TRANSACTIONS OF THE ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (1992) 86, 100-106

A national hospital-based survey of snakes responsible for bites in Thailand

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Abstract

Snakes which had been killed and brought to hospital with the patients they had bitten were collected in 80 district and provincial hospitals throughout 67 provinces in Thailand in order to establish the geographical distribution and relative medical importance of the venomous species. Of the 1631 snakes collected, 1145 were venomous: Malayan pit vipers (*Calloselasma rhodostoma*), green pit vipers (*Trimeresurus albolabris*) and Russell's vipers (*Daboia russelii*) were the most numerous, while *T. albolabris*, *C. rhodostoma* and spitting cobras ('*Naja atra*') were the most widely distributed. In 22 cases, non-venomous species were mistaken for venomous ones and antivenom was used unnecessarily. The Malayan krait (*Bungarus candidus*) was confused with *B. fasciatus* in 5 cases and *B. fasciatus* antivenom was used inappropriately. The study extended the known ranges of most of the medically-important venomous species in Thailand. Correct identification of venomous snakes is especially important in Thailand because the locally-produced antivenoms are monospecific. The technique of hospital-based collection, labelling and preservation of dead snakes brought by bitten patients is recommended when rapid assessment of a country's medically important herpetofauna is required.

Introduction

Snake bite is an important medical problem in Thailand. In the 1940s more than 200 deaths were reported each year (SWAROOP & GRAB, 1954), but this figure declined to 80 a year in the 1960s (TRISHNANANDA, 1979) and to less than 20 a year in the 1980s (DIVISION OF EPIDEMIOLOGY, 1982–1990). The Queen Saovabha Memorial Institute (Thai Red Cross Society) has produced antivenoms since the 1920s (PURANANANDA, 1956). Monospecific antivenoms are manufactured for treatment of bites by the 6 terrestrial snakes originally considered to be the most important: *Naja kaouthia* (common (monocellate) cobra), *Ophiophagus hannah* (king cobra), *Bungarus fasciatus* (banded krait), *Calloselasma rhodostoma* (formerly *Ancistrodon* or *Agkistrodon rhodostoma*) (Malayan pit viper), *Daboia russelii siamensis* (formerly *Vipera russelli* (Russell's viper), and *Trimeresurus* species (green pit viper) (GANTHAVORN, 1969). These antivenoms can be used appropriately only if the biting species is known or can accurately be inferred from the clinical features. However, in Thailand, both of the main clinical syndromes following snake bite can be caused by several species. Thus, the combination of local swelling, spontaneous systemic bleeding and incoagulable blood can follow envenoming by *D. russelii*, *C. rhodostoma* or *Trimeresurus* species, while neurotoxic envenoming can be caused by the Malayan krait (*B. candidus*), *B. fasciatus*, *N. kaouthia*, spitting cobras ('*N. atra*' [also known as *N. naja sputatrix* and *N. sputatrix*] and *N. sumatrana* [WARRELL, 1986; WÜSTER & THORPE, 1991]), and *O. hannah*. Species diagnosis might be helped if the precise geographical distribution of the medically-important snakes were known. The present study was designed to obtain this information and hence provide a basis for a more logical development of monospecific antivenoms throughout the country, and to discover the relative importance of the various species as causes of snake bite.

Methods

We visited 80 district and provincial hospitals in 67 provinces in Thailand and discussed the study protocol with the doctors and nurses who staffed the emergency rooms (Fig. 1). A minority of bitten patients brought the dead snake with them to hospital. In these cases the patient's name and hospital number and the date were written with a lead pencil on a small luggage label which was tied tightly round the snake's body. In large snakes the body cavity was opened by a series of scalpel cuts along the ventral surface or formaldehyde solution was injected into the body cavity. Snakes were immersed in formaldehyde solution (dilution of stock 40% solution with water 5:1). Brief clinical details were recorded on a standard pro forma: these included signs, symptoms, treatment and outcome and the identification of the snake by the medical staff. At intervals over the next 3

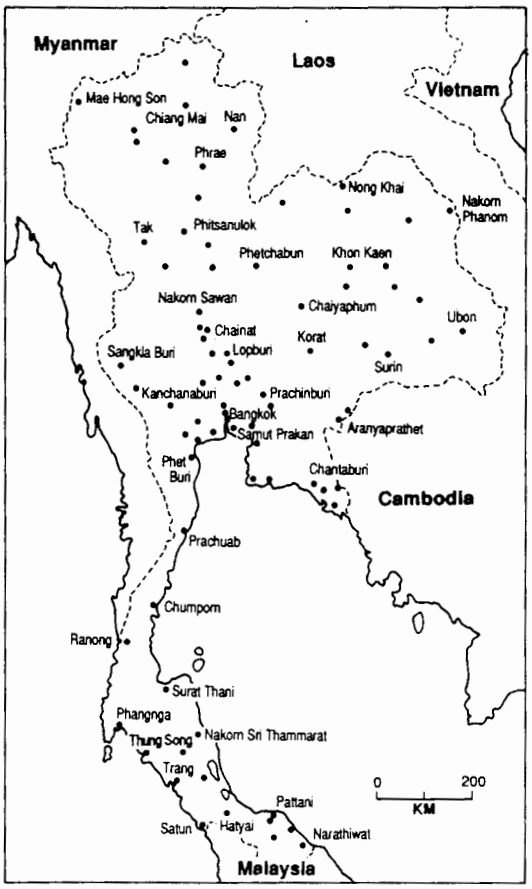

Fig. 1. Map of Thailand showing the principal locations of district and provincial hospitals where dead snakes were collected.

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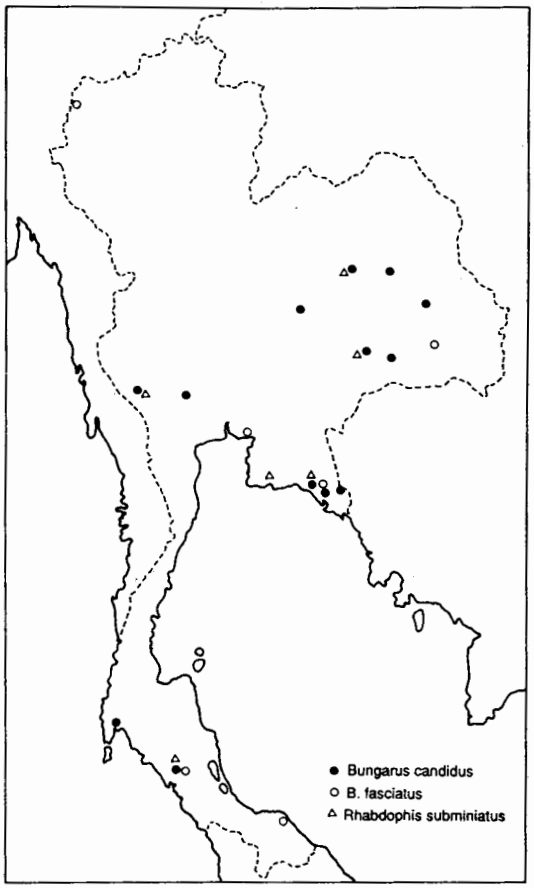

Fig. 2. Thailand: distribution of kraits (genus *Bungarus*) and red-necked keelbacks (*Rhabdophis subminiatus*).

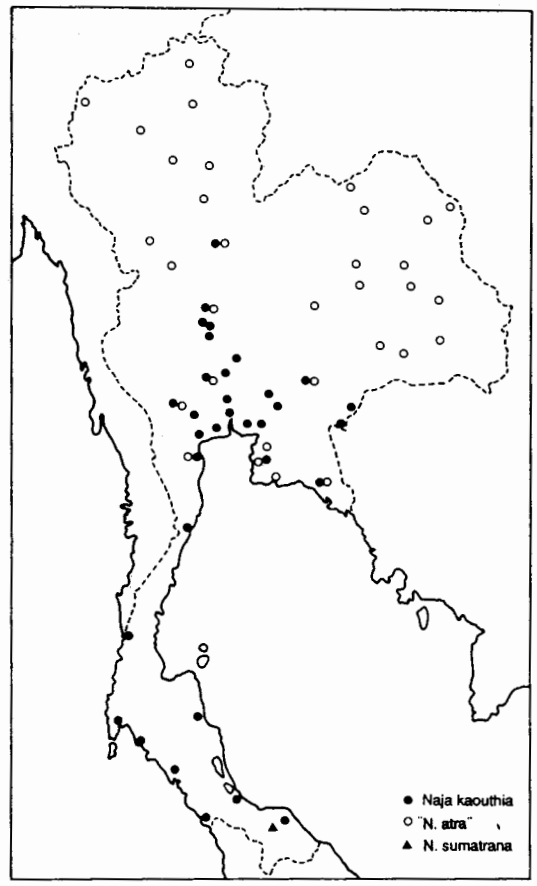

Fig. 3. Thailand: distribution of cobras (genus *Naja*).

years we visited the hospitals to check that the protocol was being followed correctly and to collect the specimens and completed pro formas which had accumulated.

At some hospitals, the staff were able to collect pretreatment serum samples from the patients for immunodiagnosis using enzyme immunoassay (THEAKSTON *et al.*, 1977; HO *et al.*, 1986) (the results of this study have been reported by SILAMUT *et al.*,1987). Selected fatal cases were the subject of a separate study which has been reported elsewhere (LOOAREESUWAN *et al.*, 1988).

At the Faculty of Tropical Medicine in Bangkok, all specimens were identified by D.A.W. and measured. The stomach was opened to determine the type of prey. In freshly killed snakes, males were identified by injecting formalin solution into the tail to evert the hemipenes. In preserved specimens the hemipenes were revealed by dissection. Most of the specimens were deposited at the British Museum (Natural History), London, where all the species diagnoses were confirmed by C.J.M. and A.S.F.

Results

Identification of snakes

A total of 1631 dead snakes was brought with the patients whom they had bitten to the 80 participating hospitals. There were 1145 specimens of 16 species of venomous snakes and 486 specimens of 26 species of non-venomous snakes. *C. rhodostoma, T. albolabris* and *D. russelii* were the most numerous, while *T. albolabris, C. rhodostoma* and '*N. atra*' were the most widely distributed (Table 1, Figs 2–5). In the maps (Figs 2–5), locations of some additional specimens which were not responsible for bites have been added to indicate the extreme distribution. Lengths, sex ratios and stomach contents of the 5 most frequently collected species are given in Table 2. Non-venomous species are listed in Table 3. The following non-venomous species were mistaken for venomous ones by the hospital staff, leading to unnecessary use of antivenom: *Oligodon dorsolateralis* for *C. rhodostoma* (2 cases); *O. cyclurus* (Fig. 6) for *D. russelii* (Fig. 9) (1 case); *O. cyclurus* for *C. rhodostoma* (Fig. 7) (6 cases); *Boiga multomaculata* (Fig. 8) for *D. russelii* (7 cases); *Lycodon laoensis* (Fig. 13) for *B. candidus* (Figs 11, 13) (1 case); *Rhabdophis subminiatus* (Fig. 14) for *C. rhodostoma* (1 case); *Dryocalamus davisonii* (Figs 10, 13) for *B. fasciatus* (Figs 12, 13) or *B. candidus* (4 cases).

In 5 cases, *B. candidus* was confused with *B. fasciatus*, with the result that *B. fasciatus* antivenom was given inappropriately.

Clinical features

Neurotoxic signs (ptosis and difficulty in breathing) were observed in 12 of the 114 cases of bites by '*N. atra*' (10·5%) and in 7 of the 83 bites by *N. kaouthia* (8·4%). Local swelling and necrosis were common after bites by *N. kaouthia* and '*N. atra*', but many of the patients were followed up for too short a time to allow a precise assessment of the incidence of these effects. Incoagulable blood was detected in 57 of 147 cases of *C. rhodostoma* bite seen in Trang, Chantaburi and Kanchanaburi (38·8%), in 13 of 63 cases of *T. albolabris* bite (20·6%) and in 19 of 68 cases of *D. russelii* bites (27·9%). Antivenom was used in 28·6% of bites by *C. rhodostoma*, 21·5% by *N. kaouthia*, 20% by *D. russelii*, 19·5% by '*N. atra*' and 5·5% by *T. albolabris*.

Bites by the other species of pit viper (*T. macrops, T. purpureomaculatus, T. wagleri*) caused mild local swelling and no serious consequences; in most cases blood coagu-

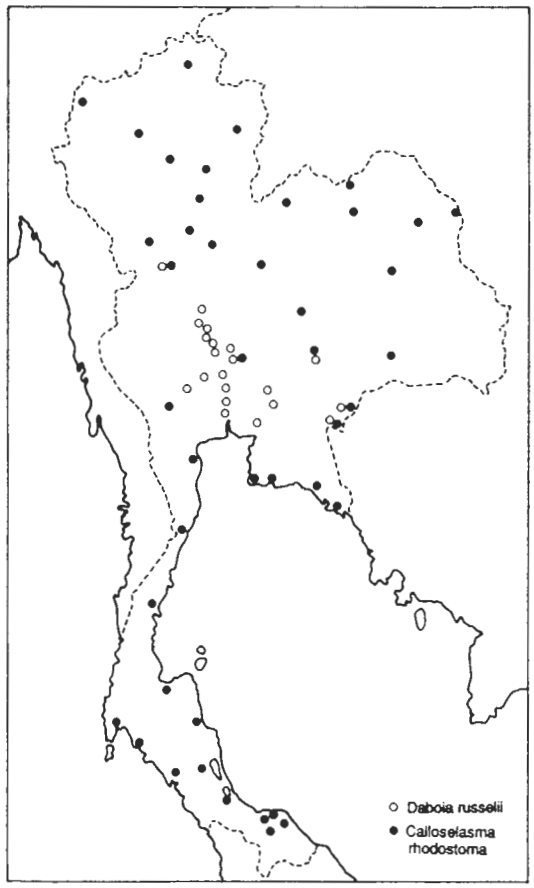

Fig. 4. Thailand: distribution of Russell's vipers (*Daboia russelii*) and Malayan pit vipers (*Calloselasma rhodostoma*).

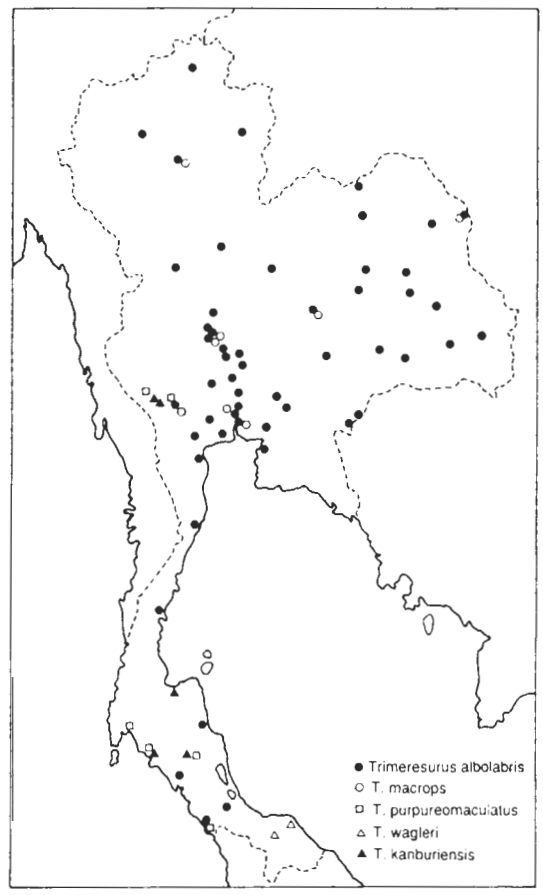

Fig. 5. Thailand: distribution of pit vipers (genus *Trimeresurus*).

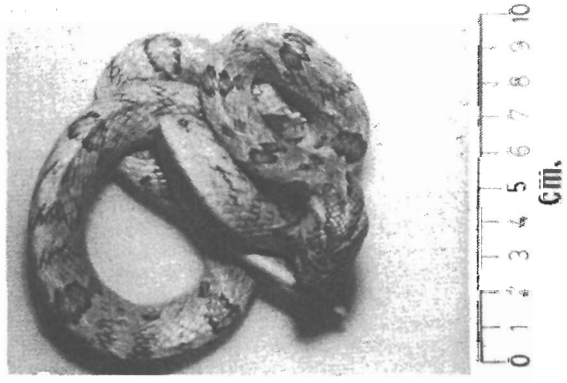

Fig. 6. Common kukri snake (*Oligodon cyclurus*), the non-venomous species responsible for most bites. It has also been mistaken for Malayan pit viper (Fig. 7) and Russell's viper (Fig. 9), but note its slimmer build and different dorsal pattern. (Scale in cm.)

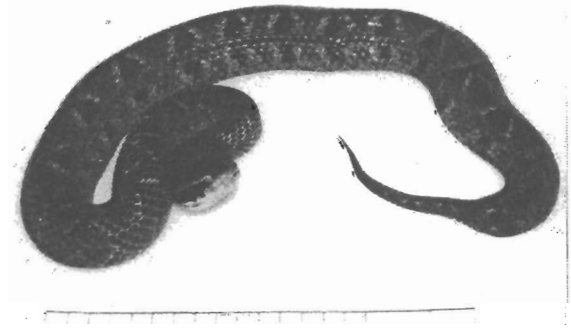

Fig. 7. Malayan pit viper (*Calloselasma rhodostoma*). Note thick body, short thin tail, triangular head and dorsal pattern. (Scale in cm.)

lability was not commented upon. The bite by *T. kanburiensis*, the first ever reported, caused extensive local swelling and a mild coagulation disturbance (WARRELL *et al.*, 1992). Bites by *B. fasciatus* and the 3 species of sea snakes caused no envenoming. Among the 5 cases of bites by *Rhabdophis subminiatus*, 2 patients noticed bleeding from the bite wound, while the others had no symptoms at all.

Discussion

This study extends the known ranges of many of the medically-important venomous species in Thailand. *D. russelii* was found throughout the central rice-growing area as far north as Kamphaeng Phet, west to Uthong and east to the Thai-Cambodian border at Aranyaprathet (Fig. 4). There is a single record from Cambodia 'between Pailin and the Thai frontier' (SAINT GIRONS, 1972). According to SMITH (1943) and TAYLOR (1965), the species is confined to a small area bounded by Lopburi and Korat in the north and extending south on the left bank of the Chao Phraya river to Bangkok. Our most southern records were from Nonthaburi and Chachoengsao. The supply of Russell's viper antivenom to hospitals in the south of Thailand is not warranted. Claims that this species occurs in the south (COX, 1991) have probably arisen from misidentification of the somewhat similarly marked *B. multomaculata* (Figs 8, 9).

The Malayan pit viper (*C. rhodostoma*) was the most frequently collected (37·9%) of all venomous snakes responsible for bites. It was found in most parts of the country (62·5% of collecting sites); its range overlaps with that of Russell's viper in several areas (Fig. 4). The white-lipped green pit viper (*T. albolabris*) was the second most commonly collected species, but the most widely distributed (at 65% of the collecting sites) (Fig. 5). *T. macrops*, like *T. albolabris*, is common in the Bang-

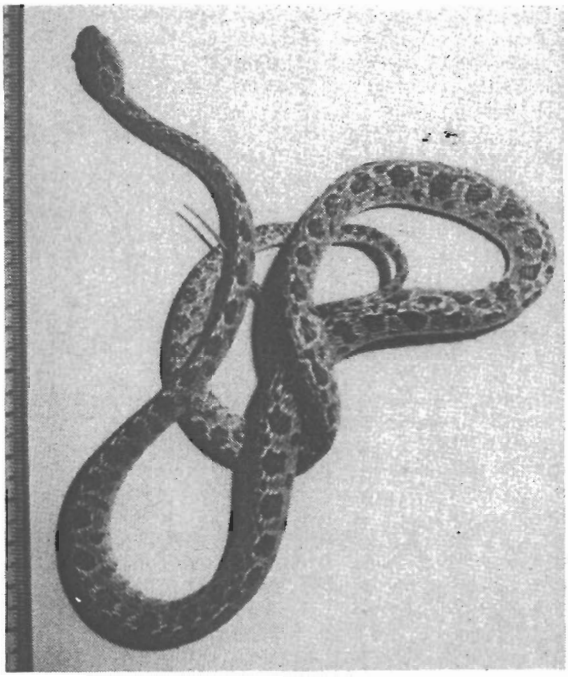

Fig. 8. Spotted cat snake (*Boiga multomaculata*), a non-venomous species commonly mistaken for Russell's viper (Fig. 9). Note slim body, long thin tail and a series of large paired spots on the dorsal surface. (Scale in mm.)

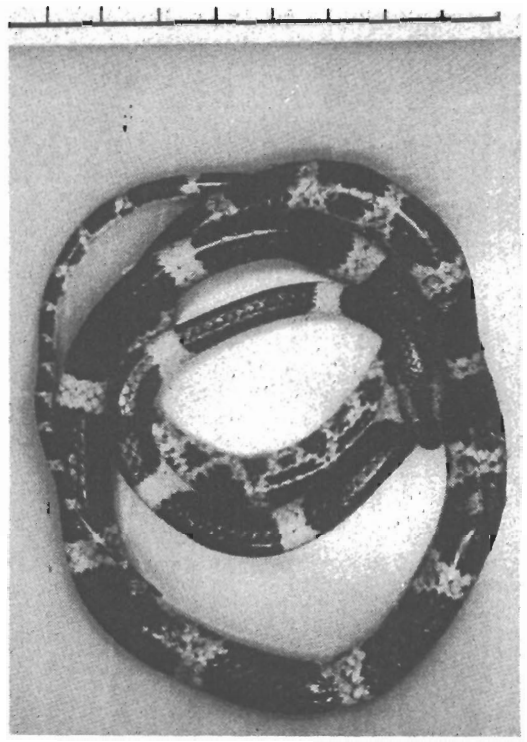

Fig. 10. *Dryocalamus davisonii*, a non-venomous species commonly mistaken for the Malayan krait (*Bungarus candidus*) (Fig. 11) or banded krait (*B. fasciatus*) (Fig. 12). Note relatively narrow white bands between the black saddle-shaped dorsal markings. (Scale in cm.)

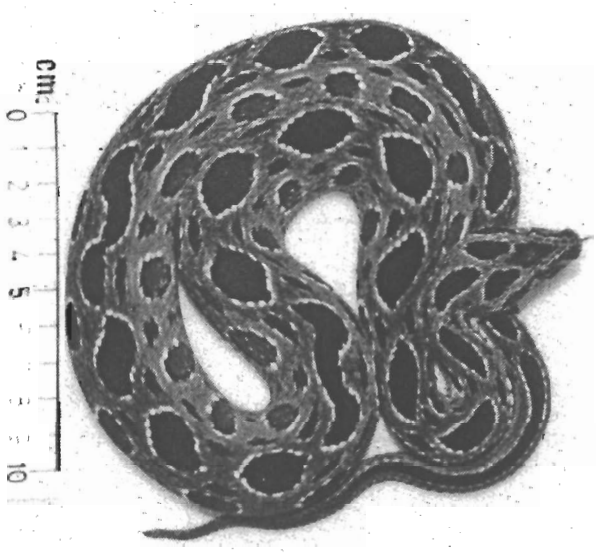

Fig. 9. Russell's viper (*Daboia russelii siamensis*). Note thick body, short tail and dorsal midline series of large spots. (Scale in cm.)

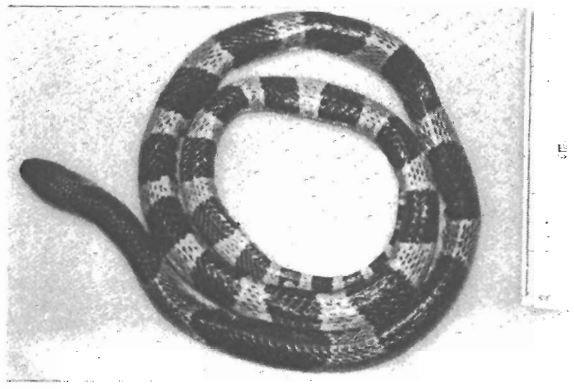

Fig. 11. Malayan krait (*Bungarus candidus*). Note relatively wide white bands between the black saddle-shaped dorsal markings. The kraits grow much larger than their non-venomous mimics in the genera *Dryocalamus* and *Lycodon*. (Scale in cm.)

kok area. In this survey, *T. macrops* was found as far north as Chiang Mai, west to Kanchanaburi, north-east to Nakorn Phanom, and south to Bangkok. It has also been found in Cambodia and Vietnam (REGENASS & KRAMER, 1981). It has been widely misnamed *T. popeorum* (see WARRELL, 1986; WARRELL, 1990; HUTTON *et al.*, 1990). There has been great confusion about the status of the 'varieties' of cobras in Thailand (TAYLOR, 1965). Initially, we divided the cobras into 2 species: those with monocellate nuchal marking did not 'spit' their venom, and were regarded as *N. kaouthia,* while those with no nuchal marking or a spectacle pattern, which were known to be capable of 'spitting', were regarded as '*N. sputatrix*'. Recent studies by WÜSTER & THORPE (1987, 1989, 1990, 1991) have lent support to this distinction and have provided more reliable methods, such as multivariate analysis of more than 100 quantitative characters, for separating the 'species' of cobra in Thailand (e.g. by ventral scale counts). As a result, one of the specimens from Yala in southern Thailand, initially identified as '*N. sputatrix*', has been redesignated *N. sumatrana* (W. Wüster, personal communication). Wüster and Thorpe rightly restricted the name *N. sputatrix* to the southern Indonesian spitting cobra, and suggested '*N. atra*' for the Chinese/Indo-Chinese spitting cobras (WÜSTER & THORPE, 1991) which we originally referred to as *N. sputatrix* (see WARRELL, 1986). In this study '*N. atra*' was more frequent and more widespread as a cause of snake bite than *N. kaouthia*. Until now, antivenom manufacturers in Thailand have not taken account of the colour and nuchal pattern of cobras when choosing snakes for venom pro-

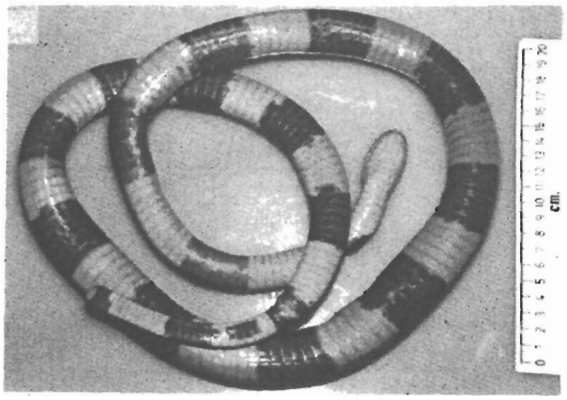

Fig. 12. Ventral surface of banded krait (*Bungarus fasciatus*). Note relatively thick body and unpaired subcaudal scales; the black bands encircle the body (compare with the black saddle-shaped dorsal markings of *B. candidus* and *Dryocalamus* and *Lycodon* species). (Scale in cm.)

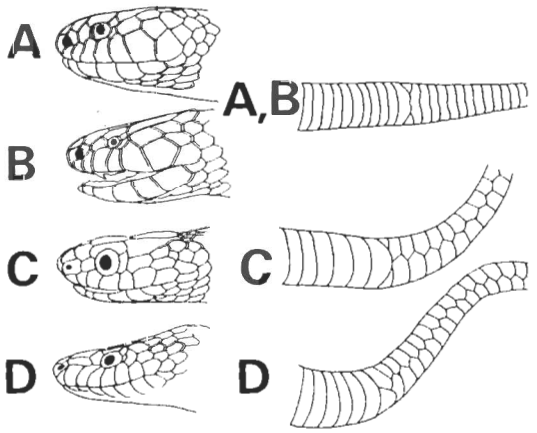

Fig. 13. Head scales and ventral surface of the tails of banded (A) and Malayan (B) kraits, and two of their non-venomous mimics—*Dryocalamus davisonii* (C) and *Lycodon laoensis* (D). Note the relatively large nasal scales in the kraits, large eye of *Dryocalamus* and flattened head of *Lycodon*, which, unlike the other species, has two scales (loreal and preocular) between the nasal scale and the eye. The kraits, which have front fangs and unpaired subcaudal scales, grow much larger than *Dryocalamus* and *Lycodon*.

against *N. kaouthia* venom from Thailand and *N. naja* venoms from India and Sri Lanka (R. D. G. Theakston, unpublished observations). The Malayan krait (*B. candidus*) had not been implicated as a cause of snake bites in Thailand until the early 1980s (WARRELL *et al.*, 1983). However, this species was proved to be responsible for 13 of 46 cases of fatal snake bite in Thailand (LOOAREESUWAN *et al.*, 1988). Hospital staff in Thailand often confuse it with the banded krait, *B. fasciatus*, and the harmless colubrids *D. davisonii*, *L. laoensis*, and *L. subcinctus* (Figs 10–13). Thai Red Cross *B. fasciatus* antivenom is ineffective against the venom of *B. candidus* both clinically and in laboratory rodent assays (WARRELL *et al.*, 1983), and no specific antivenom is currently available. Imported specimens of the red-necked keelback (*R. subminiatus*), an aglyphous colubrid with enlarged posterior maxillary teeth (Figs 14, 15), have been responsible for severe envenoming in Britain (MATHER *et al.*, 1978), Germany (MEBS *et al.*, 1987) and the United States (CABLE *et al.*, 1984). The closely related yamakagashi (*R. tigrinus*) has caused severe and fatal envenoming in Japan (MITTLEMAN & GORIS, 1978; OGAWA & SAWAI, 1986). All the reported cases of envenoming by *R. subminiatus* resulted from the snakes' being handled. In contrast, the 5 patients bitten by this species in Thailand had trodden on or touched the snakes accidentally and, although struck, suffered negligible effects.

None of the patients bitten by mangrove pit vipers (*T. purpureomaculatus*) or Wagler's pit vipers (*T. wagleri* = *Tropidolaemus wagleri*) showed any sign of envenoming. These cases, and even more strikingly the 3 cases of sea snake bites without envenoming, re-emphasize the point made by REID (1968) that venomous snakes frequently fail to inject venom when they bite humans. In Reid's series of 28 proved bites by *T. purpureomaculatus* in north Malaya, 2 patients showed no envenoming, 17 had local swelling with necrosis in 2 of them but no systemic symptoms, 8 had incoagulable blood and a 3 years old child died 12 h after the bite (REID, 1968). FRITH & FRITH (1975) described an unpleasant bite by this species in Phuket Island, Thailand. According to LIM-BOO-LIAT (1979), bites by this species are common among people who work in swamps and mangrove forests. *T. purpureomaculatus* is reported from the west coast of Thailand, on the seashore in mangrove and other coastal vegetation. It is said to be far more common on small offshore islands than on the mainland (TWEEDIE, 1983). WERLER & KEEGAN (1963) stated that

Table 1. Venomous snakes responsible for bites and brought to hospitals in Thailand

Species	English name	Family	Number of specimens	Number of hospitals to which brought
Calloselasma rhodostoma	Malayan pit viper	Viperidae	434 (37·9%)	50 (62·5%)
Trimeresurus albolabris	White-lipped green pit viper	Viperidae	307 (26·8%)	52 (65·0%)
Daboia russelii siamensis	Russell's viper	Viperidae	164 (14·3%)	19 (23·8%)
'Naja atra'	Northern spitting cobra	Elapidae	114 (10·0%)	48 (60·0%)
N. kaouthia	Monocellate cobra	Elapidae	83 (7·2%)	20 (25·0%)
Bungarus candidus	Malayan krait	Elapidae	13 (1·1%)	9 (11·3%)
T. macrops	Dark green pit viper	Viperidae	12 (1·0%)	8 (10·0%)
Rhabdophis subminiatus	Red-necked keel back	Colubridae	5 (0·4%)	4 (5·0%)
T. purpureomaculatus	Mangrove or shore pit viper	Viperidae	3 (0·3%)	2 (2·5%)
T. wagleri	Wagler's pit viper	Viperidae	2 (0·2%)	2 (2·5%)
B. fasciatus	Banded krait	Elapidae	2 (0·2%)	2 (2·5%)
Hydrophis cyanocinctus	Blue-spotted seasnake	Hydrophiidae	2 (0·2%)	2 (2·5%)
Enhydrina schistosa	Beaked seasnake	Hydrophiidae	1 (0·1%)	1 (1·3%)
Pelamis platurus	Yellow bellied or pelagic seasnake	Hydrophiidae	1 (0·1%)	1 (1·3%)
T. kanburiensis	Kanchanaburi pit viper	Viperidae	1 (0·1%)	1 (1·3%)
N. sumatrana	Sumatran spitting cobra	Elapidae	1 (0·1%)	1 (1·3%)
Totals			1145 (100%)	80 (100%)

duction. There may be important antigenic differences between the venoms of these 'species'. The Twyford antivenom raised against Malayan '*N. n. sputatrix*' venom (probably *N. sumatrana*) was effective against *N. sumatrana* venom from Malaysia but was ineffective

'Away from the coast it may frequently be found in bamboo jungle at elevations from 200 to 3000 feet [70–1000 m]'. This is confirmed by our records from Saiyok near the Myanmar border and Kanchanaburi (Fig. 5), where the species is often collected by Bangkok snake

Table 2. Total length, sex ratio and stomach contents of five species of venomous snakes responsible for bites

Venomous snakes	No.	Length (mm) Mean	Range	Sex ratio (male:female)	Stomach contents
Naja kaouthia	83	775	281–1680	1.4:1	Frogs, lizards, fish
'N. atra'	114	852	210–1330	1.8:1	None
Calloselasma rhodostoma	434	577	152–1029	1:1	Rodents, bird, toads, frogs, lizards snake (*Enhydris jagori*)
Daboia russelii siamensis	164	531	210–1280	1:1.3	Rodents
Trimeresurus albolabris	307	487	120–895	1:1	Rodents, birds, frogs

Table 3. Non-venomous species represented among 491 specimens brought to hospitals by patients who claimed to have been bitten

Families	Genera and species
Reptilia: Serpentes	
Typhlopidae	*Ramphotyphlops braminus*
Aniliidae	*Cylindrophis rufus*
Xenopeltidae	*Xenopeltis unicolor*
Acrochordidae	*Acrochordus javanicus*
Colubridae	*Xenochrophis flavipunctatus*
	X. piscator
	Dryocalamus davisonii
	Elaphe radiata
	Gonyosoma oxycephalum
	Lycodon aulicus capucinus
	L. laoensis
	Oligodon cyclurus
	O. dorsolateralis
	O. taeniatus
	Pareas carinatus
	Ahaetulla prasina
	Boiga cyanea
	B. cynodon
	B. multomaculata
	Chrysopelea ornata
	Psammodynastes pulverulentus
	Enhydris bocourti
	E. enhydris
	E. jagorii
	E. plumbea
	Homolopsis buccata
Amphibia: Gymnophiona	
Ichthyophiidae	*Ichthyophis* sp.

dealers who have marketed it under the misleading name of *T. kanburiensis* (REGENASS & KRAMER, 1981).

REID (1968) studied 48 proved bites by *T. wagleri*. There was no envenoming in 24 cases. In the other 24 cases there was local swelling, with necrosis in one of them. Blood coagulation was assessed in 6 of these patients but none developed coagulopathy. Our specimens were from the far south of Thailand (Yala and Narathiwat), but the species has been reported as far north as Surat Thani.

A unique case of local and systemic envenoming by *T. kanburiensis* near Kanchanaburi has been reported elsewhere (WARRELL *et al.*, 1992). Other examples of this species (not causing bites) have been collected at Saiyok near Kanchanaburi and from Thungsong, Krabi and Surat Thani in the south of Thailand (Fig. 5) (D. A. Warrell, S. Looareesuwan, J. Nabhitabhata & P. Jintakune, unpublished observations). We have found Hagen's pit viper (*T. hageni*) in Trang, southern Thailand. This species was also reported (as *T. sumatranus* BMNH 1936.9.12.4) by Smith near Pattani (SMITH, 1930; DRING, 1979). LIM-BOO-LIAT (1979) referred to cases of bites by *T. sumatranus* in Malaya and Sabah, but none was discovered during the present survey. Among the 26 species of non-venomous snakes and one caecilian (a serpentoid amphibian) responsible for 491 bites, *O. cyclurus* was the most commonly represented. This is consistent with its abundance, wide distribution and its reputation of being vicious and ready to bite (TAYLOR, 1965; SMITH, 1943, p. 197). *O. cyclurus* was also confused with *D. russelii* and *C. rhodostoma*.

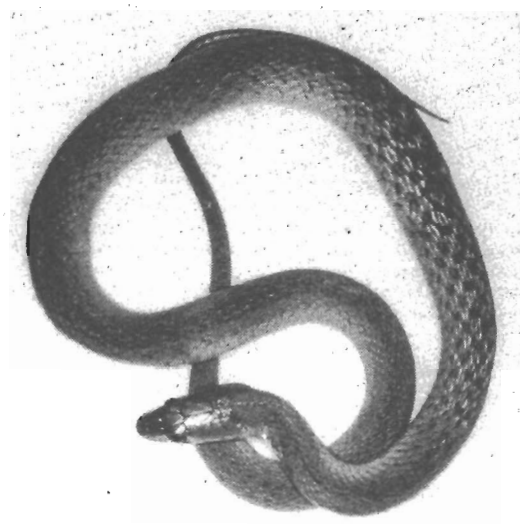

Fig. 14. Red-necked keelback (*Rhabdophis subminiatus*), a common and widely distributed colubrid of potential medical importance (this specimen was 38 cm long).

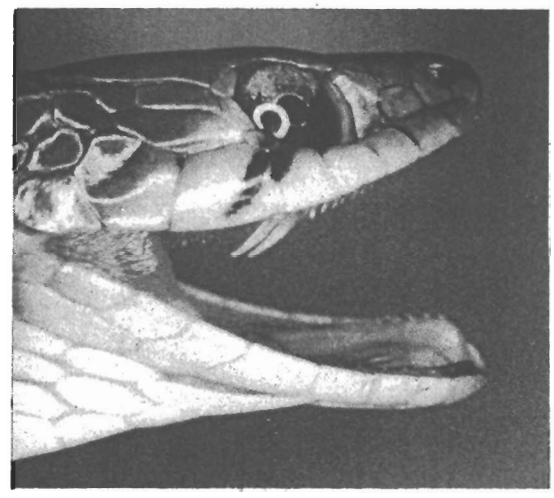

Fig. 15. Head of *Rhabdophis subminiatus*, showing enlarged solid posterior maxillary teeth.

The technique employed in this survey is recommended as a simple means of obtaining information about the relative importance of different species of venomous snakes throughout a country. Dead snakes brought to hospital by the people they have bitten are usually thrown away by the medical staff after a cursory inspection. In this study we merely asked the emergency room staff, usually nurses, to label the snake and drop it in a bucket of formalin which was covered by a tight-fit-

ting lid and kept somewhere in the emergency area. Time spent in explaining the study was amply rewarded by the enthusiastic co-operation we obtained. Collections can be made in any area served by a district or provincial hospital. The major limitation of the technique is that it depends on the patient's ability to see and kill the snake after the bite. Sluggish species which do not try to escape after biting, such as *C. rhodostoma* (REID *et al.*, 1963), are likely to be relatively over-represented in hospital collections, compared with the more agile and fugitive elapids. Snakes which bite at night while the patient is asleep, such as *B. candidus*, are also less likely to be killed. Rapid enzyme immunoassays (THEAKSTON *et al.*, 1977; HO *et al.*, 1986) may ultimately prove a more reliable guide, but these tests will need to be confirmed with cases of envenoming in which the snake responsible was killed and identified.

Acknowledgements

We are grateful to the directors and emergency room staff of all the hospitals participating in this study and especially to Drs Udom Veeravat, Saroj Kongprasart, Song Srisuparb, Suthat Vejcho, Jun Karnchanajethnee, Sanga Boomramrung and Bunsom Chaimongkol; and to Miss Eunice Berry and Mrs Mary Tilley for preparing the manuscript. This study was part of the Wellcome-Mahidol University, Oxford Tropical Medicine Research Programme funded by the Wellcome Trust.

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Received 22 May 1991; revised 29 July 1991; accepted for publication 12 August 1991