

Prey items of some amphibians and reptiles in Phu Khieo-Nam Nao Forest Complex, northeastern Thailand

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Manuscript received: 20 July 2020. Revision accepted: 14 August 2020.

Abstract. Thongproh P, Chunskul J, Rongchapho P, Chuaynkern C, Chuaynkern Y, Srisonchai R, Saengsrı C, Aonpıme P, Phochayavanıch R, Kanıshthajata P, Phusaensrı S, Prompalad S, Tongpun S, Arkajag J, Duengkae P. 2020. Prey items of some amphibians and reptiles in Phu Khieo-Nam Nao Forest Complex, Northeastern Thailand. *Biodiversitas* 21: 4124-4130. We reported prey items for two amphibians (*Fejervarya limnocharis* and *Sylvirana nigrovittata*) and three reptiles (*Hebius* sp., *Bungarus candidus* and *Xenopeltis unicolor*) from several areas of Phu Khieo-Nam Nao Forest Complex (northeastern Thailand) based on direct observation method. *Fejervarya limnocharis* (Anura: Dicroglossidae) consumed *Amyntas* sp. (Clitellata: Megascolecidae) in Nam Nao National Park (Phetchabun Province), while *Sylvirana nigrovittata* (Anura: Ranidae) consumed *Megaustenia* sp. (Gastropoda: Ariophantidae) in Phu Long Forest (Chaiyaphum Province). Consumption of snails in *Sylvirana nigrovittata* was documented as the first report on this prey item for the species. In Phu Luang Wildlife Sanctuary (Loei Province), *Hebius* sp. (Serpentes: Colubridae) consumed *Fejervarya limnocharis* while *Bungarus candidus* (Serpentes: Elapidae) consumed *Argyrophis muelleri* (Serpentes: Typhlopidae). *Xenopeltis unicolor* (Serpentes: Xenopeltidae) consumed *Glyphoglossus molossus* (Anura: Microhylidae) in Phu Wiang National Park (Khon Kaen Province).

Keywords: Anuran, snake, Phu Khieo-Nam Nao Forest Complex, prey items

INTRODUCTION

Food is an essential factor for the existence and well-being for all living organisms. Information on dietary patterns is necessary to understand the life history, population fluctuations, impact of habitat modification, and development of conservation strategies for most amphibians (Anderson 1991) and reptiles (Pianka 1986; Brown and Gillooly 2003). To understand their food consumption patterns, there are various methods for examining diet and trophic interaction of amphibians and reptiles, such as direct observation, stomach dissection, stomach flushing, fecal pellets, forced regurgitation, stable isotopes and doubly-labelled water (Luiselli and Amori 2016). Likewise, for amphibians and reptiles, the same methods are shared for studying their prey. Examination of stomach contents is the traditional method to observe amphibian food items from euthanized amphibians, while stomach-flushing (Opatrny 1980; Chacornac and Joly 1985; Joly 1987; Wilson and Larsen 1988; Kuzmin 2000)

and forced regurgitation are used in live amphibians (Kuzmin 2000). Other methods, for example, direct observation and analysis of feces are rarely used (Kuzmin 2000). In Thailand, information on herpetofauna dietary and feeding behavior has been reported from several methods in various groups (see e.g., Chuaynkern and Sarimanon 2009; Chuaynkern et al. 2009; Moonasa et al. 2018; Thongproh et al. 2019). Although the publications on herpetofauna of Thailand seem to be numerous, however, food information for them was reported for less than half of the total number of herpetofauna species reported in Thailand.

Herein, we fill the gap of knowledge about prey items and feeding patterns of amphibians and reptiles from several areas of Phu Khieo-Nam Nao Forest Complex (northeastern Thailand) using direct observation. The prey items and feeding habits of two amphibians (*Fejervarya limnocharis* and *Sylvirana nigrovittata*) and three reptiles (*Hebius* sp., *Bungarus candidus* and *Xenopeltis unicolor*) are photographed and described in detail.

MATERIALS AND METHODS

Phu Khieo-Nam Nao Forest Complex is located in the upper part of northeastern Thailand (Latitude: $15^{\circ}19'18''\text{N}$ - $17^{\circ}33'00''\text{N}$; Longitude: $101^{\circ}16'00''\text{E}$ - $102^{\circ}43'50''\text{E}$) (Division of Information System on Wildlife Conservation 2020). The forest complex covers an area of approximately 7,990.5 km² in six provincial areas of Loei, Phetchabun, Khon Kaen, Chaiyaphum, Nong Bua Lam Phu, and Lop Buri. In this forest complex, there are 13 national parks and seven wildlife sanctuaries. The vegetation types are mixed deciduous forest, dry evergreen forest, dry dipterocarp forest, hill evergreen forest, pine forest, and savanna forest (Department of National Parks, Wildlife and Plant Conservation 2014).

Observations were conducted in four protected areas of the Phu Khieo-Nam Nao Forest Complex (Figure 1), including Nam Nao National Park (Phetchabun Province), Phu Wiang National Park (Khon Kaen Province), Phu Luang Wildlife Sanctuary (Loei Province) and Phu Long Forest (Chaiyaphum Province). Habitats of observation sites in Phu Khieo-Nam Nao Forest Complex are shown in Figure 2. Feedings were photographed using a digital camera or mobile phone. Permission for conducting research was granted by the Department of National Parks, Wildlife and Plant Conservation, Thailand (permit numbers 0907.4/15590 and 0907.4/22080). The research has been reviewed and approved by the Institutional Animal Care and Use Committee of Khon Kaen University, based on the Ethics of Animal Experimentation of National Research Council of Thailand (reference no. 660201.2.11/235).

RESULTS AND DISCUSSION

We observed prey items in two anurans, *Fejervarya limnocharis* (Dicroglossidae) and *Sylvirana nigrovittata* (Ranidae), and three snakes, *Hebius* sp. (Colubridae), *Bungarus candidus* (Elapidae) and *Xenopeltis unicolor* (Xenopeltidae) from several areas of the Phu Khieo-Nam Nao Forest Complex (northeastern Thailand). On 2 September 2019, we observed *Fejervarya limnocharis* swallowing a terrestrial earthworm *Amyntas* sp. (Clitellata: Megascolecidae) (Figure 3A, 5A) in the area of the headquarters of the Nam Nao National Park, Phetchabun Province (Latitude: $16^{\circ}14'19''\text{N}$, Longitude: $101^{\circ}34'27''\text{E}$) at approximately 19:17 h (Figure 3A). While the frog was eating the earthworm, we found the anterior half of the earthworm was swallowed successfully, and we were able to observe movement within the frog's belly. We surmised that the anterior half of the earthworm reached its stomach. Furthermore, it was indicative that the frog did not kill the earthworm before swallowing it. Unfortunately, the earthworm was immediately released after the frog detected our disturbance. The feeding behavior of *Sylvirana nigrovittata* was observed in a small stream in Phu Long Forest, Chaiyaphum Province (Latitude: $16^{\circ}13'50''\text{N}$, Longitude: $102^{\circ}06'6''\text{E}$) on 27 October 2017 at approximately 20:00 h. The frog was eating the whole body of a gastropod, *Megaustenia* sp. (Ariophantidae) (Figure 5B), without spitting out the shell (Figure 3B).

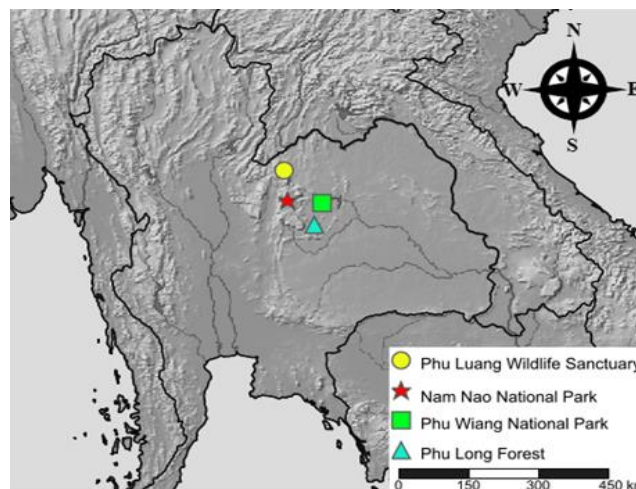


Figure 1. Map showing observational locations within the Phu Khieo-Nam Nao Forest Complex, northeastern Thailand (Created from simplemappr.net).

At Phu Luang Wildlife Sanctuary (Loei Province), the feeding behaviors of two snakes, *Hebius* sp. and *Bungarus candidus*, were observed. *Hebius* sp. was observed swallowing *Fejervarya limnocharis* (field number YC 02678) on the ground adjacent to Huay San Noi Stream (Latitude: $17^{\circ}21'43''\text{N}$, Longitude: $101^{\circ}30'9''\text{E}$) on 9 February 2020 at approximately 19:30 h. The prey (snout-vent length 33.8 mm; head length 11.1 mm) was bitten on its hind limb (Figure 3C). After that, both the snake and frog were caught, and we observed another biting position with a skin tear (5 x 5 mm) on the frog's throat (Figure 4). The feeding behavior of *Bungarus candidus* (Figure 3D) was observed and recorded on video using a mobile phone on 30 August 2019 in front of the headquarters of the Phu Luang Wildlife Research Station (Latitude: $17^{\circ}20'59''\text{N}$, Longitude: $101^{\circ}30'25''\text{E}$) at approximately 14:30 h. The snake was found on the ground during a drizzly, rainy day while it was swallowing a blind snake, *Argyrophis muelleri* (Typhlopidae). This activity occurred during daytime close to the research station building. The *Argyrophis muelleri* tried to strap on *Bungarus candidus* but this could not prevent the attack from the *Bungarus candidus*. The *Bungarus candidus* did not constrict *Argyrophis muelleri*, but it bit the prey at a position behind the skull (neck). When the *Argyrophis muelleri*'s movement slowed down, the *Bungarus candidus* slowly started swallowing *Argyrophis muelleri* from the anterior part of its body. *Bungarus candidus* swallowed the *Argyrophis muelleri* from the anterior part to the tip of its tail by alternating biting and releasing until finishing the job.

At Phu Wiang National Park (Khon Kaen Province), *Xenopeltis unicolor* was observed preying on *Glyphoglossus molossus* (Microhylidae) near the headquarters in collective areas of the timber seized during a crackdown on illegal logging (Latitude: $16^{\circ}40'56''\text{N}$, Longitude: $102^{\circ}14'22''\text{E}$) at approximately 20:15 h. *Xenopeltis unicolor* tightly constricted a juvenile *Glyphoglossus molossus* (Figure 3E, 5C) on the moist

ground near the timbers. Although this snake was disturbed by our observation, its feeding continued. The frog inflated its body, but this ability could not protect it from the snake attack. Approximately 20 minutes after observation, the frog was completely swallowed.

Discussion

Based on stomach content analysis of *Fejervarya limnocharis* inhabiting a palm plantation and secondary forest in Santzepu, Sheishan District, Chiayi County, southern Taiwan, its stomach contents included arachnids (Acarina and Aranea) and insects (Coleoptera, Collembola, Dermaptera, Diptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Orthoptera and Psocoptera) (Norval et al.

2014). Similar to those of *Fejervarya* from three localities on the Andaman archipelago, the diets of *Fejervarya* were comprised of Acari, Aranea, Artgropada, Coleoptera, Siphonaptera, Chilopoda, Diptera, Hymenoptera, Hemiptera, Isoptera, Lepidoptera larva and Orthoptera (Mohanty and Measey 2018). Observation of food items in frog feces from Yoddom Wildlife Sanctuary, Thailand filled the gap of dietary knowledge in *Fejervarya limnocharis* which consisted only of insects, including the Coleoptera (Curculionidae, Elateridae, Scarabaeidae, and Tenebrionidae), Diptera, Hemiptera (Gerridae), Heteroptera, Hymenoptera (Formicidae), Orthoptera and Isoptera (Termitidae) (Thongproh et al. 2019).



Figure 2. Habitats in which feeding of herpetofauna was observed in Phu Khieo-Nam Nao Forest Complex, northeastern Thailand. A. Phu Luang Wildlife Research Station, B. Huay San Noi Stream in Phu Luang Wildlife Sanctuary, C. Headquarters of Phu Wiang National Park, D. Unnamed stream in Phu Long Forest, E. The area nearby the headquarters office of Nam Nao National Park

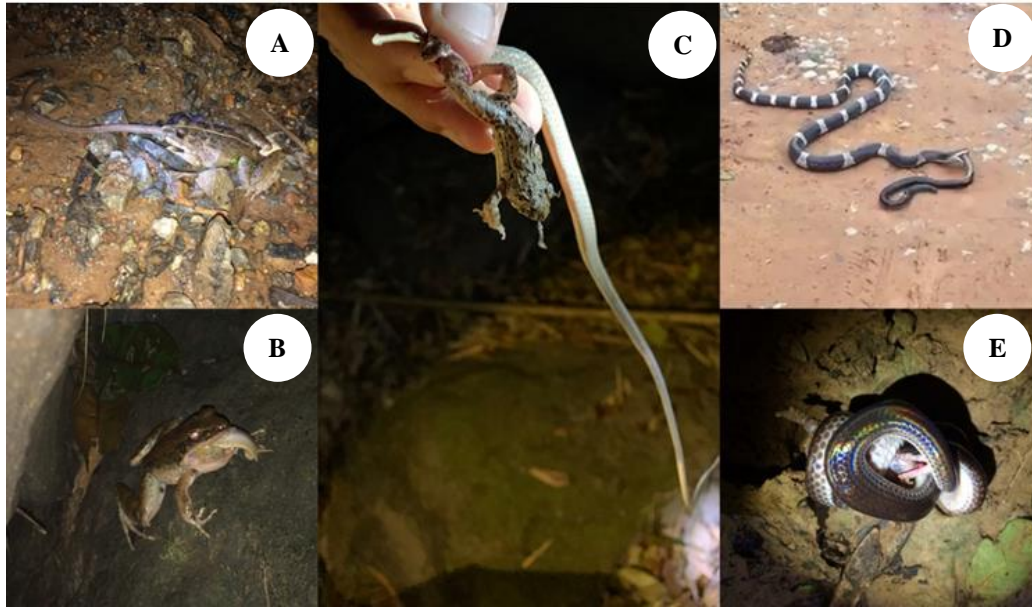


Figure 3. Feeding behavior of herpetofauna in the Phu Khieo-Nam Nao Forest Complex, northeastern Thailand. A. *Fejervarya limnocharis* was swallowing *Amyntas* sp. at an area near the headquarters office of Nam Nao National Park, B. *Sylvirana nigrovittata* was eating *Megaustenia* sp. in an unnamed stream in Phu Long Forest, C. *Hebius* sp. was biting *Fejervarya limnocharis* in Huay San Noi Stream in Phu Luang Wildlife Sanctuary, D. *Bungarus candidus* was eating *Argyrophis muelleri* on the ground in front of Phu Luang Wildlife Research Station, E. *Xenopeltis unicolor* was strapping and swallowing *Glyphoglossus molossus* at an area near the headquarters of Phu Wiang National Park



Figure 4. Specimen of *Fejervarya limnocharis* (field number YC 02678) bitten by *Hebius* sp. A. dorsal view, B. ventral view. In B, the red arrow (above) indicates the wound of snakebite and the black arrow (below) indicates the position of incision to take off piece of liver for DNA analysis. Bar equals 10 mm

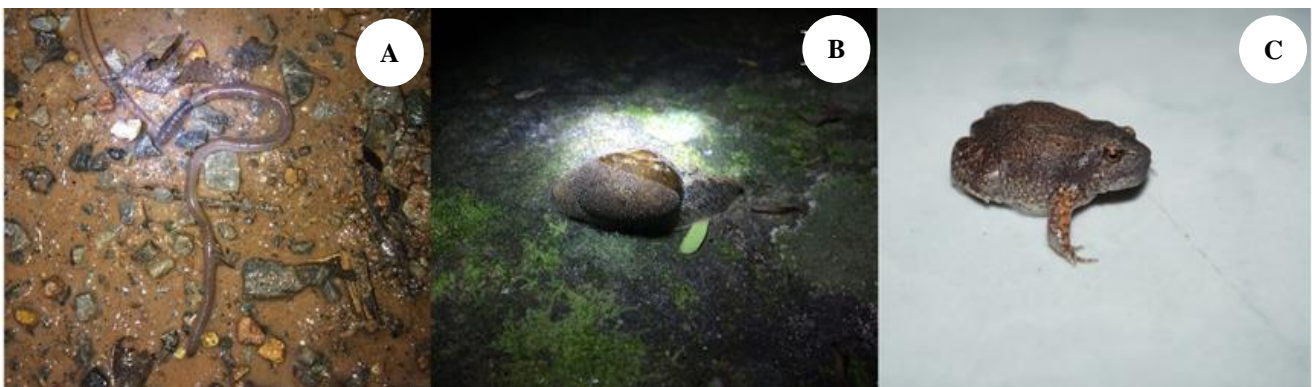


Figure 5. Photographs of some prey of herpetofauna in Phu Khieo-Nam Nao Forest Complex, northeastern Thailand. A. *Amyntas* sp., B. *Megaustenia* sp., C. *Glyphoglossus molossus*

An interesting finding of a prey item of *Fejervarya limnocharis* from forced regurgitation, showed that arthropods were the main food items, and froglets and tadpoles were also found in their stomachs (Hirai and Matsui 2001). Chuang and Borzée (2019) found *Fejervarya limnocharis* feeding on a smaller anuran (*Buergeria otai*) in Tainan County, Taiwan, and the smaller frog was released by this observational disturbance. This is similar to our study in which *Fejervarya limnocharis* detected the disturbance from us. The frog released its prey, and thus the prey escaped from the predator. In addition, Mohanty and Measey (2018) reported that *Fejervarya* selected evasive prey which was suggesting that this species is an ambush predator ('sit and wait').

Our work documented the first report of snail-eating (with shell) in *Sylvirana nigrovittata*. Mollusks were known to be consumed by several species of amphibians and reptiles. Drewes and Roth (1981) analyzed gut contents of two species of frogs in the family Hyperolidae (*Paracassina kounhiensis* and *Paracassina obscura*) found in the herpetological collections of the British Museum (Natural History), National Museum of Kenya, Field Museum of Natural History and California Academic of Sciences. They found snail tissue, subulinid snails, urocyclid snails, urocyclid slugs, and shell fragments in *Paracassina kounhiensis*. In *Paracassina obscura*, they found only snail tissue and succineid snails. Furthermore, Drewes and Roth (1981) explained that both species of frogs could eat whole mollusks without removing soft parts from the shells. The snake, *Pareas carinatus* (Pareidae), swallowed soft body parts of snails and then dropped out the shell (Danaisawadi et al. 2016). Based on fecal pellets analysis, the main food of *Sylvirana nigrovittata* is Coleoptera. Furthermore, about 50% of *Sylvirana nigrovittata* food items overlap with *Rhacophorus bipunctatus* (Rhacophoridae) (Ponpituk et al. 2015). However, *Rhacophorus bipunctatus* was not included in an updated amphibian species list of Thailand (Niyomwan et al. 2019), *Rhacophorus bipunctatus* in Ponpituk et al. (2015) should now be *Rhacophorus rhodopus*. In a closely related species, fecal pellets of *Sylvirana mortenseni* in Yoddom Wildlife Sanctuary (Ubon Ratchathani, northeastern Thailand) were recorded (Thongproh et al. 2019). The fecal pellets of *Sylvirana mortenseni* were also composed of Coleoptera (Chrysomelidae, Scarabaeidae), Diptera, Hemiptera (Gerridae), Hymenoptera (Formicidae) and Orthoptera (Acrididae). Thongproh et al. (2019) further reported cannibalism in the species by observing an adult frog eating a juvenile.

The snakes of genus *Amphiesma* and *Hebius* present similar morphology. Some species of *Amphiesma* were referred to *Hebius* (Guo et al. 2014). The snakes of genus *Amphiesma* (Colubridae) are known to be predators. Based on regurgitation of 117 individuals of *Amphiesma stolatum* (Baruah et al. 2001), its main food items are anurans (53.2% of Ranidae, 12.7% of Bufonidae, 7.5% of Microhylidae). The snake preys are *Hoplobatrachus tigerinus*, *Hylarana taipehensis*, *Fejervarya limnocharis*, *Microhyla ornata*, *Duttaphrynus melanostictus* and

Euphlyctis cyanophlyctis. However, *Amphiesma stolatum* also ate reptiles (6.0% of Gekkonidae, 1.0% of Scincidae, 1.7% of Typhlopidae) and miscellaneous (6.8% of insects and roughages). In Sri Lanka, *Amphiesma stolatum* also consumed *Sphaerotheca breviceps* (Dicroglossidae) (Dissanayake and Wellappuliarachchi 2016). However, *Amphiesma* species also acts as prey in the ecological food web. *Amphiesma stolatum* was eaten by *Melanocheilus tricarinata* (Geoemydidae) (Das and Kumar 2014) and *Amphiesma sauteri* was eaten by *Trimeresurus stejnegeri* (Viperidae) (Murphy and Belanger 2014). Ostroshabov et al. (2016) observed an adult female *Hebius leucomystax* eating eggs of *Polypedates megacephalus* from Vietnam. The snake dipped its head into foam nest (length = 14 cm, width = 8 cm) and ate the contents. Nest foam was identified by adults and tadpoles of *Polypedates megacephalus* nearby nest site. *Hebius ishigakiensis* is an endemic species restricted in Ishigaki Island and Iriomote Island, Ryukyu Archipelago, Japan. This species is known to be amphibian specialist predator and it was reported to consume eggs and foam nest of *Rhacophorus owstoni* (Takeuchi 2018). Moreover, *Hebius beddomei* (previously *Amphiesma beddomei*), was reported to consume *Nyctibatrachus jog* (Nyctibatrachidae) in Kathalekan, Uttara Kannada, Karnataka, India (Shamanna et al. 2016).

Bungarus candidus is known to predate on other snakes. Mohammadi et al. (2014) speculated that *Bungarus candidus* hunted typhlops. Our work confirmed their suspicion in detail. Moreover, *Bungarus candidus* can consume *Coelognathus radiatus* (Kuch and Zug 2004). In captivity, *Bungarus candidus* accepted feeding on a variety of food items such as *Monopterus albus* (synbranchid eel), rodents (Kuch 2001; Kuch and Zug 2004), fish, chickens and homemade sausages (Kuch and Schneyer 1991; Chanhome et al. 2001). In another case from Nakhon Ratchasima Province (northeastern Thailand), a dead *Bungarus candidus* was found in a fishing trap that was set in a canal (Crane et al. 2016). The snake may have been searching for food near or in the water. When the snake detected some prey (maybe fish or homalopsid snakes) in the fishing trap, the snake then wiggled and swam to attack its prey. *Bungarus candidus* normally is nocturnal (Knierim et al. 2018). Our work added another piece of information, that the snake also is active during the daytime. *Bungarus candidus* preyed during a rainy, drizzly day which is similar to observations made by Knierim et al. (2018) in that the snake had daytime movement at 14:37 h beneath rocks during an ambient temperature of 27.1 °C and light rain. As above, members of snakes in genus *Bungarus* are not specialists in eating Ophiophagus animals. Although some species were reported to consume a variety of snakes such as *Bungarus fasciatus* (Daniel 2002; Vinh and Nghia 2018) or *Bungarus candidus* as mentioned above. The gut content analysis of 35 stomachs of *Bungarus caeruleus* revealed that the snakes consumed frogs, snakes, birds, and mammals (Pandey et al. 2020). At Umphang Wildlife Sanctuary (Tak Province, western Thailand), *Bungarus fasciatus* was observed swallowing *Xenochrophis* sp. near a pond rim (Y. Chuaynkern, pers. obs.). Moreover, two

captive *Bungarus candidus* collected from their natural habitat in Chanthaburi Province (southeastern Thailand) were released in the same box. After the release, the larger snake attacked the smaller one immediately. The snakes bit each other during a fight, after which the larger snake swallowed the smaller one completely. However, the bigger snake died on the next day which may have been caused by the venom from the smaller snake (Y. Chuaynkern, per. obs.). Therefore, our understanding of prey types of *Bungarus* snakes is not complete and requires further study to fill the gap of knowledge about the dietary patterns of these snakes.

Xenopeltis unicolor is known as a nocturnal snake that consumes anurans, reptiles, and small mammals (Das 2013; Chan-ard et al. 2015). Previous research reported insights into the diets of *Xenopeltis unicolor* including of *Kaloula pulchra* (Microhylidae) (Milto 2014; Gilbert and Goodyear 2019), *Polypedates leucomystax* (Rhacophoridae) (Aslam 2019), *Sphenomorphus* sp. (Scincidae) (Martins and Rosa 2012), *Hypsiscopus plumbea* (Homalopsidae) (Vinh and Tung 2018). Our work provides insight for another prey item, *Glyphoglossus molossus* for *Xenopeltis unicolor*. *Xenopeltis unicolor* selected and ate smaller prey. This is similar to findings of previous work, but larger prey is selected as well. For larger prey, *Xenopeltis unicolor* will coil and constrict the prey until it is dead, but due to the skull structure of *Xenopeltis unicolor*, it is unable to allow swallow relatively large prey items (Cox 1993). Vinh and Tung (2018) found the plumbeous water snake *Hypsiscopus plumbea* was eaten by *Xenopeltis unicolor* at the Hin Nam No National Protected Area, Khammouane Province, Lao PDR, and *Xenopeltis unicolor* still strapped its prey when it was interrupted by human appearance. Whereas Milto (2014) found *Kaloula pulchra* was coiled by *Xenopeltis unicolor* at Phi Phi Don Island, Andaman Sea, Thailand, and the snake released the live frog after it was captured. In contrast to our observation, the feeding of *Xenopeltis unicolor* continued, even though it was disturbed.

ACKNOWLEDGEMENTS

The authors would like to thank the staff members from all areas in this study. We thank Warisa Nampochai, Pannita Wongcha, Nipaporn Chaiyasit, Tiwat Thanwiset and Sumart Onlamay for kind assistance during field surveys. We appreciated all the beneficial suggestions from Assoc. Prof. Chutima Hanjavanit. We would like to thank the Department of National Parks, Wildlife and Plant Conservation for permission to access protected areas. This research was partially supported by (i) the research fund for supporting lecturers to admit high potential students to study and conduct research on his expert program year 2019 for Prapaiporn Thongproh and Asst. Prof. Chantip Chuaynkern; (ii) the research capability enhancement program through graduate student scholarships, Faculty of Science, Khon Kaen University for Jidapa Chunksul and Asst. Prof. Yodchaiy Chuaynkern; and (iii) the Faculty of

Science Research Grant 2019-2020 for Asst. Prof. Chantip Chuaynkern.

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