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Eviscerated alive: Novel and macabre feeding strategy in *Oligodon fasciolatus* (Günther, 1864) eating organs of *Duttaphrynus melanostictus* (Schneider, 1799) in Thailand

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Abstract

A hitherto unknown feeding mode among snakes is described for the colubrid snake *Oligodon fasciolatus* in Northeast Thailand. Three cases of *O. fasciolatus* using enlarged posterior maxillary teeth to cut open the abdomen of a live poisonous toad *Duttaphrynus melanostictus* and eat its organs are described. The snakes and toads fought vigorously, and the toads secreted toxic white liquid on the dorsum and neck. The snakes inserted their heads into the abdomen of the toads, pulled out some of the organs and swallowed them. The snakes and toads were adults. All three cases were documented by extensive photographic material.

In a fourth case from Central Thailand, an adult *O. fasciolatus* was observed swallowing an entire semi-adult *D. melanostictus*.

The majority of all snake species swallow their prey in one piece, but to place our observations in a broader context we review a number of exceptions.

Key Words

Anura, behaviour, bufadienolide, Bufonidae, bufotoxin, Colubridae, Duvernoy's gland, poison, posterior maxillary teeth, Squamata

Introduction

The genus *Oligodon* currently contains 80 species that collectively range from Iran, Turkmenistan, Afghanistan in the west, over large parts of India and Sri Lanka to China and the Philippines in the east and south through South Asia to Indonesia (De Lang 2017; Midtgaard 2019; Nguyen et al 2020; Uetz et al 2020). These snakes are small to medium-sized with a muscular body and short head which is not distinct from the body. The eye is small to moderate with a round pupil. The snout is blunt with a large rostral shield. Using their sharp curved posterior maxillary teeth members of the genus *Oligodon* are known to be able to inflict large bleeding wounds which form lacerations rather than punctures. This ability has given them the popular name Kukri Snakes which stems from the kukri knives with curved blades of the Nepali-speaking Gurkhas soldiers. A bite from a Kukri snake may cause profuse, long-lasting bleeding. This is probably caused by anticoagulant activity of the serous Duvernoy's gland secretions (Taub 1967; Grossmann 1992; Wüster and Cox 1992). *Oligodon fasciolatus*, the Small-banded Kukri Snake, is a common aglyphous colubrid snake distributed in southeastern Myanmar, Thailand, Cambodia, Laos and Vietnam, but was previously often confused with *O. cyclurus* (Pauwels et al. 2002). It is widely distributed in Thailand (Niyomwan et al. 2017).

In this paper we describe a hitherto unknown feeding behaviour of adult *O. fasciolatus* eating solely organs of adult *Duttaphrynus melanostictus*, the Asian Black-spot-

ted Toad. This anuran is widely distributed in southern and southeastern Asia, particularly common in urban areas, and is ecologically versatile. This toad secretes toxins from its prominent parotid glands in the neck region and many smaller glands in the back (Taylor 1962; Manthey and Grossmann 1997; Schleich and Kästle 2002). Three such cases from Northeast Thailand are described. In addition, in a fourth case an adult *O. fasciolatus* was observed swallowing a large juvenile *D. melanostictus* in Central Thailand.

Methods

Three observations on *O. fasciolatus* eating organs of *D. melanostictus* were made at one locality near Loei, Northeast Thailand, in August 2016, April 2020 and June 2020 respectively. The coordinates of the locality are 17°36.81'N, 101°41.34'E, altitude approx. 280 m a.s.l. and located in Na Muang village 15 km north of Loei, Sri Songrak subdistrict, Muang district, Loei province. The habitat consisted of cultivated land near human habitation on the estate belonging to two of the authors (WS and MS) who made the observations and WS took photos in all three cases. In two of these three serpent observations sexing was possible by observing the shape of the base of the tail.

Additionally, one observation on *O. fasciolatus* swallowing an entire large juvenile *D. melanostictus* was made at a locality in Phitsanulok, Central Thailand, in June 2020. The coordinates of the locality are 16°47.64'N, 100°20.40'E, altitude approx. 45 m a.s.l. and located in the southeastern outskirts of the town Phitsanulok, Mueang Phitsanulok district, Phitsanulok province. The habitat consisted of cultivated land in direct connection with human habitation near the house of one author (KN) who made the observations and took video recordings which were converted to still photos.

At no time were the snakes or the toads touched by the observers. The four observations are presented in chronological order.

Results

The **first observation** was made near **Loei** just outside the plant nursery of WS and MS on **9 August 2016** at 08:36–08:53. Along with WS and MS also Steve and Joanna Suthanthangjai witnessed the act of predation. A large adult female *O. fasciolatus* was observed eating parts of an adult *D. melanostictus*. The toad was dead upon the observers' arrival, but the soil around the two animals was bloody, indicating there had been a fight which eventually killed the toad. The snake used its enlarged posterior maxillary teeth to slit through the left side of the abdomen just underneath the left front leg. Its head was swung from side to side as it managed to cut through the skin of the toad. Slowly the snake inserted its head into the left side of the toad's abdomen and subsequently it pulled out organs like liver, heart, lung and part

Figure 1. After *Oligodon fasciolatus* cut through the abdomen of *Duttaphrynus melanostictus* it inserted its head into the toad's abdomen to extract and eat organs. Loei, 9 August 2016. Photo WS.

of the gastrointestinal tract (at least the full stomach and full small intestines). During the process of retraction, the head was moved in different directions with a partly open mouth, allowing the teeth to cut the organs into smaller pieces which were then swallowed. Two millipedes (one brown and 10–15 cm, the other one red and 3–5 cm) had been attracted by the dead toad with exposed organs of which they started eating minor parts. After leaving the dead toad at 08:53, the kukri snake rubbed its head against the soil and dead leaves to remove the intestines and millipedes. It is unknown for how long the fight had lasted. See Fig. 1 and Appendix 1: Figs A1, A2.

The **second observation** was made 15 m from the above-mentioned "battle field" near **Loei** from 2016 and took place on **22 April 2020** starting at approx. 13:00. The snake was also a large adult female *O. fasciolatus* and the toad was also an adult *D. melanostictus*. The fight took place in an area of approx. 5 m^2 near the bank of a pond and lasted for almost three hours as it ended at approx. 16:00. The snake and toad were observed fighting for a considerably longer period of time compared to the 2016 incident. Upon the arrival of the two observers the snake's head was inserted in the abdomen of the toad. Despite this injury, the toad moved toward the pond, but stopped at the bank. The snake then pulled out of the toad's abdomen, possibly to pause and breathe. The toad was observed spraying poison like a fine mist, some of which hit the head of the snake. In addition, some fluid from the back of the toad dripped down and covered the snake's head and eyes. The toad jumped away. The snake rubbed its head against the substrate including dead leaves to remove some poison around the eyes etc., and it retreated under a pile of logs where it remained for approx. 10 minutes before it reappeared and started searching for the toad again. It found the toad which jumped approx. 2.5 m towards the pond again, but the snake grabbed it by a hind leg. White toxic fluid appeared in the dorsal region of the toad, some of which was transferred to the eyes of the snake. Subsequently the snake retreated and rubbed and cleaned its eyes again. The toad managed to jump in

Figure 2. *Oligodon fasciolatus* inserted its head through the right side of the abdomen of *Duttaphrynus melanostictus* in order to extract and eat organs. Tissue of a collapsed lung (above, left), and possibly fat tissue, covered by clear liquid foaming as it mixes with air bubble from the lung at expiration. The upper part of the front leg is covered by foaming blood, likewise, mixed with air bubbles from the collapsed lung. The poison on the dorsum and neck of the toad is still conspicuous. Loei, 22 April 2020. Photo WS.

Figure 3. After the kukri snake had pulled out its head from the toad's abdomen and the toad jumped a few m away, the snake rubbed itself against the substrate to remove the poison of the toad. Subsequently additional attacks were made. Loei, 22 April 2020. Photo WS.

Figure 4. Adult *Oligodon fasciolatus* swallowing a large juvenile *Duttaphrynus melanostictus* whole. The toad was turned so that the belly pointed upward. Phitsanulok, 5 June 2020. Photo KN.

the pond, but swam to a bank where it tried to hide under a log for approx. 30 minutes. During that period of time the snake hid under a nearby log trying to remove poison from its head including its mouth by rubbing the head. At the same time it opened the mouth and moved the jaws in different positions repeatedly. Then the snake attacked again and inserted its head into the abdomen of the toad through the wound which had been made earlier and gained direct access to the organs. A collapsed lung, muscular tissue and possibly fat tissue were pulled out. As the toad was cornered and subjugated it remained motionless, closed its eyes and spread its legs on the ground, but it was still breathing. The method of extracting and swallowing organs was similar to the one described above for the first case from 2016. However, this time the toad and the snake were attacked by ants which made the snake retreat yet again, leaving the toad with ants. WS sprayed the ants away from the toad with water, but noticed that the toad was now dead. The duration of the above process of attacking and feeding was approx. 45 minutes from 15:15 to 16:00. The dead toad was photographed just before midnight. See Figs 2, 3 and Appendix 1: Figs A3, A4.

The **third observation** took place in **Phitsanulok** on **5 June 2020** approx. from 06:00 to 07:00. The snake was an adult *O. fasciolatus*, approx. 70 cm total length, and the toad was a semi-adult *D. melanostictus*, approx. 5 cm SVL. Initially the snake was observed having the toad's head in its gape near a big tree by KN's house. It moved away from the observer as it maintained its bite-hold on the toad and tried to hide in a clay saucer of a large plant pot. From there it completed swallowing the small toad. During the entire action the toad was inverted with the underside turned upward. A small part of its upper side was visible and no white toxic liquid was apparently excreted from parotid or dorsal glands. Most of the upper side was not visible. See Fig. 4 and Appendix 1: Fig. A5.

The **fourth observation** was made in **Loei** on **19 June 2020** starting at 11:50. It took place approx. 15 m from the place of 22 April 2020 (on the other side of the pond). The adult snake, *O. fasciolatus*, hunted the adult toad, *D. melanostictus*, in a similar way. However, this time it attacked the toad directly from the centre of the abdomen from where it slit through the skin to access the organs (instead of a more lateral access in April). Subsequently the snake left the toad, but returned approx. five hours later and completed eating organs of the dead toad at 18:00. On the basis of the pattern and size it is assumed that this snake was the same individual as the one which was recorded feeding on 22 April 2020.

Discussion

These are the first known cases of serpents inserting their heads into prey and subsequently extracting and eating

organs, then discarding the rest of the prey. However, it is striking that a smaller toad was swallowed whole. The fact that solely organs were eaten in three cases might have been caused by adult toads either being more toxic or too large to be swallowed even by adult kukri snakes. A combination of the two factors might also have applied. It was not clearly seen whether the young toad which was swallowed whole excreted any white toxins from the upper side because generally only its underside was visible. Our observations are indicative of vigorous snake-toad fights in which the toads defended themselves desperately to avoid being cut open and having their organs removed while still alive.

As a general rule snakes swallow their prey in one piece and it is unusual that they deliberately tear or cut off parts of a prey to swallow them. It is well-documented that several Asian snakes of the family Pareidae and Latin American snakes of the subfamily Dipsadinae (Colubridae) feed on snails which they extract from their shells (Greene 1997; Lillywhite 2014; Arteaga et al 2018; Wang et al 2020, Kojima et al 2020). Similar habits of snail extraction are known in the two North American colubrids *Storeria dekayi* and *S. occipitomaculata* (Rossman and Myer 1990).

The Southeast Asian homalopsid snakes *Fordonia leucobalia* and *Gerarda prevostiana* tear off and consume pieces of crabs (Murphy and Voris 2002; Jayne et al. 2002, 2018). In *F. leucobalia* legs of hard-shelled individuals are torn off and swallowed. A somewhat different strategy is used by *G. prevostiana* as it attacks freshly moulted crabs breaking off legs and parts of the carapace. It is considered that the main purpose of this technique is to be able to consume larger prey than could be swallowed whole.

In three species of Typhlopoidea predation by only eating part of their prey has also been observed. *Epictia phenops* (Leptotyphlopidae) may suck abdominal contents of termites while discarding the remains (Smith 1957). *Rena dulcis*, another leptotyphlopid, breaks off the head of termites by grasping the abdomen with the jaws and then rubbing termite heads against objects (Reid and Lott 1963). Furthermore, the small typhlopid *Indotyphlops braminus* may decapitate its termite prey and consume only the thorax and abdomen or it may break orthopteran insects into smaller parts such as legs before swallowing them (Mizuno and Kojima 2015; Jani 2019).

A different way in which serpents only eat part of their prey occurs in four Central American species of Colubridae, *Leptophis ahaetulla*, *Leptodeira annulata*, *Leptodeira septentrionalis* and *Imantodes inornatus*. These species feed on frog eggs of *Agalychnis callidryas*, which are laid in trees. They tear out chunks of egg clutches as some embryos develop rapidly and hatch early, to escape predation (D'Amato and Warkentin 2006; Warkentin et al. 2007; Caldwell et al. 2009).

Kukri snakes of the genus *Oligodon* are known to be egg-eaters as they slit open soft-shelled squamate eggs, insert the head into the egg and consume the contents (Minton and Anderson 1963; Toriba 1987). The collapsed eggs may be swallowed afterwards. For hard-shelled gecko eggs the same technique can be applied or they can be swallowed whole. In *O. formosanus* females defend nests of the sea turtle *Chelonia mydas* by repelling conspecifics until the turtle eggs hatch or are consumed by slitting the leathery eggshells (Huang et al. 2011). The technique of slitting the egg shell and consuming the contents to some extent resembles the case described here, i.e. cutting a hole into the abdomen of toad and eating the organs. In addition to *Oligodon* spp. preying mainly on live reptiles and amphibians and to a lesser extent mammals and invertebrates, scavenging is also known in *Oligodon arnensis* which has been observed eating a roadkill of *Calotes versicolor* (Pandirkar et al. 2015).

The North American colubrid *Cemophora coccinea* (Eastern Scarlet Snake) has also been observed cutting or piercing reptile eggs, inserting its head and eating the contents (Dickson 1948; Minton and Bechtel 1958).

Use of the enlarged teeth as formidable weaponry has been documented in the above-mentioned study of *O. formosanus* on Orchid Island off Taiwan by Huang et al. (2011). During intraspecific combat bouts severe bites to the tails had been inflicted. Consequently 38% of the females had lost more than 45% of their tails whereas 25% of the males had suffered such losses. Some females had lost almost all of their tails which was, however, not observed in males; they would under such circumstances also have lost their hemipenes.

D. melanostictus produces potent bufotoxins in their parotid glands, containing bufadienolides which are cardiac glycosides, and they may potentially even be lethal to humans (Chern et al. 1991; Keomany et al. 2007; Gao et al. 2010). As *O. fasciolatus* attacked the toads ventrally and penetrated them from the belly in three cases, it could avoid the toxins, although these fluids were to some degree transferred to the snakes during the fighting, and attempts to rub off the substances were made (Fig. 3). But since an entire large juvenile *D. melanostictus* was swallowed in the fourth case, it is an open question whether *O. fasciolatus* has developed resistance to the toxins of this toad. The anticoagulant agent of the snake's gland secretions might have been beneficial for the process potentially lasting up to approx. an hour.

Varanus bengalensis and *V. salvator* are known to prey on *D. melanostictus* which is swallowed whole despite its strong poison and the monitors do not attempt to avoid contact with the parotid glands (Karunarathna et al. 2017; Mahaprom and Kulabtong 2018). Via the process of convergence a group of African and Asian monitor lizards including *V. bengalensis* and *V. salvator* and at least three serpent groups (Natricinae, *Naja* and *Bitis*) from Africa, Asia, Europe and North America have evolved resistance to toads' cardiac glycoside toxins (Ujvari et al. 2015). Many other toad-eating snakes like *Heterodon*, *Xenodon* and *Causus* have also developed such resistance (Mohammadi 2017). According to these studies the genus *Oligodon* is not among them.

Some mammalian and avian predators with good cognitive capabilities have demonstrated similar feeding strategies to those we have recorded in *O. fasciolatus*, i.e., they attack poisonous toads ventrally and others have skinned toads before eating organs or other parts. They are most probably not resistant to bufotoxins. In the USA *Procyon lotor* (Raccoon) has been observed eating *Incilius alvarius* (Colorado River Toad) from the belly, using one forefoot to hold down the toad on its back while the claws of the other forefoot rip open the abdominal cavity as the contents are eaten, and *P. lotor* is also known to be able to kill *Anaxyrus americanus* (American Toad) and subsequently eat the abdomen, viscera and other parts (Wright 1966; Schaaf and Garton 1970). In the USA Olson (1989) reported that *Anaxyrus boreas* (Boreal Toad) was eviscerated by *Corvus corax* (Common Raven) and other parts of the toads were also eaten. In Spain *Lutra lutra* (Eurasian Otter) has been observed slicing and skinning *Bufo spinosus* (Southern Common Toad) while eating some of the contents (Morales et al. 2015). *Buteo buteo* (Common Buzzard) has been recorded skinning and eating *Bufo bufo* (Common European Toad) in Croatia (Jovanović et al. 2011). In Australia one mammal and three birds are known to have adapted to eating non-toxic parts from the underside of the introduced and highly toxic toad *Rhinella marina* (Marine Toad, Cane Toad), even though their natural distributions are restricted to the Old World and *R. marina* has only existed in Australia since 1935: The native water rat species *Hydromys chrysogaster* (Rakali) can remove and eat the heart and liver from the toads whereas the toxic gallbladders are left outside their bodies (Parrott et al. 2019); *Corvus orru* (Torresian Crow) rolls toads on their back and consumes some intestines and the fleshy thighs (Donato and Potts 2004); the two raptors *Milvus migrans* (Black Kite) and *Haliastur sphenurus* (Whistling Kite) use a similar technique of eating only soft parts (tongue) of road killed toads, avoiding the toxic glands (Beckmann and Shine 2011).

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Appendix 1

Figure A1. *Oligodon fasciolatus* managed to slit through the left side of the abdomen of *Duttaphrynus melanostictus* underneath the left front leg. Two liver lobes next to the toad are visible. It took place along the cement wall of a plant nursery and at this moment the toad is dead. Loei, 9 August 2016. Photo WS.

Figure A2. After having retracted its head and organs of the toad, *Oligodon fasciolatus* swallowed a segment of full small intestine (above) and full stomach (below). Loei, 9 August 2016. Photo WS.

Figure A3. *Oligodon fasciolatus* attempted to slit through the right side of the abdomen of *Duttaphrynus melanostictus*. The toad fought and secreted its milky-white toxic fluid from glands on its upper side. Loei, 22 April 2020. Photo WS.

Figure A4. The deceased *Duttaphrynus melanostictus* approx. eight hours after the attacks and feeding of *Oligodon fasciolatus* had been completed. Fat tissue surrounding the lower part of a mass of exposed muscle tissue is visible. Furthermore, muscular tissue is exposed through two scratches on the right front leg. Loei, 22 April 2020. Photo WS.

Figure A5. The finale of the adult *Oligodon fasciolatus* swallowing a large juvenile *Duttaphrynus melanostictus*. Phitsanulok, 5 June 2020. Photo KN.