NOTES ON THE DIET OF THE MALAYAN KRAIT, *BUNGARUS CANDIDUS* (LINNAEUS, 1758)

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ABSTRACT. – The genus *Bungarus* comprises medically important venomous snakes of the Oriental region, which have predominantly nocturnal and snake-eating habits. Faecal samples of two adult specimens of the Malayan Krait (*Bungarus candidus*) from northwestern Java were found to contain hair and incisors of adult, mouse-size rodents. This record is the first to provide evidence that rodents are part of the prey spectrum of wild *B. candidus*. The Malayan Krait is frequently found in rice fields and other agricultural areas, and its potential contribution to the natural control of rodent populations is discussed. In feeding experiments with recently collected Malayan Kraits, synbranchid eels (*Monopterus albus*) were also eaten. Captive *B. candidus* are known to thrive on a diet of small rats and mice.

THE genus *Bungarus* Daudin, 1803 comprises about 13 species of dangerously venomous snakes (Golay, 1985; Golay et al., 1993). Several of these have a wide distribution in south and southeast Asia, and some contribute significantly to the problem of regional snakebite morbidity and mortality (Warrell et al., 1983; Sawai et al., 1984; Hati et al., 1988). *Bungarus* species, generally known as kraits, are terrestrial and largely nocturnal snakes. Numerous observations made on wild and captive specimens of kraits have suggested that these animals prey exclusively on other snakes (see Kuch & Schneyer 1991, 1992, 1993, 1996 for reviews). However, analysis of published prey records and stomach contents reveals that there is a significant proportion of other food in the prey spectrum of the krait species for which data are available (Mao, 1970; Slowinski, 1994; Kuch, 1998). In addition, there are apparent differences between species as to the extent of non-snake prey (Slowinski, 1994). Species differences in the degree to which rodent prey are accepted were also observed in captive specimens of four *Bungarus* species (Kuch & Schneyer, 1996).

The Malayan Krait, *B. candidus* (Linnaeus, 1758), is widely distributed in mainland southeast Asia, peninsular Malaysia, Sumatra, Java, and Bali. It has also been collected in Sulawesi. *Bungarus candidus* is reported to prefer snakes, especially fresh-water snakes, as prey (Van Hoesel, 1959). Lim (cit. *fide* Tweedie, 1983) found skinks of the genus *Mabuya* in the stomachs of two *Bungarus candidus*, and Slowinski (1994a) found three tail fragments of an unidentified skink in a *B. candidus* of 105 cm total length. Schäfer & Grossmann (2000) report on a field observation of an adult *B. candidus* swallowing a caecilian (*Ichthyophis* sp.). The Malayan Krait is said to also feed on 'toads, lizards and small mammals' (De Rooij, 1917), however, this appears not to have been substantiated with data from wild specimens. A photograph showing a *B. candidus* in the process of swallowing a tree snake (*Ahaetulla prasina*) is contained in Van Hoesel (1959), but likely to have been taken in captivity, where the species is known to thrive on a diet of laboratory mice and rats (Kuch & Schneyer, 1991). In this communication I report on the prey items of two wild *B. candidus*, as suggested by undigested prey remains in faecal samples, and on a feeding experiment using potential natural prey and recently-collected Malayan Kraits.

Adult *Bungarus candidus* with head hidden beneath body coils in typical defensive posture. Photograph by Peter Stafford.

Captive adult male *B. candidus* (120 cm total length) feeding. Photograph by author.

MATERIALS AND METHODS

Live adult *B. candidus* were obtained from local snake dealers in West Java province, Indonesia. The snakes had been collected in rice fields, sugar cane plantations, and unspecified habitat in the vicinity of villages. While some snakes appeared to have been captive for a prolonged period as suggested by the relatively high degree of dehydration and malnutrition, others had obviously been collected very recently. All kraits were sexed by probing, marked by ventral scale clipping (following the technique proposed by Brown & Parker [1976]), and housed individually in plastic boxes. The boxes were kept in the shade and subjected to the local climate and daylight cycle of the Depok area, West Java. Initially a 1-2 cm water level was maintained in the boxes to allow for continuous transcutaneous water intake, and to facilitate defecation. After one or two days, newspaper sheets were used as substrate and shelter, and water was provided *ad libitum* in small plastic water containers. Faecal samples were collected and preserved in 70 % ethanol, and examined macroscopically and microscopically.

For feeding experiments, live synbranchid eels (*Monopterus albus*) of 25-40 cm total length and 1.5-2 cm body diameter were obtained from local markets. Water was added to the boxes with the snakes to achieve a 1-2 cm level, and then one *Monopterus* was put into each box in the early afternoon. Observation was continued for two hours, and the boxes were again controlled on the next morning.

RESULTS

On 10 January 1998, two of the apparently recently collected *B. candidus* defecated while partly submerged in the water, and prey remains were found. Both snakes (field numbers UK-B13 and B44) were healthy adult males measuring approximately 110 cm in total length. UK-B13 had a body mass of 525 g. The suspended faeces of both UK-B13 and B44 contained a high amount of dark mammalian hair. Additionally, the sample from UK-B44 contained three only partly digested incisors of a rodent. The overall evidence indicates that the two snakes had recently preyed upon adult rodents of mouse-size. No prey remains were detected in the faecal samples of more than 50 other specimens of *B. candidus* and *B. fasciatus.*

Feeding experiments with *M. albus* (known in Bahasa Indonesia as ikan belut) were carried out on 5 March 1998 (using 17 *B. candidus* of both sexes) and 6/7 March 1998 (using twelve *B. candidus* not before tested). On both dates, many kraits showed a decided interest in these fishes as demonstrated by close inspection and increased tongue-flicking. This was however not

correlated with successful predation or observed predation attempts. On 5 March, two *B. candidus* (one of them UK-B13) swallowed the offered swamp eel within the first two hours of observation (13:00-15:00 hr). On the following morning, four more *B. candidus* were found to have consumed this food. Eleven additional Malayan Kraits had refused to feed on the *Monopterus*. In the morning of 7 March, three *B. candidus* had fed while nine had not. Both the group that had accepted *M. albus* as food and the specimens which refused to feed on the swamp eels comprised kraits of both sexes, with body masses ranging from 200-400 g in the females and 300-550 g in the males. Digestion of the fish was uneventful in seven of the nine Java Kraits, however, two males regurgitated their apparently too large prey on 11 March 1998.

DISCUSSION

Although the hypothesis cannot be refuted in principle that the two kraits which had remains of rodents in their faeces had swallowed other snakes, which in turn had contained rodents, I consider this scenario extremely unlikely. Snakes which contain prey tend to be rarely encountered at least by herpetologists (see Lim, 1956; Mao, 1970), and no reptile scales, teeth, or bones were observed in either faecal sample, whereas the quantity of undigested hair and incisors was high. In addition, any snake capable of swallowing an adult mouse, and with such a prey in the stomach, would very likely be too big and bulky to be swallowed and digested by the two kraits in question. No water or food had been offered to the kraits by the local snake dealers where the animals had been kept in rodent-proof facilities. This excludes the possibility of the prey having been ingested in captivity where, in fact, several specimens of *B. candidus* have been maintained successfully on a diet of live or dead rodents (Kuch & Schneyer, 1991). Food intake in these snakes is frequent and the number of prey ingested high. Digestion is generally complete, i.e., no undigested hair, bones or teeth are found in the faeces. Regular shedding of the skin, increase in total length and body mass, and normal behaviour indicate that rodents of manageable size are an adequate diet for adult *B. candidus*, and that their long-term survival (nine to more than 13 years) on an exclusive rodent diet is possible at least under laboratory conditions. Similar observations have been made in three other *Bungarus* species (Kuch & Schneyer, 1991, 1992, 1993, and unpubl. data).

The observed spontaneous acceptance of synbranchid eels as prey is not surprising as these animals occur in virtually the same habitats frequented by *B. candidus*, and are also nocturnal. Consequently, *B. candidus* is often best known to those who collect *M. albus* at night, and neurotoxic envenomation from snakebite is an occupational hazard for these people. Synbranchid eels are an elongate, heavy-bodied prey type that would seem very suitable for those krait species which inhabit rice fields or live in close proximity of similar water bodies. In Taiwan, *M. albus* was shown to be a major part of the diet of the Many-banded Krait, when swamp eels were found in the stomachs of 14 out of 36 *Bungarus m. multicinctus* which had contained food (Mao, 1970).

The observed large number of Malayan Kraits that refused the swamp eel in the experiment may be explained by two reasons. On the one hand, kraits are highly susceptible to stress due to capture, inadequate housing, transport, and prolonged contact with conspecifics. Recently collected kraits will therefore often refuse to eat for a long time, even if apparently suitable food is offered (Petzold, 1976). On the other hand, kraits which are seriously dehydrated, malnourished and otherwise in poor condition, will also frequently refuse any prey. In the studied series of *B. candidus*, there was a strong tendency of specimens in poor condition not to eat the swamp eel. This had also been observed in a different series of captive Malayan Kraits in which the best nourished and healthiest looking specimens accepted rodent prey spontaneously or after a very short period of time, while malnourished and ill specimens ate only snakes, if at all (unpubl. data).

In Java, *B. candidus* and *B. fasciatus* are known to be able to cope with disturbed habitats like rice fields and other plantations and gardens. However, their actual prey spectrum in these areas, and their possible impact on rodent populations, has not been studied so far. Rats and moles are a major pest in the rice-producing regions of Java. These rodents are believed to cause a 6 % annual waste between rice harvest and consumption (Whitten et al., 1996), and they damage the structure of the rice fields by digging holes in the dams. Directing research to the natural control of rodent populations would therefore appear to be an important means of increasing rice production (Whitten et al., 1996). In this context it would be useful to assess the diversity of snake species in this habitat type, and their relative contribution to rodent control. The present communication demonstrates how little is actually known about the natural history of most Oriental snakes, and that even species with a reputation of being strictly ophiophagous might turn out to play a significant role in the natural control of rodents. Regardless of the limited database, countries such as Thailand have acknowledged the importance of effective rodent control by introducing programmes to educate farmers about the advantages of protecting snakes and other predators (Hodges, 1993). This is unheard of in Indonesia, where farmers are encouraged to pay for rodenticides which they can ill afford and which are at best only partially effective (Hodges, 1993).

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