurements (SVL) and abiotic conditions affected the onset of thanatosis.

1 Universidade Estadual do Sudoeste da Bahia, Rua José Moreira Sobrinho, s/n, Jequié-BA, Brazil, CEP: 45206-190.
2 Universidade Estadual de Santa Cruz, km 16, Rodovia Ilhéus-Itabuna, Ilhéus-BA, Brazil, CEP: 45662-000.
*corresponding author e-mail: chelly_gally@hotmail.com

Material and Methods

The study was conducted in a semi-permanent pond (subject to reduction in area by 70% during periods of drought in summer and winter) in Fazenda Brejo Novo, Jequié, State of Bahia (13°56'34.5"S, 40°06'31.6"W, altitude 700 m. a.s.l.) (Fig. 1). From October 2010 to January 2011, eight field trips were conducted at night, during which individuals of *Physalaemus kroyeri* were found actively calling at the margins of the water body described above. After the observation of an individual in the field performing thanatosis, fifteen individuals (adult males) were captured and disturbed by simulating a predator attack in the water. The tested individuals were repeatedly seized by hand (five to seven times) while in the water. Snout-vent length (SVL) of the individuals and air temperature were measured after the individuals had been tested. The duration of the behaviour was estimated in

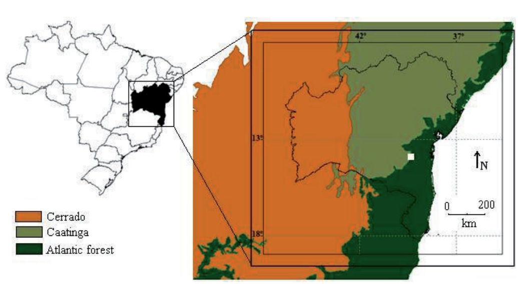

Figure 1. Location of the study site, Jequié, State of Bahia, Brazil.

Table 1. List of abiotic factors and execution of thanatosis described in the present study, Jequié, State of Bahia, Brazil.

Date	Air Temperature (°C)	Rainfall (mm)	Moon Phase	Tanathosis
10/22/2010	22	0.22	Full Moon	no
10/22/2010	22	0.22	Full Moon	no
11/19/2010	21	4.81	Waxing Gibbous	yes
11/19/2010	21	4.81	Waxing Gibbous	no
11/19/2010	21	4.81	Waxing Gibbous	yes
11/27/2010	23	0.21	Waning Gibbous	no
11/27/2010	23	0.21	Waning Gibbous	no
12/8/2010	25	0.61	New Moon	no
12/14/2010	23	1.19	First Quarter	yes
12/14/2010	23	1.19	First Quarter	no
12/14/2010	23	1.19	First Quarter	no
12/14/2010	23	1.19	First Quarter	no
1/13/2011	23	4.41	First Quarter	yes
1/14/2011	23	0.54	First Quarter	yes
1/25/2011	21.5	7.9	Last Quarter	no

six individuals. Abiotic factors (presence of precipitation, moon phase, and air temperature) were recorded at the time of testing. Based on the distribution of SVL values of the studied population, we considered small males those who present SVL between 28.2 and 30.5 mm, medium males 30.6 and 32.9 mm, and large males 33 and 35.3 mm.

Results and Discussion

The first individual to exhibit the thanatosis behaviour described herein was captured on August 27, 2010. As it was captured and after being manipulated the individual inflated its body, turned upside down when in contact with the water, kept its arms and legs outstretched and at a slight distance from its body while keeping the snout immersed in the water (Fig. 2). The individual remained in this position for a few minutes. This behaviour was repeated a few times, only when the individual was manipulated in the water, and the interval between the stimulus and the execution of the behaviour became shorter over time.

Figure 2. Male of *Physalaemus kroyeri* (SVL= 28.4 mm) displaying thanatosis behaviour as described herein after being disturbed by the researcher.

Of the 15 individuals observed and tested in the field, all showed a flight reaction but when unable to escape (because of an artificial or natural barrier) they inflated their bodies. Only six individuals displayed the thanatosis behaviour as described above (Fig. 3). These individuals executed the behaviour during 10 to 20 seconds. The time interval between the first stimulus and the execution of the behaviour ranged from 20 to 30 seconds (N = 6), after which the time between the next stimulus employed by the researcher and the implementation of thanatosis reduced to 10-20 seconds, a similar result to that observed with the first individual.

The behaviour of thanatosis is widely used by a large number of anuran species and has already been observed for other species of the genus *Physalaemus*, such as *P. cuvieri* Fitzinger, 1826 and *P. nanus* (Boulenger, 1888) (Toledo, Sazima and Haddad, 2010). The efficiency of this behaviour may lie in the fact that the predator will abandon the predation event or may be related to a defence mechanism employed to prevent injuries after ingestion and regurgitation by the predator (see Sazima, 1974; Toledo, Sazima and Haddad, 2010).

In this study the term *thanatosis* seems to apply very well. The Greek origin of this term refers to Thanatos, god of death (Toledo, Sazima and Haddad, 2010). Some signals emitted during the performance of the behaviour described herein refer to characteristics found in dead animals, such as immobility, an overturned position and body swelling.

Thanatosis is employed in a wide range of situations and can interact synergistically with other defensive behaviours, such as flight and body swelling (Williams et al., 2000; Toledo, Sazima and Haddad, 2010), as observed in this study. Another aspect which corroborates our results with the available literature is the intrapopulation variation in the manifestation of this behaviour, observed by several authors for different animals (see Sazima, 1974; Lima and Dill, 1990; Alexander and Covich, 1991; Gomes, Bevier and Navas, 2002). In this study, none of abiotic factors measured appeared to influence the execution of thanatosis, since there was no apparent relationship between precipitation and moonlight in the manifestation of the behaviour (Table 1). The range of body sizes in which the behaviour occurred more frequently (see Fig. 3) may be related to the energetic cost as a function of the efficiency of the behaviour against predator attacks, being perhaps more costly for small to medium- sized individuals when trying to escape while constrained. However, due to differences related to the number of individuals tested in all SVL classes and the naturally uneven distribution of these classes in a population, we cannot categorically state that the execution of the behaviour was related to morphometric aspects of the individuals. More studies linking defensive behaviour and physiomorphological aspects would be necessary to state more precisely the effects of the physical condition of the individuals performing defensive displays.

When stimulated more than once, individuals of *P. kroyeri* repeated the thanatosis behaviour at progressively shorter intervals. Considering that defensive behaviours involve individual interpretation of environment signals (predator type, escape possibilities, distance and direction of the predator) and execution of a particular movement, there must be a chain of events linking these events. As the death feigning appears to be an effective weapon against predator attacks, the time spend on analysis of all sources noted before may be discarded, therefore the individual repeats the behaviour faster

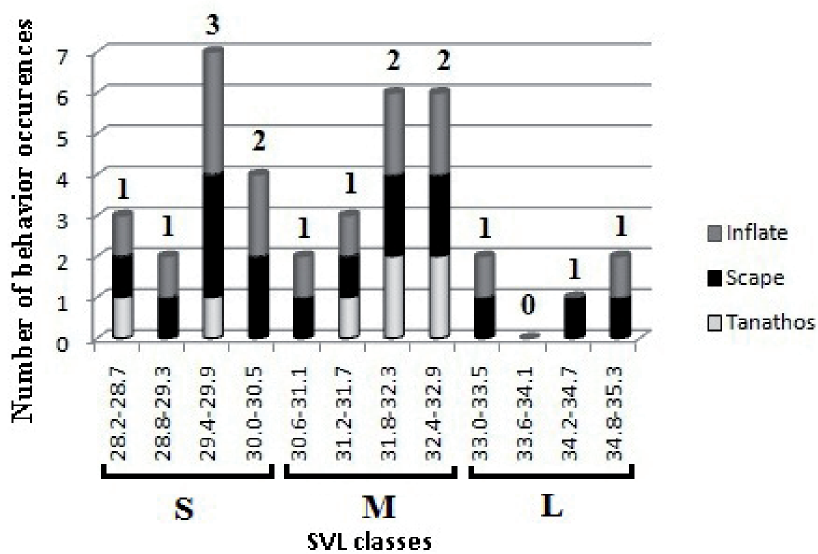

Figure 3. Frequency distribution of the occurrence of defensive behaviours in males of *Physalaemus kroyeri* as a function of the snout-vent length class (SVL), Jequié, State of Bahia, Brazil. Above the columns is the number of individuals tested for each SVL class. S= small males; M= medium males, and L= large males.

than before.

This study presents important information regarding the behavioural plasticity of anuran behaviour in the presence of predation, as well as information on natural history and behaviour that may be used in comparative studies between species of the *P. cuvieri* group. This group comprises widely distributed species which are however difficult to discriminate morphologically, and of which biological understanding is still incipient. Furthermore, the current results provide suggestions for ecophysiological studies.

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