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NEST DEFENSIVE BEHAVIOR BY A MALE OF *PHYSALAEMUS ATLANTICUS* HADDAD & SAZIMA 2004 (ANURA: LEPTODACTYLIDAE)

COMPORTAMENTO DE DEFESA DE NINHO POR UM MACHO DE *PHYSALAEMUS ATLANTICUS* HADDAD & SAZIMA 2004 (ANURA: LEPTODACTYLIDAE)

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Resumo.— Relatamos um comportamento defensivo de ninho apresentado por um macho de *Physalaemus atlanticus* durante a estação reprodutiva da espécie. Esta é a primeira observação de comportamento de defesa ativa de um ninho no gênero *Physalaemus*. Estudos futuros devem explorar a frequência do comportamento de cuidado parental nesta espécie, bem como a relevância do comportamento defensivo dos machos para a sobrevivência e aptidão da ninhada.

Palavras chave.— Cuidado paternal, defesa, ninho de espuma, comportamento reprodutivo, cuidado parental.

Abstract.— We report a nest defensive behavior presented by a male of *Physalaemus atlanticus* during the species reproductive season. This is the first observation of active nest defensive behavior on genus *Physalaemus*. Future studies should explore how frequent this parental care behavior is displayed in this species and what is the relevance of male defensive behavior to clutch survival and fitness.

Key words.— Paternal care, defense, foam nest, reproductive behavior, parental care.

Parental care is any costly behavior directed to the offspring by a parental, post-fertilization, with the potential to increase offspring's fitness (Trivers, 1974; Klug, 2016). Parental care behaviors evolved independently several times in amphibians (Class Amphibia), presenting a huge diversity in modes, in the caring sex and in the amount of parental investment (Nunes-de-Almeida et al., 2021). Anura is the most diverse amphibian order – both in species richness and in parental-care modes –, comprising 28 of the 30 parental care modes already described for amphibians (reviewed by Schulte et al., 2020). Feeding and transporting tadpoles (reviewed by Weygoldt, 1987), cautious choice of reproductive sites (Crump, 1991), defending cleaning and hydrating of eggs (Townsend et al., 1984) are the most studied anuran parental care behaviors. Despite the current accumulated knowledge, studies on anuran parental care are strongly biased toward few clades, with a huge gap on studies about Neotropical taxa (Schulte et al., 2020).

The genus *Physalaemus* Fitzinger, 1826 (Anura: Leptodactylidae) is a Neotropical anuran clade composed exclusively by species that construct foam nests during egg deposition (Fouquet et al., 2013). Foam nests operate by maintaining egg temperature, eggs and tadpoles protected from dehydration and diseases, and increasing oxygen supply in temporary puddles or environments with unpredictable rainfall (Zweifel, 1968; Dobkin & Gettinger, 1985; Fleming et al., 2009). Foam nests can also work as food supply for tadpoles after hatching, which allow them to achieve properly weight gain and growth (Tanaka & Nishihira, 1987; Kusano et al., 2006). Foam nests construction during egg-laying is considered a form of parental care due to its costly production

Figure 1. Foam nest of *Physalaemus atlanticus* constructed among roots and leaves at the municipality of Ubatuba, São Paulo State, southeastern Brazil. Photo: Thiago Silva-Soares.
Figura 1. Ninho de espuma de *Physalaemus atlanticus*, construído entre raízes e folhas no municpício de Ubatuba, Estado de São Paulo, sudeste do Brasil. Foto: Thiago Silva-Soares.

for parental individuals and to its advantages for the offspring (Schulte et al., 2020). However, besides foam nest construction, no other active parental care behavior has been reported in *Physalaemus* genus.

Physalaemus atlanticus Haddad & Sazima 2004 is a cryptic anuran found only in the municipality of Ubatuba, on the north coast of the state of São Paulo, in southeastern Brazil (Frost, 2021). *P. atlanticus* is the unique species of *Physalaemus* genus that occurs in the area (Hartmann et al. 2010; Sasso et al., 2017). Foam nests of *P. atlanticus* are found in the mirror of water in ponds, anchored in vegetation under the moist foliage near forest edges (Haddad & Sazima, 2004), on wet leaf litter far from ponds (Hartmann et al., 2010), or in water-filled bract of the palm trees (Tanaka et al., 2020). This species inhabits plain seashores at altitudes from sea level to 50 m, usually associated with ponds at the Atlantic Forest coast (Haddad & Sazima, 2004).

On 25 November 2006, at 7:06 PM, a foam nest of *P. atlanticus* was found in the type locality of *P. atlanticus*, in the Serra do Mar State Park, Núcleo Picinguaba, municipality of Ubatuba, state of São Paulo, southeastern Brazil (23°21'29.98"S, 44°50'56.99"W, WGS84; 6 m elev.). The region is characterized by Coastal Rainforest (named as Restinga) (da Silva et al., 2016). The nest was found amongst roots and leaves nearby a temporary pond, in a short land slope inside a lair, partially covered by the leaf litter (Fig. 1). We found the nest by following the advertisement call of one of the several *P. atlanticus* males that were calling in the area (advertisement call described by Haddad & Sazima, 2004).

Figura 2. Macho de *Physalaemus atlanticus* exibindo comportamento defensivo a um ninho de espuma. Município de Ubatuba, Estado de São Paulo, sudeste do Brasil. Foto: Thiago Silva-Soares.

Figure 2. Male of *Physalaemus atlanticus* exhibiting defensive behavior of a foam nest. Municipality of Ubatuba, São Paulo State, southeastern Brazil. Photo: Thiago Silva-Soares.

We describe below the behavioral observations concerning this focal calling male.

Upon nest locating, the author TSS removed the leaf litter out of the surroundings of the foam nest, i.e., approaching the hand to the nest. An adult individual of *P. atlanticus* – that was deep in the lair hidden somewhere behind the foam nest – firmly jumped out to the lair's entrance in response to TSS action. The individual stayed there steady at the foam nest (Fig. 2) until TSS moved away. TSS stepped away two meters from the nest and, about one minute later, the individual hooped back into the deep of the lair. TSS waited one minute and once more approached his hand to the foam nest and touched the leaves and roots that closely surrounded the nest. Promptly, the *P. atlanticus* individual repeated the behavior and showed itself jumping out the nest. Again, TSS stepped back one meter away from the nest and waited two minutes to initiate a third and last provocation. Once more, the individual reacted investing against the simulated threat (TSS), hopping out from the lair to its entrance, remaining steady in this position. This individual was handled and identified as an adult male of *P. atlanticus* by external morphology – i.e. presence of vocal sac, small size, canthus rostralis distinct, orange belly and dorsal skin texture smooth (Haddad & Sazima, 2004). We also could confirm species identification by species-specific advertisement call emitted by the focal and surrounding individuals (Haddad & Sazima, 2004). After species and sex determination, the individual was released. We left the foam nest untouched.

According to Schulte et al. (2020), active egg guarding by females is the most common parental care behavior in amphibians. In the Family Leptodactylidae, most species construct foam nests to egg-laying, and the majority of active parental care behaviors are presented by females (de Sá et al., 2014). In *Leptodactylus* genus, there are several reports of males aggressively defending clutches with eggs, as *L. fallax* (Gibson & Buley, 2004), *L. chaquensis* (Prado et al., 2000) and *L. latrans* (de Sá et al., 2014). In *Physalaemus* genus, previous studies has been shown that males can defend territories against intruder males (with or without foam nests deposited), but this behavior has been pointed out as defense of calling sites, not parental care (see Arzabe & Prado, 2006, and Oliveira Filho & Giaretta, 2008). Thus, the *P. atlanticus* behavior reported in our study is to our knowledge, the first record of active defensive paternal care in the genus.

We were not able to confirm that the observed foam nest was constructed by the focal male, since we did not observed the foam nest construction. Given that males of *L. fallax* only defend the nests that they have constructed with females during egg-laying (Gibson & Buley, 2004), future studies should confirm whether *P. atlanticus* males also only defend foam nests constructed by them. Additionally, we recommend that future studies explore the presence and magnitude of positive effects of *P. atlanticus* male care behavior to offspring survival.

Few hypothesis-testing studies on anuran parental care were developed with species of the Family Leptodactylidae, a knowledge gap that needs to be fulfilled (Schulte et al., 2020). This is especially important considering that Leptodactylidae is one of the species richest, and most geographically widespread, Neotropical anuran families (Frost, 2021). Understanding the evolutionary, physiological and ecological roles of parental care for species of such diverse anuran taxa can clarify theoretical questions about anuran evolution and provide insights on anuran conservation. Thus, we strongly encourage behavioral experiments to confirm the hypothesis of parental care behavior by *P. atlanticus* males, as well in other *Physalaemus*, Leptodactylidae and Neotropical anuran species.

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