

# Systematic Review

## Implementation of Ecological Distribution of Venomous Snakes for Clinical Management of Snakebite in Bangladesh

Ibrahim Khalil Al Haidar<sup>1,2\*</sup>, Aniruddha Ghose<sup>2,3\*†</sup>, Mohammed Noman<sup>2</sup>, Md. Mizanur Rahman<sup>2</sup>, Sajib Rudra<sup>2</sup>, Abdul Auawal<sup>2</sup>, Md. Rafiqul Islam<sup>2</sup>, Md. Asir Uddin<sup>2</sup>, Rabiul Alam Md. Erfan Uddin<sup>2,3</sup>, Abdullah Abu Sayeed<sup>2,3</sup>, Md. Robed Amin<sup>2,4</sup>, Md. Farid Ahsan<sup>1,2</sup>, Md. Abul Faiz<sup>2,5</sup>, Mohammad Abdul Wahed Chowdhury<sup>1,2†</sup>

### Abstract

**Background:** Snakebite envenoming is a global health problem, mostly in tropical and subtropical countries. Bangladesh is a subtropical country facing thousands of snakebite envenoming death every year. Knowledge of the distribution of venomous snakes is necessary to identify snakebite-prone areas, develop strategies for prevention and management, and reduce venom-induced mortalities and morbidities.

**Methods:** An integrated effort of direct observations of snakes, qualitative analysis of museum specimen records, clinical records of snakebites, and scholarly literature records were used to understand the pattern of distribution of venomous snakes in Bangladesh.

**Results:** We enlist 65 venomous snake species from Bangladesh and present detailed documentation on their distribution pattern. However, only nine species were considered medically relevant species because of their venom potentiality to kill humans and available clinical records of envenomation. The distribution pattern of those species divides the country into two major portions. A portion consists of northern, northwestern, and western parts of the country, which are habitats of *Naja naja*, *Bungarus caeruleus*, and *B. lividus*. Another portion comprised of the northeastern, southeastern, and southern parts of the country provides habitats for *N. kaouthia*, *B. niger*, and *Trimeresurus erythrurus*. However; *Daboia. russelii* had a different distribution pattern along the bank of the Padma and Meghna, and some coastal districts. Moreover, *B. walli* had a scattered distribution over the country. The knowledge of this ecological distribution of venomous snakes across the country bears a significant practical effect on clinical management of snakebite. Treating physicians can have a better understanding of possible offending snake species using this knowledge and the clinical syndromes produced by venoms.

**Conclusion:** Pattern of distribution of medically relevant venomous snakes in Bangladesh approaches to initiate concise and specific bite management strategies for two distinct distributional regions of the country. Moreover, the distribution of *D. russelii* and *B. walli* demands specific strategies for bite management.

**Keywords:** Cobra, Envenomation, Epidemiology, Krait, Neglected Disease, Viper

DOI: <https://doi.org/10.3329/jom.v24i2.67278>

**Copyright:** © 2023 Haidar IKA. This is an open access article published under the Creative Commons Attribution-Non Commercial-No Derivatives 4.0 International License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited, is not changed in any way and it is not used for commercial purposes.

**Received:** 22.02.2023

**Accepted:** 23.04.2023

1. Department of Zoology, University of Chittagong, Chattogram-4331
2. Venom Research Centre, Chittagong Medical College, Chattogram-4203
3. Department of Medicine, Chittagong Medical College, Chattogram-4203
4. Non Communicable Disease Control (NCDC), Directorate General of Health Services (DGHS), Dhaka-1212
5. Dev Care Foundation, Dhaka-1209

\* Contributed equally to the article

†Correspondence: MAWC, E. mail: wahed.chowdhury@cu.ac.bd; AG, E. mail: anrdghs@yahoo.com.

### Introduction

Snakebite envenoming is a serious threat to public health in tropical and subtropical countries.<sup>1-3</sup> The World Health Organization (WHO) categorized snakebite envenoming as a Category A Neglected Tropical Disease (NTD) caused by toxins in the bite of a venomous snake.<sup>4</sup> Globally there are around 5.4 million snakebite incidents and 138,000 venom-induced mortality reported per year.<sup>3</sup> Bangladesh is one of the most snakebite-prone countries in the world, where annually around 700,000 annual snakebite incidents with more than 6,000 envenoming deaths were estimated.<sup>5,6</sup>

Proper identification and knowledge of the geographical distribution of venomous snakes are the two primary needs to understand eco-epidemiology and management of snakebites in clinical aspects.<sup>7</sup> Because of their high diversity and congeneric morphology, understanding the distribution borderline of venomous snakes may provide precision in snakebite eco-epidemiology.<sup>8</sup> Proper identification of venomous snakes and following their distribution is a vital key to determining snakebite-prone areas, developing precautionary bite management strategies, and reducing snakebite incidents.<sup>9</sup>

Bangladesh is a subtropical country situated in the Indo-Himalayan delta on the Bay of Bengal that is occupied with diverse venomous and non-venomous snake species. Recent additions of a few new species in the country checklist indicate that the total number of snake species occurring in Bangladesh is yet to be finalized. There are more than a hundred snake species recorded so far from Bangladesh. For instance, IUCN Bangladesh (2015) evaluated the status of 100 species, Khan (2015) enlisted 123 species, Khan (2018) described 105 species, and Chowdhury et al. (2022) reported 102 species from Bangladesh.<sup>10–13</sup> Therefore, a conclusive and authentic report on venomous snake species and their distribution in the country is needed that may guide academicians, clinicians, researchers, and non-academic snake handlers in snake conservation and snakebite management.

We reviewed all available published books and research papers on snake taxonomy and distribution; collected and examined snake specimens from different countryside for Venom Research Centre (VRC), Bangladesh to achieve a comprehensive scenario about the distribution of venomous snakes in Bangladesh along with their venom-type and medical relevance. Such an authentic presentation of the country's venomous snakes may be an aid to spot snakebite-prone areas, understanding the eco-epidemiology of snakebite, preparing precautionary bite management strategies, reducing snakebite incidents, optimizing clinical management, and reducing snake venom-induced mortalities and morbidities.

### Materials and Methods

This systematic review was conducted by an integrated effort combining direct observations and qualitative analysis of field records. The taxonomic identities of the snakes were confirmed by examining the snake as live or dead, museum specimen records, clinical records of snakebites, and published literatures. During the descriptive review of published literature, a total of 66 pieces of literatures were screened, and then, non-relevant 17 were excluded

(Appendix I). The medical relevance of the venomous snakes causing envenomation was screened on available clinical records of envenomation by a particular species of snakes. Therefore, knowledge and experiences in snake rescue, capture, collection, and identification from different parts of the country, and snakebite treatment and management at the clinical level were complemented to the textual records.

### Results and Discussion

Sixty-five species of venomous snakes were compiled in this study. They were classified into two groups: 32 species of rear-fanged (opisthoglyphous) and 33 species of front-fanged (proteroglyphous and solenoglyphous) venomous snakes. The front-fanged venomous snakes were again sub-divided into marine venomous snakes comprised of 16 species and terrestrial venomous snakes included 17 species (Figure 1). Although the terrestrial front-fanged snakes were considered severely venomous due to their venom's potentiality to kill a human, only eight species were synonymized as medically relevant due to their frequent occurrence of envenoming throughout the year, and other nine species weren't considered as medically relevant species.

**Rear-fanged venomous snakes:** Rear-fanged venomous snakes are mildly venomous having no or less medical relevance as their venoms are not lethal enough to kill humans except Red-necked Keelback *Rhabdophis subminiatus*. The list and geographical distribution of opisthoglyphous venomous snakes in Bangladesh was compiled suspecting possible minor medical complexities in patients because of their bites (Appendix II).

**Marine venomous snakes:** The marine snakes are front-fanged (proteroglyphous) and severely venomous which may cause the death of envenomed human victims. So far, 16 species of marine venomous snakes have been enlisted from Bangladesh (Table 1). Among them, three are doubtfully recorded and some have no evidence of occurring in the Bangladesh portion of the Bay of Bengal. For example, *Hydrophis lapemoides* was reported once from coastal areas of Chattogram<sup>13</sup>, *Hydrophis stricticollis* from coastal belt Chattogram and Hatiya island of Noakhali<sup>14</sup>, and *Laticauda laticaudata* reported by Khan (1992)<sup>12,15–17</sup>. Other 10 species are widely distributed over the coastal belt of Bangladesh including the mangrove forest of Sundarbans (Satkhira, Khulna, Bagerhat), the coastal districts of Barishal (Pirojpur, Barguna, Patuakhali, Bhola), and Chattogram Division (Noakhali, Chattogram, Cox's Bazar), and in their islands.

**Terrestrial front-fanged venomous snakes:** A total of 17 species of front-fanged venomous snakes were enlisted from Bangladesh, among them 10 were proteroglyphous (fixed front-fanged) kraits and cobras, and seven solenoglyphous (hinged front-fanged) vipers (Figure 2; Table 2).

**Table 1.** Distribution of marine venomous (proteroglyphous) marine snakes in Bangladesh

Sl.	Scientific Name	Common Name	*Distribution
1	<i>Hydrophis cantoris</i> (Günther, 1864)	Cantor's Narrowheaded Sea Snake	Coastal belt and Bay of Bengal
2	<i>Hydrophis cyanocinctus</i> Daudin, 1803	Annulated Sea Snake	Coastal belt and Bay of Bengal
3	<i>Hydrophis caerulescens</i> (Shaw, 1802)	Malacca Sea Snake	Coastal belt and Bay of Bengal
4	<i>Hydrophis curtus</i> (Shaw, 1802)	Spine-bellied Sea Snake	Coastal belt and Bay of Bengal
5	<i>Hydrophis fasciatus</i> (Schneider, 1799)	Stripped Sea Snake	Coastal belt and Bay of Bengal
6	<i>Hydrophis nigrocinctus</i> Daudin, 1803	Daudin's Sea Snake	Coastal belt and Bay of Bengal
7	<i>Hydrophis lapemoides</i> (Gray, 1849)	Persian Gulf Sea Snake	Coastal belt of Chattogram in the Bay of Bengal
8	<i>Hydrophis ornatus</i> (Gray, 1842)	Ornate Reef Sea Snake	∅
9	<i>Hydrophis obscurus</i> Daudin, 1803	Russell's Sea Snake	Coastal belt and Bay of Bengal
10	<i>Hydrophis platurus</i> (Linnaeus, 1766)	Yellow-bellied Sea Snake	Coastal belt and Bay of Bengal
11	<i>Hydrophis schistosus</i> Daudin, 1803	Hook-nosed Sea Snake	Coastal belt and Bay of Bengal
12	<i>Hydrophis stokesii</i> (Gray, 1846)	Stokes' Sea Snake	∅
13	<i>Hydrophis stricticollis</i> Günther, 1864	Collared Sea Snake	Coastal belt of Chattogram & Noakhali in the Bay of Bengal
14	<i>Microcephalophis gracilis</i> (Duméril, Bibron & Duméril, 1854)	Graceful Small-headed Sea Snake	Coastal belt and Bay of Bengal
15	<i>Laticauda colubrina</i> (Schneider, 1799)	Yellow-lipped Sea Krait	∅
16	<i>Laticauda Laticaudata</i> (Linnaeus, 1758)	Black-banded Sea Krait	Coastal belt and Bay of Bengal

\*distribution: ∅ = no confirmed record

**Table 2.** Distribution of terrestrial venomous snakes (proteroglyphous and solenoglyphous) in Bangladesh

Sl.	Scientific Name	Common Name	Medical Relevance	*Distribution
1	<i>Bungarus caeruleus</i> (Schneider, 1801)	Common Krait	Yes	All over the country; rare in Chattogram and Sylhet regions
2	<i>Bungarus fasciatus</i> (Schneider, 1801)	Banded Krait	No	Entire country
3	<i>Bungarus lividus</i> Cantor, 1839	Lesser Black Krait	Yes	Entire country except MEF of Chattogram & Sylhet, CHT, Cox's Bazar
4	<i>Bungarus niger</i> Wall, 1908	Greater Black Krait	Yes	MEF of Chattogram, Sylhet & Cox's Bazar, CHT, MF-SB
5	<i>Bungarus walli</i> Wall, 1907	Wall's Krait	Yes	Scattered distribution throughout the entire country
6	<i>Calliophis melanurus</i> (Shaw, 1802)	Slender Coral Snake	No	MEF of Chattogram, Sylhet & Cox's Bazar, CHT
7	<i>Sinomicrurus maccllellandi</i> (Reinhardt, 1844)	Maccllelland's Coral Snake	No	MEF of Sylhet; confirmed record from Sunamganj and Moulavibazar
8	<i>Ophiophagus hannah</i> (Cantor, 1836)	King Cobra	No	MEF of Chattogram, Sylhet & Cox's Bazar, CHT, MF-SB
9	<i>Naja kaouthia</i> Lesson, 1831	Monocled Cobra	Yes	Entire country; rare in Rajshahi regions
10	<i>Naja naja</i> (Linnaeus, 1758)	Spectacled Cobra	Yes	Entire country; rare in Chattogram and Sylhet regions

**Table 2.** Cont'd

Sl.	Scientific Name	Common Name	Medical Relevance	*Distribution
11	<i>Daboia russelii</i> (Shaw & Nodder, 1797)	Russell's Viper	Yes	Rajshahi division except Bagura & Sirajganj; Kushtia, Chuadanga, Rajbari, Faridpur, Shariatpur, Madaripur, Manikganj, Dhaka, Munshiganj, Chandpur, Lakshmipur, Noakhali, and Barishal division except Pirojpur
12	<i>Ovophis monticola</i> (Günther, 1864)	Mountain Pit Viper	No	∅
13	<i>Protobothrops jerdonii</i> (Günther, 1875)	Jerdon's Pitviper	No	∅
14	<i>Trimeresurus albolabris</i> Gray, 1842	White-lipped Pit Viper	No	∅
15	<i>Trimeresurus erythrurus</i> (Cantor, 1839)	Spot-tailed Pit Viper	Yes	MEF of Chattogram, Sylhet & Cox's Bazar, CHT, MF-SB
16	<i>Trimeresurus gramineus</i> (Shaw, 1802)	Bamboo Pit Viper	No	∅
17	<i>Trimeresurus popeiorum</i> Smith, 1937	Pope's Pit Viper	No	Bandarban

\*distribution: MEF = mixed evergreen forest, MF-SB = mangrove forest of Sundarban, CHT = Chittagong hill tracts, ∅ = no confirmed record

#### Appendix I: List of reviewed literatures

Sl.	Literature	Focal Topic	Types of Publication
1	Husain 1977 <sup>29</sup>	Wildlife	Article
2	Montaquim et al. 1980 <sup>30</sup>	Snake diversity and distribution	Article
3	Khan 1982 <sup>31</sup>	Wildlife	Book
4	Sarker and Sarker 1985 <sup>32</sup>	Reptiles	Article
5	Khan 1987 <sup>15</sup>	Wildlife	Book
6	Sarker and Sarker 1988 <sup>33</sup>	Wildlife	Book
7	Khan 1992 <sup>16</sup>	Snake diversity and distribution	Book
8	Sarker and Hossain 1997 <sup>34</sup>	Wildlife	Article
9	Ahsan 1998 <sup>35</sup>	Herpetofaunal distribution	Conference proceeding
10	IUCN 2000 <sup>36</sup>	Wildlife	Book
11	Asmat and Hannan 2007 <sup>37</sup>	Wildlife	Book
12	Khan 2008 <sup>38</sup>	Wildlife	Book
13	Mahony and Reza 2008 <sup>39</sup>	Herpetofaunal distribution	Article
14	Kabir et al. 2009 <sup>40</sup>	Wildlife	Book
15	Mahony et al. 2009 <sup>41</sup>	Herpetofaunal collection	Article
16	Khan 2010 <sup>17</sup>	Wildlife	Book
17	Faiz et al. 2010 <sup>25</sup>	Snakebite	Article
18	Rahman et al. 2010 <sup>5</sup>	Snakebite	Article
19	Chowdhury et al. 2011 <sup>42</sup>	Snake taxonomy and distribution	Conference proceeding

**Appendix I: Cont'd**

Sl.	Literature	Focal Topic	Types of Publication
20	Feeroz et al. 2011 <sup>43</sup>	Wildlife	Book
21	Feeroz et al. 2012 <sup>44</sup>	Wildlife	Book
22	Rahman et al. 2012 <sup>45</sup>	Wildlife	Article
23	Feeroz 2013 <sup>46</sup>	Wildlife	Book
24	Sarmin et al. 2013 <sup>47</sup>	Snakebite	Article
25	Hassan et al. 2014 <sup>48</sup>	Herpetofauna	Book
26	Ghose and Faiz 2014 <sup>6</sup>	Snakebite	Conference proceeding
27	Chakraborty et al. 2014 <sup>49</sup>	Snakebite	Article
28	Rahman et al. 2014 <sup>50</sup>	Snake habitat	
29	Karim and Ahsan 2014 <sup>51</sup>	Snake diversity and distribution	Article
30	Khan 2015 <sup>12</sup>	Wildlife	Book
31	IUCN Bangladesh 2015 <sup>10</sup>	Herpetofaunal distribution	Book
32	Ahsan et al. 2015 <sup>18</sup>	Snake diversity and distribution	Article
33	Alam et al. 2016 <sup>52</sup>	Snakebite	Article
34	Ahsan and Rahman 2017 <sup>53</sup>	Snake distribution	Article
35	Sarker et al. 2017 <sup>28</sup>	Snake distribution	Article
36	Khan 2018 <sup>11</sup>	Wildlife	Book
37	Ahsan and Saeed 2018 <sup>54</sup>	Snake distribution	Book
38	Haidar et al. 2020 <sup>55</sup>	Snake taxonomy and distribution	Article
39	Hakim et al. 2020 <sup>19</sup>	Herpetofaunal taxonomy and distribution	Article
40	Shome et al. 2020 <sup>56</sup>	Snake taxonomy and distribution	Article
41	Romon et al. 2021 <sup>57</sup>	Snake taxonomy and distribution	Article
42	Chowdhury et al. 2021 <sup>13</sup>	Snake taxonomy	Article
43	Hasan et al. 2022 <sup>58</sup>	Snake taxonomy	Article
44	Rabbe et al. 2022 <sup>59</sup>	Herpetofaunal distribution	Article
45	Rabbe et al. 2022 <sup>59</sup>		Article
46	Chowdhury et al. 2022 <sup>60</sup>	Snake distribution	Article
47	Islam et al. 2022 <sup>61</sup>	Snake taxonomy	Article
48	Sarker et al. 2023 <sup>14</sup>	Snake taxonomy and distribution	Article
49	Ahsan 2022 <sup>62</sup>	Snake distribution	Book

**Appendix II.** Distribution of rear-fanged (opisthoglyphous) venomous snakes in Bangladesh

Sl.	Scientific Name	Common Name	*Venomous type	**Distribution
1	<i>Ahaetulla nasuta</i> (Lacépède, 1789)	Common Vine Snake	MV	Entire Country
2	<i>Ahaetulla prasina</i> (Boie, 1827)	Short-nosed Vine Snake	MV	MEF of Chattogram, Sylhet & Cox's Bazar, CHT, MF-SB, DF of Modhupur
3	<i>Ahaetulla pulverulenta</i> (Duméril, Bibron & Duméril, 1854)	Brown Vine Snake	MV	MF-SB
4	<i>Boiga cyanea</i> (Duméril, Bibron & Duméril, 1854)	Green Cat Snake	MV	MEF of Chattogram, Sylhet & Cox's Bazar, CHT, MF-SB
5	<i>Boiga cynodon</i> (Boie, 1827)	Bengal Cat Snake	MV	MEF of Chattogram & Sylhet, CHT, GH
6	<i>Boiga gokool</i> (Gray, 1834)	Eastern Cat Snake	MV	MEF & HV of Chattogram, Sylhet, Cox's Bazar, CHT
7	<i>Boiga multomaculata</i> (Boie, 1827)	Large-spotted Cat Snake	MV	ψ
8	<i>Boiga ochracea</i> (Theobald, 1868)	Tawny Cat Snake	MV	MEF of Chattogram, Sylhet & Cox's Bazar, CHT
9	<i>Boiga siamensis</i> Nutaphand, 1971	Eyed Cat Snake	MV	MEF of Chattogram & Sylhet, CHT
10	<i>Boiga trigonata</i> (Schneider, 1802)	Common Cat Snake	MV	Faridpur, Kushtia, Rajshahi, Chapainawabganj & Mymensingh
11	<i>Chrysopelea ornata</i> (Shaw, 1802)	Ornate Flying Snake	MV	Entire Country
12	<i>Oligodon albocinctus</i> (Cantor, 1839)	White-barred Kukri Snake	MV	MEF of Chattogram & Sylhet, CHT, Rangpur
13	<i>Oligodon arnensis</i> (Shaw, 1802)	Banded Kukri Snake	MV	MEF of Sylhet, Mymensingh, and Rangpur
14	<i>Oligodon cinereus</i> (Günther, 1864)	Black-barred Kukri Snake	MV	MEF of Chattogram & Sylhet, CHT
15	<i>Oligodon cyclurus</i> (Cantor, 1839)	Cantor's Kukri Snake	MV	MEF of Chattogram & Sylhet, Cox's Bazar, CHT, Dhaka, Mymensingh & Rangpur
16	<i>Oligodon dorsalis</i> (Gray, 1834)	Spot-tailed Kukri Snake	MV	MEF of Chattogram & Sylhet, CHT
17	<i>Oligodon taeniolatus</i> (Günther, 1861)	Streaked Kukri Snake	MV	Adampur of Moulavibazar
18	<i>Oligodon theobaldi</i> (Günther, 1868)	Theobald's Kukri Snake	MV	ψ
19	<i>Oligodon kheriensis</i> Acharji and Ray, 1936	Coral Red Kukri Snake	MV	Panchagarh
20	<i>Psammodynastes pulverulentus</i> (Boie, 1827)	Common Mock Viper	MV	MEF of Chattogram, Sylhet & Cox's Bazar, CHT, DF of Moadhupur
21	<i>Psammophis condanarus</i> (Merrem, 1820)	Condanarous Snad Racer	MV	Rajshahi
22	<i>Herpetoreas platyceps</i> (Blyth, 1854)	Himalayan Mountain Keelback	MV	Rajshahi and Rangpur divisions
23	<i>Pseudoxenodon macrops</i> (Blyth, 1854)	Large-eyed False Cobra	MV	MEF of Sylhet
24	<i>Rhabdophis himalayanus</i> (Günther, 1864)	Orange-collared Keelback	MV	MEF of Sylhet
25	<i>Rhabdophis subminiatus</i> (Schlegel, 1837)	Red-necked Keelback	SV	MEF of Chattogram, Sylhet & Cox's Bazar, CHT, DF of Madhupur & Naogaon
26	<i>Cerberus rynchops</i> (Schneider, 1799)	Dog-faced Water Snake	MV	Entire coastal belt
27	<i>Enhydryis enhydryis</i> (Schneider, 1799)	Rainbow Water Snake	MV	Entire Country
28	<i>Ferania sieboldii</i> (Schlegel, 1837)	Siebold's Water Snake	MV	Wetlands of Sylhet & Mymensingh divisions and plains of Rangpur divisions
29	<i>Fordonia leucobalia</i> (Schlegel, 1837)	Crab-eating Snake	MV	Entire coastal belt
30	<i>Gerarda prevostiana</i> (Eydoux & Gervais, 1837)	Glossy Marsh Snake	MV	Entire coastal belt
31	<i>Homalopsis buccata</i> (Linnaeus, 1758)	Banded Swamp Snake	MV	ψ
32	<i>Dieurostus dussumieri</i> (Duméril, Bibron	Dussumier's Smooth	MV	ψ

\*venomous type: MV = mildly venomous, SV = severely venomous; \*\*distribution: MEF = mixed evergreen forest, DF = deciduous forest, HV = homestead vegetation; MF-SB = mangrove forest of Sundarban, CHT = Chittagong hill tracts, ø = no confirmed record

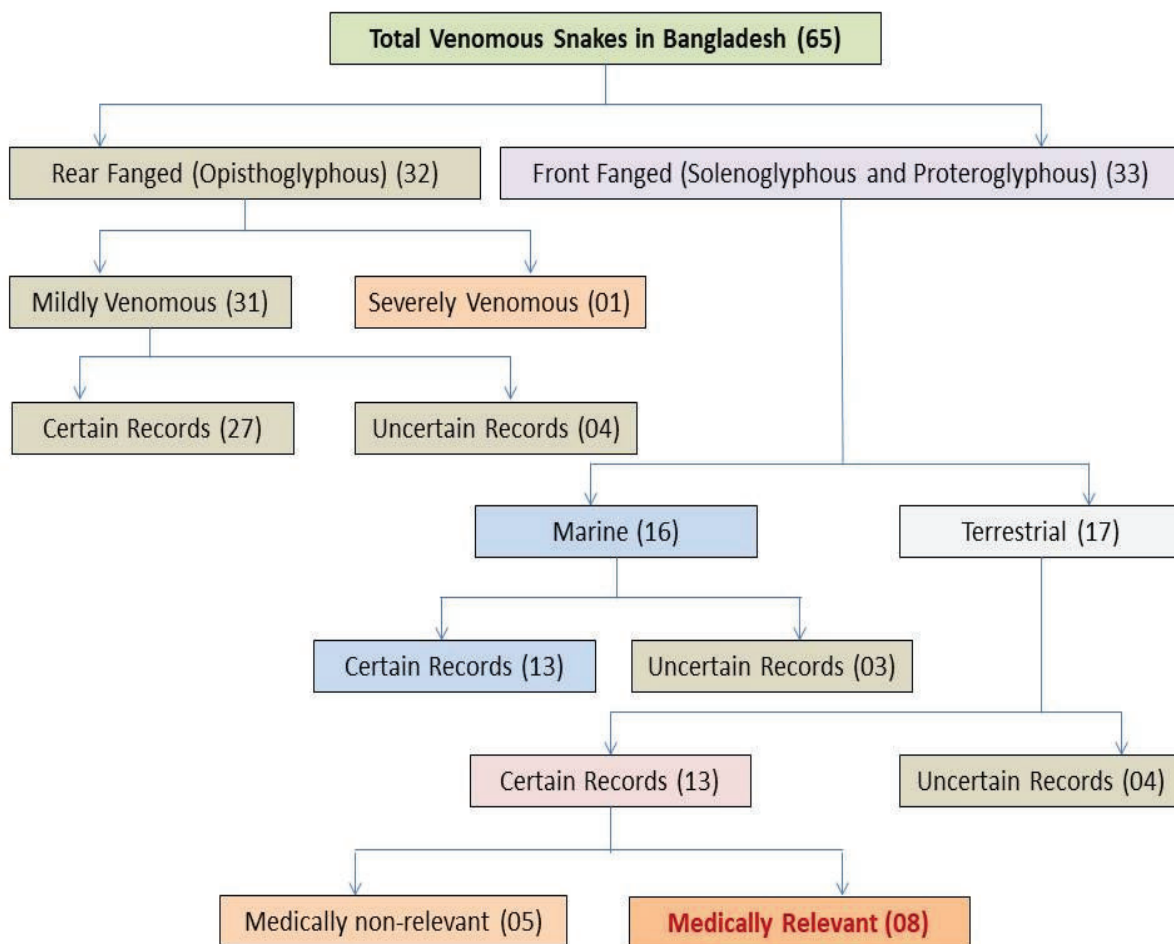


Figure 1. A flowchart of different types of the venomous snake species in Bangladesh.

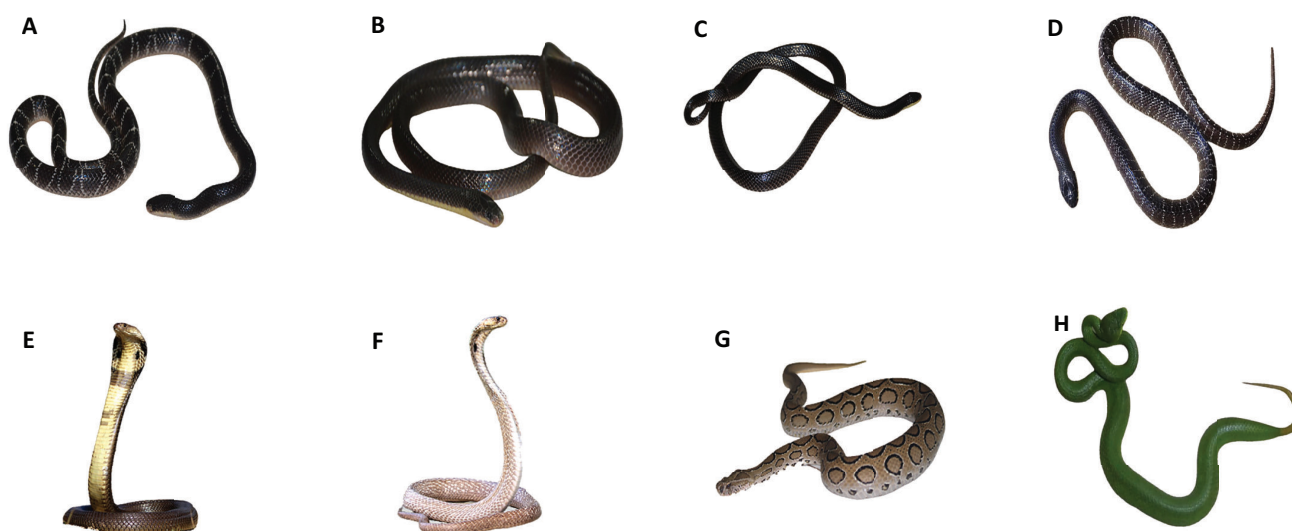
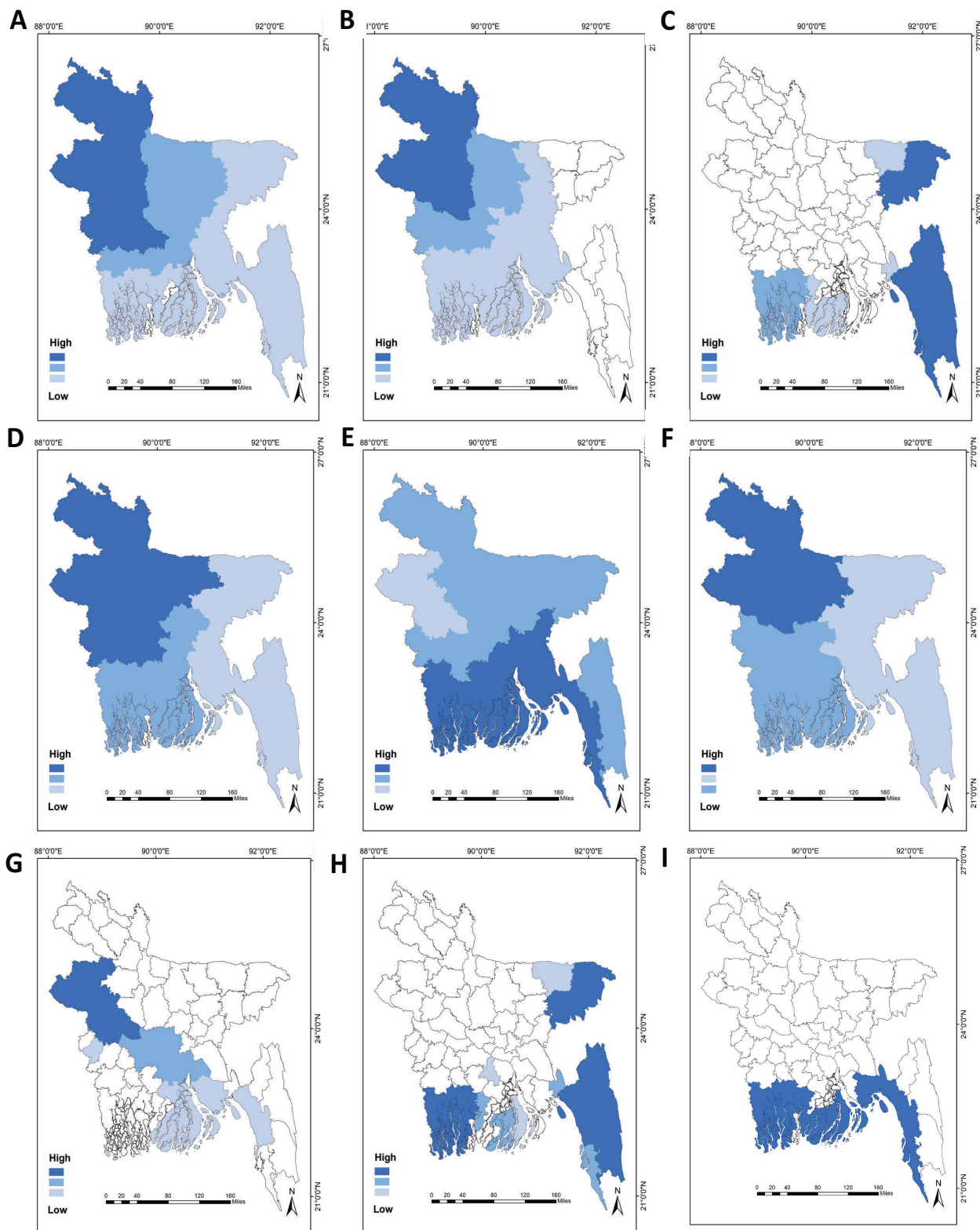


Figure 2. Photographs of medically relevant venomous snakes (A- *Bungarus caeruleus*, B- *Bungarus lividus*, C- *Bungarus niger*, D- *Bungarus walli*, E- *Naja kaouthia*, F- *Naja naja*, G- *Daboia russelii*, H- *Trimeresurus erythrurus*) in Bangladesh.



**Figure 3.** Distribution of medically relevant venomous snakes (A- *Bungarus caeruleus*, B- *Bungarus lividus*, C- *Bungarus niger*, D- *Bungarus walli*, E- *Naja kaouthia*, F- *Naja naja*, G- *Daboia russelii*, H- *Trimeresurus erythrurus* and I- marine venomous snakes) in Bangladesh.



There were five proteroglyphous kraits, of which *Bungarus fasciatus* was not considered medically relevant due to no clinical records of envenomation from Bangladesh.<sup>5</sup> None of the medically relevant kraits are distributed country-wide rather have shown distinct distribution in Bangladesh. The common krait *B. caeruleus* mostly occurs in the northwestern part (Rajshahi and Rangpur regions, northern districts of Khulna and west of Padma River in Dhaka division) of Bangladesh and merely recorded from Chattogram and Sylhet regions. Similarly, the lesser black krait *B. lividus* occurs in the north (Mymensingh region), Feni (northeast), and northwestern (Rangpur and Rajshahi regions) part, the greater black krait *B. niger* in the southeast (Chattogram region), northeast (Sylhet region), and southern (mangrove forest of the Sundarbans) part, and the walls krait *B. walli* shown scattered spread all over the country.

There are two true cobras: *Naja naja* and *N. kaouthia* abundantly occur in Bangladesh (Figure 2). The Spectacled Cobra *N. naja* commonly occurs in the north (Rangpur region), northwest (Rajshahi region), and west (west of the Padma River), and is rarely reported from Chattogram and Sylhet regions.<sup>16,18</sup> Geographically, *N. naja* does not occur east of the Brahmaputra, south of Jamuna, and east of the Padma and Meghna rivers. On the other hand, the Monocled Cobra *N. kaouthia* is the most abundant in the mangrove forest of Sundarbans, some parts of Chattogram and Barishal, and rarely found in the Rajshahi regions. The King Cobra *Ophiophagus hannah*, the largest venomous snake in the world occurs in the southeast (Chattogram region), northeast (Sylhet region), southern (mangrove forest of the Sundarbans) and Barishal, however, not considered a medically relevant snake species because of mere clinical envenoming records.

Although seven species of vipers were reported from Bangladesh, we did not find evidence of the occurrence of four species. Among them, *Trimeresurus popeiorum* was observed only twice, *Ovophis monticola* and *Protobothrops jerdonii* were enlisted in Bangladesh as expected to occur as they were found in the nearby States of India. *T. albolabris* was thought as the most abundant pit viper in Bangladesh. However, morphological and morphometric examination of taxonomic features shown that all of the collected and encountered specimens from the mixed evergreen forests (Chattogram, Cox's Bazar, Feni, Chittagong Hill Tracts, Sylhet regions) and mangrove forest of the Sundarbans were *T. erythrurus*. Some recent studies declare that *T. albolabris* is not expected to be occur in the Indian subcontinent including Bangladesh and also eliminated from snake list of India.<sup>19,20</sup> Similarly, *T. gramineus* check the spelling were

also recorded by MAR Khan as a misidentification and later he corrected it as *T. erythrurus*.<sup>12,16</sup> Finally, *T. erythrurus* was the most abundant pit viper in Bangladesh based on direct encountered and clinical records; found in the mixed evergreen forest of Chattogram regions, Sylhet regions, Chittagong Hill Tracts, and mangrove forest of the Sundarbans and rarely in the Cox's Bazar, Feni, Patuakhali, Pirojpur, and there was a record from Madaripur district. The Russell's viper *Daboia russelii* was thought of as extinct in Bangladesh, however its presence and envenomation cases reported from Rajshahi, from where it has been spreading out south along the Padma River since 2012. After reappearance, it has been recorded from Rajshahi division except for Bagura and Sirajganj districts; Kushtia and Chuadanga of Khulna Division, Rajbari, Faridpur, Shariatpur, Madaripur, Manikganj, Dhaka, Munshiganj of Dhaka Division; Chandpur, Lakshimpur, Noakhali of Chattogram Division and throughout the Barishal Division except Pirojpur.

#### **Eco-epidemiology of medically relevant venomous snakes:**

The distribution of medically relevant venomous snake species divides the country into two regions: region-A and region-B (Figure 3). Region-A consists of the western part of Brahmaputra in Mymensingh division, Rangpur division, Rajshahi Division, the west of the Padma River in the Dhaka Division, and the northern part of the Khulna Division. This region is abundant with *N. naja*, *B. caeruleus*, *B. lividus*, and parts of Rangpur, Mymensingh, and Dhaka with also *N. kaouthia*. Region-B comprises east of Brahmaputra River in Mymensingh Division, east of the Padma and south of Jamuna Rivers in Dhaka Division, Sylhet Division, Chattogram division, Barishal Division, and the southern part of Khulna Division. The common and abundant medically relevant venomous snakes of this region are *N. kaouthia*, *B. niger*, and *T. erythrurus*. Hence, medical attention and strategy for snakebite management for these two regions should be different, concise, and specific. On the other hand, scatter distribution of *B. walli* over the country was observed; henceforth the same medical strategy should be followed for bite management of this species throughout the country. Therefore, *D. russelii* was inhabitant on both banks of the Padma River in Rajshahi, Dhaka, and Khulna Divisions, both banks of the Meghna River including some coastal districts of Chattogram and Barishal Divisions, hence specific medical attention and bite management strategies should be followed for this species in those particular areas.

#### **Clinical importance of Eco-epidemiology of medically relevant venomous snakes:**

The different toxins in venoms of different species of snakes produce five distinct clinical

syndromes in Bangladesh (National Guideline for Management of Snakebite, DGHS). As there is no diagnostic kit or test available to identify the venom or snake so far in Bangladesh, the management mostly depends on this 'syndromic approach'. The antivenom used in Bangladesh is produced against venoms of four local species of snakes of India of which only two are found in Bangladesh (*N. naja* and *B. Caeruleus*). Also, the geographical and inter and intra species differences in composition of venom is now well established.<sup>21,22</sup> All of these make the management of venomous snakebite further complicated.

Cobra is believed to cause most of the neurotoxic (along with local tissue toxicity) snakebites in Bangladesh; *N. kaouthia* being the commonest and most studied.<sup>23</sup> But there are only one fatal published case identified in Rangpur and 4 additional proven cases of *N. naja* bites in southeastern region (unpublished data collected by MA Faiz); the species is being documented to occur all over the country most notably in the Northwest.<sup>24</sup> The physicians in that part of the country should be prepared to encounter patients of *N. naja* bites, the specific and differentiating features of which, if any, is mostly unknown.

The presence and distribution of five species of kraits create a more complex scenario. The blockade of presynaptic receptor (in all species) and destruction of presynaptic nerve ending (by *B. niger*) at neuromuscular junction make treatment with neostigmine ineffective and greatly delays the recovery.<sup>25</sup> Moreover, difference in efficacy of the antivenom against the venom of different species should also be considered.<sup>26</sup> Physicians managing cases of Krait bite should be aware of these facts and arrange long term respiratory assistance for the patients. The additional unique property of *B. niger* of myotoxicity and resulting cardiotoxicity due to hyperkalemia and nephrotoxicity makes management of the cases much more difficult and resource demanding.<sup>25</sup> Physicians working in the south, southeast and northeast part of the country should consider these facts whenever encountered with any case of Krait suspected according to syndromic approach.

So far, there was a clear distinction in distribution pattern of Vipers; *D. russelii* being in the northwest, *T. erythrurus* in southeast, northeast, and south generally. But the gradual spread of *D. russelii* eastward along the Padma and Meghna Rivers and encroaching southward into territories of *T. erythrurus* will further complicate the clinical pictures for the treating physicians. The efficacy of current antivenom against the venom of *D. russelii* in Bangladesh has also been questioned.<sup>22</sup>

The presence of rear-fanged venomous snakes in Bangladesh is not a well-known fact among physicians of Bangladesh. The national guidelines or training modules on management of snakebite do not list these snakes as medically important snakes. But they can produce some clinical features which may confuse the treating physicians. Red-necked Keelback (*Rhabdophis subminiatus*) is reported to produce significant clinical illness in human including fatality.<sup>27</sup> Physicians should be made aware of the presence of these snakes and also regarding the management of the patient. The presence of sea snakes and occurrence of sea snakebite among the sea going fisherman community along the coast of the Bay of Bengal has been reported long ago.<sup>28</sup> But there is no recent published epidemiological data or case report about this. Some of the authors of this article have recently completed a survey on incidence of sea snakebite in a selected community in the South and Southeast region (Submitted for publication). The survey documented a significant number (~25%) of fishermen being bitten at some point of their work life in sea. The physicians in the coastal regions of the country should be made aware of this fact and trained accordingly to be prepared to manage these cases.

It seems knowledge of local fauna of venomous snakes will aid the treating physician regarding possible identity of the offending snake and taking decision regarding management. It will also help the physicians to be prepared for possible complications. Bangladesh is now in a unique position by establishing the Venom Research Centre (VRC) at Chittagong Medical College, Chattogram which have successfully collected venoms from all the medically relevant venomous snakes found in different geographical locations across the country. This opportunity should be used for production of country specific antivenom(s) and for periodic pharmaco-efficacy surveillance of any antivenom in use. This may also be used for the development of diagnostic kits for specific envenomation. These measures will greatly contribute to the future management of snake envenomation in this country.

### Conclusion

There were 65 species of venomous snake species recorded from Bangladesh; however, most of them have no medical relevance. Maximum snakes are mildly venomous and rear-fanged colubrid snakes, marine snakes, rare records, and no or mere clinical records. Only eight species of venomous snakes (write the names) can be considered medically relevant because of their common occurrences, snake-human encounters, envenoming bite incidents, and available clinical records of medical history. Therefore, the entire country might be divided into two parts: some snake species were

recorded from non-forested areas or deciduous forests of the northern, northwestern, and western parts of the country; and some were inhabitants of mixed evergreen forests of northwestern, southeastern, and mangrove forest of the southern countryside, and both became overlapped in the middle part. This is noteworthy that each district of the country should be considered a snakebite-prone area because of the frequent occurrence of several numbers of medically relevant venomous snake species. Hence, medical attention for snakebite management should be different for a region comprised of Rangpur, Rajshahi, west of Dhaka and north of Khulna; another region consists of Sylhet, Chattogram, Barishal, and southern Khulna.

### Acknowledgment

The authors pleasantly acknowledge the support of Professor (Associate) Dr. Fazle Rabbi Chowdhury for his cordial cooperation during the study.

### Competing Interests

The authors declare that there is no competing interest.

### Authors Contributions

IKAH, AG, and MAWC designed the study protocol; IKAH, MN, MMR, SR, AA, MRI and MAU were involved in collecting snake data, prepared materials and analyzed data, IKAH, MAWC and AG conducted the study and wrote the manuscript, and RAMEU, AAS, MRA, MFA, MAF and AG revised the manuscript.

### Financial Disclosure

Venom Research Centre, Bangladesh (VRC,B) partially supports collecting study materials and rest of the study was self-funded.

### References

- Warrell DA. Venomous bites and stings in the tropical world. *Med J Aust.* 1993;159(11-12):773-779. doi:10.5694/j.1326-5377.1993.tb141345.x
- Sharma SK, Chappuis F, Jha N, Bovier PA, Loutan L, Koirala S. Impact of snake bites and determinants of fatal outcomes in Southeastern Nepal. *Am J Trop Med Hyg.* 2004;71(2):234-238. <http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed6&NEWS=N&AN=2004359400>
- Bawaskar HS, Bawaskar PH. Snakebite envenoming. *Lancet.* 2019;393(10167):131. doi:10.1016/S0140-6736(18)32745-4
- Gutiérrez JM, Calvete JJ, Habib AG, Harrison RA, Williams DJ, Warrell DA. Snakebite envenoming. *Nat Rev Dis Prim.* 2017;3(1). doi:10.1038/nrdp.2017.64
- Rahman R, Faiz MA, Selim S, et al. Annual Incidence of Snake Bite in Rural Bangladesh. 2010;4(10). doi:10.1371/journal.pntd.0000860
- Ghose A, Faiz A. Snake Envenomation in Bangladesh Snakebite Epidemiology in Bangladesh. Published online 2014:1-14. doi:10.1007/978-94-007-6288-6
- Williams HF, Layfield HJ, Vallance T, et al. The urgent need to develop novel strategies for the diagnosis and treatment of snakebites. *Toxins (Basel).* 2019;11(6). doi:10.3390/toxins11060363
- Ariaratnam CA, Rezvi Sheriff MH, Arambepola C, Theakston RDG, Warrell DA. Syndromic approach to treatment of snake bite in Sri Lanka based on results of a prospective national hospital-based survey of patients envenomed by identified snakes. *Am J Trop Med Hyg.* 2009;81(4):725-731. doi:10.4269/ajtmh.2009.09-0225
- Bolon I, Durso AM, Mesa SB, et al. Identifying the snake: First scoping review on practices of communities and healthcare providers confronted with snakebite across the world. *PLoS One.* 2020;15(3). doi:10.1371/journal.pone.0229989
- IUCN Bangladesh. *Red List of Bangladesh: Reptiles and Amphibians.* Vol 4.; 2015.
- Khan M. Photographic guide to the wildlife of Bangladesh. *Arannayk Found Dhaka, Bangladesh.* Published online 2018:488 pp.
- Khan M. Wildlife of Bangladesh: checklist-cum-guide. *MJ Alam, Chayabithi, Dhaka, Bangladesh.* Published online 2015:568 pp.
- Chowdhury MAW, Islam MR, Auawal A, Uddin H, Hasan N, Haidar IK Al. On the occurrence of persian gulf sea snake, *Hydrophis lapemoides* (Gray, 1849) (reptilia, squamata, elapidae, hydrophiinae), along the coast of bangladesh. *Check List.* 2021;17(4):1075-1080. doi:10.15560/17.4.1075
- Sarker M, Sanders K, MF J. First report of the Collard sea Snake, *Hydrophis strictocollis* Gunther, 1864, and the Estuarine Sea Snake, *H. obscurus* Daudin, 1803, in the coastal waters of Bangladesh, with some remarks on their natural history. *Herpetol Notes.* 2023;9(16):253-259.
- Khan M. Bangladesher banaya prani (wildlife of Bangladesh). *Bangla Acad Dhaka, Bangladesh.* 1987;1:169pp.
- Khan M. Bangladesher shap. *Bangla Acad Dhaka, Bangladesh.* Published online 1992:227 pp.
- Khan M. *Wildlife of Bangladesh - A Checklist (from Amphibia to Mammalia with Bengali Names).* Shahitya Prakash; 2010.
- Ahsan M, Haidar I, Rahman M. Status and diversity of snakes (Reptilia: Squamata: Serpentes) at the Chittagong University Campus in Chittagong, Bangladesh. *J Threat Taxa.* 2015;7(14):8159. doi:10.11609/jott.2431.7.14.8159-8166

19. Hakim J, Trageser SJ, Ghose A, Das K, Rashid SMA, Rahman SC. Amphibians and reptiles from lawachara national park in Bangladesh. *Check List*. 2020;16(5):1239-1268. doi:10.15560/16.5.1239
20. Vogel G, Mallik AK, Chandramouli SR, Sharma V, Ganesh SR. A review of records of the *Trimeresurus albolabris* Gray, 1842 group from the Indian subcontinent: expanded description and range extension of *Trimeresurus salazar*, redescription of *Trimeresurus septentrionalis* and rediscovery of historical specimens of Tr. *Zootaxa*. 2022;5175(3):343-366. doi:10.11646/zootaxa.5175.3.2
21. Deka A, Reza MA, Faisal Hoque KM, Deka K, Saha S, Doley R. Comparative analysis of *Naja kaouthia* venom from North-East India and Bangladesh and its cross reactivity with Indian polyvalent antivenoms. *Toxicon*. 2019;164:31-43. doi:10.1016/j.toxicon.2019.03.025
22. Pla D, Sanz L, Quesada-Bernat S, et al. Phylovenomics of *Daboia russelii* across the Indian subcontinent. Bioactivities and comparative in vivo neutralization and in vitro third-generation antivenomics of antivenoms against venoms from India, Bangladesh and Sri Lanka. *J Proteomics*. 2019;207. doi:10.1016/j.jprot.2019.103443
23. Faiz MA, Ahsan MF, Ghose A, et al. Bites by the Monocled Cobra, *Naja kaouthia*, in Chittagong Division, Bangladesh: Epidemiology, clinical features of envenoming and management of 70 identified cases. *Am J Trop Med Hyg*. 2017;96(4):876-884. doi:10.4269/ajtmh.16-0842
24. Hossain MZ, Atiqullah S, Saha AC, Chowdhury AJ, Jahangir KM, Faiz MA. A fatal cobra-bite in a snake expert. *Mymensingh Med J*. 2010;19(2):303-307.
25. Faiz MA, Ghose A, Ahsan MF, et al. The greater black krait (*Bungarus niger*), a newly recognized cause of neuro-myotoxic snake bite envenoming in Bangladesh. *Brain*. 2010;133(11):3181-3193. doi:10.1093/brain/awq265
26. Alam MJ, Maruf MMH, Iqbal MA, et al. Evaluation of the properties of *Bungarus caeruleus* venom and checking the efficacy of antivenom used in Bangladesh for its bite treatment. *Toxicon X*. 2023;17. doi:10.1016/j.toxcx.2023.100149
27. Chowdhury A, Lewin MR, Carter RW, Casewell NR, Fry BG. Keel venom: *Rhabdophis subminiatus* (red-necked keelback) venom pathophysiologically affects diverse blood clotting pathways. *Toxicon*. 2022;218:19-24. doi:10.1016/j.toxicon.2022.08.017
28. Sarker MAR, Sanders KL, Ukuwela KDB, Jamam MF. Sea snakes of Bangladesh: A preliminary survey of cox's bazar district with notes on diet, reproduction, and conservation status. *Herpetol Conserv Biol*. 2017;12(2):384-393.
29. Husain K. Bangladesher banayanjontu shampad o tar sangrakshan (in Bengali). *Bangla Acad Bijnan Patrica*. 1977;3(3):1-11.
30. Montaquim M, Sarkar A, Khan M, Husain K. List of the snakes of Bangladesh. *Bangladesh J Zool*. 1980;8 (2):127-129.
31. Khan M. Wildlife of Bangladesh—a checklist. *Dhaka, Univ Press Dhaka, Bangladesh*. Published online 1982:174pp.
32. Sarker M, Sarker N. Reptiles of Bangladesh (with their status, distribution and habitat). *Tiger Pap*. 1985;12 (2):6-12.
33. Sarker M, Sarker N. Wildlife of Bangladesh (a systematic list with status, distribution and habitat). *Rico Printers, Dhaka, Bangladesh*. Published online 1988:69 pp.
34. Sarker SU, Hossain ML. Ecological Study on the Wildlife Resources in Coastal Islands and Their Conservation. *J NOAMI*. 1997;14(1-2):39-54.
35. Ahsan M. Country reports for Bangladesh—herpetofauna of Bangladesh: present status, distribution and conservation. In: Biology and conservation of the amphibians, reptiles and their habitats in South Asia. In: *Proceedings of the International Conference on the Biology and Conservation of the Amphibians and Reptiles of the South Asia, Sri Lanka*. ; 1998:9-17.
36. IUCN. *Red List of Threatened Animals*. IUCN Bangladesh Country Office; 2000.
37. Asmat G, Hannan M. *Checklist of Wild Animals of Bangladesh*.; 2007.
38. Khan MMM. Protected Areas of Bangladesh: A Guide to Wildlife. Published online 2008:304.
39. Mahony S, Reza A. A herpetofaunal collection from the Chittagong Hill tracts, Bangladesh, with two new species records for the country. *Hamadryad*. 2008;32(1):45-56.
40. Kabir S, Ahmad M, Ahmed A, et al. *Encyclopedia of Flora and Fauna of Bangladesh*. Vol 25.; 2009.
41. Mahony S, Hasan M, Kabir M, Ahemd M, Hossain M. A catalogue of amphibians and reptiles in the collection of Jahangirnagar University, Dhaka, Bangladesh. *Hamadryad*. 2009;34 (1):80-94.
42. Chowdhury FR, Bari MS, Ahsan MS. Snakes in the northern part of Bangladesh: species specific identification. In: *10th Scientific Congress of the Asia Pacific Association of Medical Toxicology (APAMT)*. ; 2011.
43. Feeroz MM, Hasan MK, Khan MMH. Biodiversity of Protected Areas of Bangladesh, Vol. I, Rema-Kalenga Wildlife Sanctuary. *BioTrack, Arannayk Found Dhaka, 214pp*. Published online 2011.
44. Feeroz MM, Hasan MK, Hossain MK. *Biodiversity of Protected Areas of Bangladesh, Vol. II, Dudpukuria-Dhopachari Wildlife Sanctuary*. BioTrack, Arannayk Foundation; 2012.
45. Rahman MS, Sarker SU, Jaman MF. Ecological Status of the Herpeto-Mammalian Fauna of the Padma River and its

- Adjacent Areas, Rajshahi and their Conservation Issues. *Bangladesh J Zool.* 2012;40(1):135-145. doi:10.3329/bjz.v40i1.12903
46. Feeroz MM. Biodiversity of protected areas of Bangladesh, Vol. III: Teknaf Wildlife Sanctuary. *Bio Track, Arannayk Found Dhaka, Bangladesh, 240pp.* Published online 2013.
  47. Sarmin S, Amin MR, Al-mamun H, Rahman R, Faiz MA. Clinical Aspects of Green Pit Viper Bites in Bangladesh/ : A Study on 40 Patients. *Asia Pacific J Med Toxicol.* 2013;2(3)(September):96-100.
  48. Hassan MK, Feeroz MM, Khan MMH. *Amphibians and Reptiles of Bangladesh:A Field Guide.* Arannayk Foundation; 2014.
  49. Chakraborty P, Deb Nath J, Faiz M, Das A, Chowdhury AQ. Clinical Study of Snakebite Cases Admitted in Dhaka Medical College Hospital. *Chattagram Maa-O-Shishu Hosp Med Coll J.* 2014;13(1):7-12. doi:10.3329/cmshmcj.v13i1.19410
  50. Rahman SC, Reza AA, Data R, Jenkins CL, Luiselli L. Niche partitioning and Population structure of sympatric mud snakes (Homalopsidae) from Bangladesh. *Herpetol J.* 2014;24(2):123-128.
  51. Karim MR, Ahsan MF. Herpetofauna of Baraiyadhala National Park in Chittagong, Bangladesh. *Bangladesh J For Sci.* 2014;33(1&2):39-48.
  52. Alam AS, Islam AM, Jesmin H. Snake Bite as a Public Health Problem: Bangladesh Perspective. *BIRDEM Med J.* 2016;5(1):24-29. doi:10.3329/birdem.v5i1.28370
  53. Ahsan MF, Rahman MM. Status, distribution and threats of kraits (Squamata: Elapidae: Bungarus) in Bangladesh. *J Threat Taxa.* 2017;9(3):9903-9910. doi:10.11609/jott.2929.9.3.9903-9910
  54. Ahsan MF, Saeed MA. Russell's Viper (*Daboia Russelii*) in Bangladesh: Its Boom and Threat to Human Life. *J Asiat Soc Bangladesh, Sci.* 2018;44(1):15-22. doi:10.3329/jasbs.v44i1.46542
  55. Haidar IKA, Romon BB, Chowdhury MAW. First record of the Condanarous sand snake (*Psammophis condanarus*)(Reptilia: Squamata: Lamprophiidae) from Bangladesh. *J Asia-Pacific Biodivers.* 2020;13(4):716-719. doi:10.1016/j.japb.2020.08.013
  56. Shome AR, Jaman MF, Rabbe MF, Barkat AI, Alam MM. New distribution record of rhabdophis subminiatus (Schlegel, 1837; squamata, colubridae) from Madhupur National Park, Tangail, Bangladesh. *Herpetol Notes.* 2020;13:549-551.
  57. Romon BB, Chowdhury MAW, Haidar IKA. First record of the Coral Red Kukri Snake *Oligodon kheriensis* (Reptilia: Squamata: Colubridae) from Bangladesh. *J Asia-Pacific Biodivers.* 2021;14(3):434-438. doi:10.1016/j.japb.2021.04.001
  58. Hasan M, Anik ZH, Kurabayashi A. Wildlife diversity of the Padma River islands, Rajshahi, Bangladesh with special notes on the operation of sand snake (*Psammophis condanarus*) (*Merrem*, 1820) (*Reptilia* : *Squamata* : *Lamprophiidae*). 2022;6(x).
  59. Rabbe M, Mohammad N, Roy D, Jaman M, Naser M. A rapid survey of herpetofaunal diversity in Nijhum Dwip National Park, Bangladesh. *Reptil Amphib.* 2022;29(1):9-16. doi:10.17161/randa.v29i1.15794
  60. Chowdhury MAW, Varela S, Roy S, et al. Favourable climatic niche in low elevations outside the flood zone characterises the distribution pattern of venomous snakes in Bangladesh. *J Trop Ecol.* Published online 2022:1-14. doi:10.1017/s0266467422000359
  61. Islam NN, Sajib AA, Islam MS, Ahmed MS. Molecular identification of snakes from cast-off skin based on COI marker in Bangladesh. *Herpetol Notes.* 2022;15:699-709.
  62. Ahsan M. *Amphibians and Reptiles of the Chittagong University Campus: A Field Guide.* Boighor Trading Care; 2022.