Observations and Comments on the Diet of the Many-banded Krait (*Bungarus multicinctus multicinctus*) in Taiwan

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The Many-banded Krait (*Bungarus multicinctus multicinctus*; Fig. 1) occurs naturally in Burma, the Indo-Chinese Peninsula, southern China, Hainan, Hong Kong, and Taiwan (U.S. Department of the Navy 1991, Zhao and Adler 1993). We found a dead-on-road (DOR) male on 2 November 2007 on the Northern Cross Road (Route No. 7) close to Minchi (elevation 1,021 m; TWD 97, N 24.614164°, E 121.482272°), Yilan County, northern Taiwan. Snout-vent length (SVL in mm), tail-length (TL in mm), and body mass (BM in g) were 740 mm, 100 mm, and 98.9 g (excluding stomach contents), respectively. We immediately noticed that an undigested snake's tail and the krait's own heart were protruding from the damaged part of the upper throat region (Fig. 2). Dissection revealed two ophidian prey items in the digestive tract, a juvenile male Mountain Wolf Snake (*Lycodon ruhstrati ruhstrati*; SVL 260 mm, TL 82 mm, BM 6 g) and an adult female Mountain Keelback (*Pseudoxenodon stejnegeri stejnegeri*; SVL 490 mm, TL 88 mm, BM 41.1 g). The anteriormost portions of both prey items were partly digested, which indicated they had been ingested in headfirst positions (Fig. 3).

Lue et al. (2002) suggested that the coloration of *L. r. ruhstrati* is a form of Batesian mimicry, causing it to resemble *B. m. multicinctus*, although these two species differ in their defensive behavior (Norcal [*sic*] and Mao 2006). Mao (1970) reported cannibalism in *B. m. multicinctus* in Taiwan. Therefore, the krait-resembling coloration of *L. r. ruhstrati* may provide a degree of protection in most predator encounters, but not against predation by *B. m. multicinctus*.

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Fig. 1. The Many-banded Krait (*Bungarus multicinctus multicinctus*) in Taiwan occurs in a variety of habitats, many of which (e.g., low grassy areas, rice paddies, irrigation ditches) are associated with water.

Pseudoxenodon s. stejnegeri occurs mainly in mountainous regions at elevations of about 1,000 m above sea level, but *B. m. multicinctus* usually occurs at lower elevations. Pope (1935) reported *B. m. multicinctus* at 700 m in Kuatun, mainland China, and assumed that that was the species' maximum elevational distribution. Kuntz (1963) stated that they occur primarily at low elevations (below 600 m) in Taiwan, and Lue et al. (2002) surmised that this snake species occurs mainly at altitudes below 500 m, and that they only rarely can be found at 500–1,000 m. Our observation, however, can not conclusively prove that *B. m. multicinctus* occurs naturally in Minchi, because some snakes, especially the Chinese Cobra (*Naja atra*), Many-banded Krait, and Oriental Ratsnake (*Ptyas mucosa*) are released by certain religious groups along Route No. 7, especially between Sze-lan and Minchi (Mao, pers. obs.; Yo and Wong 2007). However, our observation does show that snakes can be exploited by *B. m. multicinctus* in mountainous areas.

Kuntz (1963) indicated that *B. m. multicinctus* in Taiwan occurs in a variety of habitats (e.g., lowland wooded areas, bamboo thickets, grassy areas associated with water, rice paddies, irrigation ditches), whereas Mao (1970) simply stated that *B. m. multicinctus* prefers habitats near water. Many-banded Kraits reportedly feed primarily on loaches, frogs, skinks, snakes, and mice (Mao 1993, Zhao et al. 1998). Slowinski (1994) noted that, compared to the other kraits in the genus *Bungarus* (e.g., *B. ceylonicus*, *B. fasciatus*, and *B. caeruleus*), *B. m. multicinctus* appears to be more piscivorous (63.16%) than ophiophagous (34.21%). This conclusion was based on the results of Mao (1970), who also reported that larger individuals tend to be more ophiophagous than smaller ones, and that prey correlated closely with habitat, although he failed to provide habitat descriptions, and listed only Taoyuan County as a collection site. Lin et al. (1995), on the other hand, reported *B. m. multicinctus* to be more ophiophagous, and attributed piscivory to ontogenetic changes in diet or to low-elevation wetland pollution and/or habitat destruction for industrial and community development. Based on the prey items reported and the collection site description in Mao (1970), we determined that all prey types described were species restricted to low-elevation rice paddies, ponds, and adjacent areas. Our conclusion is further supported by descriptions of the dominant land utilization of the Taoyuan area at that time (Yang 1994), which were ideal for wetland fauna and flora. The report of Lin (1995), in contrast, was based on specimens collected by road sampling, especially in mountainous areas. We thus concluded that the apparently contradictory dietary preferences reported by Mao (1970) and Lin (1995) may merely reflect sampling of different habitats, leading to the question whether habitat heterogeneity could account for unusual prey exploitation by *B. m. multicinctus*.


JEAN-JAY MAO

Fig. 3. From left to right: The road-killed *Bungarus multicinctus multicinctus* and its prey: *Lycodon ruhstrati ruhstrati* and *Pseudoxenodon stejnegeri stejnegeri*. Note the partly digested head regions of the snakes that were consumed.

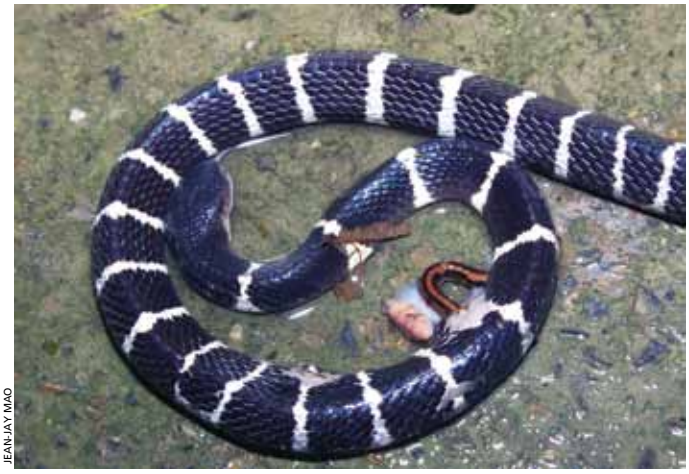
JEAN-JAY MAO

Fig. 2. The road-killed Many-banded Krait, with its heart and the tail of a *Pseudoxenodon stejnegeri stejnegeri* protruding from the damaged section of its body.

In 1997–2009, we conducted ecological studies on snakes in wetland (e.g., rice paddies, drainage ditches, ponds, streams, etc.) and non-wetland

Table 1. Prey of Many-banded Kraits (*Bungarus multicinctus multicinctus*) collected from wetland (e.g., ponds and rice paddies) and non-wetland (e.g., secondary forests and dry cultivated areas) habitats in Taiwan. An asterisk (*) indicates that a species occurs in both habitat types, but, in this case, it was recorded from a Betel Nut Palm plantation, which is classified as dry cultivated land. References: [1]this study; [2]Mao 1970; [3]Day et al. 1994; [4]Lin et al. 1995; [5]Mao et al. 2006; [6]Lin 2008; [7]Mao, unpubl. data; [8]Norval, unpubl. data; [9]Ji-Shou Yang, pers comm.

	Wetlands	Non-wetlands
Snakes	*Enhydris plumbea* (n = 9)[2]	*Ramphotyphlops braminus* (n = 1)[4]
	Bungarus m. multicinctus (n = 1)[2]	*Amphiesma stolatum** (n = 1)[7]
	Xenochrophis piscator (n = 3)[7]	*Cyclophiops major* (n = 2)[3,7]
		Orthriophis taeniura friesei (n = 1)[8]
		Lycodon r. ruhstrati (n = 1)[1]
		Pseudoxenodon s. stejnegeri (n = 1)[1]
		Protobothrops mucrosquamatus (n = 1)[5]
		Viridovipera s. stejnegeri (n = 2)[7, 9]
Lizards	*Plestiodon chinensis formosensis* (n = 1)[2]	*Plestiodon elegans* (n = 2)[4]
	Eutropis multifasciata (n = 1)[6]	*Sphenomorphus indicus* (n = 1)[4]
Fish	*Misgurnus anguillicaudatus* (n = 10)[2]	
	Fulta alba (n = 14)[2]	

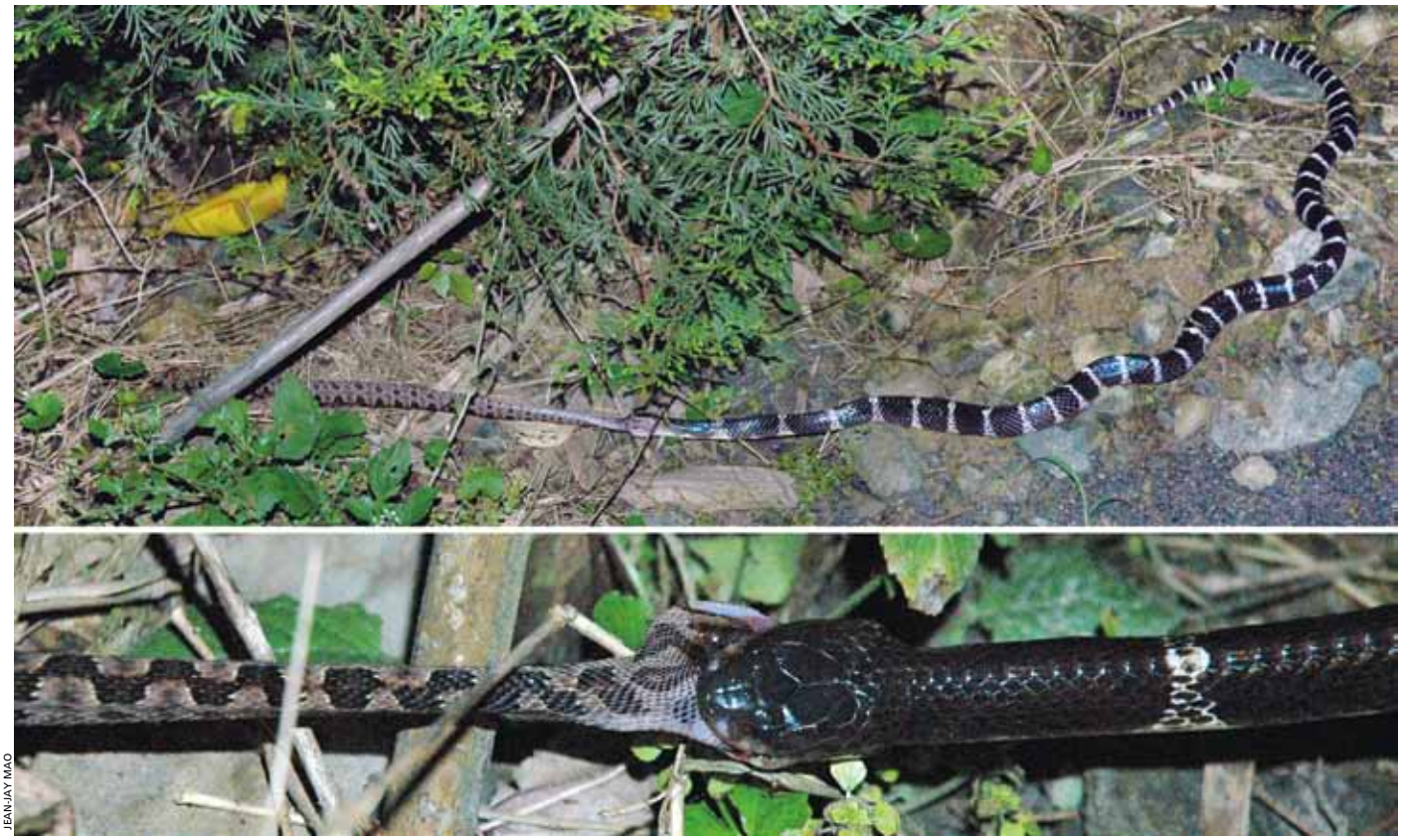

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Fig. 4. A Many-banded Krait catching and consuming a Taiwan Habu (*Protobothrops mucrosquamatus*).

areas (e.g., dry cultivated lands, betel nut palm plantations, mountainous and foothill secondary forests, bamboo thickets, etc.) of Taiwan. Apart from chance encounters, we also made use of traps to collect snakes. In wetland habitats, we employed floating funnel traps, baited with loaches to collect semi-aquatic snakes, and, except for these water snakes (i.e., Chinese Water Snake, *Enhydris chinensis*; Plumbeous Water Snake, *E. plumbea*; Ringed Water Snake, *Sinonatrix annularis*; Olive Keelback, *S. percarinata suriki*; and Chequered Keelback, *Xenochrophis piscator*), *B. m. multicinctus* was the most frequently collected species and always ate all of the bait in the trap. A short drift-fence/funnel-trap unit was utilized in non-wetland areas. Again, some *B. m. multicinctus* were collected, although the nearest permanent water sources (e.g., stream, wetland, pond, etc.) were as far as 1 km away. We compared the prey items of all *B. m. multicinctus* encountered in these habitats and those recorded in the literature (Table 1).

Except for species such as the Five-lined Blue-tailed Skink (*Plestiodon elegans*), Indian Forest Skink (*Sphenomorphus indicus*), Chinese Green Snake (*Cyclophiops major*), *L. r. ruhstrati, P. s. stejnegeri*, and Chinese Green Treeviper (*Viridovipera stejnegeri stejnegeri*), which occur to moderate elevations (~1,000 m) in Taiwan, most of the reptilian prey of *B. m. multicinctus* are species that occur in the lowlands (Lue et al. 2002). We also found that *B. m. multicinctus* from wetland habitats prey more frequently on loaches, eels, and semi-aquatic snakes in that order of frequency, whereas *B. m. multicinctus* from non-wetland or mountainous forest habitats prey primarily on terrestrial or semi-arboreal snakes (e.g., *C. major*; *V. s. stejnegeri*; Taiwan Habu, *Protobothrops mucrosquamatus*, Fig. 4) and terrestrial skinks (e.g., *P. elegans, S. indicus*).

Pope (1935) reported predation on mice and frogs by *B. m. multicinctus*, but neither of these prey types were recorded from *B. m. multicinctus* in nature. Consumption of mice and frogs appears to be based on observations under captive conditions; at best, they are rare dietary items of *B. m. multicinctus*, despite references to the contrary (e.g., Maki, 1935). Under captive conditions, we have observed that a few *B. m. multicinctus* accept newborn mice as prey, which suggests individual variation in accepting various prey. As for frogs, even though Maki (1935), Kuntz (1963), and Mao (1970, 1993) listed frogs as prey items of *B. m. multicinctus*, we were unable to confirm that possibility. While working at the Wildlife Animal Shelter, National Pingtung University of Science and Technology in 2001, the first author never observed *B. m. multicinctus* attempting to prey on two sympatric wetland frogs (Cricket Frog, *Fejervarya limnocharis* and Taiwanese Frog, *Hoplobatrachus rugulosus*) that were offered as food. Frogs recorded in stomach contents of *B. m. multicinctus* might have been prey of other snakes, such as the Buff-striped Keelback (*Amphiesma stolatum*), *E. plumbea*, or *X. piscator*, which had been eaten by kraits. However, regardless of prey type (snakes, loaches, eels, or skinks), all share one feature — a cylindrical body shape. This would indicate that *B. m. multicinctus* exhibits a preference for cylindrical prey items, as do some sea snakes (e.g., Voris and Voris 1983).

In conclusion, prey availability in different habitat types appears to be reflected in the diet of *B. m. multicinctus*, with only cylindrical body shape as a common denominator. Consequently, studies describing prey taken by kraits should consider the type of habitat from which the animals in question were taken.

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Blocked-flight Aggressive Behavior in Snakes

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Every naturalist accumulates field observations and experiences worthy of expanding into full-blown research projects. More often than not, however, the information languishes undeveloped in memory, paper piles, and these days, computer files. Some interesting observations on snake behavior I have made over the years are among my many unfinished projects.

Experienced naturalists know that most snakes flee when encountered in nature. More sedentary, slow-moving, or cryptic snakes will remain still or coiled in order to go unnoticed. Rattlesnakes, when disturbed, coil and rattle. After a while, they also may move away from the intruder, perhaps continuing to rattle as they break out of their coil and flee. A few snakes, however, do something different.

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Fig. 1. A Cottonmouth (*Agkistrodon piscivorus*) "chasing" the author while engaged in aggressive behavior during blocked flight with head raised, striking, flattening its body, vibrating its tail, and moving directly toward the author. This snake did not follow the author when he stepped aside, but raced to safety into the water beyond.

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Fig. 2. A Cottonmouth mouth-gaping as it crawls toward the author.