

Shallow water sea slugs (Gastropoda: Heterobranchia) from Andhra Pradesh, India

J.S. YOGESH KUMAR^{1,✉}, ARYA SEN¹, C. RAGHUNATHAN², C. VENKATRAMAN³

¹Zoological Survey of India, Sunderban Regional Centre, Canning, West Bengal 743329, India. Tel.: +91-9476006830, ✉email: yogeshkumarzsi16@gmail.com

²Zoological Survey of India, M-Block, New Alipore, Kolkata, West Bengal 700053, India

³Zoological Survey of India, Marine Biology Regional Centre, Chennai, Tamil Nadu 600028, India

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Abstract. Kumar JSY, Sen A, Raghunathan C, Venkatraman C. 2024. Shallow water sea slugs (Gastropoda: Heterobranchia) from Andhra Pradesh, India. *Nusantara Bioscience* 16: 154-168. The current manuscript explores the initial underwater survey findings, revealing 19 heterobranch species across 10 genera, 6 families, 2 suborders, one order, and one superorder within the Visakhapatnam coast of Andhra Pradesh, India. While, the heterobranchs fauna of Andhra Pradesh has been studied by several authors, it has been observed that underwater surveys to discover this marine group are lacking from the region, and therefore, the present study has been done. These species from the study site include *Coryphellina exoptata*, *Pteraeolidia semperi*, *Dendrodoris krusenstenii*, *Doriprismatica atromarginata*, *Glossodoris* sp. cf. *cincta*, *G. rufomarginata*, *Goniobranchus alius*, *G. setoensis*, *G. fidelis*, *G. trimarginatus*, *Hypselodoris bullockii*, *H. nigrostriata*, *H. sagamiensis*, *H. kanga*, *Jorunna funebris*, *Phyllidia ocellata*, *P. polkadotsa*, *Phyllidiopsis phippiensis*, and *Elysia marginata*. Remarkably, 13 of these heterobranchs species are documented for the first time in the Andhra Pradesh region, with 12 belonging to the order Nudibranchia and one to the superorder Sacoglossa. The manuscript provides a comprehensive analysis of morphometric characteristics, detailed descriptions, photography, and distribution trends of 19 heterobranchs species, as well as a comprehensive literature record of sea slugs found in Andhra Pradesh, India. Sea slugs, being the butterflies of the ocean, are a great part of the ecosystem, although based on economic valuation, they are regarded as a low-value bycatch, trash. The bottom trawl is one of the major threats to the habitat destruction for these animals. Thus, the habitats along the Andhra coastline should be known so that fishing activities in these parts could be restricted for the better survival of sea slugs.

Keywords: East Coast, Heterobranchia, Nudibranchia, sea slugs, Visakhapatnam

INTRODUCTION

Heterobranchs, also known as different-gilled snails, sea slugs, sea hares, sea rabbits, and nudibranchs, are a diverse group of marine gastropod mollusks. The term "nudibranch" originates from the Latin "nudus," which translates to naked, and the Greek "brankhia," which means gills. This name reflects the absence of a protective shell and the existence of exposed gills or gill-like structures found in numerous species. This fascinating group belongs to the subclass Heterobranchia. It encompasses various colorations and growth forms, including head-shield slugs (Cephalaspidea), sap-sucking slugs (Sacoglossa), sea hares (Anaspidea or Aplysiida), side-gill slugs (Pleurobranchomorpha or Pleurobranchida), nudibranchs (Nudibranchia), and umbrella shells (Umbraculida) (Gosliner and Behrens 2015; Apte and Desai 2017). Approximately 6,000 species of heterobranchs have been described worldwide, although around 5,194 species are currently considered valid per the WoRMS (World Register of Marine Species). Among these, nudibranchs are particularly diverse, with approximately 2,520 species identified. Nudibranchs are further classified into two suborders: Cladobranchia and Doridina. The suborder Cladobranchia comprises seven superfamilies, 49 families, 158 genera, and 1,034 species, while the suborder Doridina

consists of two infraorders, six superfamilies, 20 families, 108 genera, and 1,486 species (Gosliner et al. 2008; Gobbeler and Klussmann-Kolb 2011).

This classification underscores the vast diversity and intricacy of the nudibranch group, emphasizing the ongoing need for research and exploration to deepen our understanding of these captivating marine organisms (Gosliner and Behrens 2015). Recent studies have focused on monitoring and assessing sea slug communities globally and at regional levels, including India (Raghunathan et al. 2016; Apte and Desai 2017). Fortunately, the colorful sea slugs were observed by recreational SCUBA divers, underwater photographers, and researchers (Nimbs et al. 2015, 2016). Research has identified approximately 400 species spanning seven orders within the Heterobranchia subclass in India. Among these, 213 species have been documented in the Andaman and Nicobar Islands, 88 species along the Tamil Nadu coast, 76 species in the Lakshadweep Islands, 56 species along the Gujarat coast, 55 species along the Andhra Pradesh coast, 28 species in Maharashtra, 9 species in Orissa, 8 species in Kerala, 6 species in Karnataka, 6 species in West Bengal, and 2 species in Goa (Raghunathan et al. 2016; Apte and Desai 2017).

The current investigation was conducted along the Visakhapatnam coast in Andhra Pradesh, which boasts

India's second longest coastline (975 km) and forms part of the Coromandel Coast along the eastern seaboard. Sea slugs were initially documented along the Visakhapatnam coast in the 1880s by Alder and Hancock, along with Eliot, who reported 42 species (Alder and Hancock 1864; Eliot 1906). Subsequently, Sarma (1974) recorded 26 species from this area, while Ramakrishna et al. (2007) reported five species from Andhra Pradesh. Additionally, Srinivasulu et al. (2012) documented the presence of the blue sea slug (*Glaucus atlanticus* Forster, 1777) along the Visakhapatnam coast. Bhawe and Apte (2013) updated the current status of the Indian Opisthobranch and mentioned 40 species belonging to 26 genera, 18 families from the Andhra Pradesh coast. Venkataraman et al. (2015) listed 47 species, and Raghunathan et al. (2016) reported an updated list of opisthobranchs from the Indian coast with 55 species from Andhra Pradesh. Apte and Desai (2017) recently published a field guide with good underwater photos, including 26 species from the Andhra Pradesh coast.

Numerous researchers have studied the distribution of heterobranchs along the Indian coastline. However, the authors of this study identified 19 species of heterobranchs, among which 13 species had not been previously recorded. Therefore, this study intends to document these previously unrecorded species from coastal parts of Andhra Pradesh and to furnish a comprehensive and updated list of heterobranch sea slugs in this state.

MATERIAL AND METHODS

The current research was conducted across nine sub-tidal study sites spanning from Rushikonda beach to Chinthapalli beach along Visakhapatnam, Andhra Pradesh State, India (Figure 1, Table 1). Coral reefs and associated fauna surveys were conducted between 24 February to 2 March 2019 and 13 to 20 December 2019. Sub-tidal surveys were conducted at depths ranging from 8 to 24 meters with the assistance of SCUBA diving. Specimens were collected through direct searches within reef and rocky ecosystems, and those collected were anesthetized using a solution containing 72 g L^{-1} of MgCl_2 . After morphological examinations, the anesthetized specimens were preserved in 100% ethyl alcohol. Underwater photographs were taken of live specimens to record their colors accurately. Identification of specimens was based on morphological characteristics (Jensen 1992; Gosliner 1995; Gosliner et al. 2008; Apte and Desai 2017), and afterward, they were placed in the National Zoological Collections at the Marine Aquarium Regional Centre of the Zoological Survey of India, located in Digha, West Bengal, with each specimen assigned a voucher number.



Figure 1. Study site map and surveyed habitats along Visakhapatnam coast of Andhra Pradesh, India; rocky shore and sandy shore

Table 1 Detail of the study areas with GPS coordinates

Date	Name of the place	GPS coordinates	Depth	Habitat
26.02.19	Off Chinthapalli village Shipwreck	Lat. N 18° 00.249', Long. E 83° 43.026'	9 m	Rocky Bottom
27.02.19	Off Chinthapalli village	Lat. N 18° 00.265', Long. E 83° 43.022'	12 m	Rocky Bottom
27.02.19	Off Chinthapalli village	Lat. N 18° 00.199', Long. E 83° 43.108'	22 m	Rocky Bottom
01.03.19	Off Chinthapalli village	Lat. N 18° 00.457', Long. E 83° 43.683'	24 m	Sandy Bottom
14.12.19	Off Vammivanipalem	Lat. N 17° 47.421', Long. E 83° 23.618'	9 m	Rocky Bottom
15.12.19	Off Rushikonda	Lat. N 17° 46.868', Long. E 83° 23.426'	8 m	Rocky Bottom
16.12.19	Off Mangamari Peta	Lat. N 17° 49.558', Long. E 83° 25.110'	9 m	Rocky Bottom
18.12.19	Off Timmapuram	Lat. N 17° 48.272', Long. E 83° 24.869'	12 m	Rocky Bottom
19.12.19	Off Mangamari Peta	Lat. N 17° 49.656', Long. E 83° 27.096'	15 m	Rocky Bottom

RESULTS AND DISCUSSION

During the underwater exploration conducted on the Visakhapatnam coast of Andhra Pradesh, 19 species of heterobranchs from 10 genera and 6 families were discovered (Figures 2-9). Notably, 13 of these species were documented for the first time in the study sites. These newly reported species include *Hypselodoris bullockii* (Collingwood, 1881); *H. sagamiensis* (Baba, 1949); *Phyllidia ocellata* (Cuvier 1804); *P. polkadotsa* (Brunckhorst, 1993); *Phyllidiopsis phiphiensis* (Brunckhorst, 1993); *Glossodoris cincta* (Bergh, 1888); *G. rufomarginata* (Bergh, 1890); *Goniobranchus alius* (Rudman, 1987); *G. decorus* (Pease, 1860); *G. trimarginatus* (Winckworth, 1946); *Coryphellina exoptata* (Gosliner & Willan, 1991); *Pteraeolidia semperi* (Bergh, 1870); and *Elysia marginata* (Pease, 1871).

In terms of higher-order classification, the majority of the identified species belonged to the order Nudibranchia, with the suborder Doridina comprising the highest number (16 species, 8 genera, 4 families) and the suborder Cladobranchia featuring the lowest number (2 species, 2

genera, 2 families). Additionally, the superorder Sacoglossa was represented by one species from the genus *Elysia* and the family Plakobranchidae. Among the study sites, the highest number of species was reported from Off Chinthapalli (12 species), followed by five species from Off Rushikonda beach, four species from Off Vammivanipalem, two species from Off Mangamari Peta, and one species from Off Timmapuram (Table 2).

This comprehensive study revealed 103 species of Heterobranchs belonging to 59 genera, 33 families, and 4 orders in Andhra Pradesh (refer to Table 3). Notably, all authors in the updated list commonly reported two species, *Dendrodoris krusensternii* (Gray, 1850), and *Jorunna funebris* (Kelaart, 1859). The majority of the species (77 species) belonged to the Order Nudibranchia, followed by the Superorder Sacoglossa (13 species), Order Cephalaspidea (6 species), Order Aplysiida (4 species), Order Pleurobranchida (2 species), and Superorder Ringiculimorpha (1 species). The systematic features of the 19 species of Heterobranchs collected in this study are outlined accordingly.

Table 2. Heterobranchs distribution from the present study sites in Visakhapatnam coast, Andhra Pradesh, India

Species	1	2	3	4	5
<i>Coryphellina exoptata</i> (Gosliner & Willan, 1991)	+	-	-	-	-
<i>Pteraeolidia semperi</i> (Bergh, 1870)	-	+	-	-	-
<i>Dendrodoris krusensternii</i> (Gray, 1850)	-	+	-	-	-
<i>Doriprismatica atromarginata</i> (Cuvier, 1804)	+	+	-	-	-
<i>Glossodoris</i> sp. cf. <i>cincta</i> (Bergh, 1888)	-	+	+	-	-
<i>Glossodoris rufomarginata</i> (Bergh, 1890)	+	-	-	-	-
<i>Goniobranchus alius</i> (Rudman, 1987)	-	-	+	-	-
<i>Goniobranchus setoensis</i> (Baba, 1938)	-	-	+	-	-
<i>Goniobranchus fidelis</i> (Kelaart, 1858)	-	+	-	-	-
<i>Goniobranchus trimarginatus</i> (Winckworth, 1946)	-	+	+	-	-
<i>Hypselodoris bullockii</i> (Collingwood, 1881)	-	+	-	+	-
<i>Hypselodoris nigrostriata</i> (Eliot, 1904)	+	+	-	-	-
<i>Hypselodoris sagamiensis</i> (Baba, 1949)	-	-	-	-	+
<i>Hypselodoris kanga</i> (Rudman, 1977)	+	-	-	-	-
<i>Jorunna funebris</i> (Kelaart, 1859)	-	+	-	-	-
<i>Phyllidia ocellata</i> (Cuvier, 1804)	-	-	-	-	+
<i>Phyllidia polkadotsa</i> (Brunckhorst, 1993)	-	+	-	-	-
<i>Phyllidiopsis phiphiensis</i> (Brunckhorst, 1993)	-	+	-	-	-
<i>Elysia marginata</i> (Pease, 1871)	-	+	-	-	-
Total	5	12	4	1	2

Note: + Present; - Absent; Study sites 1. Off Rushikonda; 2. Off Chinthapalli; 3. Off Vammivanipalem; 4. Off Timmapuram; 5. Off Mangamari Peta

Table 3. List of Heterobranchs reported from the Andhra Pradesh, India

Species	R1	R2	R3	R4	R5	PS
Superorder Nudipleura (Wagele & Willan, 2000)						
Order: Nudibranchia (Cuvier, 1817)						
Family: Arminidae (Iredale & O'Donoghue, 1923)						
<i>Armina formosa</i> (Kelaart, 1858)	-	-	-	+	-	-
<i>Armina taeniolata</i> (Bergh, 1866)	-	-	-	+	-	-
<i>Armina variolosa</i> (Bergh, 1904)	-	-	-	+	-	-
Suborder Doridina						
Family Discodorididae (Bergh, 1891)						
<i>Asteronotus cespitosus</i> (van Hasselt, 1824)	-	-	-	+	-	-
Family Discodorididae (Bergh, 1891)						
<i>Atagama carinata</i> (Quoy & Gaimard, 1832)	+	-	-	-	-	-
<i>Atagama intecta</i> (Kelaart, 1859)	-	-	-	+	-	-
<i>Atagama osseosa</i> (Kelaart, 1859)	+	-	-	-	-	-
<i>Atagama spongiosa</i> (Kelaart, 1858)	-	-	-	+	+	-
<i>Atagama tristis</i> (Alder & Hancock, 1864)	+	-	-	+	-	-
Family Chromodorididae (Bergh, 1891)						
<i>Ceratosoma trilobatum</i> (J.E. Gray, 1827)	-	-	-	+	-	-
<i>Chromodoris inopinata</i> (Bergh, 1905)	-	-	-	+	-	-
<i>Doriprismatica atromarginata</i> (Cuvier, 1804)	-	-	-	+	-	+
<i>Hypselodoris bullockii</i> (Collingwood, 1881)	-	-	-	-	-	+
<i>Hypselodoris infucata</i> (Ruppell & Leuckart, 1828)	-	-	-	+	-	-
<i>Hypselodoris kanga</i> (Rudman, 1977)	-	-	-	+	-	+
<i>Hypselodoris nigrostriata</i> (Eliot, 1904)	-	-	-	-	+	+
<i>Hypselodoris sagamiensis</i> (Baba, 1949)	-	-	-	-	-	+
<i>Hypselodoris zebrina</i> (Alder & Hancock, 1864)	+	-	-	+	-	-
Family Phyllidiidae (Rafinesque, 1814)						
<i>Phyllidia ocellata</i> (Cuvier, 1804)	-	-	-	-	-	+
<i>Phyllidia polkadotsa</i> (Brunckhorst, 1993)	-	-	-	-	-	+
<i>Phyllidiella zeylanica</i> (Kelaart, 1859)	-	-	-	+	-	-
<i>Phyllidiopsis phippiensis</i> (Brunckhorst, 1993)	-	-	-	-	-	+
Family Dendrodorididae (O'Donoghue, 1924)						
<i>Dendrodoris areolata</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
<i>Dendrodoris atromaculata</i> (Alder & Hancock, 1864)	+	-	-	-	+	-
<i>Dendrodoris fumata</i> (Ruppell & Leuckart, 1830)	+	-	-	+	+	-
<i>Dendrodoris fusca</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
<i>Dendrodoris krusensternii</i> (Gray, 1850)	+	-	-	+	+	+
<i>Dendrodoris nigra</i> (Stimpson, 1855)	+	+	-	+	+	-
<i>Dendrodoris punctata</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
<i>Dendrodoris pustulosa</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
<i>Dendrodoris tuberculosa</i> (Quoy & Gaimard, 1832)	+	-	-	+	+	-
<i>Doriopsilla miniata</i> (Alder & Hancock, 1864)	+	+	-	-	-	-
Family Discodorididae (Bergh, 1891)						
<i>Discodoris concinna</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
<i>Discodoris pardalis</i> (Alder & Hancock, 1864)	+	-	-	+	-	-
<i>Jorunna funebris</i> (Kelaart, 1859)	+	-	-	+	-	+
<i>Platydoridopsis ellioti</i> (Alder & Hancock, 1864)	+	-	-	+	+	-
<i>Platydoridopsis formosa</i> (Alder & Hancock, 1864)	+	-	-	+	-	-
<i>Platydoridopsis scabra</i> (Cuvier, 1804)	-	-	-	+	-	-
<i>Platydoridopsis striata</i> (Kelaart, 1858)	+	-	-	+	-	-
<i>Sclerodoris apiculata</i> (Alder & Hancock, 1864)	+	-	-	+	+	-
<i>Sclerodoris tuberculata</i> (Eliot, 1904)	+	-	-	-	-	-
<i>Sebadoris fragilis</i> (Alder & Hancock, 1864)	+	-	-	-	+	-
<i>Sebadoris nubilosa</i> (Pease, 1871)	-	-	-	+	-	-
<i>Tayuva lilacina</i> (Gould, 1852)	-	-	-	+	+	-
<i>Thordisa villosa</i> (Alder & Hancock, 1864)	+	-	-	-	+	-
Family Dorididae (Rafinesque, 1815)						
<i>Doris immonda</i> (Risbec, 1928)	-	-	-	-	+	-
<i>Doris rusticata</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
<i>Glossodoris</i> sp. cf. <i>cincta</i> (Bergh, 1888)	-	-	-	-	-	+
<i>Glossodoris rufomarginata</i> (Bergh, 1890)	-	-	-	-	-	+
<i>Goniobranchus alius</i> (Rudman, 1987)	-	-	-	-	-	+
<i>Goniobranchus setoensis</i> (Baba, 1938)	-	-	-	-	-	+
<i>Goniobranchus fidelis</i> (Kelaart, 1858)	-	-	-	+	-	+

<i>Goniobranchus gleniei</i> (Kelaart, 1858)	-	-	-	+	-	-
<i>Goniobranchus preciosa</i> (Kelaart, 1858)	-	-	-	+	-	-
<i>Goniobranchus tennentanus</i> (Kelaart, 1859)	-	-	-	+	-	-
<i>Goniobranchus trimarginatus</i> (Winckworth, 1946)	-	-	-	-	-	+
Family Goniodorididae (H. Adams & A. Adams, 1854)						
<i>Goniodoris aspersa</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
<i>Goniodoris citrina</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
<i>Goniodoris modesta</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
Family Polyceridae (Alder & Hancock, 1845)						
<i>Gymnodoris bicolor</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
<i>Gymnodoris ceylonica</i> (Kelaart, 1858)	-	-	-	+	-	-
<i>Kalinga ornata</i> (Alder & Hancock, 1864)	+	-	+	+	-	-
<i>Plocamopherus ceylonicus</i> (Kelaart, 1858)	+	+	-	-	-	-
Suborder Cladobranchia						
Family Arminidae (Iredale & O'Donoghue, 1923)						
<i>Pleurophyllidiella paucidentata</i> (O'Donoghue, 1932)	-	+	-	-	-	-
Family Bornellidae (Bergh, 1874)						
<i>Bornella stellifera</i> (A. Adams & Reeve, 1848)	+	+	-	+	+	-
Family Facelinidae (Bergh, 1889)						
<i>Coryphellina exoptata</i> (Gosliner & Willan, 1991)	-	-	-	-	-	+
<i>Favorinus japonicus</i> (Baba, 1949)	-	-	-	+	-	-
<i>Phidiana militaris</i> (Alder & Hancock, 1864)	+	+	-	+	+	-
<i>Phidiana unilineata</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
<i>Pteraeolidia semperi</i> (Bergh, 1870)	-	-	-	-	-	+
Family Eubbranchidae (Odhner, 1934)						
<i>Eubbranchus ocellatus</i> (Alder & Hancock, 1864)	+	-	-	-	-	-
Family Glaucidae (Gray, 1827)						
<i>Glaucus atlanticus</i> (Forster, 1777)	-	-	-	+	+	-
<i>Glaucus forsteri</i> (Lamarck, 1819)	+	-	-	-	-	-
Family Madrellidae (Preston, 1911)						
<i>Madrella ferruginosa</i> (Alder & Hancock, 1864)	+	-	-	-	+	-
Family Tethydidae (Rafinesque, 1815)						
<i>Melibe viridis</i> (Kelaart, 1858)	+	-	-	-	+	-
Family Samlidae (Korshunova, et al. 2017)						
<i>Samla bicolor</i> (Kelaart, 1858)	-	-	-	+	-	-
Family Scyllaeidae (Alder & Hancock, 1855)						
<i>Scyllaea pelagica</i> (Linnaeus, 1758)	+	-	-	-	+	-
Superorder Nudipleura						
Order Pleurobranchida						
Family Pleurobranchidae (Gray, 1827)						
<i>Berthella stellata</i> (Risso, 1826)	-	-	-	-	+	-
Family Pleurobranchaeidae (Pilsbry, 1896)						
<i>Pleurobranchaea morula</i> (Bergh, 1905)	-	+	-	-	-	-
Order Cephalaspidea (P. Fischer, 1883)						
Family Bullidae (Gray, 1827)						
<i>Bulla ampulla</i> (Linnaeus, 1758)	-	-	+	+	-	-
Family Haminoeidae (Pilsbry, 1895)						
<i>Lamprohaminoea cymbalum</i> (Quoy & Gaimard, 1833)	-	-	+	-	+	-
<i>Lamprohaminoea ovalis</i> (Pease, 1868)	-	+	-	-	-	-
<i>Haminoea elegans</i> (Gray, 1825)	-	-	+	-	-	-
<i>Bakawan rotundata</i> (A. Adams, 1850)	-	+	-	-	-	-
Family Tornatinidae (P. Fischer, 1883)						
<i>Acteocina townsendi</i> (Melvill, 1898)	-	+	-	-	-	-
Order Aplysiida						
Family Aplysiidae (Lamarck, 1809)						
<i>Aplysia argus</i> (Ruppell & Leuckart, 1830)	-	+	-	-	-	-
<i>Aplysia oculifera</i> (A. Adams & Reeve, 1850)	-	+	-	-	-	-
<i>Bursatella leachii</i> (Blainville, 1817)	-	+	-	-	-	-
<i>Stylocheilus striatus</i> (Quoy & Gaimard, 1832)	-	-	-	-	+	-
Superorder Sacoglossa						
Family Juliidae (E.A. Smith, 1885)						
<i>Berthelinia limax</i> (Kawaguti & Baba, 1959)	-	+	-	+	+	-
<i>Elysia bangtawaensis</i> (Swennen, 1998)	-	-	-	-	+	-
<i>Elysia bengalensis</i> (Swennen, 2011)	-	-	-	-	+	-
<i>Elysia grandifolia</i> (Kelaart, 1858)	-	+	-	+	-	-
<i>Elysia marginata</i> (Pease, 1871)	-	-	-	-	-	+

Family Oxynoidae (Stoliczka, 1868)						
<i>Lobiger nevillei</i> (Pilsbry, 1896)	-	+	-	-	-	-
<i>Oxynae viridis</i> (Pease, 1861)	-	+	-	-	+	-
Family Hermaeidae (H. Adams & A. Adams, 1854)						
<i>Polybranchia orientalis</i> (Kelaart, 1858)	+	+	-	+	-	-
Family Volvatellidae (Pilsbry, 1895)						
<i>Ascobulla fischeri</i> (A.Adams & Angas, 1864)	-	+	-	-	-	-
<i>Volvatella pyriformis</i> (Pease, 1868)	-	+	-	-	-	-
Family Limapontiidae (Gray 1847)						
<i>Stiliger viridis</i> (Kelaart, 1858)	-	-	-	+	-	-
Family Plakobranchidae (Gray, 1840)						
<i>Thuridilla coerulea</i> (Kelaart, 1857)	-	-	-	+	-	-
Family Aplustridae (Gray, 1847)						
<i>Hydatina zonata</i> (Lightfoot, 1786)	-	-	-	-	+	-
Superorder Ringiculimorpha						
Family Ringiculidae (Philippi, 1853)						
<i>Ringicula propinquans</i> (Hinds, 1844)	-	-	+	+	-	-
Total	40	20	5	45	27	19

Note: + Present; - Absent. R1: Alder and Hancock (1864), R2: Sarma (1974), R3: Ramakrishna et al. (2007), R4 - Venkataraman et al. (2015), R5: Apte and Desai (2017), PS: Present study

Phylum Mollusca Linnaeus, 1758
 Class Gastropoda Cuvier, 1795
 Order Nudibranchia Cuvier, 1817
 Family Facelinidae Bergh, 1889
 Genus *Caloria* Trinchese, 1888

Coryphellina exoptata (Gosliner & Willan, 1991) (Figure 2.A)

Synonyms: *Flabellina exoptata* Gosliner & Willan, 1991.

Material Examined: ZSI/MARC M7359, Off Rushikonda (Lat. N 17°47.421'; Long E 83°23.618'), Visakhapatnam coast, Andhra Pradesh, 15.12.2019.

Diagnosis: Underwater, the live animal is translucent violet colored; long cerata are arranged in 6-8 clusters with creamy white tips and blue bands. The oral tentacles are also the same color, with a blue band and creamy white tip. Rhinophores are bright orange colored. This particular species is defined by having a prominent central purple, occasionally violet-blue, ring on its cerata, which are capped with opaque creamy yellow tips. Its rhinophores display vibrant shades of orange to red. The front corners of its foot are notably enlarged, forming sharply pointed tentacles, while its oral tentacles are elongated and cylindrical.

Size: 12 mm.

Habitat: Rocky bottom with algae.

Distribution: Australia, Indonesia, Russell Island, Solomon Island, Indonesia, South Africa, Malaysia, South China, Reunion Island, Korea, Japan, Christmas Island, Papua New Guinea, Philippines, India (Andaman and Nicobar Island).

Remarks: New distribution report to Andhra Pradesh State.

Genus *Pteraeolidia* Bergh, 1875

Pteraeolidia semperi (Bergh, 1870) (Figure 2.B)

Synonyms: *Flabellina ianthina* Angas, 1864.

Material Examined: ZSI/MARC M6251, Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, Andhra Pradesh, 27.02.2019.

Diagnosis: The animal is commonly called a blue dragon, and the colors differ from place to place. The present study reveals that the animal is light brown, and its oral tentacles have 3 purple bands. The first two bands are close to each other and got fused. A blue line runs from rhinophores to the end of the ceratal cluster and has diamond-shaped blur spots intermittently. Cerata is short compared to body length. White markings are present overhead. The lateral side of the body is also covered with spots.

Size: 75 mm

Habitat: Artificial shipwreck ecosystem with rocky bottom covered in algae.

Distribution: Indo-West Pacific, Tropical, Subtropical, and India (Gulf of Mannar, Gujarat, Lakshadweep Islands, Andaman and Nicobar Island).

Remarks: New distribution report to Andhra Pradesh State.

Family Dendrodorididae O'Donoghue, 1924

Genus *Dendrodoris* Ehrenberg, 1831

Dendrodoris krusensternii (Gray, 1850) (Figure 3)

Synonyms: *Actinodoris krusensternii* Gray, 1850; *Dendrodoris clavulata* (Alder and Hancock, 1864); *Dendrodoris denisoni* (Angas, 1864); *Dendrodoris gemmacea* (Alder and Hancock, 1864); *Doridopsis gemmacea* Alder and Hancock, 1864; *Doris denisoni* Angas, 1864

Material Examined: ZSI/MARC M6253, Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, Andhra Pradesh, 27.02.2019.

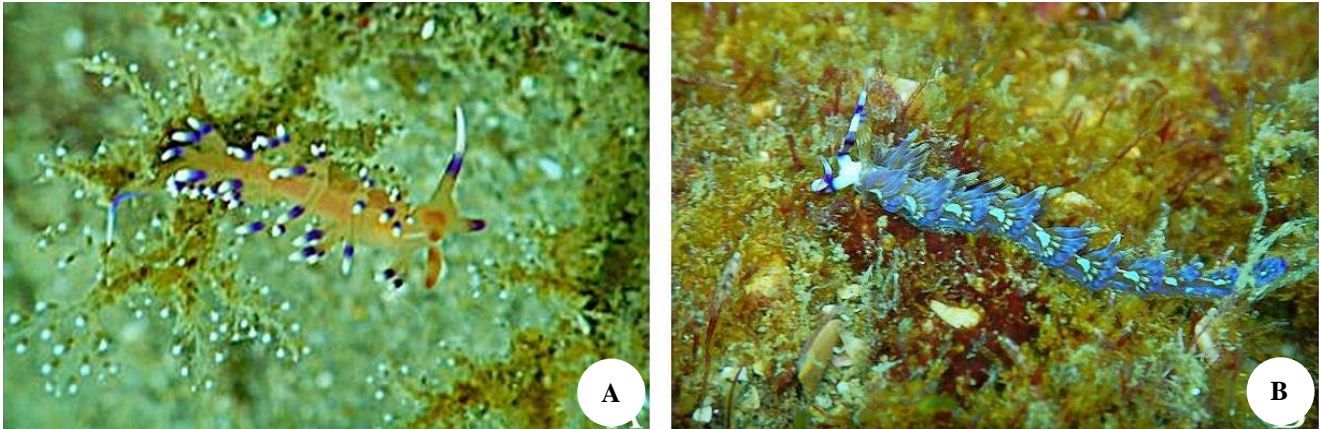


Figure 2. A. *Coryphellina exoptata* (Gosliner & Willan, 1991), B. *Pteraeolidia semperi* (Bergh, 1870)



Figure 3. *Dendrodoris krusenstenii* (Gray, 1850)

Diagnosis: The species is often called ornate elysia or leaf slugs. They exhibit a translucent greenish-yellow hue adorned with white and black speckles. The dorsal surface, or notum, is adorned with fleshy tubercles, while blue spots appear amid these tubercles. Along the body's periphery is an orange band and a black margin. The rhinophores, which are sensory structures, are robust and club-shaped, displaying orange coloring with dark tips.

Size: 25 mm

Habitat: Artificial shipwreck ecosystem with rocky bottom covered in algae.

Distribution: Australia, South Africa, Thailand, Indonesia, South Korea, Reunion Island, Singapore, New Zealand, Taiwan, Hawaii, Philippines, India (Goa, Andhra Pradesh, Andaman and Nicobar Islands).

Remarks: The species documented along the Coromandel Coast by Alder and Hancock (1864) was found in the current study off Chinthapalli, Visakhapatnam, on the Coromandel Coast after 1864, which is 155 years ago.

Family Chromodorididae Bergh, 1891
Genus *Doriprismatica* d' Orbigny, 1839

Doriprismatica atromarginata (Cuvier, 1804) (Figure 4)

Synonyms: *Casella atromarginata* (Cuvier, 1804); *Casella pallida* Bergh, 1905; *Casella macCarthyi* (Kelaart, 1859); *Casella philippinensis* Bergh, 1874; *Doris atromarginata* Cuvier, 1804; *Doris macCarthyi* Kelaart, 1859; *Glossodoris atromarginata* (Cuvier, 1804); *Glossodoris macCarthyi* (Kelaart, 1858); *Goniodoris atromarginata* (Cuvier, 1804).

Material Examined: ZSI/MARC M6243, Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, 27.02.2019; ZSI/MARC M6868, Off Rushikonda (Lat. 17°46.868' N; Long. 83°23.426' E), Visakhapatnam, Andhra Pradesh, 15.12.2019.

Diagnosis: The specimens obtained from the study site exhibit a creamy white to pale yellow hue, with a sinuous mantle edge clearly adorned with a black band. The edges are raised compared to the body. The feathery gills and rhinophores are notable for their black-edged appearance and smooth surfaces. Additionally, the base of the rhinophores features several circular dark rings.

Size: 35 - 40 mm

Habitat: Artificial shipwreck ecosystem with rocky bottom covered in algae.

Distribution: It occurs throughout tropical and subtropical Indo-Pacific water in India (Tamil Nadu, Andhra Pradesh, Kerala, Andaman and Nicobar Islands).

Remarks: Ramakrishna et al. (2010) documented the presence of *G. atromarginata* along the Andhra Pradesh coast. In our current investigation, after a gap of nine years, we report the same species with underwater live photographs from Visakhapatnam, Andhra Pradesh.

Genus *Glossodoris* Ehrenberg, 1831

Glossodoris sp. cf. *cincta* (Bergh, 1888) (Figure 5.A)

Synonyms: *Casella cincta* Bergh, 1888; *Casella foxi* O'Donoghue, 1929

Material Examined: ZSI/MARC M6244, Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, 27.02.2019; ZSI/MARC M6899, Off Vammivanipalem (Lat. 17°47.421' N; Long. 83°23.618' E), Visakhapatnam, Andhra Pradesh, 14.12.2019.



Figure 4. (A-B) *Doriprismatica atromarginata* (Cuvier, 1804)

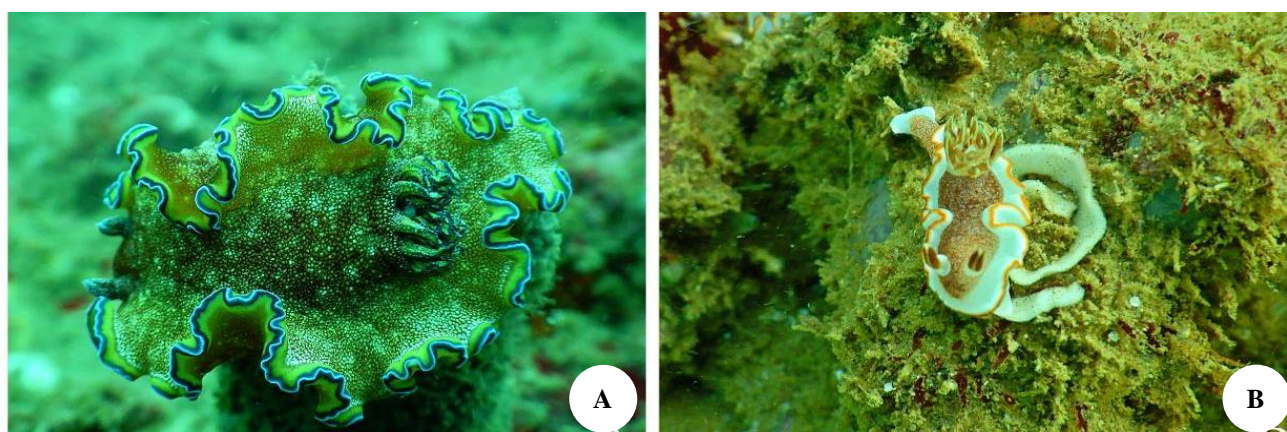


Figure 5. A. *Glossodoris* sp. cf. *cincta* (Bergh, 1888), B. *Glossodoris rufomarginata* (Bergh, 1890)

Diagnosis: The specimen exhibits red and yellow spots bordered by a blue margin. The mantle flaps display a vibrant yellow band at the edge, succeeded by a dark blue band and a light blue band along the outermost edge. The foot appears deep red or brown with a blue border. The rhinophores are ribbed and blue with a red base, while the gills are white with blue borders.

Size: 40 mm

Habitat: Artificial shipwreck ecosystem with rocky bottom covered in algae.

Distribution: The Red Sea to Tanzania, Japan, Fiji, Papua New Guinea, Australia, Maldives, Hong Kong, and India (Tamil Nadu, Lakshadweep, Andaman and Nicobar Islands).

Remarks: New distribution report to Andhra Pradesh State.

Glossodoris rufomarginata (Bergh, 1890) (Figure 5.B)

Synonyms: *Casella rufomarginata* Bergh, 1890; *Chromodoris rufomarginata* (Bergh, 1890); *Chromodoris youngbleuthi* Kay & Young, 1969; *Chromolaichma youngbleuthi* (Kay & Young, 1969); *Glossodoris youngbleuthi* (Kay & Young, 1969).

Material Examined: ZSI/MARC M6870, Off Rushikonda Beach (Lat. 17°46.868' N; Long. 83°23.426' E), Visakhapatnam coast, Andhra Pradesh, 15.12.2019.

Diagnosis: The specimens from the study site displayed a white coloration with an orange-brown speckled line pattern adorning the mantle, while the mantle's border exhibits an orange-brown hue. Typically, the margin appears white in most individuals, encircled by a delicate orange or tan line. As individuals mature, the mantle margin develops more intricate folds. The rhinophores and gills are light brown with white linings.

Size: 25 mm

Habitat: Rocky bottom covered in algae.

Distribution: Red Sea, Indonesia, Malaysia, Japan, Korea, Myanmar, Taiwan, Philippines, Tanzania, Aldabra, Papua New Guinea, Hawaii, Australia, Solomon Island, French Polynesia, India (Andaman and Nicobar Islands).

Remarks: New distribution reports to Andhra Pradesh State.

Genus *Goniobranchus* Pease, 1866

Goniobranchus alius (Rudman, 1987) (Figure 6.A)

Synonyms: *Chromodoris alius* Rudman, 1987

Material Examined: ZSI/MARC M7360, Off Vammivanipalem (Lat. 17°47.421' N; Long 83°23.618' E), Visakhapatnam coast, Andhra Pradesh, 14.12.2019.

Diagnosis: The body is creamy-white with dull brown and yellow spots all over the mantle surface. The mantle

border is decorated with a series of oblong violet spots. Rhinophores stalks are translucent white, and dark brown clubs and gills are white.

Size: 35 mm

Habitat: Rocky bottom covered in algae.

Distribution: South Africa, Madagascar, Tanzania, Reunion Island, Sri Lanka, India (Lakshadweep Islands, Andaman and Nicobar Islands).

Remarks: New distributional record for Andhra Pradesh State. This species displays a range of color variations, spanning from a white dorsum with a purple mantle edge to a brownish dorsum with light yellow spots within the purple margin. The latter pattern bears resemblance to *Goniobranchus aureopurpureus* found in the West Pacific. According to Rudman (2005), there is a suggestion that "*G. alius*, *G. aureopurpureus*, *G. rufomaculatus*, and *G. albopustulosus*" might represent the same species with extensive geographical distribution and color variations.

Goniobranchus setoensis (Baba, 1938) (Figure 6.B)

Synonyms: *Chromodoris decora* (Pease, 1860); *Chromodoris ndukuei* Risbec, 1928; *Doris decora* Pease, 1860; *Glossodoris (Chromodoris) ndukuei* (Risbec, 1928); *Glossodoris decora* (Pease, 1860); *Glossodoris ndukuei* (Risbec, 1928).

Material Examined: ZSI/MARC M7361, Off Vammivanipalem (Lat. N 17°47.421'; Long E 83°23.618'), Visakhapatnam coast, Andhra Pradesh, 14.12.2019.

Diagnosis: The species is translucent, with considerable variability in coloration. However, its most distinctive feature is an opaque white line running along the dorsal midline, branching into an inverted 'Y' shape. However, purple spots are absent in the midline (present in case of *G. decorus*). Along the mantle edge, there's a delicate, opaque white line, often fragmented into a series of white spots or patches, followed by a deep orange band and purple spots. A slender white line between the rhinophores extends along the dorsal midline towards the center, where it divides to form a loop encircling the gill pocket. The rhinophores have a translucent straw coloration with a solid white core. At the same time, the gills exhibit a similar hue, with their lamellae appearing creamy-brown straw-colored and their interior displaying an opaque white shade.

Size: 10 mm

Habitat: Rocky bottom covered in algae.

Distribution: Kenya, South Africa, Sri Lanka, Burma, Reunion Island, Maldives, Myanmar, Thailand, India (Lakshadweep Island, Andaman and Nicobar Islands, Kerala).

Remarks: New distributional record for Andhra Pradesh State.

Goniobranchus fidelis (Kelaart, 1858) (Figure 6.C)

Synonyms: *Chromodoris fidelis* (Kelaart, 1858); *Chromodoris flammulata* Bergh, 1905; *Chromodoris krishna* Rudman, 1973; *Chromodoris lactea* Bergh, 1905; *Doris fidelis* Kelaart, 1858; *Glossodoris fidelis* (Kelaart, 1858).

Material Examined: ZSI/MARC M6245, Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, Andhra Pradesh, 27.02.2019.

Diagnosis: The specimens were creamy white, and the margin of the mantle was orange. Typically, along the inner boundary of the orange band, a succession of elongated patches resembling tongues that extend into the white area is observed. The rhinophores are greyish with white tips, and the gills are the same color.

Size: 20 mm

Habitat: Artificial shipwreck ecosystem with rocky bottom covered in algae.

Distribution: New Caledonia, Hong Kong, Japan, Red Sea, Australia, Seychelles, Indonesia, Malaysia, Papua New Guinea, India (Gujarat, Tamil Nadu, Andhra Pradesh, Lakshadweep, Andaman and Nicobar Island).

Remarks: Ramakrishna et al. (2010) documented the presence of *Chromodoris fidelis* along the Andhra Pradesh coast. Our current study reports on the same species after a nine-year interval, including underwater live photographs from Visakhapatnam, Andhra Pradesh.

Goniobranchus trimarginatus (Winckworth, 1946) (Figure 6.D)

Synonyms: *Chromodoris trimarginata* Winckworth, 1946; *Glossodoris trimarginata* Winckworth, 1946.

Material Examined: ZSI/MARC M6871, Off Vammivanipalem (Lat. N 17°47.421'; Long E 83°23.618'), Visakhapatnam coast, Andhra Pradesh, 14.12.2019.

Diagnosis: The specimen appears transparent with minor black or brown markings. A delicate purple line delineates the edge of the mantle, succeeded by black and yellow lines, each of the same breadth. The rhinophores exhibit lamellate structures, and both the gill leaves and rhinophores are white.

Size: 20 mm

Habitat: Rocky bottom covered in algae.

Distribution: Thailand, Malaysia, India (Tamil Nadu, Maharashtra).

Remarks: New distributional record for Andhra Pradesh State. The species was originally documented based on a group of 80 specimens from Bombay; Rudman (1985) provided a new description of its anatomy, while Valdes et al. (1999) presented a color photograph from southern India, aiding in clarifying its association with other species of similar coloration.

Genus *Hypselodoris* Stimpson, 1855

Hypselodoris bullockii (Collingwood, 1881) (Figure 7.A)

Synonyms: *Chromodoris bullockii* Collingwood, 1881; *Risbecia bullockii* (Collingwood, 1881)

Material Examined: ZSI/MARC M6247, Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, Andhra Pradesh, 27.02.2019; ZSI/MARC M7362, Off Timmapuram (Lat. N 17°48.272'; Long E 83°24.869'), Visakhapatnam coast, Andhra Pradesh, 18.12.2019.

Diagnosis: The species displays a pale lavender hue, with the mantle featuring a slender border of white. Its rhinophores and gill leaves are yellow, adorned with bands of pink or purple. Size: 20 mm.

Habitat: Artificial shipwreck ecosystem, rocky bottom with algae.



Figure 6. A. *Goniobranchus alius* (Rudman, 1987), B. *Goniobranchus setoensis* (Baba, 1938), C. *Goniobranchus fidelis* (Kelaart, 1858), D. *Goniobranchus trimarginatus* (Winckworth, 1946)

Distribution: South China, Australia, Thailand, Malaysia, India (Tamil Nadu, Andaman and Nicobar Islands).

Remarks: New distribution reports to Andhra Pradesh State. Originally documented in the South China Sea, this species can be observed in the western Pacific, extending south of southern Queensland. Additionally, it inhabits regions of northwestern Australia and Thailand.

Hypselodoris nigrostriata (Eliot, 1904) (Figure 7.B)

Synonyms: *Chromodoris nigrostriata* Eliot, 1904

Material Examined: ZSI/MARC M6248, Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, 27.02.20219; ZSI/MARC M7884, Off Rushikonda Beach (Lat. 17°46.715' N; Long. 83°23.319' E) Andhra Pradesh, 22.01.2021.

Diagnosis: The specimen exhibits a creamy white complexion dotted with yellow spots and black-streaked lines distributed across its entire body. A distinguishing feature of this species is the presence of diagonal black lines. Both the rhinophores and gill leaves display an orange-red hue.

Size: 15 mm

Habitat: Artificial shipwreck ecosystem, rocky bottom with algae.

Distribution: Red Sea, Tanzania, United Arab Emirates, India (Andhra Pradesh, Tamil Nadu, Maharashtra, Andaman and Nicobar Islands).

Remarks: In this study, specimens of this species were obtained from a shipwreck off the Chinthapalli coast in Visakhapatnam, Andhra Pradesh.

Hypselodoris sagamiensis (Baba, 1949) (Figure 7.C)

Synonyms: *Glossodoris sagamiensis* Baba, 1949

Material Examined: ZSI/MARC M7363, Off Mangamari Peta (Lat. 17°49.656'N; Long 83°27.096'E), Visakhapatnam coast, Andhra Pradesh, 19.12.2019.

Diagnosis: The live animal is translucent colored with a white mantle and black spots over it. There is a purple band in mantle edges with a yellow or orange broken band inside. Rhinophore stalks are white with a red tip, and gills are white with a red border. The distinct trait of this species is the presence of small pustules covering its mantle.

Size: 20 mm

Habitat: Rocky bottom with algae.

Distribution: Indonesia, Vanuatu, Japan, Australia, India (Andaman and Nicobar Island).

Remarks: New distributional report to Andhra Pradesh State.

Hypselodoris kanga Rudman, 1977 (Figure 7.D)

Material Examined: ZSI/MARC M6869, Off Rushikonda Beach (Lat. 17°46.868' N; Long. 83°23.426' E), Andhra Pradesh, 15.12.2019; ZSI/MARC M7883, Off Rushikonda Beach (Lat. 17°46.715' N; Long. 83°23.319' E), Visakhapatnam coast, Andhra Pradesh, 22.01.2021.



Figure 7. A. *Hypselodoris bullockii* (Collingwood, 1881), B. *Hypselodoris nigrostriata* (Eliot, 1904), C. *Hypselodoris sagamiensis* (Baba, 1949), D. *Hypselodoris kanga* (Rudman, 1977)



Figure 8. *Jorunna funebris* (Kelaart, 1859)

Diagnosis: The species are bluish-white with yellow or orange spots and dark blue lines. Rhinophores are reddish brown and have a blue ring on the bottom. Gills edges are also bluish-coloured with a series of red or yellow spots. One of the most noticeable external features is the triangular-shaped gills, bordered in blue and adorned with a row of yellow spots along the outer edge.

Size: 15 mm

Habitat: Rocky bottom with algae.

Distribution: Indonesia, Philippines, Thailand, Bali, Singapore, Sulawesi, Papua New Guinea, Hong Kong,

Australia, India (Tamil Nadu, Kerala, Maharashtra, Andaman and Nicobar Islands).

Remarks: New distributional report to Andhra Pradesh State.

Family Discodorididae Bergh, 1891

Genus *Jorunna* Bergh, 1876

Jorunna funebris (Kelaart, 1859) (Figure 8)

Synonyms: *Discodoris wetleyi* Allan, 1932; *Doris funebris* Kelaart, 1859; *Jorunna zania* EV. Marcus, 1976; *Kentrodoris annuligera* Bergh, 1876; *Kentrodoris funebris* (Kelaart, 1859); *Kentrodoris gigas* Bergh, 1876; *Kentrodoris maculosa* Eliot, 1906

Material Examined: ZSI/MARC, M6249 Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, Andhra Pradesh, 27.02.2019.

Diagnosis: The species showcases a waxen-white coloration embellished with black markings. Its mantle, possessing a leathery texture, showcases an ivory-white shade adorned with circular black spots and fragmented rings or incomplete spotted patterns. The dorsal tentacles are substantial and club-like, tipped with black, whereas the oral tentacles are slender, with white bodies and black tips. The foot is waxy-white, displaying irregular edges speckled with both small and large linear markings.

Size: 50 mm

Habitat: Artificial shipwreck ecosystem, rocky bottom with algae.

Distribution: Oman, Red Sea, Australia, Maldives, Papua New Guinea, Hong Kong, Singapore, Australia, Japan, India (Distribution in India: Gujarat, Tamil Nadu, Andhra Pradesh, Lakshadweep, Andaman and Nicobar Islands).

Remarks: Alder and Hancock (1864) documented the species along the Coromandel Coast. In this current study, specimens of this species were collected from Off Chinthapalli, Coromandel Coast, more than 155 years after the initial report.

Family Phyllidiidae Rafinesque, 1814
Genus *Phyllidia* Cuvier, 1797

Phyllidia ocellata Cuvier, 1804 (Figure 9.A)

Synonyms: *Phyllidia baccata* Pruvot-Fol, 1957; *Phyllidia japonica* Baba, 1937; *Phyllidia ocellata* subsp. *undula* Yonow, 1986; *Phyllidia tuberculata* Baba, 1930; *Phyllidiopsis carinata* Eliot, 1910

Material Examined: ZSI/MARC M7365, Off Mangamari Peta (Lat. 17°49.656'N; Long 83°27.096'E), Visakhapatnam coast, Andhra Pradesh, 19.12.2019.

Diagnosis: The live animal mantle, bearing yellow tubercles in different sizes and a jet-black color bordered with white, expands and meanders on both sides of the mantle, forming rings.

Size: 15 mm

Habitat: Rocky bottom covered in algae.

Distribution: Indonesia, Singapore, Philippines, Red Sea, Thailand, Solomon Island, Australia, Fiji, Egypt, Mauritius, Japan, Papua New Guinea, Hong Kong, South Africa, Mozambique, India (Tamil Nadu, Andaman and Nicobar Islands).

Remarks: New distributional report to Andhra Pradesh State. *P. ocellata* stands out among predominantly gold-yellow *Phyllidia* species. While it shares a similar coloration with *P. flava*, the latter lacks any black pigmentation. *P. varicosa*, *P. tula*, and *P. coelestis* feature yellow-capped tubercles, but they all exhibit blue-grey pigmentation, with the two former also displaying a black stripe on the sole of their foot.

Phyllidia polkadotsa Brunckhorst, 1993 (Figure 9.B)

Material Examined: ZSI/MARC M6252, Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, Andhra Pradesh, 27.02.2019.

Diagnosis: The animal is yellow, and its typical dorsal pattern consists of eight black bands with a white margin from the mantle to the central part. Around four to five black spots are also present, with a white margin in the central portion.

Size: 20 mm

Habitat: Artificial shipwreck ecosystem, rocky bottom with algae.

Distribution: Hawaii, Japan, Indonesia, Thailand, Vanuatu, and India (Andaman and Nicobar Islands).

Remarks: New distributional report to Andhra Pradesh State.

Genus *Phyllidiopsis* Bergh, 1876

Phyllidiopsis phippiensis Brunckhorst, 1993 (Figure 9.C)

Material Examined: ZSI/MARC M6250, Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, Andhra Pradesh, 27.02.2019.

Diagnosis: The species presents a white body decorated with three black stripes running lengthwise and encircled by black spots along the mantle's periphery. Additionally, it showcases two subtle white ridges, each bordered by three black-outlined furrows. Both the rhinophores and the underside of the foot exhibit a white hue.

Size: 15 mm

Habitat: Reef ecosystem

Distribution: Thailand, Madagascar, India (Lakshadweep, Andaman and Nicobar Islands).

Remarks: A recent distributional report in Andhra Pradesh State. Small longitudinal stripes characterize three additional species of *Phyllidiopsis*. Among these, *P. annae* and *P. sphingis* are distinguishable from the current species by their blue coloring, grey gills, and either black (in *P. annae*) or pale yellow (in *P. sphingis*) rhinophores. While *P. striata* presents a somewhat greater challenge in differentiation, it can still be recognized. *P. striata* is identified by three low, white ridges and four black bands (in contrast to *P. phippiensis*, which has two white ridges and three black bands), lemon yellow rhinophores, and ventral coloring in shades of grey and black.

Superorder Sacoglossa

Superfamily Plakobranchoidea, Gray, 1840

Family Plakobranchidae Gray, 1840

Genus *Elysia* Risso, 1818

Elysia marginata (Pease, 1871) (Figure 9.D)

Synonyms: *Thallopeus ornata* Swainson, 1840

Material Examined: ZSI/MARC M6252, Off Chinthapalli (Lat. 18°00.265'N; Long 83°43.022' E), Vizianagaram, Andhra Pradesh, 27.02.2019.

Diagnosis: The species usually displays a semi-transparent green tone with a black outline along the parapodia. Within the margin, there's a yellow or orange strip. Occasionally, a white line may separate the orange and yellow bands. The rhinophore tips frequently mimic these color bands. Furthermore, the body is adorned with numerous black and white dots.

Size: 25 mm

Habitat: Reef ecosystem with algae

Distribution: New Caledonia, French Polynesia, Australia, Florida, Indonesia, Reunion Island, Dubai, South China, Red Sea, Bahamas, Malaysia, Singapore, Japan, Taiwan, Saudi Arabia, Papua New Guinea, Philippines, Hawaii, American Samoa, India (Gujarat, Maharashtra, Tamil Nadu, Karnataka, Goa, Lakshadweep, Andaman and Nicobar Islands).

Remarks: New distributional report to Andhra Pradesh Coast. The species was very commonly observed and photo-documented along the study sites. The species was previously identified as *E. ornata*, although *E. ornata* was originally described from the Caribbean and is part of the *E. marginata* species complex. *E. grandifolia*, similar to *E. marginata* from the Indo-West Pacific, can be distinguished by larger and thin parapodia (Jensen 1992).

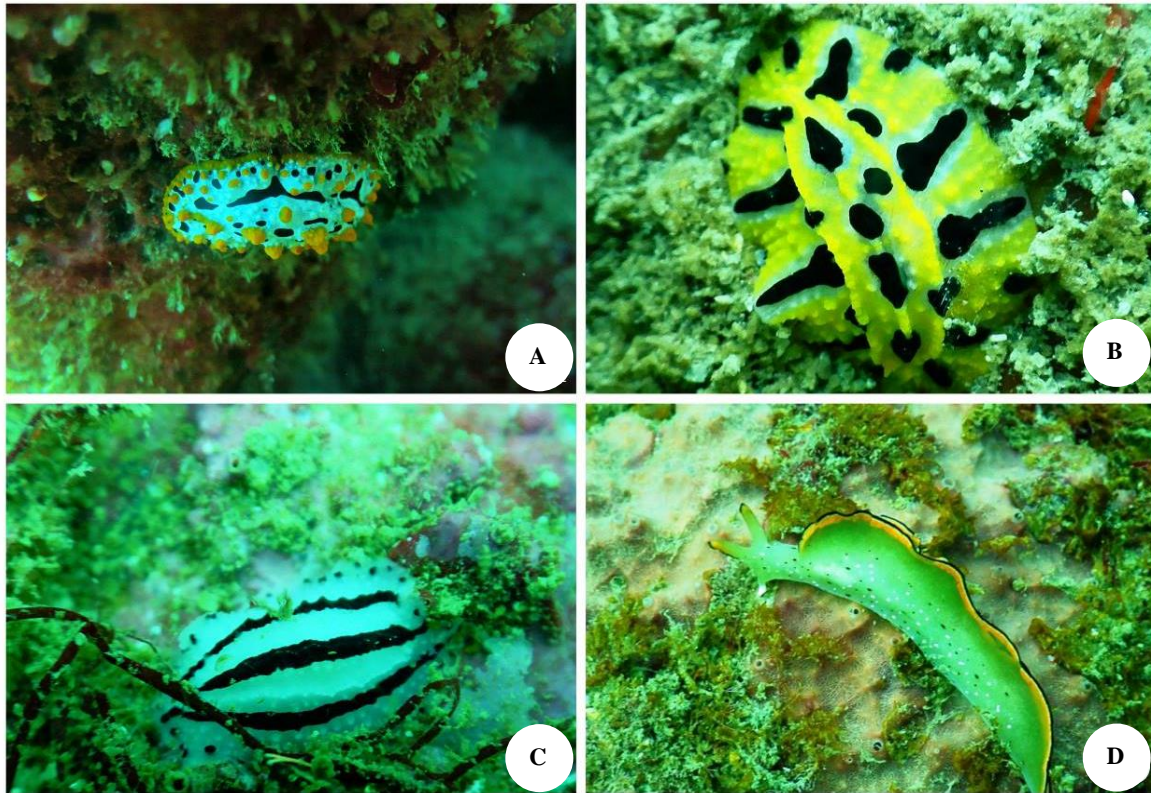


Figure 9. A. *Phyllidia ocellata* (Cuvier, 1804), B. *Phyllidia polkadotsa* (Brunckhorst, 1993), C. *Phyllidiopsis phiphiensis* (Brunckhorst, 1993), D. *Elysia marginata* (Pease, 1871)

Discussion

Andhra Pradesh, as a maritime state located on the east coast of India, boasts a coastline stretching 974 km and a continental shelf area of 33,227 km² across 12 coastal districts (Monolisha and Edward 2015). Regarding comprehensive studies on marine slug biodiversity, only a select few prominent researchers in the country have been involved (Thambi et al. 2023). Some researchers have studied the distribution of Heterobranchs along the coast of Andhra Pradesh, as documented by a few workers. However, in the current study, the underwater survey conducted using SCUBA equipment marks the first endeavor along the Visakhapatnam coast of Andhra Pradesh. The surveyed ecosystems, predominantly rocky reefs and sandy bottoms in intertidal and sub-tidal zones (Figure 1), are favorable habitats for heterobranch sea slugs (Kumar et al. 2011, 2019). The taxonomy of heterobranchs in India traces back to the efforts of Alder and Hancock, who initiated studies along the Visakhapatnam coast. Alder and Hancock (1864) described a new species based on collections made by Walter Elliot during surveys conducted in 1853 and 1854 aboard a survey ship along this coast. This study, 19 species were identified across the study sites (Figures 2-9), among which 13 were documented for the first time in Andhra Pradesh. Including these mollusks significantly enhances the marine faunal richness of the region. Notably, species such as *C. exoptata*, *G. rufomarginata*, *G. alius*, *H. sagamiensis*, *P. polkadotsa*, and *P. phiphiensis* were previously reported only in island ecosystems of India, such as the

Lakshadweep Islands and Andaman and Nicobar Islands. However, the present study confirms that the range of these species extends to mainland reef ecosystems in India (Apte and Desai 2017). This study's findings indicate a significant underutilization of the diversity of heterobranchs in rocky reef and sandy bottom ecosystems.

According to the literature review and the additional 13 species identified in the present study, the total number of species documented from the Andhra Pradesh coast now stands at 103 (Table 3). Alder and Hancock (1864) reported 40 species during their survey of the Coromandel Coast study sites. Sarma (1974) documented algae-associated faunal density and listed mollusks from the Visakhapatnam coast, reporting 26 species of heterobranchs. Meanwhile, six species were identified solely at the generic level. Therefore, species such as *Smaragdinella* sp., *Berthelinia* (Tamanovalva) sp. 1, *Berthelinia* (Tamanovalva) sp. 2, *Glossodoris* sp., *Melibe* sp., and *Madrella* sp. were excluded from this work (Table 2). Ramakrishna et al. (2007) reported only five species from collections at landing centers along the Visakhapatnam coast. Venkataraman et al. (2015) and Raghunathan et al. (2016) updated the checklist of sea slugs from India, listing 45 species from the Andhra Pradesh coast. Apte and Desai (2017) recently published a study on sea slugs from the Indian coast, identifying 26 species from the Andhra Pradesh coast. This updated list confirms 103 species available from Andhra Pradesh, making it the second most diverse area in terms of Indian sea slugs.

According to the existing literature, the Andaman and Nicobar Islands boast the highest number of reported species, while the Goa coast has the lowest number (Venkataraman et al. 2015; Raghunathan et al. 2016). The variation in reported species numbers can be attributed to differences in research efforts and publication outputs. Regions with more extensive research tend to report higher species counts, whereas areas with limited research face species identification and collection challenges, resulting in fewer reported species. More detailed underwater surveys are essential to explore these fascinating mollusks further and uncover their ecology, reproductive biology, feeding habits, and potential pharmacological compounds. Such surveys would not only contribute to a better understanding of these organisms but also shed light on their ecological roles and potential applications in various fields.

In conclusion, compared to other regions where marine biodiversity has been extensively documented, the knowledge regarding the diversity of heterobranchs in the Indian subcontinent is notably lacking. Since 1864, there has been insufficient research on heterobranchs along the coast of Andhra Pradesh, with only limited studies conducted on this group of animals. Recent and abrupt changes in coastal ecology are attributed to pressures from both natural phenomena and human activities. Coastal ecosystems, particularly rocky reefs, are experiencing a gradual loss of biodiversity, raising concerns about the potential extinction of numerous species that may be disappearing unnoticed. Sea slugs, being benthic organisms, have a strong connection to the seabed, and the possible use of bottom trawling in Andhra Pradesh, a significant hub for marine fish production in India, poses a grave threat to these sea slugs' diversity. While these slugs play a vital role in the lower levels of the food chain, the impacts of pollution, fishing activities, and climate change on their diversity have not been thoroughly documented. This underscores the need for targeted conservation efforts in the future. It is important to note that these organisms are highly sensitive to environmental changes. Rising sea temperatures and ocean acidification could potentially disrupt their food sources and alter their reproductive cycles, ultimately leading to a decline in their populations. In addition to climate change, other human activities, such as pollution and coastal development, can significantly impact sea slug populations. Polluted waters can lead to the death of these delicate creatures, while development along coastlines can destroy their natural habitats, leaving them nowhere to go. Additionally, it's important to consider that this study was conducted at specific diving sites along the Andhra Pradesh coast, which introduces sampling bias in population analysis. However, regarding diversity study, it can be confirmed that these species are indeed present in the study area. Conducting future population estimations will provide a clearer understanding of the distribution patterns of these species.

Despite not being consumed as food in India, sea slugs are recognized for possessing anti-cancer, anti-tumor, and anti-viral compounds, which are valuable in the pharmaceutical industry. Compounds such as Dolastatin-10 (ILX651, Cemadotin, and Kahalalide F, derived from sea

slugs (*Dolabella auricularia*, *Symploca* sp.), are currently undergoing various stages of clinical trials (Sethi and Pattnaik 2012). However, in India, sea slugs are considered low-value bycatch and are often discarded or used for manure and fish feed production. Nonetheless, the ecological significance of these organisms, including their feeding habits, nutrient recycling, chemical defense mechanisms, and role as indicator species, cannot be ignored for the overall health of ecosystems (Andrimida 2022). To those who argue that the economic value of sea slugs is not significant enough to warrant conservation efforts, it is important to remember that all species play a crucial role in maintaining the balance of our ecosystem. Furthermore, sea slugs have been found to have potential medicinal properties that could be beneficial for humans. Ultimately, the conservation of sea slugs and other marine species is not only important for their survival but also for the health and well-being of our planet as a whole. The recent underwater exploration report has expanded our understanding of the distribution of heterobranchs along the Visakhapatnam coast in Andhra Pradesh. However, it is crucial to conduct additional thorough surveys and in-depth taxonomic research to fully investigate the variety of these fascinating sea slugs along the coast of Andhra Pradesh, India. It's conceivable that not all sea slug diversity in the region has been documented so far. Consequently, future conservation strategies may need to be developed, as these organisms have largely been overlooked in many coastal areas of India. As of now, there has been no conservation planning specifically focused on these organisms.

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