

## Insights into the rare Viperine sea snake, *Hydrophis viperinus* (Schmidt, 1852): Addressing research gaps along the Indian coastline

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The Viperine sea snake (*Hydrophis viperinus*), occasionally called the Grey Sea Snake, is an elapid sea snake found in tropical and subtropical reefs and coasts of the Indo-Pacific waters. The species has been reported in limited numbers along the Indian coast, either as bycatch or stranded. Given its naturally rare occurrence, there is a considerable lack of information about its research history in India. This review assembles all available information on species (n = 112) through various search engines and databases, ranging from 1852 to 2024. The literature was then analysed to determine areas where further research is required. Despite recognising that India has listed *H. viperinus* as a scheduled species, it remains vital to understand how anthropogenic activities affect the species' habitats to conduct vulnerability assessments and prevent exploitation. This article reviews the ecology, population dynamics, and threats while highlighting research gaps concerning the species in its Indian distribution.

[**Keywords:** Elapidae, Grey sea snake, Hydrophiinae, Marine reptiles, Ophiology, Squamata]

### Introduction

Sea snakes are marine reptiles known to spend the entirety or part of their lives inhabiting the world's tropical and subtropical waters<sup>1</sup>, with morphological adaptations suited for aquatic lifestyles, including a laterally compressed, fin-like tail modified to assist efficient propulsion during underwater locomotion<sup>2,3</sup>.

In recent years, there has been an evident rise in interest in studying sea snakes owing to their significance in the marine food chain<sup>4,5</sup> and their infamy ability to possess one of the most potent animal toxins<sup>6</sup>. While sea snakes have been recorded to be exploited commercially for a variety of purposes in coastal countries such as Japan, Australia, Philippines, Thailand, etc.<sup>7</sup>, in India, all sea snakes receive the highest levels of protection against exploitation and their trade, under Schedule II of the Indian Wildlife (Protection) Amendment Act, 2022.

The waters off the Indian coastline house around 19 species of 'true sea snakes' (Elapidae; Hydrophiinae)<sup>8</sup>. The ovoviviparous species of Hydrophiinae<sup>9</sup> are the only relatively successful group of marine snakes to have colonised oceanic habitats, as they are the only lineage to have adapted to evolve extra skeletal support dorsally and ventrally in their paddle-like tails with elongated vertebral

processes<sup>10,11</sup>. Extensive morphological and molecular findings identified two strong marine clades within the Hydrophiinae family: the *Aipysurus* and *Hydrophis* lineages<sup>5,12-15</sup>.

One such Hydrophiinae sea snake is the Viperine sea snake or Grey sea snake *Hydrophis viperinus* (Schmidt, 1852) (Fig. 1). The species was first described by Philipp Schmidt in 1852 from Java<sup>16</sup>. In India, it is locally known as 'Katal mandali' in Malayalam. Though it has been recorded to have a wide range of distribution, its relatively few strandings and sighting reports suggest its sporadic occurrence, which is discussed ahead. It is enlisted in the Least Concern category on IUCN Red List<sup>17</sup> and is protected under Schedule II of the Wildlife (Protection) Amendment Act of India, 2022.

The correct name for the Viperine sea snake has been a subject of contention for years since it was first described, as three forms of its names were most commonly used across all literature. It was named '*Thallasophina viperina*' when initially described by Schmidt<sup>16</sup> and has also been referred to as '*T. viperina*' or '*Praescutata viperina*'<sup>16</sup>. The species name '*viperina*' means 'viper-like' due to its relatively broader head, a characteristic feature of Viper snakes. Results of a meticulous phylogenetic

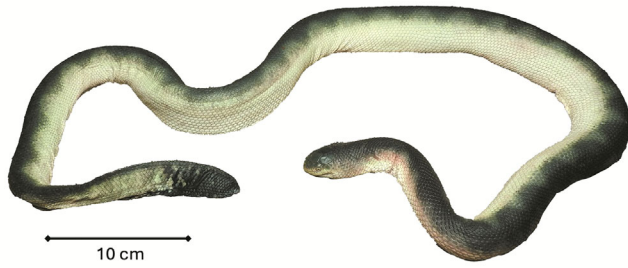


Fig. 1 — Viperine sea snake *Hydrophis viperinus* (Photo credits: Sanjaya Kanishka)

analysis<sup>13</sup> lead to the species currently being treated under the *Hydrophis*, making ‘*Hydrophis viperinus*’ the only accepted terminology for the Viperine sea snake<sup>18</sup>.

Though field guides such as ‘Guide to the Dangerous and Venomous Marine Animals of India’<sup>19</sup> have enlisted *H. viperinus* as a venomous sea snake species, the text lacks essential information on the species, such as a thorough description of the species for identification when sighted for detailed distribution and occurrence analyses. Additionally, the studies done on the species are sparse, leading to a lot of research areas that are yet to be investigated. Significant insights into the pathological and anatomical characteristics of *H. viperinus* have been revealed by its histological examination<sup>10,11,20</sup>. While there are few studies on *H. viperinus*, previous related research on other sea snake species does provide enough context that could be relevant to fill gaps on this species as well. In this context, this article aims to draw attention to this particular species, which has been historically under-represented in scientific research despite its presence in Indian waters. The article explores and discusses the available literature on the scarcely studied *H. viperinus* to summarise relevant known information and highlight prevailing research gaps.

### Materials and Methods

Available information on *H. viperinus* was assembled from various online search engines and databases such as Google Scholar, ResearchGate, Web of Science, The Reptile database and Academia. Literature and relevant data were compiled from the years 1852 to 2024 from sources available in English, which included scholarly research articles and articles from books, along with some grey literature such as field guides reports and online database websites, PhD dissertations, etc., covering a range of countries without any bias for India. The information thus gathered is visualised in a stacked

column graph and a pie chart, representing the available topic-wise information on *H. viperinus*. The literature was meticulously analysed to produce a comprehensive review summarising the species information and interpreting areas of research gaps about Viperine sea snakes.

### Results

Among the global literature collected discussing original accounts and information on *H. viperinus* (N = 112), the largest share of publications originated from Southeast and East Asian countries, accounting for 33.6 %, followed by Middle-East Asia (22.7 %) (as shown in Fig. 2). Only 18.8 % of the articles mentioned the species in its Indian distribution, with a significant portion of these mentions having been produced within the last three decades. The species’ interest globally and in India has drastically increased in the past two decades. Most of this literature consisted of research journal articles (40.6 %), followed by field guides (24.75 %) and species checklists (19.80 %), mentions in book chapters (9.90 %), and the rest were reports, web sources (4.95 %).

A review of published literature spanning from 1852 to 2024 reveals a gradual but limited increase in scientific interest in this species. Early documentation focused primarily on taxonomy and morphology, with sporadic reports on its distribution, particularly in the Indo-Pacific region. However, comprehensive studies were largely absent until the late 20th century, when researchers began documenting sightings, ecological aspects, and conservation concerns. The last two decades (2000 – 2024) have witnessed a rise in publications, mainly addressing threats such as fisheries bycatch, habitat degradation, and venom studies (Fig. 2).

A range of facets *viz.* geographical distribution, morphology, scalation, colouration, habitat, diet, behavioural ecology, histopathological changes, predators, and reproduction, population status, bite and venom toxicology, disease, threats of *H. viperinus* were examined for a detailed review of the documented information of the species (Fig. 3). The analysis unveiled that the highest proportion of papers 50 % (n = 58) had accounts mentioning the description and morphology of the species of which 18 % of studies were morphological studies from freshly collected specimens. The distribution of the species was documented by 12 % of articles (n = 14), shedding light on its range and rare occurrence. Studies that discussed threats due to commercial uses in food and medicine for trade and bycatch reports (n = 16; 14 %) are also

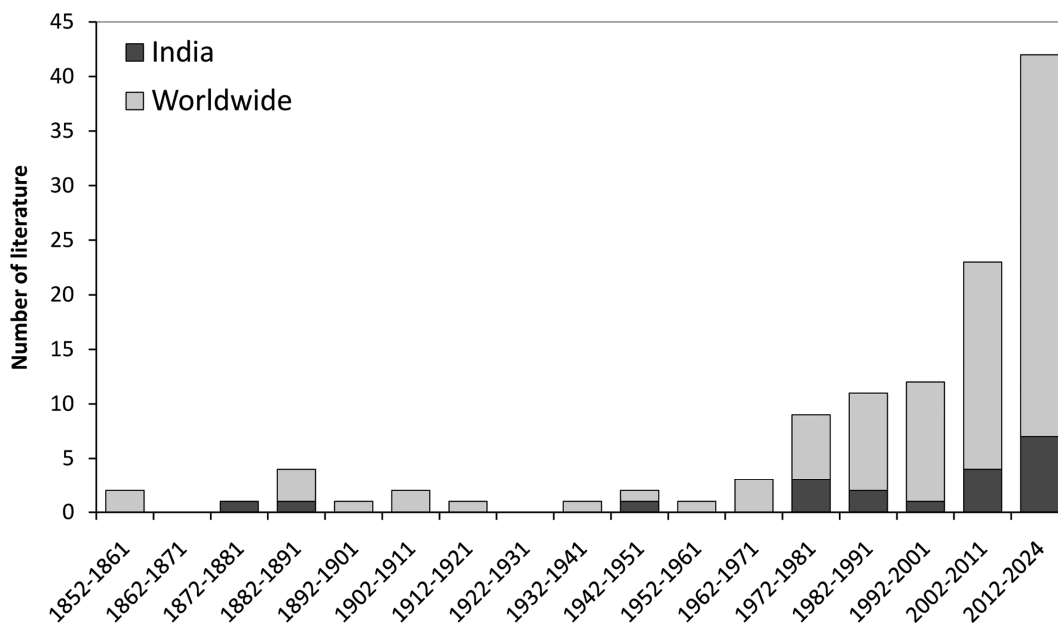


Fig. 2 — Literature published with mentions of *Hydrophis viperinus* since its discovery in 1852 to 2024

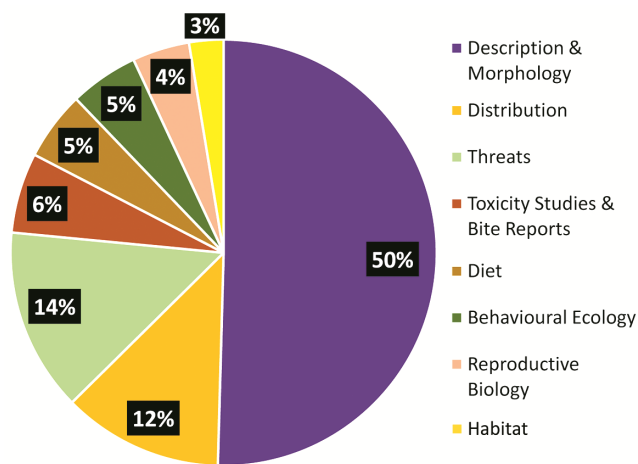


Fig. 3 — Proportions of different areas of study from past research papers on *Hydrophis viperinus*

frequently featured. Toxicity studies followed, including bite reports of the sea snake species (6 %). Further studies included an examination of the feeding patterns and diet (n = 6; 5 %), as well as its behavioural ecology (n = 6; 5 %). The remaining papers investigated the breeding and reproductive biology of *H. viperinus* (n = 5; 4 %), while a few mentioned its frequented habitat types (n = 3; 3 %) <sup>22-69</sup>.

**Distribution**

**Indian distribution**

The species has a widespread distribution with a naturally rare occurrence. There have been only a few

reports of *H. viperinus* individuals in India <sup>21</sup>. A few reports of *H. viperinus* individuals have been made in India, with several specimens present in museum collections and collections of the Zoological Survey of India (ZSI), which have been collected from Puri <sup>22</sup>, Ganjam coast of Odisha <sup>22</sup>, and Digha, West Bengal <sup>23</sup> along the eastern coast of India. Records from the Indian western coast are present from the Karwar coast of Karnataka <sup>22</sup>, the Sindhudurg and Konkan Coasts of Maharashtra <sup>24,25</sup> and the coasts of Goa <sup>26</sup>. After a sighting from the Coromandel coast of Tamil Nadu <sup>6,27</sup> in 1977, the species was not sighted in its Indian distribution for the next three decades before being reported in the Gulf of Mannar Marine National Park <sup>27</sup> again in 2006 (Table 1; Fig. 4).

**Geographical distribution**

*Hydrophis viperinus* populations are found to be distributed along reefs and coasts of the Persian Gulf, Gulf of Oman, Pakistan, India, Sri Lanka, China, Myanmar, Malaysia, Thailand, Straits of Taiwan and Malacca, Vietnam, and Indonesia <sup>3,17,20,28-34,71-112</sup>.

**Morphology**

*Hydrophis viperinus* has an elongated body and a neck that is distinct from its shorter, depressed head <sup>29,32</sup>. The average Total Length (TL) of *H. viperinus* adults, captured in a trawl in Goa, India, is approximately 97 cm <sup>(refs. 26,27)</sup>. They bear distinct paddle-shaped tails (Fig. 1, 5) and show slight sexual dimorphism as males

Table 1 — Distributional records of <i>Hydrophis viperinus</i> in India					
Sr. No	Latitude	Longitude	Location of sighting or collection	Status of individual	References
1.	19°46'48.1" N	85°46'40.7" E	Puri, Odisha	ZSI specimen; dead; specimen source undocumented	Ahmed <sup>22</sup>
2.	19°22'50.4" N	85°04'54.3" E	Ganjam coast, Odisha	ZSI specimen; dead; specimen source undocumented	Ahmed <sup>22</sup>
3.	14°49'33.7" N	74°07'31.1" E	Karwar, Karnataka	ZSI specimen; dead; specimen source undocumented	Ahmed <sup>22</sup>
4.	08°47' to 09°15' N	78°12' to 79°14' E	Gulf of Mannar MNP	In-situ sighting; live	Lobo <sup>37</sup>
5.	11°50'23.3" N	79°48'41.3" E	Marina beach; Coromandel coast, Tamil Nadu	In-situ sighting; live	Murthy <sup>6</sup> ; Karthikeyan & Balasubramanian <sup>27</sup>
6.	15°19'56.4" N	73°52'44.2" E	Goa	Bycatch; dead	Rasmussen <i>et al.</i> <sup>26</sup>
7.	16°02'55.2" N	73°28'07.0" E	Sindhudurg coast, Maharashtra	Bycatch; dead	Khan <i>et al.</i> <sup>68</sup>
8.	18°11'25.0" N	72°58'46.6" E	Konkan coast, Maharashtra	Bycatch; dead	Rao <i>et al.</i> <sup>67</sup>
9.	21°37'09.0" N	87°30'32.3" E	Digha, West Bengal	Bycatch; dead	Mondal <i>et al.</i> <sup>23</sup>

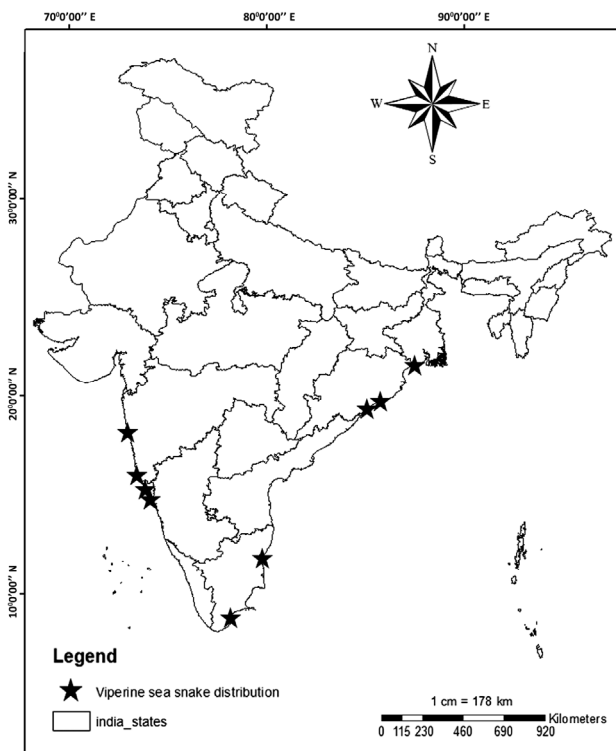


Fig. 4 — Distributional records of Viperine sea snake in India

are somewhat larger than females, averaging 93 cm and 82 cm, respectively. Tail lengths measure about 10 cm and 8 cm for males and females, respectively<sup>27</sup>, and the snout-vent length measures approximately 260 – 680 mm<sup>28,35</sup>. The head measures 1.4 – 2.5 cm in length and 0.7 – 1.25 cm in width (Fig. 6)<sup>32,35</sup>. The *Hydrophis* genus generally bears highly elongated pleurapophyses

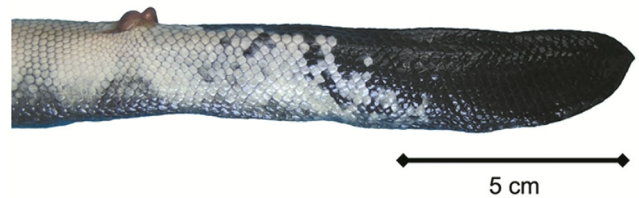


Fig. 5 — Paddle-shaped tail of *H. viperinus*

(exceeding centrum length)<sup>14</sup>, with the hemipenis forked near the tip and spinose throughout except at the proximal end<sup>22</sup>. The *H. viperinus* species has five maxillary teeth behind its four fangs. These teeth are evenly spaced, subequal, and grooved. This is fewer than the other *Hydrophis* species and sets them apart<sup>36,37</sup>.

#### Scalation

*Hydrophis viperinus* possesses hexagonal, juxtaposed scales, positioned in 27 to 34 rows on the neck, 37 to 50 at the midbody<sup>22</sup>, and 226 to 274 ventrals; they are twice the width of adjacent scales and are broader anteriorly, decreasing in size posteriorly till the vent, another key for identification against other *Hydrophis* species<sup>7,23,36</sup>. The nasal shields are subtriangular, and the frontal is twice as broad as the supraocular<sup>22</sup> (Fig. 6d – e).

The scales measure half the diameter of the body anteriorly, narrowing posteriorly to approximately two times the breadth of the adjacent scales<sup>23,36</sup>. The head shield is entire; nostrils are positioned superiorly, with the nasal shields in contact. Pre-frontals longer than

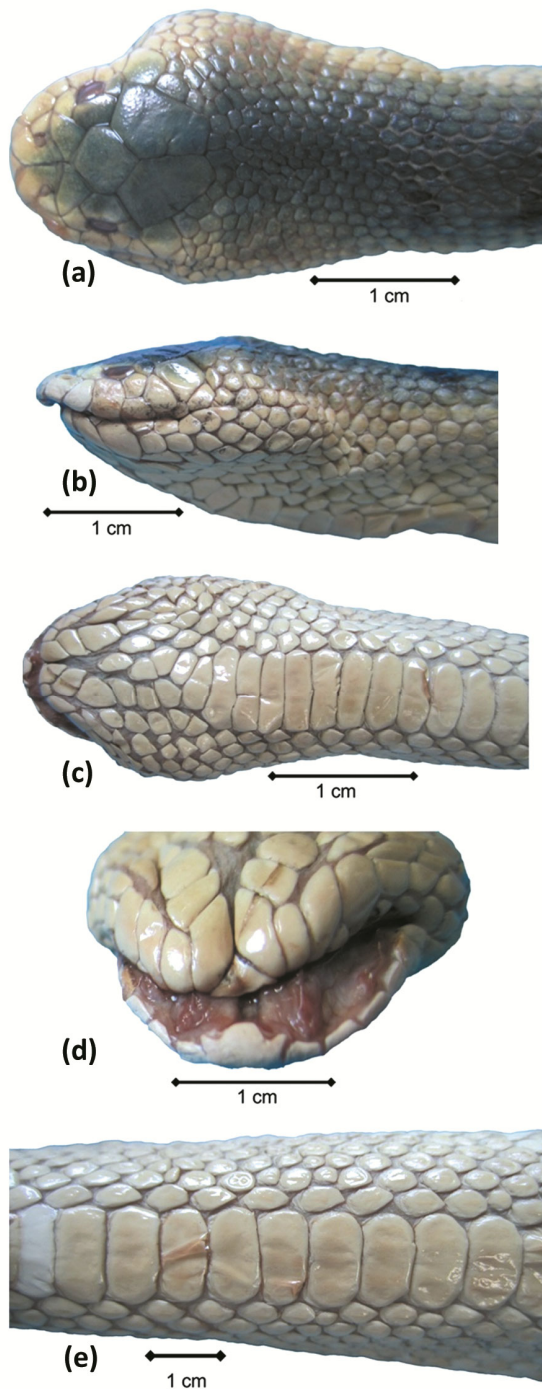


Fig. 6 — Scalation in *Hydrophis viperinus*: a) Dorsal view, b) Lateral view, c) Ventral view, d) Rostral and Mental scales, and e) Ventral scales (Photo credits: Mohsen Rezaie-Atagholipour)

broad, while not being in contact with the upper supra-labials, part of the upper jaw<sup>23,29,36</sup>. Usually one, rarely two pre-oculars, one or two post-oculars, and seven to nine supra-labials, of which the second is the largest and two reach the eye, generally third and fifth<sup>23,29,36</sup>.

Preanals slightly enlarged<sup>23</sup>. Usually, *H. viperinus* has one anterior temporal scale, but sometimes it can be up to three. The infralabial scales are seven to nine, with the first to fourth generally touching the chin shields<sup>23</sup>, while the posterior shield is larger and is in contact with one another<sup>29,36</sup>. Both pairs of chin shields are well developed and are in contact with each other, rarely separated<sup>23</sup>.

#### Colouration

The body is typically more or less bicoloured, being white ventrally and dark grey on the dorsal side. The upper and lower labials are creamy white, with the two colours usually being demarcated on the sides throughout the body<sup>23,32,36</sup>. Moreover, some have about 18-35 dark rhomboidal bands on the dorsal side<sup>36</sup>, usually with a dark band present as well towards the tail end<sup>32</sup>. It is thought that frequency-dependent selection is what keeps different colour forms, like black and banded patterns, that have been seen in *H. viperinus*<sup>38</sup>. This means that less common morphs may have a better chance of survival; for example, because enemies that are more familiar with common morphs may not be able to spot them as easily. Because of this, selection pressure has made it easier for different morphs of the species to live together over time. This means that rarer morphs may have a survival advantage, for instance, by being less recognisable to predators that are more familiar with the common morphs. As a result, this selective pressure has helped facilitate the coexistence of various morphs in the species over time<sup>38</sup>.

#### Habitat

*Hydrophis viperinus* is found across the Indo-West Pacific in warm, shallow-water habitats and is particularly prevalent in Northern Australia and Southeastern Asia, regions known to have a high species diversity and varied habitat types<sup>21</sup>. There are also brief mentions of sightings being reported in waters over a wide range of sediment types, from reefs, seagrass beds, and sandy sediments<sup>39</sup>, with reports of it occasionally being found venturing into creeks, estuaries and lagoons<sup>39</sup>. It is found frequently in the sub-tidal marine neritic waters between depths of 15 and 30 meters<sup>26</sup>. From the Gulf of Oman, two bycatch specimens were found from depths between 20 and 40 meters off Beris and Pasabandar, Iran<sup>32</sup>. However, the preferred habitat and its suitability criteria for *H. viperinus* regarding vegetation and prey presence have yet to be investigated.

### Diet

*Hydrophis viperinus*, like other Hydrophiinae sea snakes, is a mid-trophic level predator<sup>40</sup>. It is speculated to be a specialist crevice-forager based on gut content studies that have found benthic fish prey, such as eels and gobies<sup>5</sup>, belonging to the family Platycephalidae<sup>37</sup>, along with traces of dragonets (Callionymidae) and Apodes eels in the past<sup>4</sup>. Several instances of *H. viperinus* feeding on spiny flatheads have also been documented in India<sup>26</sup>. However, these reports are from the handful of studies carried out on specimens that were caught as bycatch or have been washed ashore, and no recent studies have been conducted to determine the exact diet of the species.

In *H. viperinus*, a reduced number of teeth is considered particularly advantageous when feeding. Fewer teeth lower the risk of self-injury when consuming larger prey, allowing the snake to handle its catch without damaging its mouth or throat. This reduction in teeth also improves swallowing efficiency, which is particularly important for consuming large fish. By making prey consumption smoother and less energy-intensive, the adaptation enhances hunting and feeding efficiency, ultimately supporting the snake's survival and success in the marine environment<sup>41</sup>.

### Behavioural ecology

Given their high position in multiple food chains and ability to feed on smaller fish and marine invertebrates, sea snakes constitute a crucial component of the marine ecosystem<sup>42,43</sup>. They also host epibionts such as barnacles, which have been reported to be fouling on specific sea snake species<sup>44</sup> and other marine organisms<sup>2,45</sup>.

Like other Hydrophiinae species, *H. viperinus* plays a crucial role in its ecosystem as a mid-trophic level predatory species. *Hydrophis viperinus* exhibits unique diel activity patterns, mainly emerging for feeding during crepuscular and nocturnal hours, in contrast to the diurnal behaviour of related species<sup>46</sup>. This modification might be advantageous in increasing its foraging efficiency in poorly-lit environments. Though its prey-capturing techniques are yet to be determined, *H. viperinus* is presumed to forage to locate its prey actively<sup>47</sup>. Given its nocturnal feeding patterns and that its identified preferred prey involves members of the benthic fish family that often bury themselves just below the bottom substrate to hide from predators, the possibility of odour playing a crucial role in locating this concealed prey has been

speculated<sup>43</sup> and that the *H. viperinus* may be utilising olfactory and tactile stimuli to overcome this<sup>43</sup>.

### Histopathological changes

Granulomatous lesions have been noted in specimens of other sea snake species, suggesting the possibility of comparable complications in *H. viperinus*, particularly in muscle and adipose tissues<sup>48</sup>.

### Predators

Identifying predators of *H. viperinus* has not been an area of research interest in the past. Moreover, there are no gut content studies for larger predatory species, such as elasmobranchs, wherein *H. viperinus* has been identified in the remains.

### Reproduction

Like other Hydrophiinae sea snakes, *H. viperinus* is viviparous, which influences its population dynamics and genetic structure<sup>48</sup>. A relatively thorough study on the reproductive biology of *H. viperinus* conducted from specimens collected from the coast off the Malay peninsula<sup>47</sup> found that the females of the species are gravid, possibly from the period of March to early May<sup>47,49</sup> and being ovoviviparous, they have a small clutch, with a relative clutch mass (total offspring mass/ female total mass, including the clutch) of 0.24, consisting an average of three to four offsprings with a mean birth weight of about 19.9 g each<sup>47</sup>. Given its low reproductive output, this may be a contributing factor to its population subdivision<sup>50</sup>. The in-vitro average embryo snout-vent length measures 226.53 mm, with TL averaging 33.57 mm<sup>49</sup>. Moreover, their mean reproductive effort per embryo (energy invested by the female and proportioned into an embryo)<sup>51</sup> of 9.1 is relatively high, along with the amount of effort per clutch estimated at 31.8<sup>(ref. 47)</sup>. While the rate of infertility in the sampled female individuals was 12.8 %<sup>(ref. 47)</sup>. Though there is substantial evidence on the reproductive biology of *H. viperinus* females that of male *H. viperinus* individuals is still lacking, along with knowledge on their mating strategies and ideal nesting locations.

### Population status

A single study from Pakistan<sup>52</sup> reported the population status of *H. viperinus*, to range from 18 – 28 individuals based on sightings from 2001 to 2009. Apart from this, few papers (n = 5) have mentioned live sightings of the species<sup>7,27,37,39,47</sup>, which appear to be the only data available on the population status.

### Bite and venom toxicology

Sea snakes of Hydrophiinae are known for their highly potent neurotoxin. Likewise, envenomation by *Hydrophis viperinus*, can lead to symptoms such as localised lymph node enlargement and pain at the bite site, leading to serious systemic symptoms like extreme fatigue, muscle weakness, failure in respiration and even total paralysis<sup>53,54</sup>. The venom toxicity studies of *H. viperinus* reported have utilised wild specimens captured by trawling from the Gulf of Thailand<sup>55-57</sup>. The potent purified form of the toxin derived from the venom of *H. viperinus* is named the 'praescuta toxin'<sup>55</sup> (based on one of its previously accepted taxonomic names - *Praescutata viperina*), which is a non-enzymatic neurotoxin (comprising polypeptides that inhibit transmission at neuromuscular junctions)<sup>55</sup>. While *H. viperinus* venom itself has a yield of 0.2 mg/snake<sup>56</sup>, the praescuta toxin was found to constitute a yield of approximately 2.0 mg of the 20 mg of *H. viperinus* venom that was extracted and possesses LD50 of 0.45 µg/g when tested through an intravenous dosage in mice<sup>55</sup>. The toxin also has high thermal stability, showing full potency even at 70 °C in mice, with the protein denaturing only at 100 °C<sup>(ref. 55)</sup>. Moreover, the venom showed a precipitation line in immune-electrophoresis with anti-*Hydrophis schistose*<sup>57</sup>, hence proving the hook-nosed sea snake (*Hydrophis schistosa*) anti-venom to be effective at neutralising the *H. viperinus* venom. However, the exact protein composition of *H. viperinus* venom has not yet been studied.

There have been only a few reports of *H. viperinus* bites<sup>35,58,59</sup> with only one mention of its tendency to be aggressive being reported yet<sup>60</sup>. However, this lack of reports could also be due to its rare occurrence.

### Diseases

Given that closely related species of *H. viperinus* have been prone to parasitic infections like *Hydrophitrema gigantea*, it is possible that *H. viperinus* may also be vulnerable to similar diseases<sup>61</sup>. However, no studies have been conducted where diseases specifically occurring in it, or may be susceptible to, have been identified and is a potential area to be explored.

### Threats

Habitat degradation and depletion in habitat quality brought about by anthropogenic activities is a major threat that continuously looms over marine ecosystems<sup>62</sup>. It was discovered recently that marine

reptiles, especially sea snakes, are comparatively overlooked in the available literature studying the effects of oil spills and other marine pollutants on marine wildlife<sup>63</sup>. This gap may be attributed to the logistical challenges that arise due to the tendency of most sea snake species' distribution to be offshore, along with their partly nocturnal habits<sup>64</sup>.

There have been few reports of *H. viperinus*, in particular, being sold commercially in Vietnam for their skin and for being consumed as food<sup>26</sup>. However, the degree of this exploitation and other related direct threats to this particular species must be investigated.

It has been reported that *H. viperinus* is utilised for consumption as food and in traditional medicinal purposes<sup>20</sup>; however, the details of these uses have not been elaborated.

Fisheries-induced threats such as accidental catch in fishing gears (bycatch) persist to threaten most marine fauna, including the *H. viperinus*, which, despite being quite rare, have been non-target victims of bycatch worldwide. While some may be released back into the sea, the survival rate of these released individuals is uncertain, especially if they have sustained injuries or experienced prolonged stress during capture. The practice of releasing live sea snakes is not consistently documented, and in some regions, they are killed intentionally due to perceived threats or lack of economic value. Reports show *H. viperinus* commonly found in bycatch off Southern Vietnam<sup>3,52,65,66</sup>. Interestingly, in a bycatch study<sup>34</sup>, *H. viperinus* was found abundantly in regions of the South China Sea, where it accounted for 32 % of the total catch (n = 63) but was still rare in other regions.

In Indonesia, from March to April of 2010, six out of the 83 sea snake specimens (7 %) collected from fishermen near coral reefs were identified as *H. viperinus*, where they are reportedly caught in nets using lamp baits<sup>26</sup>. Though not very commonly caught on the western coast of Thailand<sup>26,31</sup>, in Malaysia, some *H. viperinus* bycatch has been reported in the Sabah region<sup>17</sup>, and in Pulau Tiga and surrounding areas, where of the 277 specimens representing 11 species of sea snakes that were caught over a year, only one specimen was that of *H. viperinus* (0.3 %)<sup>17</sup>. Further reports of the sea snakes being caught have been recorded in the Persian Gulf and the Gulf of Oman<sup>32</sup> and along the northern coastline of Jaffna, Sri Lanka<sup>33</sup>.

In most studies in India, *H. viperinus* has never been found abundantly when collected from bycatch, while specific studies on the diel activity patterns of

*H. viperinus* are limited, research on related species suggests that some sea snakes exhibit nocturnal behaviours. In general, sea snakes are recognized for their dexterity and swimming proficiency. Their sleek physiques facilitate efficient navigation through water, allowing them to frequently elude capture by nets, particularly if not ensnared<sup>20</sup>. Of the total of 394 fishing trips (gillnet and trawlers trips) off the Konkan coast of Maharashtra from 2016 to 2018, of the total sea snake bycatch of 1,157, only two individuals were identified to be *H. viperinus* (0.17 %) <sup>47,67</sup>. In the Sindhudurg district of Malvan, Maharashtra, of the total of 793 snakes that were sampled from gillnets and trawl nets after 825 haul hours from 2018 to 2019, *H. viperinus* specimens were present only occasionally (< 1 %) <sup>25</sup>. There have also been some reports of trawl nets rarely catching *H. viperinus* in Goa<sup>26</sup> and Andaman Sea<sup>64</sup>, and of a single bycatch specimen from Digha, West Bengal<sup>35</sup>. The rarity of *H. viperinus* in bycatch is not solely due to its distribution but is also influenced by its behavioural patterns, escape responses, and potentially low population density.

## Conclusion

The Viperine sea snake, a marine reptilian species occupying waters off the Indo-Pacific coastline, remains a scarcely studied marine reptile. Regardless of being a scheduled species in India, due to its rare occurrence along the Indian shorelines, *H. viperinus* populations may be particularly vulnerable to anthropogenic threats, highlighting the need to assess its vulnerabilities where research is lacking. Key gaps include understanding its reproductive and behavioural biology, identifying natural threats such as diseases and predators, and examining the impact of environmental toxicants and human exploitation. Although the live post-capture release of sea snakes is said to be done whenever they are not utilised commercially<sup>68</sup>, further implications, such as post-release injuries and mortalities, still need to be studied.

The existence of predators and resource competition may further complicate the survival of *H. viperinus*, forcing trade-offs between foraging opportunities and predator avoidance<sup>69</sup>. Moreover, human activities like habitat degradation and bycatch in fisheries pose significant threats to the species, calling for targeted conservation measures<sup>50,70</sup>. *Hydrophis viperinus* is not typically targeted for commercial purposes; fisheries-induced bycatch remains a critical concern. Addressing this issue through improved fishing practices and

conservation awareness is essential to ensure the survival of this and other sea snake species.

A holistic understanding of population dynamics and factors influencing the distribution of *H. viperinus* is necessary to formulate suitable conservation measures, if necessary, for these reptiles in India and other regions in its range of distribution. It is important to carefully assess the absence of data from areas where the species was historically present, as this could indicate its rarity. Additionally, the species' ability to travel over large distances may account for its sporadic or infrequent sightings, highlighting the need to consider its vagility when interpreting distribution patterns.

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## Conflicts of Interest

The authors declare no competing interests.

## Ethical Statement

This study is a review paper and does not involve any direct data collection, experiments, or handling of live organisms. All information presented is derived from previously published literature, which has been duly cited. The review adheres to ethical academic standards, ensuring proper attribution and integrity in reporting scientific findings.

## Author Contributions

PH: Conceptualization, investigation, writing – original draft, and writing – review & editing. AN: Writing – original draft, formal analysis, and writing – review & editing. CR: Conceptualization, supervision, and writing – review & editing.

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