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‘Fantastic Voyage’: a live blindsnake (*Ramphotyphlops braminus*) journeys through the gastrointestinal system of a toad (*Duttaphrynus melanostictus*)

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Abstract. We report an unusual predator-prey interaction between the Common Asian toad, *Duttaphrynus melanostictus*, and the Brahminy blindsnake, *Ramphotyphlops braminus*, as observed in Manufahi District, Timor-Leste. The live blindsnake was found emerging headfirst from the cloaca of the toad, with about one-third of its body length still inside. This interaction may indicate that indiscriminate foraging by invasive toads could endanger small vertebrate prey, while it appears that the physiology and habits of blindsnakes may allow them on occasion to elude predation in an unexpected manner.

Keywords. *Duttaphrynus melanostictus,* Bufonidae, *Ramphotyphlops braminus,* Typhlopidae, Timor-Leste, predation, diet, invasive species.

Introduction

Timor is the largest island of the Outer Banda Arc of the Indo-Australian Archipelago, a chain of diverse islands situated off the northern coast of Western Australia. With coastlines on the Savu and Timor Seas, the country of Timor-Leste (total surface area 15,410 km^2) comprises the eastern half of Timor, the Oecusse exclave on the northern coast of Indonesian West Timor, and the islands of Ataúro and Jaco (Kaiser et al., 2011a). A Portuguese colony for almost five centuries, Timor-Leste, also known as East Timor, has had a traumatic and bloody history, including an exploitative colonial period, occupation by Japan during the Second World War, and, most recently and most seriously, annexation by Indonesia (1975–99). Timor-Leste finally became fully independent in 2002, but only since mid-2008 have the political circumstances stabilized.

As a consequence of its geography and its history, Timor has had many diverse human visitors. It was settled during prehistoric times by waves of Melanesians, Polynesians, and Malays from New Guinea, Australia, southern China, and Southeast Asia, each bringing their baggage, chattels, and agricultural practices, including rice farming, an industry established in the region thousands of years ago (Chi and Hung, 2008). Indonesian and Chinese traders came and went, some settling into the communities or establishing their own. Colonization during the 16th Century brought the Dutch to the west and Portuguese and Indians from Goa to the east, while wars in the 20th Century brought the Japanese, Australians, and Indonesians. The uneasy peace in 1999 brought many more nationalities to the shores of East Timor, first the Australian-led multinational InterFET[1] task force, comprising troops from 19 countries sent to separate the warring factions from 1999–2000, and then an interim administration (UNTAET[2]), which controlled peacekeeping from 2000 until independence in 2002. These initiatives were followed by UNMIT[3] from 2006–12, which again involved large numbers of personnel and large quantities of equipment arriving from distant shores. Colonization, trade, agriculture, war, and peace

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[1]InterFET = International Force for East Timor
[2]UNTAET = United Nations Transitional Administration in East Timor
[3]UNMIT = United Nations Integrated Mission in Timor-Leste

all resulted not only in a mixing of humans on the island of Timor, but also in the introduction of numerous alien species. The ongoing Reptile and Amphibian Survey of Timor-Leste (Kaiser et al., 2011a; O'Shea et al., 2012) has so far confirmed the presence of six species of amphibians (of which at least three may have been introduced), three species of freshwater turtles (two introduced), 44 species of lizards (at least eight species, or 18% introduced), and 12 species of snakes (several possibly introduced).

During the latest phase of our survey (21 June–9 July 2012), we observed a curious interaction between two certainly non-native species: the Common Asian toad, *Duttaphrynus melanostictus* (Schneider, 1799), and the Brahminy blindsnake, *Ramphotyphlops braminus* (Daudin, 1803). The toad is locally known as *manduku interfet* or 'InterFET toad' due to the locally held belief that its arrival was mitigated by the first wave of peacekeeping forces (Kaiser et al., 2011a). The species has established itself widely across western and central mainland Timor-Leste (Trainor, 2009; Kaiser et al., 2011a,b, 2012; O'Shea et al., 2012), to altitudes of 1225 m, although it has yet to be documented from the easternmost part of the country (Lautém District). The Brahminy blindsnake, a parthenogenetic species, is ideally suited to colonize new habitats and its colloquial name, 'flower pot snake,' is an indication for how it has become the most widely distributed non-native snake species in the world (O'Shea, 2007). It has spread throughout the entire island of Timor, occurring at altitudes up to 1495 m in Timor-Leste (carried to this locale in plant pots destined for the Portuguese Governor's garden; O'Shea et al., unpubl. data).

Materials and Methods

The toad was discovered serendipitously by lifting a rock destined to become a doorstopper at the facility where we were assembling a specimen preparation area during a recent herpetofaunal survey in Timor-Leste (see Kaiser et al., 2011a for detailed methodology). Measurements of snout–vent length (SVL) and total length (TL) were taken to the nearest 1 mm using a ruler. Specimens have been deposited in the United States National Museum of Natural History (USNM).

Results and Discussion

At 1230 h on 3 July 2012 a *Duttaphrynus melanostictus* (SVL 58 mm; USNM 565895) was discovered under a rock in the grounds of the Convent of St. Antony d'Lisboa, at Fatucahi Suco, Manufahi District, southern Timor-Leste (9.03789°S, 125.98622°E, datum: WGS84; elev. 38 m). Protruding headfirst from its cloaca was a *Ramphotyphlops braminus* (SVL 103 mm, TL 106 mm; USNM 565896) with approximately 60% of the snake visible. When the toad hopped to escape, the blindsnake was carried along with it.

Both specimens were captured together and photographed (Fig. 1A), and after a few minutes the struggling toad completely expelled the blindsnake (Fig. 1B). Even though the blindsnake appeared passive during the encounter, it was not possible to determine with certainty whether the expulsion was due to digestive or cloacal activity of the toad or exertions from the blindsnake. Both animals were again photographed alongside a ruler (Fig. 1C). The blindsnake was clearly alive when it emerged, based on the visibility of both heartbeat and circulation when viewed ventrally using a strong light, and it still made weak movements until at least 2100 h. The following morning we found that it had died, and we vouchered it. While we do not collect specimens of *D. melanostictus* as a matter of course, the unusual circumstances under which we found this specimen made it an exception.

The only possible scenario leading up to this unusual circumstance is that the toad had predated the blindsnake, gulping it down with great speed and minimal jaw pressure, enabling the snake to survive and enter the digestive tract essentially unharmed. The blindsnake, as a species adapted to a light-restricted fossorial lifestyle, presumably continued on its *Fantastic Voyage*[4] through the digestive tract of the toad, either passively and propelled by the toad's digestive musculature, or by actively working its way through the toad, until it again emerged into daylight from the cloaca of the toad. It is a testament to the hardiness of the species that the blindsnake succumbed only after more than 7.5 h post-exposure, due to either the chemicals produced by the toad's digestive tract, from anoxia (Pizzatto et al., 2012), or from a combination of the two.

The blindsnake's escape is curious, however, since toads are generally known as voracious and effective carnivores of a great diversity of prey. While we appreciate that the blindsnake in this instance did not survive its passage through the toad, its overall condition upon emergence leaves us with the impression that safe passage may be possible. We have been unable to find

[4]*Fantastic Voyage* is the title of a 1966 science fiction movie starring Stephen Boyd, Raquel Welch and Donald Pleasence, in which a specially designed nuclear submarine, the *Proteus*, and its crew are shrunk to 0.001 mm in size so that they may be injected into the circulatory system of a scientist.

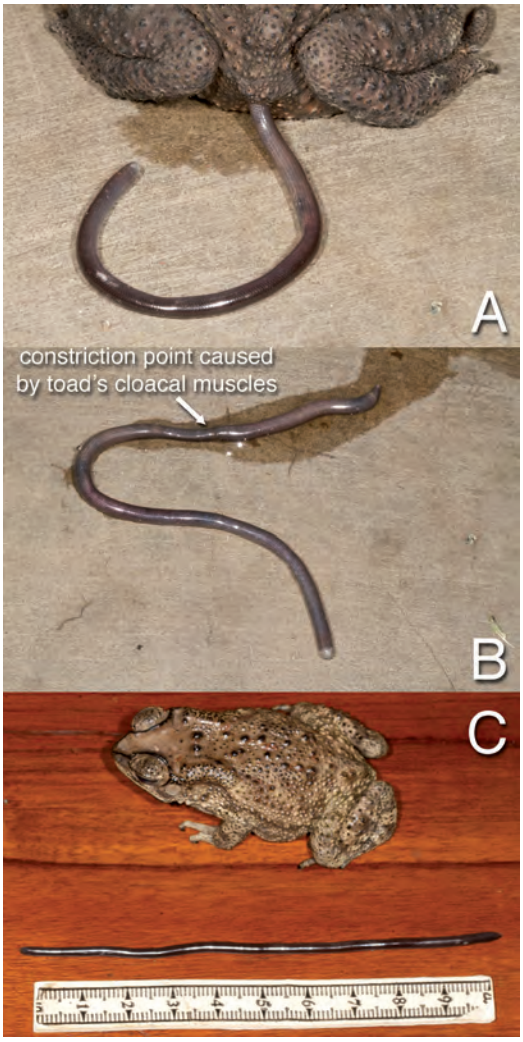

Figure 1. Participants in the 'Fantastic Voyage' of a Brahminy blindsnake (*Ramphotyphlops braminus*) through the digestive system of a Common Asian toad (*Duttaphrynus melanostictus*) in Timor-Leste. (A) In this image taken immediately after the discovery of the toad, ca. 40% of the blindsnake is still inside the toad. There were no visible signs of discomfort on the part of the toad. (B) After it completely emerged from the toad, the blindsnake did not move noticeably, but physiological functions (blood flow, heartbeat) could be observed. The body of the snake showed a constriction where the toad's cloacal muscles had most recently held it. (C) Relative dimensions of toad and blindsnake shown to illustrate that the blindsnake was considerable longer than the toad in body length.

either anecdotal or documented observations of any other prey emerging alive from a toad's digestive tract. The toad appeared to be none the worse for wear by the passage of a relatively large organism through its entire alimentary system.

Whereas prey selection among bufonid toads in nature is usually restricted to invertebrates, there are reports that one species, the cane toad *Rhinella marina* (Linnaeus, 1758), sometimes takes vertebrate prey. Such reports need to be carefully evaluated, however, because they may depend on the geographic location of the observation. It appears that *R. marina* takes vertebrate prey opportunistically but rarely, and reportedly only in locations where it is introduced (e.g., Shine, 2010; Stammer, 1981); in their broad-based study in the toad's native range on Barro Colorado Island, Panamá, Zug and Zug (1979) found no vertebrate prey in toad stomachs. Two reports from introduced cane toad populations document predation of typhlopid snakes by *R. marina*, for tropical northern Australia (*Anilios guentheri, A. unguirostris,* introduced *Ramphotyphlops braminus*: Pizzatto et al., 2012) and the Philippines (*Typhlops*: Rabor, 1952). These cases show that certainly for the large species *R. marina*, consumption of blindsnakes may be part of that species' opportunistic feeding routine, even though some blindsnakes were reported to have been regurgitated alive (Rabor, 1952) or found dead but undigested in the toads' guts or in fecal matter (Pizzatto et al., 2012). A possible simple explanation for the regurgitation of blindsnakes by toads is perhaps the inability of toads to distinguish between a blindsnake and an earthworm. The question therefore remains whether there is generally any tangible nutritional gain for toads by including blindsnakes, or other vertebrate prey, in their diet.

Unlike for *R. marina* there are no previous reports of the invertebrate generalist *D. melanostictus* preying upon vertebrates (Berry & Bullock, 1962). Even the large (70–100 mm) river toad, *Phrynoidis aspera* (Gravenhorst, 1829), is not documented as taking vertebrate prey (Berry, 1970). In the specific case we observed, and akin to the circumstances of *R. marina*, introduced *D. melanostictus* are perhaps more likely to ingest vertebrate prey than they are in their native range. Nevertheless, we believe ours is the first observation of *D. melanostictus* predating a vertebrate prey species, and it is simultaneously the first account of a living blindsnake passing completely through the digestive tract of a potential predator.

As an introduced species in Timor-Leste, *D. melanostictus* may cause similar, though perhaps less severe, ecological problems than those caused by the introduced, physically larger cane toad *R. marina* in New Guinea, Australia, and other non-native locations.

Among the key issues are the following (see Shine, 2010 for a broader discussion): (1) toads may be consumed and subsequently poison naïve vertebrate predators (potentially including humans); (2) because of their very generalized habitat needs and considerable tolerance for adverse environmental conditions, toads and their tadpoles may outcompete native anurans and their tadpoles; (3) toads can prey upon local terrestrial invertebrates and, given our finding for *D. melanostictus*, perhaps vertebrates, thus upsetting the ecological balance; (4) the predatory pressure of a fast-growing and fast-expanding toad population may endanger rare species (perhaps including small vertebrates) and remove prey species for other amphibians and reptiles.

Our observation might also provide an alternative explanation for the presence of blindsnakes in the nests of owls (Gehlbach and Baldridge, 1987). In addition to the deliberate transportation of live blindsnakes to the nest in the owl's beak as prey for its young, blindsnakes may be transported to the nest while in the owl's digestive tract and escape from its would-be predator *in situ*. While it would require additional observations to determine whether a blindsnake such as *R. braminus* is capable of surviving the digestive chemistry or oxygen-deficient alimentary system of a homeotherm, such occurrences may be rare and extreme, just like the arboreal climbing abilities of blindsnakes reported by Vanzolini (1970).

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