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New distribution records of *Daboia russelii* (Shaw & Nodder, 1797), in the Northeast of India, with notes on envenomation

(Squamata: Serpentes: Viperidae)

Neue Fundorte von *Daboia russelii* (Shaw & Nodder, 1797) in Nordostindien mit Bemerkungen zur Giftwirkung
(Squamata: Serpentes: Viperidae)

Anukul Nath & Abhijit Das & Sanjoy Sutradhar & Deepankar Barman & Biswajit Chakdar & Sanath Krishna Muliya & Gandla Chethan Kumar

KURZFASSUNG

Die Kettenviper *Daboia russelii* (Shaw & Nodder, 1797) bewohnt den indischen Subkontinent westlich des Golfes von Bengalen, das Verbreitungsgebiet von *Daboia siamensis* (Smith, 1917) schließt östlich daran an. Der Verlauf der Verbreitungsgrenze von *D. russelii* im Osten von Indien ist allerdings unklar, weshalb die Autoren hier Angaben über bestätigte Funde aus dem Bundesstaat Assam und zu Merkmalen der dortigen Vipern und ihrem Lebensraum machen. Der Fall eines in diesem Gebiet erfolgten Giftbisses bei einem 29-jährigen Mann und seine Behandlung werden beschrieben. Ein Überblick über die unterschiedlichen Vergiftungssymptome nach Bissen von *D. russelii* aus verschiedenen Gebieten wird gegeben.

ABSTRACT

The Western Russel's Viper, *Daboia russelii* (Shaw & Nodder, 1797), inhabits the Indian subcontinent west of the Bay of Bengal, whereas *Daboia siamensis* (Smith, 1917), is found east of this area. The easternmost distribution limit of *D. russelii* in India is obscure. This is why the authors present here first confirmed locality records of *D. russelii* from the federal state of Assam, including morphology and natural history data. A detailed account of a 29-year-old man's envenomation by a viper from that area and the treatment protocol is presented. Envenomation symptoms of *D. russelii* snakebites from different regions are compared.

KEYWORDS

Reptilia: Squamata: Serpentes: Viperidae; *Daboia russelii*, distribution, new records, snake-bite, envenomation, medical treatment; Assam, Republic of India

INTRODUCTION

In SE Asia, the genus *Daboia* Gray, 1842, is represented by two species, *Daboia russelii* (Shaw & Nodder, 1797), the Western Russell's Viper, restricted to the Indian subcontinent including Pakistan, India, Sri Lanka, Nepal and Bhutan, and *Daboia siamensis* (Smith, 1917), the Eastern Russell's Viper, ranging across Cambodia, China, Indonesia, Myanmar, Taiwan and Thailand (Wüster 1998; Thorpe et al. 2007). Though the western species *D. russelii* is reported to be found throughout India (Whitaker & Captain 2008), including records from Darjeeling and Bhutan, its easternmost distribution and existence in the federal state of Assam and the neighboring states of Northeast India is yet to be clearly defined (Smith 1943; Wüster 1998; Ahmed et al. 2009).

Snakebite is a common and frequently devastating environmental and occupational disease, especially in rural areas of India (Warrell 2010; Mohapatra et al. 2011). It has the highest number of deaths due to snake bites compared to rest of the world, with estimated 35,000 to 50,000 people dying every year according to World Health Organization's (WHO) estimates (Chippaux

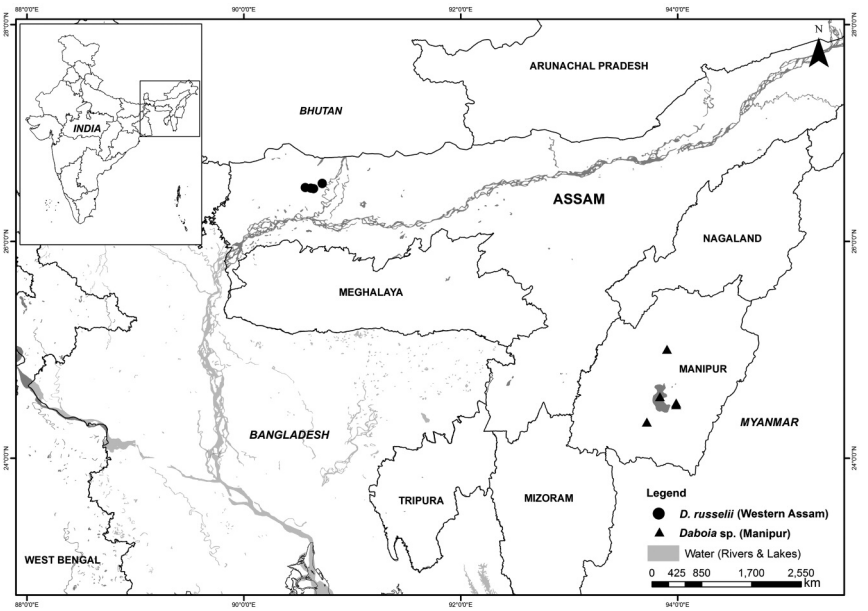

Fig.1: Locality records of *Daboia russelii* (Shaw & Nodder, 1797), in Northeast India.
Abb. 1: Fundorte von *Daboia russelii* (Shaw & Nodder, 1797) in Nordost-Indien.

1998; Kasturiratne et al. 2008; Alirol 2010). *Daboia russelii* is one among the 'Big Four': *Naja naja* (Linnaeus, 1758), the Indian Spectacled Cobra; *Echis carinatus* (Schneider 1801), the Saw-scaled Viper and *Bungarus caeruleus* (Schneider 1801), the Common Krait responsible for most human casualties, making it by far the most medically important viper in India. Studies have shown geographic variation in the Russell's Viper venom, and syndromes of envenomation experienced by victims to vary within the range of its distribution (Sharma et al. 2015; Warrell 1989, 1995, 1997; Belt et al. 1997; Jayanthi & Gowda 1988; Whitaker &Whitaker 2012). The issue is a lot more complicated in northeastern India due to lack of reliable clinical reports and envenoming profiles for the species. The present paper is an attempt to highlight and confirm the presence of the Western Russell's Viper in Northeast India along with a detailed clinical profile of an envenomation incident.

MATERIALS AND METHODS

Observations were made based on road kill specimens and opportunistic visual encounters in the Bongaigaon and Chirang districts of Assam. Dorsal scale rows were counted at one head-length behind the head, at midbody, and at one head-length anterior to the vent. Ventrals were counted following Dowling (1951). The midbody count was taken at half of the snout-vent length; the anal plate was not counted and the terminal scale was excluded in the subcaudal count. Snout-vent-length (SVL) and tail length (TL) were taken with a measuring tape to nearest millimeter. Photographs were taken with high resolution digital camera (10.1 megapixels). GPS coordinates, habitat characteristics and natural history notes were also noted. Furthermore, the clinical profile along with the symptoms of envenoming, which happened to the fourth

author (Deepankar BARMAN) at Bongaigaon, Assam, was recorded in detail. Collection acronyms: WIIR – Wildlife Institute of India, Dehradun; ZSIC – Herpetology Section, Zoological Survey of India, Kolkata.

RESULTS

Locality records.– A total of six observations were recorded from the federal state of Assam, India. In Chirang district: two from Bangaljhora village (26.535430° N, 90.722210° E; 26.53361° N, 90.72240° E); in Bongaigaon district: one each from National Highway 31C (26.496550° N, 90.566421° E) and Rakhaldubi (26.486974° N, 90.642850° E) and two observations from Chaprakata village (26.49139° N, 90.6175° E; 26.48944° N, 91.61417° E) (Fig. 1).

Morphological observations.– The road-killed specimen from the Bongaigaon district (WIIR 400; SVL: 920 mm; TL: 90 mm) had a stout body and rough appearance; head triangular, flat and broader than neck, with small strongly keeled scales on the upper surface of head, vertical pupil, vertical and large nostrils.

Colorpattern: top of head with narrow triangle shaped marking and a pair of semi-triangular spots; triangular strip behind the eye; lip scales molted with brown and creamy white; faint brown dorsally with three longitudinal series of large brown circles, encircled with prominent blackish-brown and thin irregular white margins; ventral side speckled with black semilunar markings. Blotches on the subcaudals few compared to ventral scales.

Pholidosis: longitudinal dorsal scale rows two head lengths behind the head: 25, middle of the body: 31, two head lengths before the vent: 23; supralabials 11/11, 4-5 large; ventrals: 171; sub-caudals: 51 paired.

The specimen from Bangaljhora village, Chirang district had an SVL of 960 mm, a TL of 115 mm, 11/11 supralabials (4th and 5th large), 174 ventrals and 46 subcaudals (Fig. 2).

Natural history notes.– On January 1, 2016, at around 12:30 hrs, locals killed a Russell's Viper at Bangaljhora village, Bijni, Chirang district. The snake was encountered in a paddy field adjacent to human habitation, surrounded with bamboo thickets (Fig. 3). Subsequently, on December 8, 2017, another individual was found to reside under paddy straw from the same area, just 200 m away. In addition to that, a road-killed specimen was observed on April 8, 2016, at 21:50 hrs, on the highway (NH 31-C) at Bongaigaon, federal state of Assam. Scrub vegetation was dominant along either sides of the road, and the adjacent area was encompassed by agriculture and human settlement. Subsequently, on February 10, 2016, at 11:30 hrs, a Russell's Viper bit a 29-year-old male (Deepankar BARMAN, fourth author, referred to as patient henceforth) on the muscular joint between thumb and index of his right hand while rescuing a mating pair which was threatened by the villagers at Rakhaldubi adjacent to NH 31-C, Bongaigaon district. The snakes were quickly bagged and released on a nearby hillock after 10-15 minutes of rescue. Rakhaldubi is adjacent to Kakoijona Reserve Forest and Aie River, enclosed by crop fields and scattered human settlements. People mostly practice cultivation of paddy and seasonal vegetables in and around Rakhaldubi. On January 28, 2018, at 10:54 hrs, another individual was sighted about 50 m away from a human habitation and recently a road-killed specimen was reported from National Highway 27 at Chaprakata village, Bongaigaon district on February 26, 2018.

Post-envenomation events.– The chronology of events and symptoms observed further to the envenomation were as follows: after 10-15 minutes post-envenomation, the patient experienced localized inflammation accompanied by severe local pain. Within an hour, inflammation gradually started increasing with incessant pain. Due to non-availability of anti-venom, the patient was treated with tetanus vaccine in a nearby dispensary and immediately referred to Lower Assam Hospital in Bongaigaon. During the subsequent hours, generalized throbbing pain, visible inflammation and itching sensation spread to the entire affect-

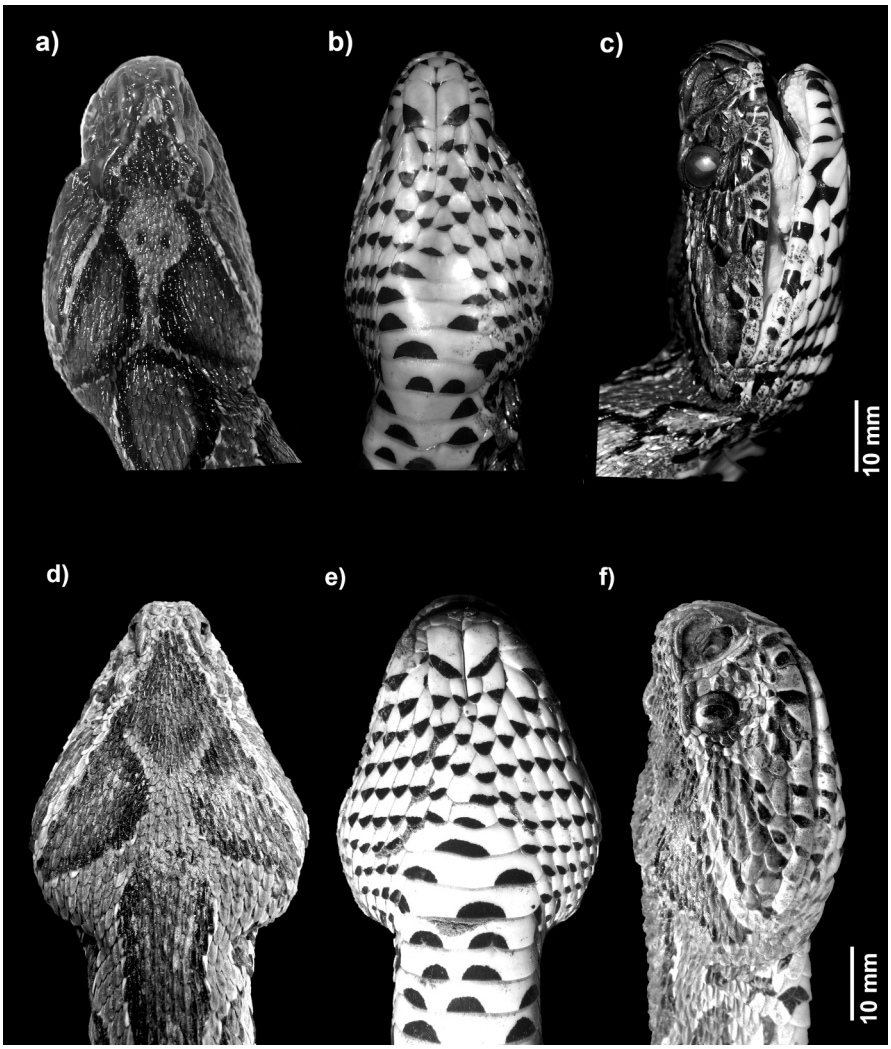

Fig. 2: Dorsal, ventral and lateral views of the head of Northeast Indian *Daboia russelii* (Shaw & Nodder, 1797), a – c representing the roadkill specimen from National Highway 31-C, Bongaigaon district (WIIR 400) and d – f the specimen from Bangaljhora village, Chirang district, federal state of Assam, India.

Abb. 2: Dorsal-, Ventral und Lateralansichten des Kopfes nordostindischer *Daboia russelii* (Shaw & Nodder, 1797). Die Figuren a – c zeigen das straßentote Exemplar von Nationalstraße 31-C, Bezirk Bongaigaon (WIIR 400), d – f das Exemplar aus dem Ort Bangaljhora, Bezirk Chirang, Bundesstaat Assam, Indien.

ed arm. This was followed by chronic headache, nausea and vomiting. On arrival at the Bongaigaon hospital, three and a half hours after the bite, the patient was immediately subjected to a prothrombin test, the results of which was a prothrombin time of 14 seconds (expected value 11-15 seconds), control 13.5 seconds with INR (International Normalized Ratio) of 1.10. He was without delay shifted to the intensive care unit (ICU) where the application of polyvalent antivenom (V-ASV, manufactured by Virchow, Gagillapur, Qutubullapur, Andhra Pradesh, India, packaged in 10 ml vials) was initiated.

Fig.3. Close-up and total views of *Daboia russelii* (SHAW & NODDER, 1797), from Bangaljhora, Chirang district, federal state of Assam, India.

Abb. 3: Nahaufnahme und Übersichtsbild von *Daboia russelii* (SHAW & NODDER, 1797) aus Bangaljhora, Bezirk Chirang, Bundesstaat Assam, Indien.

The antivenom was administered intravenously in normal saline (physiologic salt solution), without any anaphylactic reaction.

Over the the next three days the patient was administered a total of 17 vials of anti-venom through intravenous normal saline. On the third-day post-envenomation, the patient started exhibiting neurological symptoms such as severe weakness in neck and limb muscles and mild respiratory distress followed by drooping of the upper eyelid and double vision. The patient also exhibited symptoms of acute kidney injury. A renal function test revealed his blood urea nitrogen and creatinine to be 190 mg/dl and 10.14 mg/dl, respectively. Serum electrolytes, namely sodium and potassium levels ranged from 138-154 m mol/l and 3.57-4.44 m mol/l, respectively. The patient was subsequently subjected to dialysis, a total of eight times within the next ten days, until the renal function test results were within

Table 1: Hematology test reports of the presented 29-years-old male bite victim of *Daboia russelii* (SHAW & NODDER, 1797), from Chaprakata village, in Bongaigaon district, federal state of Assam, NE India. n. a. – not available.

Tab. 1: Hämatologische Befunde des vorgestellten 29-jährigen männlichen Bißopfers von *Daboia russelii* (SHAW & NODDER, 1797) aus dem Ort Chaprakata, Bezirk Bongaigaon, Bundesstaat Assam, Nordost-Indien. n. a. – nicht verfügbar.

Date Datum	Hemoglobin (g/dl) Hämoglobin	Blood Urea Nitrogen (BUN) (mg/dl) Blutharnstoff-Stickstoff (BUN)	Creatinine (mg/dl) Kreatinin	Sodium (mmol/l) Natrium	Potassium (mmol/l) Kalium
10/02/2016	8.5	143	4.06	n. a.	n. a.
11/02/2016	7.8	98	6.95	138	3.57
13.02.2016	9.5	190	8.13	139	3.49
15/02/2016	10.6	158	10.14	135	3.18
17/02/2016	11.7	92	5	140	4.44
20/02/2016	14.8	20	1.5	154	4.34
Normal range Normalwerte	13.5-18	16.5-48.5	0.5-1.2	135-155	3.5-5.2

normal range (Table 1). Since the hemoglobin concentration had also dropped below normal range (observed: 7.8 g/dl, expected range: 13.5 -18 g/dl), blood transfusion was carried out as supportive therapy. After ten days in the ICU and three days in the observation unit, he was discharged and advised to get regular medical examination for signs of renal dysfunction or secondary complications over the course of the next year. The patient has however not experienced any secondary complications so far (December 2018).

DISCUSSION

Northeast India is considered as a part of a global biodiversity hotspot (Chatterjee et al. 2006). Distribution data across multiple floral and faunal groups indicate that the region's biological affinities closely resemble those of South East Asia (Mani 1974), with few species limiting their distribution to this particular region (Sengupta et al. 2009; Choudhury 2013;Sutradhar & Nath 2013). Further, recent discoveries of new species and range extensions of snakes demonstrate the importance for more inventory (David et al. 2001; Slowinski et al. 2001; Ahmed & Das 2006; Nath et al. 2011; Sutradhar & Nath 2013; Das & Das 2017). However, the geographical proximity of the Indian and Indo Chinese regions (Corbet & Hill 1992) makes Northeast India a potential biodiversity hybrid zone for flora and fauna.

There is a fine yet distinct difference in dorsal pattern in the two species namely: *Daboia russelii* has a total of three longitudinal rows of distinct ovoid spots, whereas, *D. siamensis* has additional rows of smaller, well-defined spots between the three main rows found in *D. russelii.* Based on this, all specimens studied here were *D. russelii*, lacking additional spots.

Compared to *D. siamensis*, *D. russelii* has a more continuous distribution on a macro-scale; however, on a finer scale its distribution is discontinuous and scattered within the Indian sub-continent (Smith 1943). The discontinuity in the distribution of the species is likely to be due to a combination of habitat preferences and Pleistocene changes in sea levels and climate (Wüster et al. 1992). In general, Russell's Vipers are primarily residents of open land, grassy, scrubby or bushy vegetation, rice fields and other agricultural areas but avoid rainforests (Smith, 1943; Warrell 1989; Whitaker 1978; Das & Das 2017). This may be the reason for its apparent rarity in Northeast India, which is mesic in its ecological setting. Global climate change was shown to have greatly affected the distributional patterns of snakes (Nori et al. 2013). The increase in temperature, coupled with expansion of xeric habitat could augment the capability of *D. russelii* to expand its range in northeast India. Although, the species was collected from Goalpara district (#ZSI-19902, collected on 08.02. 1927) this was never reported in the literature (*fide* Smith 1943; Whitaker & Captain 2008; Ahmed et al. 2009). However, in recent years there were frequent sightings of this species in Western Assam (Fig. 1), possibly indicating its expanding population in the area.

According to Biswas &Pawar (2006) the Brahmaputra River and Ganga-Brahmaputra Delta may act as a barrier to the species distribution at a finer scale. This can also be supported by the fact that western Assam forms the easternmost distribution limit for many widespread Indian species such as *Uperodon taprobanicus* (Parker, 1934), *Oligodon kheriensis* Acharji & Ray, 1936, *Pavo cristatus* Linnaeus, 1758, *Axix axis* (Erxleben, 1777) and *Antelope cervicapra* (Linnaeus, 1758) (Choudhury 2013; Das et al. 2016; Sengupta et al. 2009; Sutradhar & Nath 2013). The authors thus conclude that in India, the range of *D. russelii* is currently restricted by the Manas River in the east and in in the South of India and Bangladesh by the Brahmaputra River (Hasan et al. 2014). Singh (1995) reported *D. russelii* from Kakching, Moirang, and Churachadpur of Manipur. Further it was reported from Omega School at Motbung (Anonymous 2016), and Keibul Lamjao National Park (pers. communication S.

Rohikanta) (Fig. 1). The authors could not study any of these specimens and thus refrain from comments on the specific identity as these localities are close to the range area of *D. siamensis* in Myanmar. Although Thorpe et al. (2007) hypothesized that there is no contact zone between the two *Daboia* species, the possibility of intergrades should not be rejected.

Due to its excellent camouflage, occurrence in agricultural areas and complexity of clinical symptoms exhibited to bites, *D. russelii* envenomations remain a major cause of snakebite mortality throughout its known range (Matthai & Date 1981; Phillips et al. 1988; Myint-Lwin et al. 1985; Looareesuwan et al. 1988; Belt et al. 1997). *Daboia russelii* venom can cause neurological signs suggesting elapid neurotoxicity, as well as muscle pain and dark brown urine suggesting sea-snake rhabdomyolysis (Who 2016). Studies have also demonstrated regional variation in Russell's Viper venom; venom from northern and western parts of India is known to be twice as toxic as venom samples from the south and anti-venom prepared from specimens in the south failed to protect experimental animals against venom from other parts of India (Prasad et al. 1999; Whitaker &Whitaker 2012). Thus, clinical profiling and documentation of envenoming events are extremely important and beneficial in developing a successful treatment regimen.

Russell's Viper venom contains toxins that cause platelet aggregation, coagulopathy and hemorrhage, subsequently producing hypotension, disseminated intravascular coagulation, direct nephrotoxicity, and, as observed in patients from Sri Lanka and India, intravascular haemolysis and rhabdomyolysis (Who 2016). It also causes neurological manifestations leading to symptoms such as ptosis, ophthalmoplegia, limb and neck muscle weakness, respiratory failure**,** and delayed sensory neuropathy (Wüster et al. 1992; Subasinghe et al. 2014; Who 2016). The initial symptoms in patients bitten by this viper are pain and swelling of the bitten body part, which generally appear within a few minutes (Chugh 1989), followed with severe local inflammation and sometimes blistering (Warrel et al. 2013). Myotoxicity, which is an important effect of snake envenoming, can manifest locally and systemically (Silva et al. 2016). Clinical features of myotoxicity reported for Srilankan Russell's Viper bite include myalgia and tenderness in the bitten limb (Silva et al. 2016). However, no such symptoms were reported in the present case. Studies carried out in Sri Lanka also found that abdominal pain is a common clinical feature of Russell's Viper envenoming and its severity is significantly correlated with the severity of systemic envenoming (Kularatne et al. 2014). A comparison of geographic similarities and variation in clinical symptoms exhibited following *D. russelii* envenomation is presented in Table 2.

Neurotoxicity is well known in Russell's Viper envenomation, with bites frequently leading to progressive descending paralysis (Myint-Lwin et al. 1985; Warrell 1989). Though the patient experienced 'Broken neck' sign in the present case, which is caused by paralysis of the neck flexor muscles as observed by Alirol et al. (2010), paralysis did not extend further that would have necessitated intubation. The low level of respiratory distress was also corrected by non-invasive oxygen supplementation. However, in contrast to published observations, where neurotoxicity developed within eight hours post envenomation in all patients, none of the neurotoxicity symptoms appeared in the current patient until at least 48 hours post-envenomation.

Sharma et al. (2005) reported that out of 52 patients with viper bites, 39 had acute renal failure and of these 33 required dialysis. Plasma creatinine, blood urea nitrogen and potassium concentrations are believed to get elevated in the acute kidney injury caused by Russell's Viper envenomation (Who 2016). In the present case, the patient did exhibit symptoms of acute kidney injury, with blood urea nitrogen and creatinine levels increasing since day one, warranting dialysis. However, serum sodium and potassium levels did not show major changes initially and elevated slightly only after day five. The observations correspond with Kumar & Basheer (2011), who found serum creatinine and blood urea nitrogen levels to increase immediately after the bite, along with significant elevation in sodium

Table 2: Possible clinical symptoms in response to envenomation by *Daboia russelii* (Shaw & Nodder, 1797), compiled from the available literature and including the current case from Northeast India. The clinical symptoms mentioned here may manifest alone or in combination. Footnotes 1) to 4) refer to the sources of information. + – documented in at least one case, NR – not reported so far, --- – absent in the reported case.

Tab. 2: Literaturbasierte Zusammenstellung der möglichen klinischen Symptome nach dem Biß von *Daboia russelii* (Shaw & Nodder, 1797) einschließlich derer des hier berichteten Bißfalls aus Nordost-Indien. Die angeführten klinischen Symptome können einzeln oder kombiniert auftreten. Die Fußnoten 1) bis 4) verweisen auf die Informationsquellen. + – zumindest in einem Fall nachgewiesen, NR – bisher nicht beobachtet, --- – im berichteten Fall nicht beobachtet.

Clinical symptom Klinisches Symptom	Sri Lanka [1]	Southern India [2] Südindien	Northern India [3] Nordindien	Assam-Northeast India [4] Assam- Nordostindien
Presenting symptoms of viper bite at the time of admission to hospital / Vipernbiß-Symptome bei der Einlieferung ins Spital				
Pain at the site / Schmerz an der Bißstelle	+	+	+	+
Bleeding from site / Blutung an der Bißstelle	+	+	+	+
Vomition / Erbrechen	NR	+	NR	+
Ecchymosis (subcutaneous bleeding with typical skin discoloration / Ecchymose (Einblutungen in die Haut mit charakteristischen Verfärbungen)	+	+	+	+
Abdominal Pain / Bauchschmerz	+	NR	NR	---
Confusion / Verwirrtheit	NR	+	NR	---
Haematotoxic and Myotoxic manifestations / Giftwirkung auf Blutgefäße und Muskulatur				
Haematemesis (vomiting of blood) / Bluterbrechen	+	+	+	---
Epistaxis (nosebleed) / Nasenbluten	+	+	+	---
Intracerebral bleeding / Hirnblutung	+	+	+	---
Gangrene at bite area / Gangrän der Bißstelle	+	+	NR	---
Cellulitis / Entzündung des Unterhautgewebes	+	+	NR	---
Myocardial ischemia (inadequate blood supply to heart muscles) / Durchblutungsstörung des Herzmuskels	+	+	+	---
Hematological and coagulation profile / Blutzellen- und Gerinnungsbefund				
Increased total leucocyte count / Leukozytenzahl erhöht	+	+	+	---
Decreased platelet count / Thrombozytenzahl verringert	+	+	+	---
Increased bleeding time / Blutungszeit erhöht	+	+	+	+
Increased clotting time / Gerinnungszeit erhöht	+	+	+	+
Increased prothrombin time / Prothrombinzeit erhöht	+	+	+	+
Increased activated partial thromboplastin time / Aktivierte partielle Thromboplastinzeit erhöht	+	+	+	---

[1] Based on reports from the North Central Province of Sri Lanka (Philips et al. 1988; Kularatne et al. 2014; Subasinghe et al. 2014 and Antonypillai et al. 2010).

[2] Based on reports from Indian states including Karnataka, Kerala, Tamil Nadu and undivided Andhra Pradesh (Monteiro et al. 2012; Antonypillai et al. 2010; Saravu et al. 2012; Subburaja et al. 2015; Krishnamurthy et al. 2013; Eapen et al. 1976 and Narang et al. 2009).

[3] Based on reports from Indian states including Gujarat, Haryana, Maharashtra, Punjab, Rajasthan, Uttar Pradesh, and New Delhi (Sharma et al. 2005; Alirol et al. 2010; Antonypillai et al. 2010; Punde 2005; Bawaskar et al. 2008; Singh et al. 2008; Caudhary & Parmar 2018 and Paul et al. 2014)

[4] Based on observations from a single case of Russell's Viper envenomation from Assam in a 29-year-old male with no previous underlying medical conditions. / Auf Grundlage des in dieser Arbeit beschriebenen Bißfalles eines 29-jährigen Mannes ohne bekannte Vorerkrankungen.

Table 2 (continued from preceding page). / Tab. 2 (Fortsetzung der vorangegangenen Seite).

Clinical symptom Klinisches Symptom	Sri Lanka [1]	Southern India [2] Südindien	Northern India [3] Nordindien	Assam-Northeast India [4] Assam- Nordostindien
Neurologic manifestations / Neurologische Erscheinungen				
Opthalmoplegia (paralysis of the muscles within or surrounding the eye) / Augenmuskellähmung	+	+	+	+
Ptosis (drooping of the upper eyelid) / Herabhängen des Oberlides	+	+	+	+
Diplopia (double vision) / Doppelbildsehen	+	NR	+	+
Bilateral Blindness / Beidäugige Blindheit	+	NR	NR	---
Exudative retinal detachment / Exsudative Netzhautablösung	NR	NR	+	---
Muscle weakness, paralysis / Muskelschwäche, Lähmung	+	+	+	+
Respiratory paralysis / Atemlähmung	+	+	+	---
Delayed sensory neuropathy / verzögert einsetzende neurologische Störungen	+	+	+	+
Nephrologic manifestations / Die Nierenfunktion betreffende Veränderungen				
Hematuria / Blut im Harn	+	+	NR	---
Elevated serum blood urea nitrogen / Erhöhter Blutharnstoff-Stickstoff-Wert	+	+	+	+
Elevated serum creatinine / Erhöhter Serum-Kreatininwert	+	+	+	+
Elevated sodium and potassium levels / Erhöhte Natrium- und Kaliumwerte im Blutserum	+	+	NR	---
Oliguria / Verminderte Harnproduktion	+	+	NR	---
Renal failure requiring dialysis / Nierenversagen, das Dialyse erfordert	+	+	+	+
Renal failure requiring renal replacement therapy / Nierenversagen, das Nierenersatztherapie erfordert	+	+	NR	---
Pituitary mediated manifestations / Krankheitsbilder unter Hypophysenbeteiligung				
Hypopituitarism / Hypophysenunterfunktion	+	+	+	---
Erectile dysfunction / Erektionsstörung	NR	+	NR	---
Reduced libido / Verminderte sexuelle Lust	+	+	NR	NR
Loss of body hair / Verlust der Körperbehaarung	NR	+	NR	---
Hypotension / Niedriger Blutdruck	NR	+	NR	---
Amenorrhoea (absence of a menstrual period) / Ausbleiben der Menstruation	NR	+	NR	---
Hypothyroidism / Schilddrüsenunterfunktion	+	+	NR	---
Cold intolerance / Kälteüberempfindlichkeit	NR	+	NR	---

[1] Based on reports from the North Central Province of Sri Lanka (Philips et al. 1988; Kularatne et al. 2014; Subasinghe et al. 2014 and Antonypillai et al. 2010).
[2] Based on reports from Indian states including Karnataka, Kerala, Tamil Nadu and undivided Andhra Pradesh (Monteiro et al. 2012; Antonypillai et al. 2010; Saravu et al. 2012; Subburaja et al. 2015; Krishnamurthy et al. 2013; Eapen et al. 1976 and Narang et al. 2009).
[3] Based on reports from Indian states including Gujarat, Haryana, Maharashtra, Punjab, Rajasthan, Uttar Pradesh, and New Delhi (Sharma et al. 2005; Alirol et al. 2010; Antonypillai et al. 2010; Punde 2005; Bawaskar et al. 2008; Singh et al. 2008; Caudhary & Parmar 2018 and Paul et al. 2014)
[4] Based on observations from a single case of Russell's Viper envenomation from Assam in a 29-year-old male with no previous underlying medical conditions. / Auf Grundlage des in dieser Arbeit beschriebenen Bißfalles eines 29-jährigen Mannes ohne bekannte Vorerkrankungen.

and potassium only by the fifth and sixth day, due to the secondary effect of renal insufficiency. However, in contrast to their observations, there was no major increment in sodium and potassium levels, which can be possibly attributed to dialysis the patient underwent.

Hypopituitarism following Russell's Viper bite was first reported by Eapen et al. (1976) in three adults from Kerala in South India. Later, there were several reports in the literature of Russell's Viper envenomation causing hypopituitarism and subsequent manifestations such as hypotension, loss of facial, pubic and axillary hair, loss of libido and biochemical features to confirm the clinical impression of a pituitary failure. In the current case, the patient has however not shown any signs of hypopituitarism so far (i.e., three years post envenomation). Though the pursual of literature showed an average of 32 (range: 1–130) vials of anti-venom being used to treat patients with *Daboia* envenomation in North India (Sharma et al. 2005), the case under consideration necessitated the usage of only 17 vails to cope with the effect of the venom. Overall, the management of the case further stresses that availability of appropriate anti-venom at primary healthcare centers, coupled with prompt transportation facilities and awareness may thus significantly reduce venomous snake bite induced human morbidity and mortalities in the country.

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REFERENCES

Ahmed, M. F. & Das, A. (2006): First record of *Rhabdophis nuchalis* (Boulenger) (Serpentes: Colubridae) from India with notes on its distribution and natural history.-Hamadryad, Chennai; 30 (1&2): 120-126.

Ahmed, M. F. & Das, A. & Dutta, S. K. (2009): Amphibians and reptiles of Northeast India. A photographic guide. Guwahati (Aaranyak), pp. 167.

Alirol, E. & Sharma, S. K. & Bawaskar, H. S. & Kuch, U. & Chappuis, F. (2010): Snake bite in South Asia: A review.- PLOS Neglected Tropical Disease, Lawrence; 4 (1): e603. [doi: 10.1371/journal.pntd.0000603]

Anonymous (2016): Russell's viper rescued.- The Sangai Express, Manipur; February 17. WWW document available at < http://www.e-pao.net/GP.asp?src=Snipp10..180216.feb16 > [last accessed: September 13, 2018].

Antonypillai, C. N. & Wass, J. A. H. & Warrell, D. A. & Rajaratnam, H. N. (2010): Hypopituitarism following envenoming by Russell's Vipers (*Daboia siamensis* and *D. russelii*) resembling Sheehan's Syndrome: First case report from Sri Lanka, a review of the literature and recommendations for endocrine management.- QJM: An International Journal of Medicine, Oxford; 104 (2): 97-108.

Bawaskar, H. S. & Bawaskar, P. H. & Punde, D. P. & Inamdar, M. K. & Dongare, R. B. & Bhoite, R. R. (2008): Profile of snakebite envenoming in rural Maharashtra, India.- The Journal of the Association of Physicians of India, Mumbai; 56: 88-95.

Belt, P. & Malhotra, A. & Thorpe, R. S. & Warrell, D. A. & Wüster.W. (1997): Russell's viper in Indonesia: snakebite and systematics. pp: 219-234. In: Thorpe, R. S. & Wüster, W. & Malhotra, A. (Eds.): Venomous snakes: ecology, evolution and snakebite. Symposia of the Zoological Society of London, London; No.70. Oxford (Clarendon Press).

Biswas, S. & Pawar, S. (2006): Phylogenetic tests of distribution patterns in South Asia: towards an integrative approach.- Journal of Biosciences, Bengaluru; 31 (1): 95-113.

Caudhary, A. & Parmar, P. (2018): Study of ocular manifestation of snake bite at tertiary care hospital, Valsad.- International Archives of Integrated Medicine, Gujarat; 5: 27-29.

Chatterjee, S. & Saikia, A. & Dutta, P. & Ghosh, D. & Pangging, G. & Goswami, A. K. (2006): Biodiversity significance of Northeast India. Background Paper No. 13. June 2006. Working paper prepared for the World Bank and Ministry of Development of the Northeastern Region (MODONER) (Government of India), pp. i-iv, 1-75.

Chippaux, J. P. (1998): Snake-bites: appraisal of the global situation.- Bulletin of the World Health Organisation, Genève; 76 (5): 515-524.

Choudhury, A. (2013): The mammals of North East India. Guwahati (Gibbon Books and the Rhino Foundation for Nature in NE India), pp. 432.

Chugh, K. S. (1989): Snake-bite-induced acute renal failure in India.- Kidney International, New York; 35: 891-907.

Corbet, G. B. & Hill, J. E. (1992): The mammals of the Indomalayan Region: A systematic review. Oxford (Oxford University Press), pp. i-viii, 1-488.

Das, A. & Nath, A. & Thakur, T. & Dutta, S. K. (2016): Taxonomy and natural history of snakes of

the genus *Oligodon* (Fitzinger, 1826) from northeast India.- Pranikee : Journal of Zoological Society of Orissa, Bhubaneswar; 28: 21-50.

Das, I. & Das, A. (2017): A naturalist's guide to the reptiles of India, Bangladesh, Bhutan, Nepal, Pakistan and Sri Lanka. Oxford (John Beaufoy Publishing Ltd.), pp. 176.

David, P. & Vidal, N. & Pauwels, O. S. G. (2001): A morphological study of Stejneger's pit viper *Trimeresurus stejnegeri* (Serpentes: Viperidae: Crotalinae), with the description of a new species from Thailand.- Russian Journal of Herpetology, Moskva; 8 (3): 205-222.

Dowling, H. G. (1951): A proposed standard of counting ventrals in snakes.- British Journal of Herpetology, London; 1 (5): 97-99.

Eapen, C. K. & Chandy, N. & Kochuvarkey, K. L.& Zacharia, P. K.& Thomas, P. J. & Ipe, T. I. (1976): Unusual complication of snake bite: hypopituitarism after viper bites; pp. 467-473. In: Ohsaka, A. & Hayashi, K. & Sawai, Y. & Murata, R. & Funatsu, M. & Tamiya, N (Eds.): Animal, plant, and microbial toxins. Volume 2 - Chemistry, Pharmacology and Immunology. Boston (Springer).

Hasan, M. K. & Khan, M. M. H & Feeroz, M. M. (2014): Amphibians and reptiles of Bangladesh - a field guide. Dhaka (Arannayk Foundation), pp. 191.

Jayanthi, G. P. & Gowda, T. V. (1988): Geographical variation in India in the composition and lethal potency of Russell's viper (*Vipera russelli*) venom.- Toxicon, Oxford; 26: 257-264.

Kasturiratne, A. & Wickremasinghe, A. R. & de Silva, N. & Gunawardena, N. K. & Pathmeswaran, A. & Premaratna, R. & Savioli, L. & Lalloo, D. G. & de Silva, H. J. (2008): The global burden of snakebite: A literature analysis and modelling based on regional estimates of envenoming and deaths.- PLOS Medicine, San Francisco; 5 (11): e218. [doi: 10.1371/journal.pmed.0050218]

Krishnamurthy, S. & Gunasekaran, K. & Mahadevan, S. & Bobby, Z. & Kumar, A. P. (2015): Russell's viper envenomation-associated acute kidney injury in children in Southern India.- Indian pediatrics, New Delhi; 52 (7): 583-586.

Kularatne, S. A. M. & Silva, A. & Weerakoon, K. & Maduwage, K. & Walathara, C. & Paranagama, R. & Mendis, S. (2014): Revisiting Russell's Viper (*Daboia russelii*) bite in Sri Lanka: Is abdominal pain an early feature of systemic envenoming?- PLOS ONE, San Francisco; 9 (2): e90198. [doi: 10.1371/journal.pone.0090198]

Kumar, P. K. M. & Basheer, M. P. (2011): Snake bite: Biochemical changes in blood after envenomation by viper and cobra.- Journal of Medical and Allied Sciences, Hyderabad; 1 (1): 36-41.

Looareesuwan, S. & Viravan, C. & Warrell, D. A. (1988): Factors contributing to fatal snake bite in the tropics: analysis of 46 cases in Thailand.- Transactions of the Royal Society of Tropical Medicine and Hygiene, London; 82: 930-934.

Mani, M. S. (Ed.) (1974): Ecology and biogeography in India. 's-Gravenhage (W. Junk b.v., Publishers), pp. XIX, 773. [Monographiae Biologicae 23].

Matthai, T. P. & Date, A. (1981): Acute renal failure in children following snake bite.- Annals of Tropical Paediatrics, London; 1: 73-76.

Mohapatra, B. & Warrell, D. A. & Suraweera, W. & Bhatia, P. & Dhingra, N. & Jotkar, R. M. & Rodriquez, P. S. & Mishra, K. & Whitaker, R. & Jha, P. (2011): Snakebite mortality in India: A nationally representative mortality survey.- PLOS Neglected Tropical Disease, San Francisco; 5 (4): e1018. [doi: 10.1371/journal.pntd.0001018]

Monteiro, F. N. P. & Kanchan, T. & Bhagavath, P. & Kumar, G. P. & Menezes, R. G. & Yoganarasimha, K. (2012): Clinico-epidemiological features of viper bite envenomation: A study from Manipal, South India.- Singapore Medical Journal, Singapore; 53 (3): 203-207.

Myint-Lwin & Phillips, R. E. & Tun-Pe & Warrell, D.A. & Tin-Nu-Swe & Maung-Maung-Lay (1985): Bites by Russell's viper (*Vipera russelli siamensis*) in Burma: Haemostatic, vascular, and renal disturbance and response treatment.- The Lancet, London; 2 (8467): 1259-1264.

Narang, S. K. & Paleti, S. & Asad, M. A. A. & Samina, T. (2009): Acute ischemic infarct in the middle cerebral artery territory following a Russell's viper bite.- Neurology India, Mumbai; 57 (4): 479-480.

Nath, A. & Singha, H. & Das, A. (2011): Snakes of Bongaigaon Municipality Area, Assam, India.- Reptile Rap : South Asian Reptile Network Newsletter, Coimbatore; 13: 9-13.

Nori, J. & Carrasco, P. A. & Leynaud, G. C. (2013): Venomous snakes and climate change: ophidism as a dynamic problem.- Climate Change, Dordrecht; 122 (1-2): 67-80. [doi: 10.1007/s10584-013-1019-6]

Paul, G. & Paul, B. & Puri, S. (2014): Snake bite and stroke: Our experience of two cases.- Indian Journal of Critical Care Medicine, Mumbai; 18 (4): 257-258.

Philips, R. E. & Theakston, R. D. G. & Warrell, D. A. & Galigedara, Y. & Abeysekera, D. T. D. J. & Dissanayaka, P. & Hutton, R. A. & Aloysius, D. J. (1988): Paralysis, rhabdomyolysis and haemolysis caused by bites of Russell's viper (*Vipera russelii pulchella*) in Sri Lanka – failure of Indian (Haffkine) antivenom.- Quarterly Journal of Medicine, London; 68: 691-717.

Prasad, N. B. & Uma, B. & Bhatt, S. K. & Gowda, V. T. (1999): Comparative characterization of Russell's viper (*Daboia/Vipera russelii*) venoms from different regions of the Indian peninsula.- Biochimica et Biophysica Acta, Amsterdam; 1428: 121-136.

Punde, D. P (2005): Management of snake-bite in rural Maharashtra: A 10-year experience.-The National Medical Journal of India, New Delhi; 18 (2): 71-75.

Saravu, K. & Somavarapu, V. & Shastry, A. B. & Kumar, R. (2012): Clinical profile, species-specific severity grading, and outcome determinants of snake envenomation: An Indian tertiary care hospital-based prospective study.- Indian Journal of Critical Care Medicine, Mumbai; 16 (4): 187.

Sengupta, S. & Das, A. & Das, S. & Hussain, B. & Choudhury, N. K. & Dutta, S. K. (2009): Taxonomy and biogeography of *Kaloula* species of eastern India.- The Natural History Journal of Chulalongkorn University, Bangkok; 9 (2): 209-222.

Sharma, N. & Chauhan, S.& Faruqi, S. & Bhat, P. & Varma, S. (2005): Snake envenomation in a north Indian hospital.- Emergency Medicine Journal, London; 22: 118-120. [doi: 10.1136/emj.2003.008458]

Sharma, M. & Das, D. & Iyer, J. K. & Kini, R. M. & Doley, R. (2015): Unveiling the complexities of

Daboia russelii venom, a medically important snake of India, by tandem mass spectrometry.- Toxicon, Oxford; 107 (1): 266-281.

Silva, A. & Johnston, C. & Kuruppu, S. & Kneisz, D. & Maduwage, K. & Kleifeld, O. & Smith, A. I. & Siribaddana, S. & Buckley, N. A. & Hodgson, W. C. & Isbister, G. K. (2016): Clinical and pharmacological investigation of myotoxicity in Sri Lankan Russell's Viper (*Daboia russelii*) envenoming.- PLOS Neglected Tropical Diseases, San Francisco; 10 (12): 0005172. [doi: 10.1371/journal.pntd.0005172]

Singh, S. K. H. (1995): On a collection of reptiles and amphibians of Manipur.- Geobios New Reports, Jodhpur; 14: 135-145.

Singh, J. & Bhoi, S. & Gupta, V. & Goel, A. (2008): Clinical profile of venomous snake bites in North Indian military hospital.- Journal of Emergencies, Trauma and Shock, New Delhi; 1 (2): 78-80.

Slowinski, J. B. & Pawar, S. S. & Win, H. & Thin, T. & Gyi, S. W. & Oo, S. L. & Tun, H. (2001): A new *Lycodon* (Serpentes: Colubridae) from Northeast India and Myanmar (Burma).- Proceedings of the California Academy of Sciences, San Francisco; 52 (20): 397-405.

Smith, M. A. (1943): The fauna of British India, Ceylon and Burma, including the whole of the Indo-Chinese sub-region. Reptilia and Amphibia. Vol. III. Serpentes. London (Taylor and Francis), pp. 583.

Subasinghe, C. J. & Sarathchandra, C. & Kandeepan, T. & Kulatunga, A. (2014): Bilateral blindness following Russell's viper bite – a rare clinical presentation: a case report.- Journal of medical case reports, London; 8 (1): 99. [3 pages]

Subburaja, T. & Gandhi, T. V. & Selvyn, J. R. & Subramaniyan, K. & Sundaravadivelu, V. (2015): Russell Viper's cardiac bite: A case report.- International Journal of Scientific Study, Pune; 3: 237-239.

Sutradhar, S & Nath, A. (2013): An account on poorly known Coral Red Snake *Oligodon kheriensis* Acharji and Ray, 1936 from Assam, India.- Russian Journal of Herpetology, Moskva; 20: 247-252.

Thomas, C. D. & Cameron, A. & Green, R. E. & Bakkenes, M. & Beaumont, L. J. & Collingham, Y. C. & Erasmus, B. F. N. & Marinez Ferreira De Siqueira & Grainger, A. & Hannah, L. & Hughes, L. & Huntley, B. & Van Jaarsveld, A. S. & Midgley, G. F. & Miles, L. & Ortega-Huerta, M. A. & Townsend Peterson, A. & Phillips, O. L. & Williams, S. E. (2004): Extinction risk from climate change.- Nature, London; 427:145-148.

Thorpe, R. S. & Pook, C. E. & Malhotra, A. (2007): Phylogeography of the Russell's viper (*Daboia russelii*) complex in relation to variation in the colour pattern and symptoms of envenoming.- Herpetological Journal, London; 17: 209-218.

Warrell, D. A. (1989): Snake venoms in science and clinical medicine. 1. Russell's viper: biology, venom and treatment of bites.- Transactions of the Royal Society of Tropical Medicine and Hygiene, Oxford; 83: 732-740.

Warrell, D. A. (1995): Clinical toxicology of snakebite in Asia; pp. 493-594. In: Meier, J. & White, J. (Eds.): Handbook of clinical toxicology of animal venoms and poisons. Boca Raton (CRC Press).

Warrell, D. A. (1997): Geographical and intraspecies variation in the clinical manifestations of envenoming by snakes; pp. 189-203. In: Thorpe, R. S. & Wüster, W. & Malhotra, A. (Eds.): Venomous snakes: ecology, evolution and snakebite. Symposia of the Zoological Society of London, London; No.70. Oxford (Clarendon Press).

Warrell, D. A. (2010): Snake bite.- The Lancet, London; 375 (9708): 77-88. [doi: 10.1016/S0140-6736(09)61754-2]

Warrell, D. A. & Gutiérrez, J. M. & Calvete, J. J. & Williams, D. (2013): New approaches & technologies of venomics to meet the challenge of human envenoming by snakebites in India.- The Indian Journal of Medical Research, New Delhi; 138 (1): 38-59.

Whitaker, R. (1978): Common Indian snakes. A field guide. New Delhi (Macmillan), pp. i-xiv, 1-154.

Whitaker, R. & Captain, A. (2008): Snakes of India – The field guide. Chengalpattu (Draco Books), pp. 481.

Whitaker, R. & Whitaker, S. (2012): Venom, antivenom production and the medically important snakes of India.- Current Science, Bengaluru; 103 (6): 635-643.

WHO [World Health Organization] (2016): Guidelines for the management of snakebites, 2nd edition. World Health Organization, Regional Office for South-East Asia, New Delhi, pp. 201. WWW document available at < http://apps.searo.who.int/PDS_DOCS/B5255.pdf?ua=1 > [last accessed: January, 2017].

Wüster, W. (1998): The genus *Daboia* (Serpentes: Viperidae): Russell's Viper.- Hamadryad, Chennai; 23 (1): 33-40.

Wüster, W. & Otsuka, S. & Thorpe, R. S. (1992): Population systematics of Russell's viper: a multivariate study.- Biological Journal of the Linnean Society, London; 47: 97-113.

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