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# A new distribution record for *Chelidonura lívida* Yonow, 1994 from Gujarat coast, India with insights into its burrowing behaviour, feeding habits, and reproductive strategies

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Short communication

## Abstract

*Chelidonura livida*, commonly known as the blue velvet headshield slug, is a sea slug within the family Aglajidae of the phylum Mollusca. This species was first described by Yonow in 1994 from the Red Sea coast of Israel. It exhibits a wide distribution, ranging from Africa to the Indo-Pacific region, extending to the coasts of Japan. This study documents the first occurrence of *C. livida* from the Gujarat coast of India where the specimens were observed at dusk, moving through sand flats adjacent to a *Halophila decipiens* seagrass bed off the coast of Mithapur. This report provides a detailed morphological description of *C. livida* and offers comprehensive insights into its ecology. Observations include the species' burrowing behaviour, feeding habits, prey preferences, and reproductive strategies. The addition of this species elevates the total count of sea slug species in Gujarat to 97.

***Keywords:*** *Velvet headshield slug, Gastropoda, Aglajidae, Gulf of Kutch, Arabian Sea*

## Introduction

The molluscs of the order Cephalaspidea are commonly known as headshield slugs or bubble snails, considered the most primitive group among the Opisthobranchs (Jörger *et al.,* 2010). Within this order, the family Aglajidae has the remarkable distinction of being the second most diverse family within the heterobranchs (Bouchet, 2017). It encompasses an estimated 92 valid species of benthic carnivorous sea slugs, distributed throughout tropical, subtropical, and temperate marine waters, classified into sixteen valid genera: *Aglaja* Renier, 1807; *Aglaona* Chaban, Ekimova, Schepetov and Chernyshev, 2022; *Biuve* Zamora-Silva and Malaquias, 2017; *Camachoaglaja* Zamora-Silva and Malaquias, 2017; Chelidonura A. Adams, 1850; *Mannesia* Zamora-Silva and Malaquias, 2017; *Mariaglaja* Zamora-Silva and Malaquias, 2017; *Melanochlamys* Cheeseman, 1881; *Nakamigawaia* Kuroda and Habe, 1961; *Navanax* Pilsbry, 1895; *Niparaya* Zamora-Silva and Malaquias, 2017; *Odontoglaja* Rudman, 1978; *Philinissima* Chaban, Ekimova and Schepetov, 2023; *Philinopsis* Pease, 1860 (Bouchet, 2017); *Spinoaglaja* Ortea, Moro and Espinosa, 2007 and *Tubulophilinopsis* Zamora-Silva and Malaquias, 2017.

Among the Cephalaspidea group, the genus *Chelidonura* consists of approximately 17 species, with lengths ranging from 10 to 70 mm (Rudman, 1973). Some of these species extend their range into Japan and Southeastern Australia, while they are mostly distributed across the tropical Indo-West Pacific and Caribbean coasts (Rudman, 1973). *Chelidonura* slugs lack radula and any rigid structures in their alimentary tract (Rudman, 1973); however, they possess a rudimentary shell internally or on the body. Furthermore, they possess a distinctive headshield that prevents sand from entering the mantle cavity during their sub-surface movements which likely serves as a strategy to evade predators and cope with extreme environmental conditions during the day (Rudman, 1973). These slugs have robust foot, sometimes with parapodia, and possess highly developed sensory systems. Their advanced eyes, sensory cilia and Hancock's chemosensory organ enhance their sense of smell and overall sensory perception allowing them to effectively navigate their environment and exploit available food resources (Rudman, 1973). Their prey organisms, such as opisthobranchs, nematodes, platyhelminths, annelids, and gastropods, secrete mucus which serves a dual role in locomotion and defence (Blair and Seapy, 1972; Brusca and

Brusca, 2003). Aglajids, including members of the Chelidonura genus, detect these mucus trails using specialised sensory organs, allowing them to hunt down mobile prey and feed on it by ingesting it whole as they lack a radula (Paine, 1963; Rudman, 1978; Kohn *et al.,* 1983; Davies and Blackwell, 2007; Ng *et al.,* 2013). Notably, observations have indicated that *Chelidonura* species prefer epifaunal organisms, including flatworms, slugs, and shelled gastropods (Silva and Malaquias, 2016). This dietary preference highlights the selective feeding behaviour of *Chelidonura*, emphasising their ecological role as predators within marine ecosystems.

Aglajids are biochemically significant, with several species possessing secondary metabolites like polypropionates and small peptides, along with alarm pheromones such as navenones, likely derived from their prey (Cimino and Ghiselin, 2009; Camacho-Garcia, 2014). They also serve as model organisms for research in neurophysiology (London *et al.*, 1987) and the evolution of mating behaviours in simultaneous hermaphrodites (Anthes *et al.*, 2008). The diversity and beauty of Cephalaspidea make them highly valued by scuba divers and underwater photographers. Despite their small size, they have garnered increasing attention in evolutionary biology and biotechnology. The present study documents the first occurrence of *C. livida* from the Gujarat coast of India.

## Material and methods

This study was conducted in Mithapur, a coastal town in the Devbhoomi Dwarka district of Gujarat, India. Mithapur, situated approximately 20 kilometres north of Dwarka city (Bhonde and Desai, 2011), encompasses a significant segment of the Arabian Sea coast, showcasing diverse marine and coastal ecosystems. This region harbours various coastal habitats, including sandy beaches and rocky tidepools, while the offshore zone features coral reefs, seagrass beds, and extensive sand flats. The water depth at the study site ranged from 3 to 12 metres, with nearby reef structures causing a reduction in current intensity. The Mithapur coast is renowned for its exceptional biodiversity, hosting many invertebrates and vertebrates such as fishes, crustaceans, nudibranchs, polyclads, and polychaetes.

We observed and recorded *C. livida* during SCUBA diving expeditions along the Mithapur coast in Gujarat (Fig. 1). We captured high-resolution images using an Olympus E-PL 10 camera enclosed in an AOI UH-EPL10 underwater housing to document the key identifying characteristics of the specimens. Due to the low density of observed animals, we did not collect reference specimens. To illustrate the external morphology of *C. livida*, we sketched a detailed line diagram using Adobe Photoshop 2020 and a HUION HS64 Graphics drawing tablet.

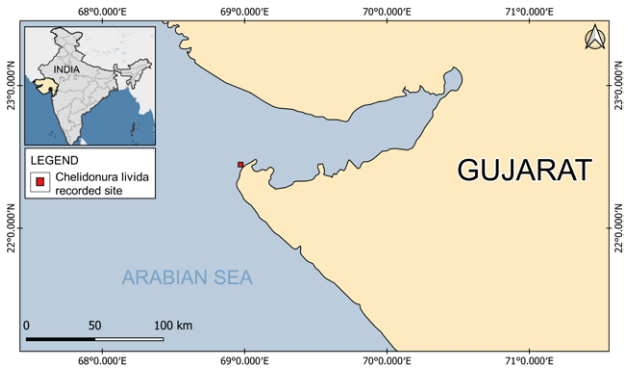


Fig. 1. Distributional map for *Chelidonura livida* from the present study site in Gujarat, India

We identified the Opisthobranchs by analysing their external morphology and colour patterns, supplemented by relevant literature by Yonow, 1994.

## Results

### *Material examined*

During an underwater survey conducted on December 16, 2022, at dusk, two specimens of *C. livida* were observed *at coordinates* 22° 26' 5.064" N, 68° 59' 36.924" E. The first specimen measured 60 mm long, 23 mm wide, and 14 mm in height, while the second measured 70 mm long, 25 mm wide, and 15 mm in height.

### *Systematics*

Phylum : Mollusca
Class : Gastropoda
Subclass : Heterobranchia
Order : Cephalaspidea
Superfamily : Philinoidea
Family : Aglajidae
Genus : *Chelidonura*
Species : *C. livida*

### *Morphology*

The specimens measured between 60 and 70 mm in length. Both specimens' notum, head, and parapodia were velvet black to dark brown, with distinct electric blue rings and blotches (Fig. 2). The parapodia extend upwards towards the dorsal end, covering the sides and part of the posterior shield but do not meet entirely on the notum. The head shield has four anterior lobes. A mound of translucent white sensory setae is on either side of the mouth. The head shield's posterior end was bluntly rounded, producing a free flap over the

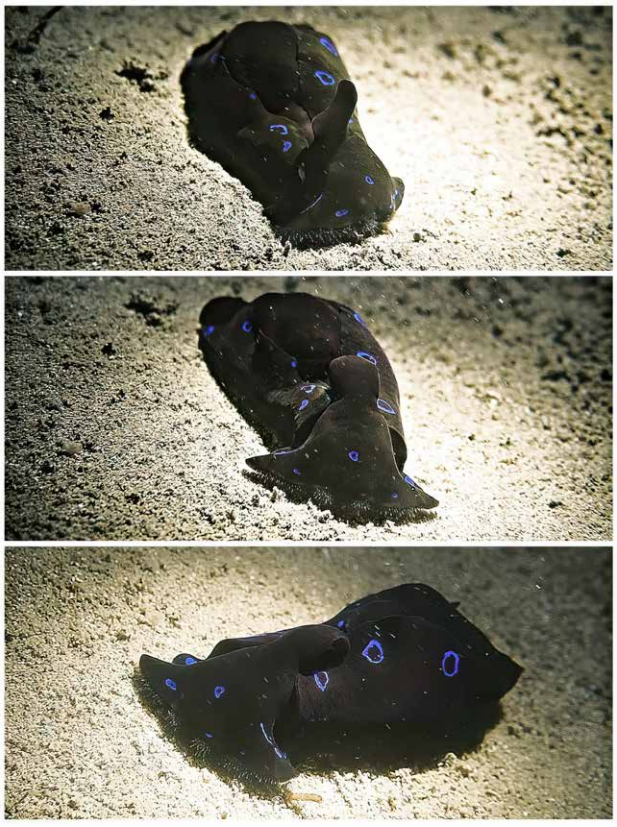

Fig. 2. *Chelidonura livida* (Yonow, 1994), 60 mm length, 23 mm in width, 14 mm height collected from the Mithapur coast

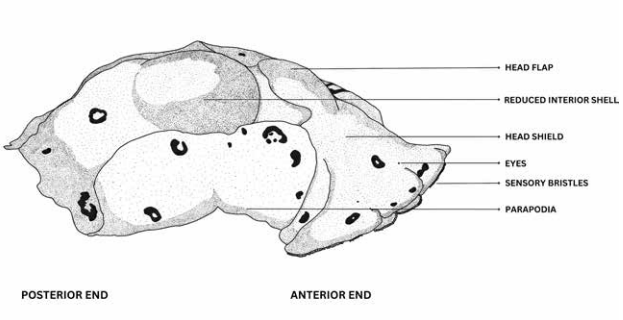


Fig. 3. Morphology of *Chelidonura livida*

posterior shield. The posterior shield is oval, with its anterior edge tucked under the head shield and two short, thin flaps on the posterior edge, the left one being slightly longer than the right (Fig. 3).

## *Distribution*

*C. livida* was first described from the Red Sea, in Israel (Yonow, 1994). This species has since been reported in the Indo-Pacific region, Abu Dhabi (Hardy, 2001), Mayotte Island, Bahrain, Egypt (Debelius, 1996), Tanzania, Mozambique (Gosliner *et al.,* 2008; Tibiriçá and Malaquias, 2017), and Kuwait (Nithyanandan *et al.,* 2021). In the present study, we report the occurrence of this species along the Gujarat coast of India for the first time.

## *Ecology*

*C. livida* is a sand-dwelling species commonly found in shallow sand flats. This species is more active during dusk and night time, preferring to dig into the sandy substrate during daylight hours and emerging once it gets dark. Likely as a strategy to avoid predators and extreme environmental conditions during the day. During our study, we observed specimens at dusk, moving through sand flats near a *Halophila decipiens* seagrass bed at a depth of five meters. The recorded environmental conditions included a surface temperature of 21°C, salinity of 37 ppt, and a pH level of 7.8. The substrate in this area was primarily composed of sand.

*C. livida* utilizes advanced visual capabilities, sensory cilia, and Hancock's chemosensory organ to enhance its olfactory and overall sensory perception. This adaptation enables the detection of various epifaunal prey organisms such as flatworms, slugs, and shelled gastropods which have been reported by Silva and Malaquias (2016) as the primary prey for this species. This dietary preference underscores the selective feeding behaviour of Chelidonura and highlights its ecological role as a predator within marine ecosystems.

The reproductive behaviour of various *Chelidonura* species was documented by Anthes and Michiels in 2007 under controlled laboratory conditions. Their findings revealed that many *Chelidonura* species mate after a remarkably low number of body contacts, typically fewer than three on average, accompanied by a short mating latency of less than 20 minutes. Mating initiation often involves rapid and nearly simultaneous penial insertion by both mating partners. In the case of *C. livida*, mating instances were observed within 1 to 15 minutes of the initial mating interaction. Notably, chain mating was observed, a sequential process involving unilateral insemination by one individual followed by simultaneous insemination by the second individual. This phase lasted from 66 to 100% of the total copulation duration, indicating a complex and synchronized reproductive behaviour. During copulation, sperm transfer occurs in pulses, characterized by distinct ejaculate droplets while the penis remains inserted. The overall duration of mating for *C. livida* ranged from 7 to 13 minutes. Furthermore, *C. livida* was found to produce egg masses with a unique double-layered disc shape. These spawns were firmly attached to the substrate, such as sand, dead plant material, or corals, through a delicate mucous thread. The size of each spawn varied between 5000 and 7000 eggs, and the embryonic development process took approximately 4.5 days (108 hours).

## Discussion

In the present study, we verified the accuracy of the specimen description by cross-referencing it with the original descriptions provided by Yonow (1994), Rudman (1974) and Gosliner (1980). Vishal and Deepak (2013) compiled a checklist of 311 species of Opisthobranchs from India distributed over 7 orders, 53 families and 141 genera. Following this, the Zoological Survey of India in 2021 reported a total of 646 species of Opisthobranchs from India, as noted by Sreeraj (2020). Apte *et al.* (2010) conducted a comprehensive survey in the Gulf of Kutch, Gujarat, and reported the presence of 33 distinct sea slug species. Vadher *et al.* (2020) subsequently compiled an annotated checklist comprising 95 sea slug species belonging to 62 genera in 29 families along the Gujarat coastline. Subsequently, Nanda *et al.* (2023) added another species of sea slug to the Gulf of Kutch, Gujarat region. Previous studies did not report the presence of *C. livida* from the Gujarat coasts. Thus, the discovery of *C. livida* in this region represents a new addition, elevating the total species count to 97 and bringing the total number of recorded Opisthobranch species in India to 293. Traditionally, sea slug diversity assessments primarily relied on first-hand observations from intertidal regions. However, implementing snorkelling and SCUBA diving techniques in this region and other areas of India undoubtedly holds significant potential for enhancing our understanding of India's overall Opisthobranch diversity.

The recent identification of *C. livida* along the Mithapur coast revealed a significant increase in its distributional range, underscoring the criticality of conserving and safeguarding this unique ecosystem against anthropogenic pressures. This novel finding is a powerful testament to the hidden biodiversity within this location. By establishing effective protection measures for this area, we can ensure the preservation of the newly discovered nudibranch population and create a platform for unravelling additional species that might inhabit this region. Regular and systematic seasonal surveys have become imperative for comprehensively documenting and comprehending this ecosystem's biodiversity. These surveys will facilitate the collection of robust and comprehensive data, enabling the identification and characterization of different species. Such investigations will enhance our understanding of the ecological dynamics at play and provide vital insights into the interconnections and relationships within the marine community.

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### Author contributions

Conceptualization, Methodology, Data Collection, Data Analysis, Writing Original Draft, Writing Review and Editing, Supervision: SSN, SP

### Conflict of interests

The authors declare that they have no conflict of financial or non-financial interests that could have influenced the outcome or interpretation of the results.

### Data availability

The data are available and can be requested from the corresponding author.

### Ethical statement

No ethical approval is required as the study does not include activities that require ethical approval or involve protected organisms/ human subjects/ collection sensitive of samples/ protected environments.

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