

Tadpole predation by *Mantidactylus bellyi* Mocquard, 1895 with brief description of the site and morphological measurements of the specimen

Safidy M. Rasolonjatovo^{1*}, Mark D. Scherz^{2,3}, Achille P. Raselimanana¹, and Miguel Vences³

Anurophagy is widely reported among amphibians, especially between large and small-sized animals (Glaw and Vences, 2007; Wissinger et al., 2010; Struijk et al., 2014; Comas and Escoriza, 2015; Measey et al., 2015). Frog-eating is also observed in frogs of the family Mantellidae, endemic to Madagascar and Mayotte Island (Andreone and Randriamahazo, 1997; Glaw and Vences, 2007). In an analysis of stomach contents of 18 species of mantellids, Vences et al. (1999) found small, unidentified frogs consumed by two individuals belonging to *Mantidactylus ulcerosus* (Boettger, 1880) and *Laliostoma labrosum* (Cope, 1868). Anurophagy in *Boophis goudotii* Tschudi, 1838 was reported by Ndriantsoa et al. (2014) while the species attempted to feed on *B. williamsi* Guibé, 1974. Other studies have reported cases of oophagy by conspecific tadpoles in captive reared *Mantella laevigata* Methuen & Hewitt, 1913, as well as consumption of smaller conspecific larvae by the carnivorous tadpoles of *Gephyromantis azzurrae* Mercurio and Andreone, 2007 (Glaw et al., 2000; Reeve et al., 2011).

Here, we report a field observation of an adult female *Mantidactylus bellyi* Mocquard, 1895 preying upon a tadpole of *Boophis septentrionalis* Glaw & Vences, 1994 in its natural habitat. Widely distributed in

northern Madagascar, *M. bellyi* is present from 400–1150 m in Montagne d'Ambre National Park (D'Cruze et al., 2008). In the context of a study on populations of *M. bellyi* at this site, we sampled a mostly dry streambed, which had formed three isolated temporary pools. The observation was made at the uppermost pool (12.52698°S, 49.16756°E, 1109 m a.s.l.) on 14 November 2017. An adult female *M. bellyi* repeatedly emitted a series of rapid scratch-like vocalizations from a hidden place on the rough magmatic rock forming the edge of the pool. We began recording the sounds at 11:25 a.m. After losing sight of her for no more than one minute, she was re-spotted at the same location, presumably following a brief period in the water, with a tadpole in her mouth. The specimen continued emitting the series of sounds intermittently with the tadpole in her mouth until her capture at 11:47 a.m. Because vocal sacs are only slightly distensible in male *Mantidactylus*, and, as far as is known, absent in females, we could not obtain direct proof (i.e., observation of vocal sac inflation) that indeed this specimen emitted the recorded calls, although this is very likely, due to the absence of other frogs in the vicinity. Analyses of the calls using Audacity following noise reduction revealed a series of complex calls, composed of four types of notes. Each call lasted 01.46 ± 0.52 (1.05–2.12) s on average, had a mean maximum frequency of 726.8 ± 18.99 (706–751) Hz and was separated from the next call by 01.29 ± 0.53 (0.86–1.98) s on average. During the entire study period, this call type was rarely recorded and only from males. Before any morphological measurements and weight could have been taken, she regurgitated the still living tadpole in the bag, roughly one minute after capture. We assume the release of the tadpole alive resulted from stress induced by her capture. Both specimens, adult and tadpole, were killed using MS222 overdose, fixed in 95% ethanol, subsequently stored in 70% ethanol,

¹ Mention Zoologie et Biodiversité Animale, BP 906, Université d'Antananarivo, Antananarivo 101, Madagascar.

² Department of Herpetology, Zoologische Staatssammlung München (ZSM-SNSB), Münchhausenstr. 21, 81247 Munich, Germany.

³ Department of Evolutionary Biology, Zoologisches Institut, Technische Universität Braunschweig, Mendelssohnstr. 4, 38106 Braunschweig, Germany.

* Corresponding author. E-mail: safidymalala@yahoo.com



Figure 1. Female specimen of *Mantidactylus bellyi* (MSZC 490) and tadpole (MSZC 491) from Montagne d'Ambre National Park, Madagascar, photographed shortly after the regurgitation of the latter (Photos by Mark D. Scherz).

labelled respectively with field numbers MSZC 0490 and MSZC 0491 and deposited at the Zoologische Staatssammlung München (ZSM) catalogued as ZSM 37/2018 and ZSM 36/2018. Species identifications of both, frog and tadpole, were verified based on DNA sequences of the 16S rRNA gene, which were 100% identical to reference sequences of these two species (e.g., Vieites *et al.*, 2009). The new sequences were deposited in GenBank and are available under accession numbers MH553052 and MH553053.

Temperatures were automatically recorded every five minutes by temperature loggers (iButtons), starting from 10:01 a.m. on 17 November 2017, until three days later at 08:51 a.m. on 20 November 2017, one positioned in the water and one in the surrounding terrestrial microhabitat occupied by the frogs. Mean air temperature for this period was 18.9° C ($\pm 1.5^\circ$ SD) at this site while the mean water temperature of the pool was 18.6° C ($\pm 0.3^\circ$ SD). With a diameter of 5 m and a maximum depth of 60 cm,

it was the largest pool among the three in this area. The surrounding shaded rainforest areas, from both sides of the ponds (12.52693°S, 49.16756°E, 1105 m a.s.l. and 12.52674°S, 49.16791°E, 1140 m a.s.l.), showed a leaf litter depth between 85–90 mm. The latter may explain why the water was turbid (relatively 50 Nephelometric Turbidity Units based on visual comparison of water transparency with a range of colouration corresponding to 10, 25, 50, 100 or 250 NTU). We obtained an average pH of 7.55 (measured with a pH meter, Neuftech®) and conductivity of 226 S/m (using a conductivity meter water quality tester CB31, Colemeter®) by averaging punctual measurements taken from each of the three pools. The pool lay in a stretch of riverbed with an estimated slope of *ca.* 10° and was separated from the next closest pool by *ca.* 80 m.

Under deteriorating environmental conditions, eating other anurans is one way to mitigate competition by limiting the number of tadpoles, to palliate food resource scarcity, to provide conditional survival benefits or to cope with stress (Wakahara, 1995; Jefferson and Demuth, 2014; Jefferson *et al.*, 2014; Jefferson, 2015a, b). Here, the diminishing water surface, coupled with the fact that *M. bellyi* in this pool were living in sympatry with *M. ambreensis* Mocquard, 1895, and with the tadpoles of *B. septentrionalis*, meant intensifying competition before the arrival of the rain. Considering that frogs are able to estimate the water-holding capacity of their environment (Rudolf and Rödel, 2005), the observation of anurophagy in this species may be advantageous to reduce competitor density in the local habitat.

As shown in the following measurements, the tadpole was greater in total length than its predator (Fig. 1). The tadpole-eating adult female (sex verified by incision) weighed 13 g and had a body size (SVL 46.7 mm) larger than the 37–46 mm known SVL of female *M. bellyi* (Glaw and Vences, 2007). Additional measurements of the specimen are as follows: head length 20.5 mm, head width 19.9 mm, eye diameter 7 mm, tympanum diameter 4.2 mm, length of the humerus 9.8 mm, forearm length 12.3 mm, thigh length 25.5 mm and tibia length 18.4 mm. The preyed-upon tadpole of *Boophis septentrionalis* (Gosner stage 40) had 21.2 mm body length, 10.8 mm body width and 11.1 mm body height, measured as in Randrianiana *et al.* (2011). Distances between snout and point of maximal body width and height were respectively 11.1 mm and 11.9 mm. Yet, with a tail measuring 28.1 mm, its total length (49.3 mm) surprisingly surpassed its predator's SVL, contrary to general observations of amphibians feeding on smaller

prey (e.g. Walls et al., 1993; Wakahara, 1995; Wissinger et al., 2010; Jefferson et al., 2014; Struijk et al., 2014; Comas and Escoriza, 2015; Jefferson, 2015a; Measey et al., 2015; Scherz et al., 2015).

This observation is remarkable in three ways. First, instances of anurophagy among frogs are rarely documented among Madagascan frogs, but, given the generalised diet of most species such cases are to be expected. Second, the putative prey item was longer in total length than the body length of the frog, which goes against typical expectation. Third, and perhaps most interestingly, although it was not directly observed, the implication is that the female *M. bellyi* entered the water, captured the tadpole, and then returned to the surface in order to attempt to swallow it. Aquatic feeding in frogs is well known in fully aquatic species (e.g. members of the family Pipidae, which feed with a specialized suction mechanism, Carreño and Nishikawa, 2010). Consumption of aquatic prey among terrestrial frogs is rare, though not completely unknown (e.g. Hirai and Matsui, 1999). Neobatrachian frogs such as *Mantidactylus* typically acquire prey items using their tongues in terrestrial environments, and suction feeding has been reported for only few, rather aquatic species (Barrionuevo, 2016). It remains unknown whether suction feeding might also be used by *Mantidactylus* and other neobatrachians when hunting under water.

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