Hamadryad, Vol. 23, No. 1, pp. 33 – 40, 1998.

THE GENUS *DABOIA* (SERPENTES: VIPERIDAE): RUSSELL'S VIPER

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(with one text-figure)

ABSTRACT.- The systematics and natural history of Russell's viper (*Daboia russelii*, formerly *Vipera russelii*) are reviewed. The two recognised subspecies (*D. russelii russelii* and *D. russelii siamensis*) are described, and the available literature data on systematics, distribution, natural history and medical importance are summarised, with particular emphasis on the geographic variation in venom composition and clinical effects found in this species.

KEY WORDS.- *Daboia russelii*, Vipera, Serpentes, taxonomy, morphology, natural history, venom.

INTRODUCTION

The genus *Daboia* is represented by a single species, *Daboia russelii*, the Russell's viper. This species is widespread in many parts of south-east Asia, and is a major cause of snakebite morbidity and mortality in most of its range. Russell's viper was until recently classified as a species of the genus *Vipera*, and is therefore better known as *Vipera russelii*. Obst (1983) revived the genus *Daboia* Gray, 1842, and assigned *Vipera russelii* and other large members of *Vipera*, as it was then understood (such as *V. lebetina, V. mauritanica, V. xanthina* and *V. palaestinae*), to *Daboia*. However, this was not universally followed (e.g., Joger, 1984; Brodmann, 1987; de Silva, 1990; Wüster et al., 1992a,b). Herrmann et al. (1992) examined the phylogeny of Eurasian viperines, using albumin immunology and blood serum electrophoresis. Their results show *Vipera russelii* to occupy an isolated position, the species being only distantly related to other Eurasian viperines, and they proposed the revalidation of *Daboia* as a monotypic genus, with *D. russelii* as the only species. The other large Eurasian viperines were classified as *Vipera* (*V. xanthina* and allied species), or assigned to the revalidated genus *Macrovipera* Reuss, 1927 (*V. lebetina* and related species). The restriction of *Daboia* to the single species *russelii* was followed by Golay et al. (1993) and Welch (1994).

DABOIA RUSSELII (SHAW & NODDER, 1797) - RUSSELL'S VIPER

Coluber russelii Shaw & Nodder, 1797.
Daboia russellii Gray, 1842.
Daboia elegans Gray, 1842.
Daboia pulchella Gray, 1842.
Vipera russellii Strauch, 1869.
Vipera russelli Wall, 1907.

DISTRIBUTION

The species *Daboia russelii* has a vast distribution which extends somewhat discontinuously across most of southern Asia, and into the islands of Indonesia. It occurs in many parts of Pakistan, more or less throughout India, Bangladesh and Sri Lanka, as well as in Bhutan and parts of Nepal. Further east, it is found in Taiwan and in parts of Burma, Thailand, China, and on eastern Java and some of the Lesser Sunda Islands.

INTRASPECIFIC SYSTEMATICS OF *DABOIA RUSSELII*

Until recently, the vast and discontinuous distribution of this species had led to a number of subspecies being described from different parts of its range. Most authors (e.g., Harding and Welch, 1980; Leviton, 1968) recognized five subspecies of Russell's viper: *V. r. russelii* (Shaw, 1797) from India, Pakistan and Bangladesh; *V. r. pulchella* (Gray, 1842) from Sri Lanka; *V. r. siamensis* Smith, 1917, from Burma,

Thailand, Cambodia and southern China; *V. r. formosensis* Maki, 1931, from Taiwan; and *V. r. limitis* Mertens, 1927, from Java, Komodo, Flores and Lomblen. In addition, Kopstein (1936) described the Javan populations as *V. r. sublimitis*, and Deraniyagala (1945) the northern Indian populations as *V. r. nordicus*. The subspecies *V. r. sublimitis* was recognized by van Hoesel (1954, 1958), but *V. r. nordicus* has been ignored by subsequent workers. These subspecies were defined primarily on the basis of the number of rows of dorsal spots, and a few other colour pattern characters; in some cases, purported differences, especially in the number of rows of dorsal spots, were artifacts, caused by a misinterpretation of previous published descriptions (Brongersma, 1958). The pronounced similarity between some populations assigned to different subspecies has been noted (Brongersma, 1958; Warrell, 1989).

Wüster et al. (1992a; 1992b) re-examined the systematics of *Daboia russelii*, using multivariate analysis of large numbers of morphological characters, and recognised only two subspecies of *Daboia russelii*: a western subspecies, *Daboia russelii russelii*, from India, Pakistan, Sri Lanka and neighbouring areas (including the old subspecies *russelii, pulchella* and *nordicus*), and *Daboia russelii siamensis* from Burma and the more eastern parts of the distribution (including the old subspecies *siamensis, formosensis, limitis* and *sublimitis*). It was noted that, within the latter subspecies, the specimens from the Lesser Sunda Islands differed considerably from the specimens from Java and the Asiatic mainland.

Wüster et al. (1992b) noted that the question of whether these forms should be regarded as subspecies or as separate species depends on the species concept used. Since the two forms are allopatric, there can be no conclusive evidence of reproductive isolation, or lack thereof. Consequently, the biological species concept, which relies on this criterion, is inoperative in this situation. Adherents of the phylogenetic or evolutionary species concepts (e.g., Wiley, 1981; Cracraft, 1989) would split Russell's viper into two or even three species. However, Wüster et al. (1992b) regarded an understanding of the pattern of geographic variation in this group as more important than a decision on taxonomic rank, which is dictated by a subjective decision on the species concept to be used. Further studies on the population systematics of the *D. russelii* group are currently in progress, and it was therefore felt to be premature to alter the nomenclature more than absolutely necessary at this time.

The confusion that would result in the biomedical literature from a formal split of Russell's viper into two or more species at the same time as other workers were moving it from the genus *Vipera* to the genus *Daboia* makes a conservative approach particularly important in this case. Consequently, Wüster et al. (1992b) proposed a conservative approach, in which the Russell's viper group is regarded as a single species with two subspecies, *D. r. russelii* being the western form, and *D. r. siamensis* the eastern form.

In the following paragraphs, separate descriptions of the two subspecies will be provided. However, natural history and venom information will be provided jointly for both forms, although the geographic locality to which the information pertains will be noted where necessary.

Distinguishing between *Daboia r. russelii* and *D. r. siamensis*.- The two subspecies of Russell's viper can be easily distinguished: *D. r. russelii* has a total of three rows of distinct, ovoid spots, one on each side and one along the middorsal line. Any marking between these three rows consists at most aggregations of small black speckles. In *D. r. siamensis*, there are further rows of smaller, well-defined spots between the three main rows found in *D. r. russelii* (Fig. 1). The difference appears to be absolutely diagnostic, and has also been illustrated in Warrell (1989) and Cox (1991). There are no contact zone between the two subspecies, and therefore no intergrades which might confuse the situation.

DABOIA RUSSELII RUSSELII
(SHAW & NODDER, 1797)

Vipera russelli nordicus Deraniyagala, 1945.
Vipera russelli pulchella Deraniyagala, 1945.
Daboia russelli russelli Obst, 1983.
Daboia russelli pulchella Obst, 1983.

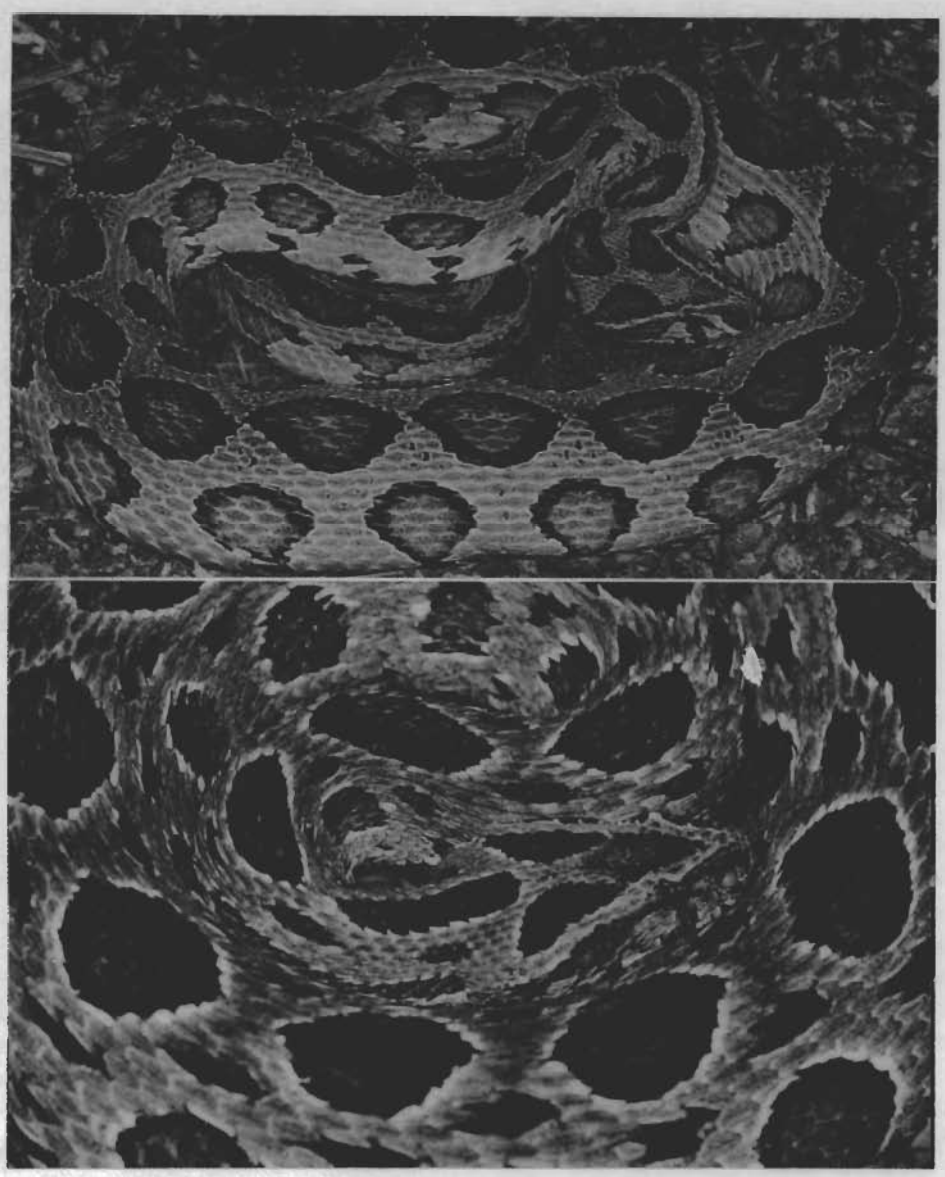

FIGURE 1: Pattern of *Daboia russelii russelii* (top: specimen from Sri Lanka) and *D. r. siamensis* (bottom: specimen from Thailand). Note the presence of additional rows of well-defined smaller spots between the principal rows in the Thai specimen; these are never present in *D. r. russelii*, which has at most groups of small speckles between the main rows, as seen here.

DISTRIBUTION

The subspecies *Daboia russelii russelii* is found more or less throughout India, although its range is somewhat discontinuous, and it may be rare in some areas, and very common in others. It appears to be absent in Assam and neighbouring states, although it is found in Bhutan and Darjeeling. Reported to be very common in the Punjab, along the west coast, and many parts of southern India; rarer in the Ganges Valley and northern Bengal (Smith, 1943). Has been found in western Nepal (O'Shea, pers. comm.). In Pakistan, it is

restricted to the northern Punjab and neighbouring areas, and the Indus Valley in Sind Province (Joger, 1984; Khan, 1990).

DESCRIPTION

Size.- Most adults measure about 100-120 cm, one record is approximately 167 cm (Smith, 1943), but Murthy (1990) puts the maximum size at 185 cm.; neonates measure 20-30 cm, and are exact replicas of the adults.

General appearance.- A fairly stout, robust snake with a fairly short tail and a thin neck. Head very distinct from body, somewhat triangular. Pupil of eye vertical. Nostril very large.

Pattern.- *Daboia russelii russelii* has a characteristic pattern which makes it difficult to confuse it with any other Indian snake species, if carefully observed. Dorsal ground colour usually some shade of brown. Three rows of oval spots along the body, one along the midline, and another along each side. Sometimes, some small darkish speckles between these main rows. These spots are normally brown in the center, and have a black or dark brown outer margin, which in turn has a very fine white outer margin (see Brongersma, 1958, for a more detailed analysis of pattern variation in Russell's viper). Normally two oval or triangular spots with black and white margins on each side of the top of the head. Ventral surface white, with numerous small, half-moon shaped marks on many ventral scales.

Scalation.- Males have 163-175 ventrals and 44-64 subcaudals, females have 160-175 ventrals and 45-56 subcaudals. Dorsal scales keeled, in 27-32 (most commonly 29) rows at midbody (defined as the level of 50% of the total ventral scale count). Upper side of head covered in small scales, only the supraoculars being noticeably differentiated. Seven to 11 small scales separate the supraoculars. Supralabials 9-13. Infralabials 12-17.

DABOIA RUSSELII SIAMENSIS
(SMITH, 1917)

Vipera russelli siamensis Smith, 1917.
Vipera russelli formosensis Maki, 1931.
Vipera russelli limitis Mertens, 1927.
Vipera russelli sublimitis Kopstein, 1936.
Daboia russelli limitis Obst, 1983.

DISTRIBUTION

Daboia russelii siamensis has a strikingly discontinuous distribution. It is very common in the central plains of Burma. In Thailand, it occurs in the central plain from Nonthaburi Province north to Kamphaeng Phet province, and east to Nakhon Ratchasima Province, and through Prachinburi Province and into adjacent Cambodia near Aranyaprathet and Pailin (Saint Girons, 1972; Viravan et al., 1992). Reports from more southerly parts of Thailand (Cox, 1991) require confirmation. It is also found in parts of southern China, in the provinces of Guangxi, Guangdong and southern Fujian (Zhao, 1990; Zhao and Adler, 1993), as well as in southern and eastern Taiwan (Lin, 1990). In Indonesia, it has a small and scattered range: it is found in the region of Surabaya and Tuban in eastern Java (van Hoesel, 1959; Hodges, 1993; Belt, 1997), and the lesser Sunda Islands of Komodo, Flores, Endeh, Lomblen, Adonara, and Solor (van Hoesel, 1954, 1958; Auffenberg, 1980; Warrell, 1989; Belt et al., 1997).

DESCRIPTION

Size.- This form appears to remain smaller than the western subspecies. Specimens from the Lesser Sunda Islands very rarely reach 100 cm (Auffenberg, 1980, reported a maximum snout-vent length of 70 cm in his series), those from Java have been recorded at up to 111 cm. The largest specimen in two large series from Burma (Myint-Lwin et al., 1985; Tun-Pe et al, 1991) measured 112 cm. Neonates in Burma measure 22 cm on average, but specimens as small as 12.5 cm have been reported from the same country (Tun-Pe et al., 1991). The smallest specimen from Komodo noted by Auffenberg (1980) measured 17 cm in snout-vent length, suggesting a total length of over 20 cm.

Pattern.- The pattern of *D. russelii siamensis* is very similar to that of the nominate form. The main difference is the presence of further rows of spots between the three principal rows (see Brongersma, 1958, for a more detailed analysis of pattern variation in Russell's viper). There are other subtle differences in pattern, and there is also geographic variation in pattern distinctness, ground colour etc. within *D.r. siamensis*.

Scalation.- Males have 146-167 ventrals and 42-61 subcaudals, the females have 146-166 ventrals and 33-58 subcaudals. Dorsal scales keeled, in 27-33 (normally 29-31) rows at midbody (defined as 50% of ventral scale count). Top of head covered in small scales, only the supraoculars being differentiated. Six to 10 small scales separate the supraoculars. Supralabials 9-12. Infralabials 11-14.

NATURAL HISTORY OF *DABOIA RUSSELII*

Habitat.- Russell's viper is primarily an inhabitant of fairly open areas, with grassy, scrubby or bushy vegetation. Also found in rice fields and other agricultural areas. May take refuge in rock crevices, termitaria or the base of bushes. Occurs from sea level to 2100 m in southern India, to a slightly lesser altitude in the western Himalayas. In Thailand, it has only been reported from fairly low-lying parts of the central plain. On Komodo, Auffenberg (1980) reported it from savanna and beachside habitats at low altitudes (0-120 m), often in association with dry river beds and stone piles.

Reproduction.- Russell's viper is ovoviviparous, i.e., it gives birth to fully developed young, which normally number 20-40. Litters of up to 63 neonates have been reported (Wall, 1906). In India, birth normally occurs from May to July, whereas Auffenberg (1980) collected neonates in January on Komodo.

Food.- Adults are generally reported to eat mostly rodents, but there is considerable geographic variation in diet, which may reflect variation in prey availability. In southern India, gerbils (*Tatera indica*) are reported to be the main food (Whitaker, 1978). Juveniles from India have been reported to eat pretty much any vertebrate they can overpower, including young conspecifics, and have even been reported to eat land crabs, scorpions and other arthropods (Whitaker, 1978). A series of stomach contents from specimens of all sizes (21 out of 34 were juveniles under 40 cm) from Burma consisted overwhelmingly of rodents (29 out of 34), with only very few frogs, lizards and birds. On Komodo, juveniles were found with insects, especially coleoptera, in their digestive tract, and adults and juveniles alike were found to contain lizards, rodents and anurans (Auffenberg,1980)

Behaviour.- Mostly nocturnal, very occasionally encountered active during the day. Reported to be generally slow-moving. Will often stand its ground when disturbed in the open. When disturbed, hisses very loudly and stridently. Once irritated, strikes rapidly and with great force. Some specimens thrash around wildly, striking in all directions. Can move with surprising rapidity in such circumstances.

MEDICAL IMPORTANCE

Due to its occurrence in agricultural areas (especially rice fields), its excellent camouflage, uncertain temper and potent venom, Russell's viper is a major cause of snakebite morbidity and mortality in many areas, such as India (Matthai and Date, 1981), Sri Lanka (Phillips et al., 1988; de Silva, 1981, 1990; de Silva and Ranasinghe, 1983), Burma (Aung-Khin, 1980; Myint-Lwin et al., 1985), Thailand (Looareesuwan et al., 1988; Sawai et al., 1972) and parts of Indonesia (Auffenberg, 1980; Belt et al., 1997).

Recent work on the clinical effects of the venom of Russell's viper, carried out in many parts of its range, has revealed an enormous degree of geographic variation in the syndrome of envenomation experienced by human bite victims (summarised by Warrell, 1989; 1995; 1997; Belt et al., 1997). Reduced blood coagulability and renal failure are widespread, but a number of other phenomena show strong geographic variation. Bites in Sri Lanka also result in neurotoxicity, rhabdomyolysis and intravascular haemolysis (Jeyarajah, 1984; Phillips et al., 1988). Neurotoxic effects have also been reported from southern India. Pituitary haemorrhage has been reported from southern India and Burma (Myint-Lwin et al., 1985; Warrell, 1986, 1989). Bites in Burma result furthermore in shock and generalised capillary permeability, whereas bites in Thailand result mostly in intravascular haemolysis and reduced blood coagulability. There is a serious shortage of detailed reports of the clinical effects of the bites of this species from India, Pakistan, Bangladesh, China, Taiwan and Indonesia.

These differences in clinical symptoms are related to profound differences in venom composition and enzymatic activity (Jayanthi and Gowda, 1988; Woodhams et al., 1990), which in turn may affect antivenom efficacy if an antivenom is used against the venom of populations other than those used for its preparation.

Antivenom effectiveness in Russell's viper is apparently not related to the principal division into eastern and western subspecies, and also not necessarily to differences in the effects of the venom. Despite profound differences in clinical venom effects, antivenom against Burmese Russell's viper (*Daboia r. siamensis*) was found to be effective against the venom of Thai Russell's vipers (also *D. r. siamensis*) and even against the venom of Russell's vipers from India (*D. r. russelii* - specific locality not noted, unfortunately) (Phillips et al., 1988). On the other hand, the Burmese antivenom was found to be ineffective in protecting mice against the lethal effects of Sri Lankan *D. r. russelii* venom (Phillips et al., 1988), as was Indian (Haffkine) antivenom, presumably produced from the venom of western Indian populations of *D. r. russelii*. The latter was found by Phillips et al. (1988) to be similarly ineffective in treating human patients envenomated by Russell's vipers in Sri Lanka. Jayanthi and Gowda (1988) mentioned reports of lack of efficacy of Haffkine antivenom when used in southern India, but Matthai and Date (1981) noted that Haffkine antivenom appeared to greatly reduce the incidence and severity of acute renal failure in children if administered within 2 hours of the bite. In Burma, monospecific Burma Pharmaceutical Industry antivenom administered even within 4 hours of the bite failed to prevent renal failure (Myint Lwin et al., 1985).

ACKNOWLEDGEMENTS

I wish to thank Satoko Otsuka for her work in our research group, Roger S. Thorpe for his support, and the staff of the following museums who loaned specimens for this study: American Museum of Natural History (New York); the Natural History Museum (London); California Academy of Sciences (San Francisco); Field Museum of Natural History (Chicago); Museum of Comparative Zoology (Cambridge, Mass.); Muséum d'Histoire Naturelle (Geneva); Naturhistorisches Museum Wien, (Vienna); Naturhistoriska Riksmuseet (Stockholm); Rijksmuseum van Natuurlijke Historie (Leiden); Florida Museum of Natural History, University of Florida (Gainesville); University Zoological Museum (Copenhagen); Zoologisches Forschungsintitut und Museum A. Koenig (Bonn); and Zoologisches Museum Hamburg (Hamburg). The author's research on Russell's viper was carried out while supported by a NERC postdoctoral fellowship, and the final version of the paper was prepared while supported by the Wellcome Trust.

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Accepted: 23 January, 1998.
Received:21 April, 1998.