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SHORT COMMUNICATION

First record of visual displays in *Scinax cardosoi* (Anura: Hylidae)

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Anurans have a variety of social behaviors (Wells 1977). Acoustic communication is the best documented, occurring in most anuran species (Hartmann *et al.* 2005). Anuran visual communication has received more attention following the reviews by Hödl and Amézquita (2001) and Hartmann *et al.* (2005). Several types of visual signals have been described in anuran species (e.g., Bertoluci 2002, Hartmann *et al.* 2005, Giasson and Haddad 2006, Toledo *et al.* 2007, Caldwell *et al.* 2010, Barros and Feio 2011, Lipinski *et al.* 2012, Caldart *et al.* 2014, Furtado *et al.* 2017).

Visual signaling is a complementary or alternate form of communication in most anurans depending on the social context (Amézquita and Hödl 2004). It is primarily associated with elements of reproductive behavior, such as courtship and aggressive interactions between conspecific males (Hödl and Amézquita 2001). Thus, anuran visual communication may have an important social function that probably is more significant than currently recognized (Caldart *et al.* 2014).

Visual signals in anurans are present in a number of species and families (Furtado *et al.* 2017), suggesting that this communication system may have evolved independently on multiple occasions (Hödl and Amézquita 2001). Within *Scinax* Wagler, 1830, visual signals are recorded for four species—*Scinax eurydice* (Bokermann, 1968), *S. fuscomarginatus* (Lutz, 1925), *S. maracaya* (Cardoso and Sazima, 1980), and *S. nasicus* (Cope, 1862). Two types of visual displays occur in the genus. Limb-lifting is documented for the four species (*S. eurydice, S. fuscomarginatus, S. maracaya, S. nasicus*) and leg-kicking only for one species (*S. eurydice;* Hartmann *et al.* 2005, Toledo and Haddad 2005, Barros and Feio 2011, Furtado *et al.* 2017).

Scinax cardosoi (Carvalho-e-Silva and Peixoto, 1991) occurs in Atlantic Forest fragments in the states of Minas Gerais, Espírito Santo, Rio de Janeiro, and São Paulo (Moroti *et al.* 2017), southeastern Brazil. This nocturnal

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species uses temporary ponds along the forest edge for breeding. Males vocalize next to one another from perches on shrub vegetation (~ 20–30 cm above ground) (Moroti *et al.* 2017). Despite its range over an enormous area in southeastern Brazil, the records of its populations are disjunct, and there is little information on the ecology and behavior of *S. cardosoi.* Here, we describe the visual displays observed in a population of *S. cardosoi* in an Atlantic Forest fragment in southeastern Brazil.

The observations were carried out at the Parque Natural Municipal Augusto Ruschi (PNMAR), municipality of São José dos Campos, state of São Paulo, Brazil, on 17 January 2016. The adult *Scinax cardosoi* were found calling from a temporary pond in an area of secondary forest (23.0714° S, 45.9313° W, WGS-84). Several males were vocalizing from scattered, shrubby vegetation in the same ephemeral pond. A total of 1:30 hr of observations was made before the sunrise, between 5:00 h and 6:30 h. The air temperature and air humidity were measured with a thermohygrometer (Instrutemp ITHT 2250) during the observations. The average temperature varied from 19.7–21.8°C and the relative air humidity from 90–94%.

Our observations followed the *ad libitum* method (Lehner 1996). The same observer (MTM) used a white-light lantern and was always at least 2 m away from the focal individuals; this distance did not seem to interfere in the interactions between the frogs. We observed nine individuals (7 males, 2 females), each for 10 min. The visual behavior of three males was recorded with a digital camera (Nikon P600) and classified according to Hartmann *et al.* (2005). Two males were collected as voucher specimens (collection permits SISBio 54493-2) and deposited in the herpetological collection of the Universidade Federal de Mato Grosso do Sul (ZUFMS-AMP 5627–5628).

Neither of the two females displayed any visual behavior. The males engaged in two kinds of visual displays. The first, limb-lifting, was observed in all male frogs; four of the frogs were in the presence of conspecific males, whereas three were not. This signal consists of moving one or more of the hind or forelimbs rapidly up and down without extending the limbs. In both contexts (i.e., with or without conspecifics), the frogs touched the substrate with limbs (Figure 1). The second behavior, leg-kicking, was observed in two males when there was another male frog nearby. The male that was calling stretched his right hind limb back to hit its conspecific. Because only one individual vocalized, it seems likely that the male that was kicked might have been a satellite male (Figure 2). The presumed satellite male maintained his position for a minute, and then jumped to other vegetation right. Leg-kicking behavior only occurred in the presence of another male, thereby suggesting that it is an aggressive behavior.

Visual signals are more commonly associated with diurnal anurans, owing mainly to their signal transmission facility and perception (Hödl and Amézquita 2001). However, optimal illumination may vary among species; many anurans are active only at low light intensities (Hartmann *et al.* 2005). When the white light of our lantern was focused on individual frogs, the males performing visual displays ceased this behavior, but did not stop calling. When the light was not focused on individuals, they resumed their visual behavior displays. We found that anuran visual displays were inversely correlated with the light intensity. It will be important to test whether the rate of visual signaling in anurans with nocturnal habits decreases with increasing light, or whether this is only in response to intense white light.

The use of visual cues in anurans usually occurs when a resident male sees a conspecific (Lindquist and Hetherington 1998). In an experiment using mirrors, Furtado and Nomura (2014) observed that *Boana albomarginata* (Spix, 1824) altered its rate of emission of acoustic signals in the presence of a possible intruder male, but did not change the rate of visual displays, thereby this suggesting that the latter is not involved in communication and is a "displaced

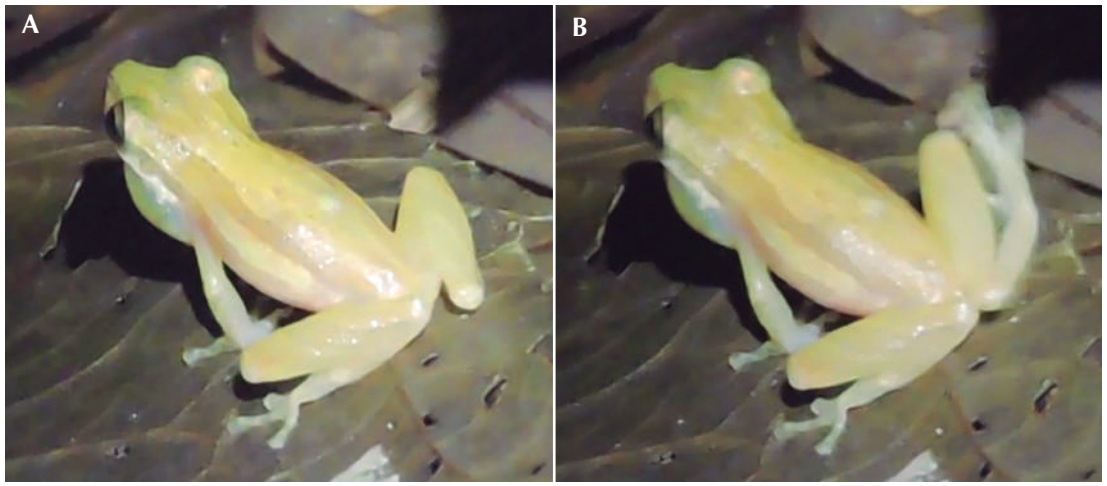

Figure 1. (**A**) A male *Scinax cardosoi* in the Parque Natural Municipal Augusto Ruschi, municipality of S o Jos dos Campos, state of S o Paulo, southeastern Brazil. (**B**) Limb-lifting observed in individuals of *S. cardosoi*. The signal consisted of rapid up and down movements of one or more limbs that are not extended.

activity" in this species (Furtado and Nomura 2014). Anurans also use seismic signals to communicate; in some cases, this may establish patterns of spacing in the chorus of the males (Narins 1990), as suggested in a study of an aboreal frog, *Agalychnis callidryas* (Cope, 1862) by Caldwell *et al.* (2010). Combined, visual and vibrational signaling compose a bimodal signal,

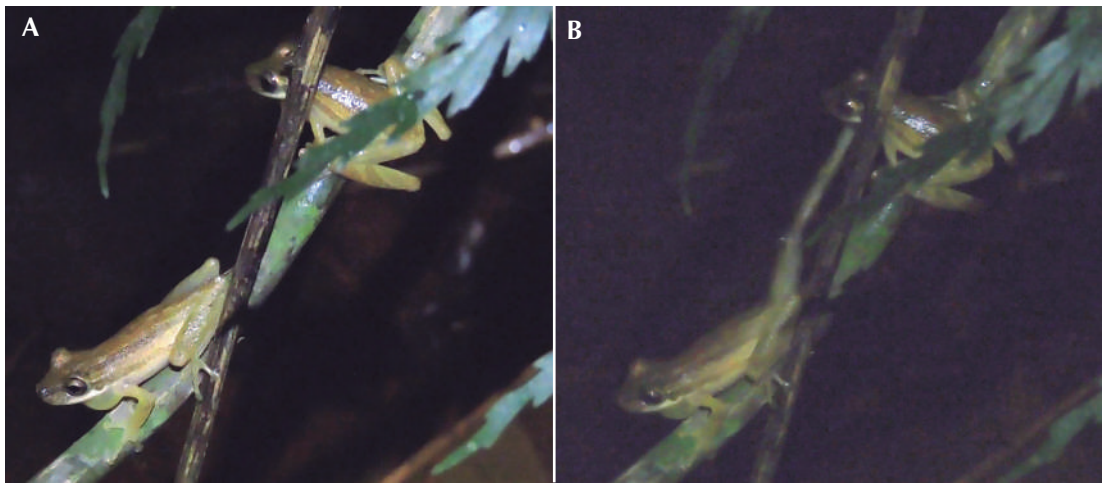

Figure 2. (**A**) Two male *Scinax cardosoi* (ZUFMS 5627-5628); the left male displayed "leg kicking" to push the other male away. The latter did not vocalize, whereas the former did; thus, the silent male may have been a satellite. (**B**) The most active male stretched his right leg back to hit other male, which remained in the same position for a minute, jumping to other vegetation right after. In our observations, the leg kicking behavior was only displayed in the imminence of another male, suggesting aggressive behavior.

because male *A. callidryas* do not respond to visual stimuli only (Caldwell *et al.* 2010).

Furtado *et al.* (2017) observed visual displays associated with agonistic interactions in three hylid species [*Boana raniceps* (Cope, 1862), *Dendropsophus nanus* (Boulenger, 1889), and *Lysapsus limellum* Cope, 1862] and found that the visual stimulus of an intruder male in the territory of the resident male does not affect the rate of visual signaling. In our study, limb-lifting behavior in *Scinax cardosoi* was reported in both the presence and absence of other conspecific males, as observed in other studies (Furtado and Nomura 2014*,* Furtado *et al.* 2017). However, Hartmann *et al.* (2005) verified that in the absence of another vocalizing male, individual *Vitreorana uranoscopa* (Müller, 1924) ceased limb-lifting behavior but continued to vocalize. Possibly, behavior differs among species depending on the type of habitat they use, their evolutionary history, the availability of light, and the noise of the environment.

The visual displays observed in *Scinax cardosoi* (limb-lifting and leg-kicking) are documented in some of its congeners (Hartmann *et al.* 2005, Toledo and Haddad 2005, Barros and Feio 2011, R. Furtado pers. obs.). However, our study shows that leg-kicking may be used in intraspecific aggressive interactions in this species. We documented that display of visual signals in *S. cardosoi* changes with light intensity, because such displays cease when the lantern light is focused directly on an individual; nevertheless, the frog continues to vocalize. Thus, our study provides new insights on visual communication in *Scinax,* while raising further research questions to explore.

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