16 Russell's viper in Indonesia: snakebite and systematics

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Synopsis

Russell's viper has a widespread but discontinuous distribution across 10 Asian countries. The presence of the species in southern Indonesia is of particular interest, as these populations are isolated by more than 2000 km from the nearest conspecific populations in Thailand. Formerly divided into five subspecies, the population systematics of this species has recently been revised as a result of a multivariate analysis of scalation and colour pattern characteristics. The analysis reveals two morphologically distinct forms occupying the eastern and western part of the range of the species respectively. While the populations from the Lesser Sunda Islands (Nusa Tenggara Timur) group with the eastern form, they appear to be somewhat divergent from the other populations in Java and continental south-east Asia. In the species as a whole there is clear lack of concordance between morphological and venom variation, but data on venom effects, or indeed on the incidence of bites by this species, is lacking for the Indonesian populations.

In this paper, fresh distributional data from recent expeditions and the results of a retrospective case study of Russell's viper bites ($n = 26$) from the Lesser Sunda Islands are presented. The magnitude of the public health problem and effect of medical and traditional treatments on outcome are assessed. The case fatality of Russell's viper bites in Indonesia is 38.5%. The mean interval between snake bite and death is 14.5 h, which is considerably shorter than that reported from other Asian populations. Incoagulable blood caused by procoagulant effects of the venom and the ensuing consumption coagulopathy is the most common feature across the entire geographical range. Spontaneous systemic haemorrhage occurred in 34.6% of the victims in Indonesia and represents a significant indicator of poor prognosis. There is a higher incidence of significant local tissue destruction and necrosis (23%) than in other populations, and some evidence of neurotoxic symptoms is present. These data strongly suggest that the effects of envenoming by Russell's viper in Indonesia are different from those of other populations, and the geographical variation in the clinical manifestations of Russell's viper bite is reviewed in the light of this new information.

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Introduction

Russell's viper (*Daboia russelli*) is one of the world's major causes of snakebite morbidity and mortality (Aung-Khin 1980; Warrell 1989; Looareesuwan, Viravan & Warrell 1988; Phillips *et al.* 1988; Aye 1990; Viravan *et al.* 1992). Formerly known as *Vipera russelli*, recent research on the phylogeny of viperine snakes (Herrmann, Joger & Nilson 1992) has placed it in the monotypic genus *Daboia*. It has a widespread distribution extending across 10 Asian countries, including parts of mainland China, western Cambodia, Thailand, Burma, Bangladesh, southern Indonesia, Taiwan, Pakistan, India and Sri Lanka. There is considerable discontinuity in this distribution, with near-ubiquitous occurrence in India, a scattered distribution in China and Indo-China and a complete absence in most of Java, Sumatra, Borneo and the Malayan Peninsula. Isolated populations occur in Indonesia, in eastern Java, Komodo, Flores and Lembata.

Russell's viper in Indonesia

The presence of Russell's viper in Indonesia was only reliably established in the 20th century, and its distribution in the archipelago is still being elucidated. In the following paragraphs, we briefly review the literature on the occurrence of Russell's viper in Indonesia.

There are two 19th century records in the literature reporting the presence of Russell's viper on Java (Duméril, Bibron & Duméril 1854; Boulenger 1896). However, there is evidence that the samples on which these reports are based did not in fact originate from Indonesia (Brongersma 1958). In view of their high ventral scale counts, it is more probable that the snakes originated from India. The first authentic record of Russell's viper from Java was published by Neuhaus (1935), from the region of Surabaya in east Java. Since then, the viper has repeatedly been found in east Java, especially in the neighbourhoods of Sepandjang and Kembang Kuning on the outskirts of Surabaya (Kopstein 1936: van Hoesel 1954). Kopstein (1936) described the Javan population as a new subspecies, *V. r. sublimitis*. Van Hoesel (1959) reported the finding of seven full-grown specimens in a small field at the cemetery at Kembang Kuning, Surabaya, and also noted the occurrence of the species in the limestone hills west of the city. Hodges (1993) recorded six specimens of Russell's viper during a three-year period which had been killed by cars on the toll road close to the Kembang Kuning military cemetery. He also mentioned reported sightings in the forested areas around Gresik and Bojonegoro, although he suggested that these might have been a result of confusion with the Malayan pitviper (*Calloselasma rhodostoma*), which is known to occur in the area.

The first evidence of Russell's viper in the Lesser Sunda Islands (Nusa Tenggara Timur), and indeed in Indonesia, was provided by the Douglas Burden expedition to the island of Komodo in the summer of 1926 (Dunn 1927), which collected two specimens from the lower hills of the island. In 1927, Mertens collected a specimen from Ende, a small island off the southern coast of Flores, which he described as the subspecies *Vipera russelli limitis* (Mertens 1927). Van Hoesel (1959) was the first to report Russell's viper from the island of Flores itself, as well as from Lembata. He commented on how common the species was on Flores and listed many regional dialect names for it (Table 1). Over 40 specimens were collected from altitudes of up to 1200 m on Flores. According to van Hoesel, the inhabitants of Adonara, Solor, Alor and Sumba claimed that the species was well known on these islands, but no specimens were ever obtained. The only evidence of the medical significance of Russell's viper in these islands comes from Auffenberg (1980), who stated that the snake caused more deaths on Komodo than any other species. It certainly appeared to be common when his collection was made in the 1960s; 59 specimens were collected from Komodo below an altitude of 120 m, in *Zizyphus* savanna and the beachside *Pandanus* community.

Table 1. Local names for Russell's viper and other snakes in specific regions of Indonesia

Island	Region	Russell's viper *Daboia russelli*	Green tree viper *Trimeresurus albolabris*	Other
Komodo		Pupu		
		Misa[3]		
Rinca		Kaka botek		
		Pupu		
Flores	Ruteng		Kaka taa	
	Ngada District	Barat[1]		
	Bajawa	Mbala		
		Bara[1]		
		Baka		
	Riung	Mbarat	Likur	
	Mbay	Spret[2]		
		Sapret[2]		
	Ende Town	Nipakaru[1]		
		Ular heutan		Cobra = Pupurupi[2]
	Maumere	Blarat[1]	Mea	Cobra = Puput
	Larantuka	Kramat	Kamea	
		Kamek[1]		
		Temuk lado		
Lembata		Kramek[1]		
		Krama	Toha	Python = Punay
Adonara	Podor	Kramek[1]		
		Krame		
Java	East Java	Bandotan puspo[2]	Ular daun[2]	Krait = Weling[2]
			Luwuk	Cobra = Ular sendok[2]
				Python = Ular sawa[2]

Source: [1]van Hoesel (1958); [2]AM/RST; [3]Auffenberg (1980); Remainder from PJB.

Geographic variation in Russell's viper

Morphological variation

Conventionally, Russell's viper has been divided into five subspecies; *D. r. russelli* from India, Pakistan and Bangladesh, *D. r. pulchella* from Sri Lanka, *D. r. siamensis* from Burma, Thailand, and southern China, *D. r. formosensis* from Taiwan and *D. r. limitis* from southern Indonesia. In addition, some workers have recognized the subspecies *D. r. sublimitis* (Kopstein 1936) from eastern Java and *D. r. nordicus* (Deraniyagala 1945) from northern India. These subspecies were based primarily on variation in the number of rows of dorsal spots and a few other colour pattern characters and their validity had been questioned (Brongersma 1958). Wüster, Otsuka, Malhotra & Thorpe (1992) carried out a multivariate analysis of scalation and colour pattern characters, as a result of which they recognized only two subspecies, a western form (*D. r. russelli*) from Pakistan, India, Sri Lanka and Bangladesh, and an eastern form (*D. r. siamensis*) from Burma, Thailand, China, Taiwan and Indonesia.

Venom variation

Clinically, Russell's viper is of particular interest in that the composition and effects of its venom vary considerably between different areas (e.g., Jayanthi & Gowda 1988; Woodhams *et al.* 1990; Warrell 1989). Envenoming by this species has been studied in Burma (Myint-Lwin *et al.* 1985), Thailand (Mahasandana, Rungruxsirivorn *et al.* 1980; Kanjanajatanee & Visutipant 1984; Mahasandana, Pochanugool *et al.* 1990) and Sri Lanka (Jeyarajah 1984; Phillips *et al.* 1988).

Clinical effects of Russell's viper bites are local, in the bitten limb, and systemic. Local symptoms include pain, swelling, bruising, blistering, necrosis and local lymphadenopathy. Systemic effects include disseminated intravascular coagulation resulting from a number of venom procoagulant enzymes, notably those activating factor V and factor X, with fibrin deposition in small blood vessels in the kidney, lungs and anterior pituitary. There is spontaneous systemic bleeding from the gingival sulci and nose and into the skin, retroperitoneal tissues and, most dangerous, into the brain and gastrointestinal tract. Acute renal failure (acute tubular necrosis and bilateral renal cortical necrosis) is more common than with other species of snake. In Sri Lanka and parts of India there is generalized rhabdomyolysis, intravascular haemolysis and neurotoxicity attributable to a pre-synaptic toxin (phospholipase A_2). In Burma, Russell's viper bites cause a generalized increase in capillary permeability causing chemosis, periorbital oedema, pulmonary oedema and heavy proteinuria. Various pathophysiological processes, including hypovolaemia, vasodilation and acute pituitary failure (in Burma) contribute to shock (Warrell 1995).

There is a marked variation in the clinical manifestations of Russell's viper bite across its discontinuous distribution, which probably reflects differences in venom composition. Approximately 90% of the venom is protein, and up to 70% of the protein is phospholipase A_2, of which seven different isoenzymes have been identified. This enzyme group exhibits a large spectrum of activities, which may explain the wide symptom profile of the venom.

Congruence between morphology and venom

It has been noted that there is little relationship between morphological differentiation and venom variation in this species (Warrell 1989). Unlike the case in other venomous snake taxa (e.g. cobras: Wüster & Thorpe 1989, 1991), a systematic revision has failed to clarify the matter as there appears to be as much variation in venom effects within the eastern and western subspecies as there is between them revealed some morphological differences between some populations of the eastern subspecies having different venom effects but formerly considered very similar (Wüster, Otsuka, Thorpe & Malhotra 1992), the link between morphological variation and venom variation appears weak in this species.

Antivenom effectiveness in Russell's viper also does not appear to be related to the principal division into eastern and western forms; it is also not necessarily related to differences in the effects of the venom. Despite profound differences in clinical effects, antivenom against Burmese Russell's viper (eastern form) was found to be effective against the venom of Thai vipers (eastern form), and even against the venom of Russell's viper from India (western form); however, it was ineffective in neutralizing the venom of Sri Lankan vipers (western form) (Phillips *et al.* 1988).

This considerable variation in venom effects and composition between different geographical areas makes Russell's viper of particular clinical interest. However, detailed studies of envenoming by this species have only been carried out in Sri Lanka, Burma and Thailand. Few details are known of the symptoms of envenoming in China, Taiwan, and Pakistan and, until now, nothing was known about the effects of envenoming by the isolated Indonesian populations. In this paper, the epidemiology and symptomatology of snakebites by Russell's viper in Indonesia will be discussed, and new information on the distribution of the species in the Indonesian Archipelago will be presented.

Materials and methods

Systematic relationships of the Indonesian populations

The population systematics of Russell's viper were studied by means of multivariate morphometric analysis of 22 morphological characters. For details of the characters and methods see Wüster, Otsuka, Malhotra & Thorpe (1992). Indonesian populations were represented by three males and two females from Java, 35 males and 18 females from Komodo, three females from Flores and two females from Lembata.

Geographical distribution of Russell's viper in Indonesia

The islands where Russell's viper had been previously recorded were visited by RST and AM in 1993 (except Rinca and Lembata). Photographs of Russell's viper as well as of snakes with similar appearance were carried to avoid confusion. These include the reticulated python (*Python reticulatus*) throughout the islands, and also the Malayan pitviper (*Calloselasma rhodostoma*) and the many-spotted cat snake (*Boiga multomaculata*) in east Java. Promising areas identified from the literature or through talking to local experts were visited and local people questioned. Searches were made in likely areas as the expedition had been timed to coincide with the expected period of greatest activity by Russell's viper (the dry season). The following year, PJB revisited the areas identified as likely to have a high incidence of snakebite, as well as islands not visited in the previous year.

Epidemiology of Russell's viper bite in Indonesia

A questionnaire (designed by PJB) was used to compile retrospective data from medical practitioners, paramedics, herbalists, local village elders and villagers regarding all aspects of Russell's viper bite, treatment and outcome in that area. The questionnaire recorded the age, sex and occupation of snakebite victims, the circumstances of bites, the location of bites on the body, the identification of the snake, the symptoms experienced, the treatment given, and the outcome of any bites. All of the subjects ($n = 68$) were interviewed in the presence of a translator. Only those subjects who were able to give precise details regarding the bite(s) and victim(s) were used for subsequent analysis.

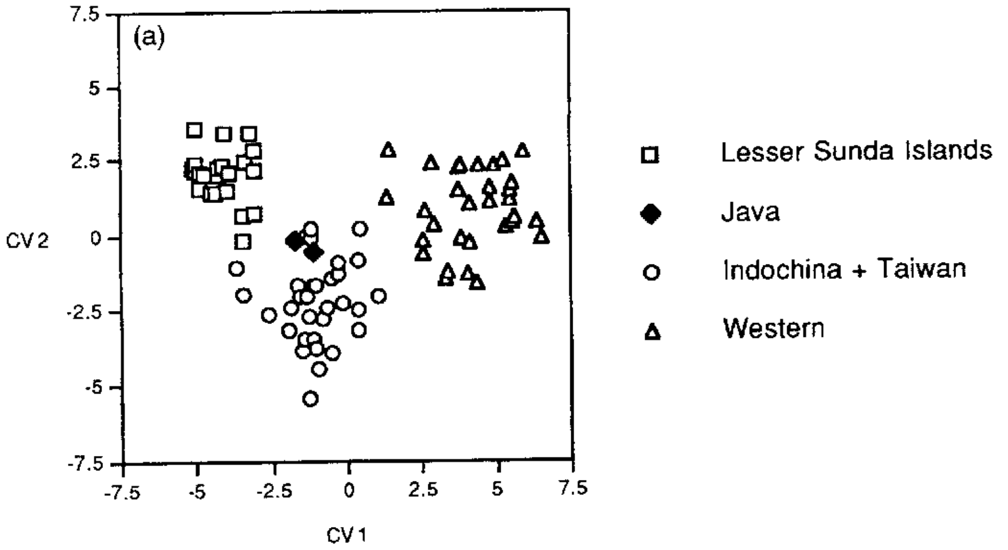
Results

Systematic relationships of Indonesian Russell's viper populations

A canonical variate analysis of populations across the entire range of Russell's viper revealed a clear morphological distinction between Russell's viper populations from west and east of the Bay of Bengal, suggesting the existence of a western and an eastern taxon in this species. However, within the eastern taxon, there was some indication of north–south differentiation (Fig. 1a). This was investigated further by running a canonical variate analysis of eastern populations only (Fig. 1b). Although the number of male specimens from the Lesser Sunda Islands is small, and the sample is restricted to Komodo, both males and females show populations from the Lesser Sunda Islands are clearly distinct from the other populations. Interestingly, the population from east Java is not morphologically distinct from the eastern mainland populations despite being separated from them by a large distributional gap.

Geographical distribution of Russell's viper in Indonesia

Although the earliest reported (and substantiated) population from east Java, in the vicinity of the Kembang Kuning cemetery near Surabaya, appears to be under threat from the expansion of the city, guards described having seen a snake that fitted the description in the cemetery itself recently. Russell's viper, known locally as 'bandotan puspo', may be more widespread than formerly thought in east Java (Fig. 2a). Possible locations of the viper include Lamongan, Nganjuk and Bojonegoro in the Kendeng foothills west of Surabaya, Tuban in the Blora-Drajat karstic hills, and Jember and Banyuwangi in the southern dissected plateau of east Java (Fig. 2a). Most of these were anecdotal reports, but eight Russell's viper, some of extremely large size, were seen by PJB at a Surabayan snake dealer's premises. These had reportedly been captured in Tuban. However, no reports of bites were obtained from eastern Java.



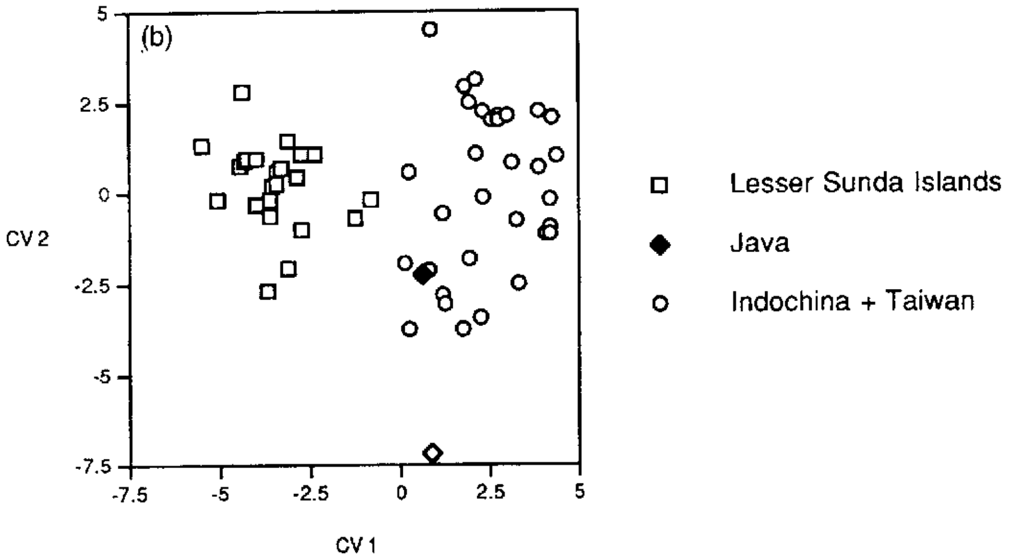


Fig. 1. Ordination of female Russell's viper populations. (a) All populations, showing the primary division into eastern and western groups along CV1 and the indication of a north–south differentiation within the eastern group along CV2; (b) Eastern group only, showing that the Lesser Sunda populations are somewhat distinct, while the east Javan specimens are morphologically indistinguishable from other mainland populations.

In Nusa Tenggara Timur (Fig. 2b), no recent cases of snakebite were reported by the National Park Rangers in Komodo, although the species was stated to be occasionally encountered in the grounds of the Loh Liang camp. They also indicated that it was present on the neighbouring island of Rinca, and when PJB visited this island the following year, local rangers were able to accurately describe the snake and reported seeing one two days prior to his visit. Whatever the current status of the species in Komodo, little evidence was seen of 'the beachside *Pandanus* community' in Loho Lavi bay, where Auffenberg (1980) states he caught the majority of his specimens. On Flores, the presence of the viper in western Flores was suggested by local reports (especially around the town of Lembor in the Cancar region) but these

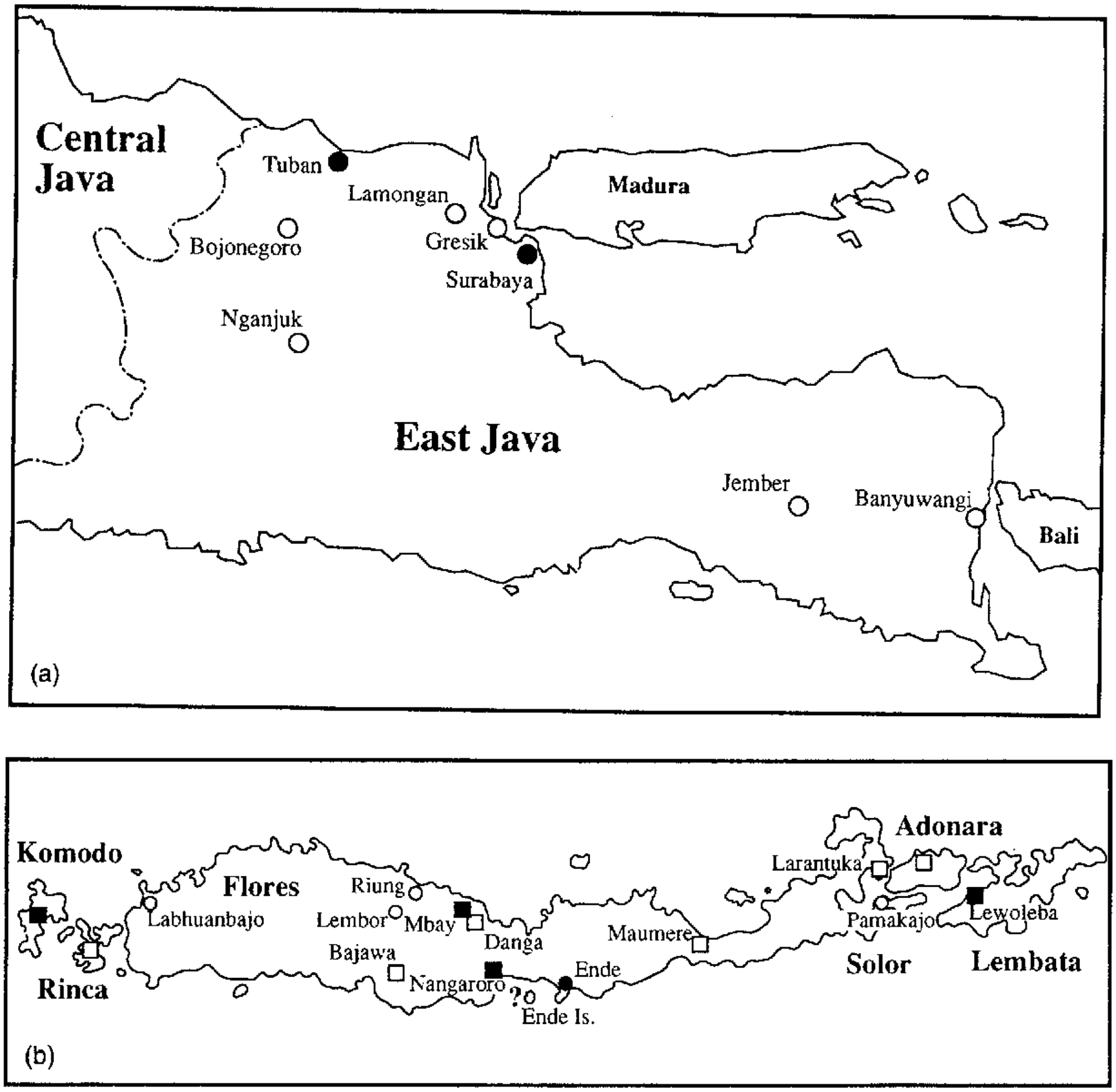


Fig. 2. Map showing the places mentioned in this study in (a) east Java, (b) Nusa Tenggara Timur (Lesser Sunda Islands). Positive records of Russell's viper are indicated by solid symbols. Localities at which the species may possibly occur (as judged by a variety of circumstantial evidence, see text) but at which its presence has not been positively confirmed are indicated by empty symbols. Localities at which histories of snakebite attributable to Russell's viper have been collected are marked with squares, others are marked with circles. Ende Island is marked with a question mark as the species has been previously recorded but is now possibly extinct there (see text).

were not confirmed. It now appears to be comparatively rare around the town of Ende on Flores, although a specimen was sighted in Nangaroro (40 km to the west of Ende town).

However, no evidence at all was found of the continuing presence of Russell's viper on Ende Island itself (the type locality for *V. r. limitis*), where it was reportedly very common 30 years ago. The island is small, and most parts of it were visited by RST and AM, who found that no part of the island contained habitat which might be expected to harbour the species. The majority of the island is given over to growing coconuts with an understorey of cassava and there is virtually no ground cover.

Russell's viper and the only snakes they could describe were likely to be pythons because of their large size, arboreal habits, season of activity (wet season) and the lack of concern displayed by the farmers. We conclude that Russell's viper is now extremely rare, or extinct, on Ende island.

While in Ende, reports of the viper in an area of the island in which it has not previously been recorded, the Ngada district on the northern coast (near the towns of Riung and Mbay), were obtained. On visiting the area, it became clear that Russell's viper may be a significant public health problem. Specimens were encountered near Riung by both parties. Many of the people in the area knew someone who had died, and the symptoms described seemed accurate. The victims did not appear to consider admission to hospital for treatment, and the nearest hospital may be quite distant from some of the villages. Because of this the true scale of the problem is largely unknown. One aim of the study was therefore to attempt to gauge the true extent of the problem. Other areas in east Flores, such as Maumere and Larantuka, also appear to have a high incidence of Russell's viper bite.

Russell's viper was also seen by PJB on Lembata, and numerous reported sightings and case histories of bites were obtained on that island. Intriguing evidence that the species has a wider distribution east of Flores than previously recorded was also found. A museum in Larantuka contained a specimen captured on 1 July 1975 by Father M. Clemens from Pamakajo on Solor, which suggests that this species is, or had been, present there. Additionally, a missionary from the town of Podor on Adonara was able to give highly accurate descriptions of the snake and claimed it was responsible for approximately two deaths on the island per year (population size 4500). However, its presence could not be confirmed by the authors. A recent survey of reptiles in Nusa Tenggara by the Western Australian Museum and the Museum Bogoriense found only a single specimen of *D. russelli*, from Lembata (R. How, pers. comm.).

Effects of envenoming by Russell's viper in Flores

Epidemiological data on Russell's viper envenoming

A total of 26 case histories were obtained. The average age was 42.5 years. Eighteen were male, eight female. The majority were farmers (21), the remainder consisting of a fisherman, a student, an army private, a clerk, and a businessman. The geographical distribution of bites is shown in Table 2. Twenty-one of the bites were on the foot, two on the thigh, one on the ankle, one on the calf and one on the hand. Most of the bites occurred in remote villages and plantations, with 14 occurring in the plantations, six on the main village road, three in the village itself, two on a hillside and one in a house. The bites occurred most frequently at dawn and dusk, when poor light conditions cause the snake to be accidentally stepped upon. The colour and general morphological descriptions were accurate and added weight to the evidence for the correct identification of the snake. The reported average length of the snake was 38 cm (range 15–130 cm).

Table 2. Regional breakdown of Russell's viper bite incidence in the Lesser Sunda Islands

Location	Number of victims	Date of incident	Outcome	Population size
Komodo	1	1964	Died	400
Rinca	1	1989	Died	300
Flores				
Labhuanbajo	1	1993	Survived	2500
Bajawa	3	1993	All survived	10 000
Danga (Mbay)	1	1980	Died	1000
	2	1992	One died, one survived	
	1	1993	Survived	
Nangaroro	1	1970	All survived	250
	1	1992		
	1	1994		
Maumere	1	1972	Died	300 in villages, 40 000 in region
	1	1978	Survived	
	1	1979	Survived	
	1	1992	Survived	
Larantuka	1	1993	Survived	25 000
Lembata				
Lewoleba	1	1967	Survived	Twelve villages, total population 11 977
	1	1982	Survived	
	1	1990	Survived	
	2	1991	Both died	
	2	1994	Both died	
Adonara	1	1985	Died	4500

Table 3. Interval between snakebite and death in different populations of Russell's viper

Population	Cases	Median	Range	Source
India	7	41.3	0.25–216	Reid (1968)
Burma	12	72	15–112	Myint-Lwin *et al.* (1985)
Thailand	7	72	2.5–264	Looareesuwan *et al.* (1988)
Indonesia (Lesser Sunda Islands)	10	14.5	0.5–46	This study

Morbidity and mortality

There were ten deaths amongst the 26 cases, giving a mortality rate of 38.5%. The average time to death (Table 3) was 14.5 h (range 30 min to 46 h). One of the subjects died one month after envenoming owing to secondary infection (this fatal case was not included in the calculation of mean time to death). Several symptoms were recorded only in the fatally envenomed cases, including haematemesis (nine cases), severe bleeding from the bite site (eight cases), generalized swelling (five cases) and systemic bleeding from other sites (two cases). Sixteen patients survived, and only one was left with a significant handicap (inability to bear weight due to necrosis of the calf muscles). The average time to make a full recovery was nine days.

Traditional treatments

Most victims of snakebite do not seek medical attention, but tend to approach village elders or herbalists. This group was most valuable for assessing incidence of bites and the prevalence of different species in that area. The main difference in the symptom profile reported was an additional inability of patients to open their mouths (reported by all herbalists interviewed). However, as it is very unusual for pure neurological sequelae to follow Russell's viper bite, it is possible that this arises out of the unwillingness of patients to swallow the substances offered to them as therapy (which include the local alcoholic beverage, arak, the water in which a dead person's femur has been boiled, banana water, one's own urine, betel nuts and the leaves and roots of certain trees). Treatment also includes the topical application of palm leaves, lime, tree roots and spit. Infections following the application of these substances may be a contributory factor to mortality and morbidity from snake bites, but this is difficult to assess.

Hospital treatment

Of the 26 victims, 19 received hospital treatment. This included nine of the 10 fatal cases, and 10 of the 16 surviving patients. Seven patients received no hospital treatment. The following treatments were given: steroid injection (three cases), antibiotics (four cases), application of a tourniquet (one case), analgesia (one case) and attachment of a black stone, 'to suck out the venom' (one case).

Medical practitioners' treatment and estimates of morbidity and mortality

Seven doctors and one paramedic were questioned regarding their management of snakebites. Each practitioner saw an average of 7.3 Russell's viper victims per year. The following treatments were given to snakebite victims (numbers in brackets refer to the number of practitioners performing the treatment): steroid administration (6), non-specific (not raised against Russell's viper venom) antivenom (5), antibiotics (5), artificial ventilation (3), tourniquets (3), cross-shaped skin incisions (3), local suction/irrigation (1), antihistamines (1), anti tetanus prophylaxis (1), black stone (1), diuretics (1) and fasciotomy (1).

In addition to the symptoms and signs reported by the villagers (Table 4), the medical practitioners also reported evidence of skin anaesthesia, shock, compartment syndrome and bleeding into the skin and mucous membranes. Death was reported as being more common with late presentation and a bleeding tendency. One medical practitioner estimated the average survival rate after Russell's viper envenoming at 80%.

Discussion

Population systematics of Russell's viper

In view of the advantages of preserving nomenclatural stability for such a medically important animal, the two main morphologically distinct forms (eastern and western) have been treated as subspecies of a single species (*Daboia russelli russelli* and *D. r. siamensis*, respectively). An analysis of the phylogenetic relationships of

Table 4. Russell's viper envenoming symptom profile in all bite case histories ($n = 26$)

Symptom	Number of cases with symptom
Local symptoms	
Swelling	23
Tissue destruction and necrosis	6
Local cyanosis	5
Prolonged local bleeding	4
Regional lymphadenopathy	4
Blister formation	2
Temporary loss of use of bitten limb	11
Systemic symptoms	
Fever	6
Thirst	4
Rigors	1
Respiratory symptoms	
Dyspnoea	12
Gastrointestinal symptoms	
Vomiting	19
Genitourinary symptoms	
Haematuria	2
Anuria	6
Neurological symptoms	
Facial weakness	4
Eyelid ptosis	4
Dizziness	3
Confusion	3
Headache	1
Haematological symptoms	
Easy bruising	2

Russell's viper populations, using mitochondrial DNA sequence information, is currently in progress at Bangor, and this may provide further evidence regarding the status of these groups, as well as on the status of the Lesser Sunda populations.

It is clear from previous analyses of geographic variation in the effect of Russell's viper venoms that there is as much variation within the eastern and western forms as there is between them. This applied even within the conventional subspecies recognized before this study, e.g. between the Burmese and Thai populations of *D. r. siamensis* (Warrell 1989) and between populations of *D. r. russelli* from different parts of India (Jayanthi & Gowda 1988). Consequently, it is of crucial importance that toxinologists and physicians ascertain the locality of origin of any Russell's viper specimens or venoms they may be dealing with, irrespective of stated taxonomic affinities. Similarly, venom suppliers must make locality information available to their customers, as failure to do so can lead to considerable confusion and misleading results.

Geographical variation in venom effects — Indonesia and mainland Asia

Local envenoming

The local signs of envenoming by Russell's viper are mild compared with those of medical importance than systemic effects. However, 88.5% of the Indonesian patients bitten suffered from notable local symptoms, the most common being swelling. As with other populations of this species, the incidence of systemic envenoming increased with the extent of local swelling and enlargement of regional lymph nodes. All the patients with systemic sequelae showed local signs, in contrast to data from Burma (Myint-Lwin *et al.* 1985). The incidence of local blistering was 7.7%, compared to 2% and 6% in Burma and Sri Lanka respectively (Myint-Lwin *et al.* 1985; Phillips *et al.* 1988). Twenty-three per cent of all bite victims suffered from significant local tissue destruction and necrosis. It therefore appears that bites by the Lesser Sunda populations of this species result in more severe local envenoming.

Table 5. Geographic variation in the clinical manifestations of Russell's viper envenomation. Data from this study are added to the data summarized in Warrell (1989)

Symptom	Western form Sri Lanka	India	Eastern form Burma	Thailand	Taiwan	Indonesia
Bleeding and coagulopathy	+	++	++	++	?	++
Renal failure	++	+	++	+	+	+
Pituitary infarction	-	+	++	-	?	?
Intravascular haemolysis	++	+	-	+	?	?
Neuromyotoxicity	++	+	-	-	?	+
Generalized capillary permeability	-	-	++	-	?	?+
Primary shock	-	+	++	-	?	?

Systemic envenoming

Incoagulable blood caused by defibrination and the ensuing consumption coagulopathy is the most common feature of Russell's viper envenoming across the entire geographical distribution of the species (Warrell 1989). However, haemostatic abnormalities are less commonly encountered in Sri Lanka. Spontaneous systemic haemorrhage occurred in 34.6% of the victims in Indonesia. This compares with 46% and 22% of the patients in Burma and Sri Lanka respectively. The sites of haemorrhage in these latter countries include the gingival sulci, the gastrointestinal tract (haematemesis and melaena), conjunctivae and skin (discoid haemorrhages), the genitourinary tract (haematuria), respiratory tract (haemoptysis) and the reproductive tract (menorrhagia and pre- and post-partum haemorrhage). In Indonesia the commonest sites of haemorrhage were the gastrointestinal tract (34.6%) and the genitourinary tract (7.7%).

Acute renal failure has a higher incidence and subsequent mortality in Russell's viper than in envenoming by any other species of snake. Anuria occurred in 23% of the Indonesian bites, compared to oliguria in 44% of the Burmese group. The incidence of neurotoxicity in the Indonesian group was considerably less than that experienced in Sri Lanka. Facial weakness was reported in 15.3% of bites in Indonesia (23% in Sri Lanka). Ptosis (drooping of the eyelids) was experienced in 11.5%, considerably less than the Sri Lankan group (77%). It is possible that the venom from Indonesia may have neurotoxic properties, which were previously believed to be unique to Sri Lanka and Southern India. Conjunctival and facial oedema would appear to remain unique to Burma. It is interesting to note that respiratory distress and failure are reported to be relatively rare after Russell's viper bites elsewhere, but 46% of Indonesian bite victims reported dyspnoea.

This study consisted of a retrospective analysis, with a relatively small sample size, thus the descriptions of local and systemic envenoming may be liable to distortion resulting from subject exaggeration and interpretation in translation. Furthermore, the study has no reliable laboratory or clinical evidence to support the symptomatology. There is, however, sufficient evidence to suggest that there are differences in the clinical effects of venom of Russell's viper from the Lesser Sunda Islands, compared to the venom from other populations of both the eastern and western groups of the species (Table 5). Further work is required to assess if the antivenoms raised against Russell's viper from other parts of its range are effective for the treatment of envenoming by the Lesser Sunda population.

Treatment conclusions

Many bite victims do not consider seeking medical attention and the local medical services will tend to underestimate the true extent of the problem. There is no proven effective antivenom to treat Russell's viper envenoming in the Lesser Sunda Islands population, and local practitioners are only able to offer supportive treatment. Many of the doctors questioned are using treatments that are contraindicated and highly dangerous, for example incising skin in patients with incoagulable blood, or use of antivenoms which were not raised against Russell's viper venom and which carry a high rate of anaphylaxis.

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