THE CEYLON MEDICAL JOURNAL

Established 1887
The Official Publication of the Sri Lanka Medical Association
Volume 64, No.4, December 2019
Quarterly ISSN 0009–0875

Evolution of herpetology and management of snakebite in Sri Lanka

DOI: http://doi.org/10.4038/cmj.v64i4.9011

Ceylon Medical Journal 2019; **64**: 121-124

The origins of ophiology, and responses to snakebites, are thought to have begun with pre-historic peoples. Later inhabitants developed a system of herbal remedies of snakebite, usually termed 'traditional snakebite treatment' with an extensive collection of written material. The modern era saw research into venoms and their effects by scientists following western traditions, leading to the development of antivenoms against specific snakes.

Snakebite is an "occupational rural hazard". So said H. A. Reid, [1] the world-renowned authority on sea snake envenoming in the nineteen-fifties. He later established the Alistair Reid Venom Research Unit of the Liverpool School of Tropical Medicine in 1963, now named the Centre for Snakebite Research Interventions [2]. Epidemiological studies of snakebite in Sri Lanka have shown that snakebite is indeed an occupational rural health hazard [3, 4, 5].

Ten of the nineteen families of snakes described are found in Sri Lanka, there being 105 species in 47 genera, including 15 species of sea snakes. Thirty-nine species possess venom secreting glands associated with fangs. Among them, only six species of terrestrial snakes, namely, Russell's viper *(Daboia russelii)*, cobra *(Naja naja)*, common krait *(Bungarus caeruleus)*, Ceylon krait *(Bungarus ceylonicus)*, saw scaled viper *(Echis carinatus)* and the hump-nosed pit vipers *(Hypnale hypnale, H. nepa* and *H. zara)* are highly venomous – envenoming by these snakes is possibly life-threatening, fatalities having been recorded. All fifteen species of sea snakes inhabiting the coastal waters of Sri Lanka are highly venomous. Fishermen release hundreds of sea snakes trapped in their nets daily, but bites are rare as most are mild-tempered. An exception is the beak-nosed sea snake *(Enhydrina schistosa*, new taxonomy *Hydrophis schistosa)* found in lagoons of the north-west coast [6].

Sri Lanka is a small tropical island of 65,610 km^2 situated north of the equator between 5° and 10° latitude with a rich biodiversity and varied geography. Rainfall and climate divide the country into three zones. The dry zone occupies 65% of the country extending from the north to the foothills of the central hilly terrain, receiving less rain, mainly from the northeast monsoon. The wet zone (23%) is confined to the southwest of the island, receiving the highest annual rainfall from both the southwest and the northeast monsoons, as well as from inter-monsoonal rains. Lying in between is the intermediate zone (12%) [7]. Most of the venomous snakebites occur in the dry zone where paddy (rice) farming is common. Cobras and Russell's vipers are widely

distributed in the Island, while other venomous snakes have more regional distributions e.g. common krait in the dry zone, Ceylon krait in the wet and intermediate zones, hump-nosed vipers mainly in the wet zone and extending up to the north-central province (but not found in the Jaffna peninsula) and the saw-scaled viper in the northern coastal belt. The annual hospital admissions due to snakebite has shown an increasing trend since the early nineteen-eighties, the numbers levelling-off in recent years to around 40,000 admissions and 100 deaths [8]. These values are an under representation as reported by a recent epidemiological study [9].

The origins of the study of snakes, their bites and related counter measures, are obscured in the dimness of the distant past. But it is not overstretching the imagination to suppose that early dwellers of the Island – Balangoda Man (35,000 to 40,000 BCE) – would have interacted with snakes and other animals, and perhaps been bitten by them. The remains of snakes e.g. *Trimeresurus trigonocephalus* (green pit viper), lizards e.g. *Lyriocephalus scutatus* (lyre head lizard) and those of many other animals at ancient habitations suggest, in the view of the naturalist and field researcher PB Karunaratne, that these reptiles were used as food [10, 11]. Snakebite may have been a common occurrence then, and the development of remedies would have been an obvious reaction to this recurring problem. Perhaps this would have been the modest beginning of ophiology and traditional snakebite treatment in Sri Lanka. Studies of pollen remains by Premathilake (2001) shows that slash-and-burn farming techniques had been used together with grazing of livestock by prehistoric people on the Horton Plains around 17,500 yrs BP. These results point to the existence at that time of a Neolithic culture on the Horton Plains, the oldest Neolithic site discovered so far in the Indian subcontinent [12].

The venomous snakes of Sri Lanka had been documented in traditional snakebite treatment literature as far back as the early historical times. These brief accounts were written in Pali, Sanskrit, Sinhala and Tamil. Cobras, kraits and vipers were mentioned by name, with descriptions of their bites, symptoms and remedies for envenoming. The ancient texts had documented a similar scenario too. An example of one of these early texts is the *Saratha Sangrahaya*, one of the earliest works authored by King Buddhadasa (340-368 AD) who is reputed to have surgically removed a tumour from a sick cobra [13].

Between the fourth and eighteenth centuries AD, nearly 70 works dealing with different aspects of traditional medicine were published in Sri Lanka [14, 15]. Some of these books included a chapter on *Agada tantra* or toxicology and they described treatment for snakebite envenoming. For example, *Bhaisajja manjusa* written in 1247 AD and *Yogarnavaya* both written by the Venerable Principal of *Mayurapada* 1276 AD, prescribes treatment for bites by snakes, frogs and skinks. During times of colonial conquest many ola leaf (palm leaf) manuscripts were either taken away to Europe or destroyed. It is likely that some of these dealt exclusively with snakebite. Two manuscripts of snakebite treatment written about two centuries ago were the *Vakirigala sarpa veda pota* and the *Sarpa veda pota*. These early traditional medical works are important as they list more or less the same snakes that are considered venomous today. Elementary accounts of the biology of some snakes contained therein are also correct. These early medical works were written (inscribed) in Sanskrit, Pali, Sinhala or Tamil on leaves of the talipot palm *(Corypha umbraculifera)* or ola leaves. There are about 100 Sinhala publications on traditional snakebite treatment commencing with C. Perera's work published in 1876 [16] [14], [17]. Emmanuel Roberts wrote the first book in the English language on *Native Remedies Used in Snake Bites, etc.*, in 1919 [18]. A western qualified doctor, John Attygalle MD published *Sinhalese Materia Medica* in 1917 which included recipes for snakebite management [19]. Between 1876 and 2019 nearly 250 Sinhala books and papers on snakes and snakebite treatment have been published [14,17].

Between the 16th and 20th centuries many visitors to the Island who wrote books about Sri Lanka (then known as Ceylon). One of the earliest references to snakes of Sri Lanka in an European language is in Garcia da Orta's work "*Coloquis dos simples drogas he medicinais*" (1563) [20]. Written in Portuguese, this describes three types of "snake-wood plants" that the mongoose is said to feed on as an antidote to snake envenoming. More than a century later Baldaeus (1672) in his book about Ceylon included a three-page chapter consisting of notes on sea snakes, the rat snake, the cobra and the viper as well as snakebite and indigenous treatment [21]. Robert Knox's (1681) work, which appeared a decade later, is the first book to be written in the English Language on Sri Lanka [22]. It contains a chapter on some snakes and tetrapod reptiles of Sri Lanka. The early 19th century writer John Davy (1818, 1820, 1821), was the first to report scientific investigations on the venoms of Sri Lankan snakes and on some aspects of traditional treatment (e.g. the snake stone) [23, 24, 25]. He also provided accounts of the python, the cobra, the Russell's viper, and the hump-nosed viper. Davy was followed by many other authors e.g. Emerson Tennent (1861) [26], William Ferguson (1877) [27], Daniel Pereira (1871) [17] and others who made contributions on the reptiles of Sri Lanka during the 19th century. References to publications on snakes of Sri Lanka and related subjects published during the 20th and 21st centuries are available in a published bibliography of snakes in Sri Lanka [17]. Frank Wall (1868-1950) worked in India, Sri Lanka and Burma from 1894 to 1925. His book *Ophidia Taprobanica,* or *The Snakes of Ceylon* is a pioneering masterpiece of modern herpetology that has been reprinted in 1993 [28].

The exposition of the concept of antisera by Emil Behring (1854-1917) in 1891 with the publication of his

paper on diphtheria and tetanus serum therapy was a paradigm shift. He was later awarded the Nobel Prize in physiology or medicine in 1901 for this work [29]. Albert Calmette (1863-1933) a French physician, bacteriologist and immunologist pioneered the development of the first antivenom serum against the Indian cobra in 1895 while working at the Pasteur Institute branch in Lille [30]. Specific antivenom sera against Indian snakes was developed by the Haffkine Institute in India that had been established in 1899 as the Plague Research Laboratory [31]. This anti-venom was also used in Sri Lanka, but there are no records as to when it was first used. The earliest reference is a case report published in 1965 that vividly describes administration of 20 vials of Haffkine antivenom to a patient as well as management of the reactions that followed [32]. The same report also mentioned that victims preferred to seek treatment from traditional or Ayurvedic practitioners rather than from the Government's hospitals.

Recognising the importance of snakebite in the country and the unavailability at the time of authoritative information on its management, the Council of the Sri Lanka Medical Association established a committee in October, 1983 to address these issues. This came to be called the SLMA Expert Committee on Snakebite. Its first chairman was Dr. Dennis J Aloysius. The first output of the committee was a symposium issue of the *Ceylon Medical Journal* in 1983 devoted to the subject of venomous snakes, snakebite and management [33]. This was complemented soon after by a colour poster of the seven snakes considered medically important at the time. In 1994 the committee published in English, Sinhala and Tamil languages a 28-page booklet for the lay public titled *Snake-bite, prevention and first aid*. An updated version of this is currently available on the SLMA website, in all three languages [34].

With the objective of disseminating recommendations regarding snakebite management throughout the Government hospital system *Guidelines for the management of snakebite in hospital* was produced in English as a double-sided foldable poster, in colour. In 2005 the contents of the poster were made available as a Power Point presentation on compact discs. In 2007 an updated and revised version was produced that included a picture library of venomous and non-venomous snakes. The CD included the English version of the Prevention and First Aid booklet in pdf format. The guidelines were further updated and extensively revised in 2013 as version 3.0, the CD including Prevention and First Aid in all three languages. The guidelines text was also made available in printed form [35]. The most recent evidence-based version is available only as webpages on the Snakebite Committee tab of the SLMA website [36]. The SLMA Snakebite Hotline was formalised in 2010 and publicised through the SLMA Newsletter. The hotline was also available on the guideline CDs, and an improved version is now available on the website that includes details of services available for identifying snakes [37].

There is increasing interest in herpetology today and some specialist groups are in existence. A Viper Specialist Group and a Sea Snake Specialist Group (IUCN SSC); the Nuchal Gland Specialist Group is another. Two Sri Lanka species are known to have nuchal glands – *Balanophis ceylonensis* and *Macropisthodon plumbicolor* – now placed under the genus *Rhabdophis* as a result of molecular studies by this group. A recent case report of severe envenoming by *Balanophis ceylonensis* highlights its medical importance, previously unsuspected [38]. Both International Society of Toxinology (IST) and the Toxinology Society of India have affiliation with Sri Lankan scientists.

Since the early 20th century, Sri Lanka has been importing polyvalent antivenom serum from India. This serum is prepared from the venoms of 4 Indian species of snakes ("the big four") which are common in South Asia – cobra, common krait, Russell's viper and saw-scaled viper. It does not provide protection for hump-nosed viper envenoming, which is the commonest snakebite in Sri Lanka causing unpredictable complications and deaths. Many patients treated with the Indian antivenom develop severe allergic reactions. There have been attempts to develop antivenoms specific to the Sri Lankan species of snakes. The Oxford-Colombo group developed a mono-specific antivenom against Russell's viper and the initial clinical trial was carried out at Anuradhapura in 1995, comparing its effects against the Haffkine antivenom of Indian manufacture [39]. The results were promising with fewer allergic reactions, but this product did not come into clinical use in Sri Lanka. Currently two teams from the University of Peradeniya are developing polyvalent antivenoms which will give protection against hump-nosed vipers as well.

Snakes play a pivotal role in the ecological balance of the tropical biodiversity of Sri Lanka. Man and snake have co-habited this land since the distant past. Conflicts may have arisen, leading to survival strategies that would have included remedies for envenoming. These traditional methods have since lost their importance with the advance of modern science. In the future, what had been learnt by the early generations is in danger of being forgotten. Even today, historical material is hard to locate. This account is an attempt to document historical facts based on the material in the personal repositories of the senior scientist in the field for the benefit of posterity.

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