

New records of nudibranchs (Gastropoda: Heterobranchia) from the coast of Pakistan (Northern Arabian Sea)

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ABSTRACT This study reports fifteen species of nudibranchs from the coast of Pakistan (Northern Arabian Sea) except *Jorunna funebris* reported here, all are new records.

KEY WORDS Heterobranchia, Cladobranchia, Doridina, Karachi, new records

INTRODUCTION

Nudibranchs or sea slugs are colorful, shell-less, marine heterobranch gastropods in the order Nudibranchia comprising more than 2000 species worldwide (Gosliner *et al.*, 2008). Due to loss of adult shell, they have evolved various anti-predator strategies, like chemical defense, use of nematocysts obtained from cnidarian prey, warning or aposematic coloration, camouflage and mimicry (Gosliner, 2001; Wägele & Klusmann-Kolb, 2005; Greenwood, 2009; Aguado & Marin, 2007; Haber *et al.*, 2010; Putz *et al.*, 2010). Because of the presence of biochemically active compounds, dietary or biosynthetic, nudibranchs have gained increasing interest in natural products research (Avila, 1995; Dean & Prinsep, 2017).

Little is known about the nudibranch fauna of Pakistan (Northern Arabian Sea). The current knowledge on the subject comes from a checklist of opisthobranchs of Karachi which documents twenty-two species (Kazmi *et al.*, 1996) and a report on new record of *Dendrodoris krusensternii* published later on (Khanam & Kazmi, 2016). The information compiled in these papers, however, mentions almost nothing about the earlier studies on nudibranchs in Pakistan, except for a single

contribution made by Eliot (1905), who provided some notes on nudibranchs of Karachi coast.

The present work is based upon opportunistic data on underwater photography of marine life recorded voluntarily by the Pakistani recreational SCUBA divers during diving/snorkeling excursions along Charna Island (24° 53' 56.422" N, 66° 36' 15.297" E) located off the Mubarak village, Karachi, and presently the most popular place for such activities. These SCUBA diving organizations post the photographs on their websites. Nudibranchs were photographed mostly, from 2015 to 2018 at average depth of 10 meter along Charna Island. Species recorded were identified by the author using W.B. Rudman's Sea Slug Forum (seaslugforum.net/), Pola *et al.* (2005), Camacho-García & Gosliner (2008) and Yonow (1988, 1989, 1996, 2001a and b, 2012, 2018).

A total of fifteen species were identified and reported here of which except *Jorunna funebris* are all new records. Each species is presented here with salient diagnostic features, its general geographic distribution and recent records of occurrence in the Arabian Sea, where available in literature. In addition, brief remarks have been given on each of the species to point out

any morphological peculiarity in relation to identification and comparison with congener. The classification of nudibranchs used herein is adapted from Bouchet *et al.* (2017) whereas, taxonomic authorities of order Nudibranchia and its suborders appear unsettled in the current literature and is thus not mentioned. This study represents an entirely a citizen science initiative.

SPECIES ACCOUNTS

Order Nudibranchia
Suborder Doridina
Family Chromodorididae Bergh, 1891

Goniobranchus annulatus (Eliot, 1904)
(Figure 1A)

Description. Body white with bright yellow raised spots on mantle. Two dark purple-black rings, each around rhinophores and gills; rings completely separated. Rhinophores, gills and mantle margin also tinged with purple-black.

Remarks. The rings, however, may be joined by a median line. Occurrence of both these forms has recently been reported from Arabian Gulf (see Nithyanandan, 2012).

Distribution. Red Sea and Western Indian Ocean. Arabian Sea: Oman (Yonow, 2012), Kerala, India (Chandran *et al.*, 2017) and Pakistan.

Goniobranchus cavae (Eliot, 1904)
(Figure 1B)

Description. Body white with scattered small, round black spots and numerous yellow spots of different sizes; black spots surrounded by white lines. Border of mantle white/free of spots and edged with faint violet shade. Gills and rhinophores tinged violet.

Remarks. Yonow (2012) pointed out variations in morphology of this species including lack of violet margin on both mantle and foot.

Distribution. Western Indian Ocean. Arabian Sea: Kerala, India (Chandran *et al.*, 2017) and Pakistan.

Goniobranchus decorus (Pease, 1860)
(Figure 1C)

Description. Body translucent grey-white bearing orange border with single row of irregular shape purple spots on inner side and a thin opaque white line running longitudinally parallel to mantle margin encircling rhinophores and gills. Dorsum has similar white line medially which bifurcates in Y-shape around gills and without any spots.

Remarks. Above morphology with median line unspotted indicates *Goniobranchus setoensis* (Baba, 1938), however, Yonow (2012, plate 41, 42) identified her specimens with similar character as *G. decorus* which supports Rudman's (2007a) view that the mentioned species is a variant of *G. decorus*, is adapted here.

Distribution. Indo-west Pacific. Arabian Sea: Oman (Yonow, 2012), Lakshadweep (Apte, 2009, as *Chromodoris* cf. *setoensis*) and Pakistan.

Goniobranchus tumuliferus (Collingwood, 1881)
(Figures 1D, E)

Description. Body white bearing brown-red spots, no or variably tint with blue, and bright yellow submarginal border on mantle and foot. Mantle below border having blue spots or mixed with red ones and interrupting border. Rhinophores and gills tinged with yellow (Rudman, 1999a).

Remarks. *Goniobranchus kitae* described from the Northern Madagascar (Gosliner, 1994) shows close resemblance to the given species and differs mainly in having tiny opaque white spots on the rhinophores and gills (Rudman, 2002a, 2002b).

Distribution. Central Indo-Pacific (Mehrotra & Scott, 2015; Sachidhanandam, 2000). For further records, see Rudman's Sea Slug Forum. This is possibly, first record of *G. tumuliferus* from the Western Indian Ocean.

Glossodoris pallida (Rüppell & Leuckart, 1830)
(Figure 1F)

Description. Body white with opaque white raised markings in the mid dorsal line. Two marks prominent; one like large spot behind rhinophores and other, inverted V-shaped mark. Mantle margin folded, edged with faint yellow. Rhinophores and gills white; tips tinged with yellow.

Distribution. Red Sea and Indo-west Pacific. Arabian Sea: Oman (Yonow, 2012) and Pakistan.

Glossodoris rufomarginata (Bergh, 1890)
(Figure 1G)

Description. Mantle bearing tan-brown colored speckled pattern on dorsum, submarginal white border and brown margin. Rhinophores and gills brown with white edges.

Distribution. Red Sea and Indo-west Pacific. Arabian Sea: Kerala, India (Chandran *et al.*, 2017) and Pakistan.

Hypselodoris ghardaqana
(Gohar & Aboul-Ela, 1957)
(Figure 1H)

Description. Body opaque white bearing bright yellow spots of different sizes on dorsal surface of mantle and foot. Mantle margin and posterior edge of foot deep blue. Rhinophore clubs maroon. Gills white with maroon edges (see Rudman, 2007b).

Distribution. Red Sea and Indian Ocean. Arabian Sea: Oman (Rudman, 2000) and Pakistan.

Hypselodoris infucata
(Rüppell & Leuckart, 1830)
(Figure 2A)

Description. Body grey-white bearing small, round spots of yellow and blue-black colour, and one row of blue-black patches on either side of dorsum. Mantle margin bordered with yellow and blue-black spots. Rhinophore clubs and gill edges light orange.

Remarks. The individual showing resemblance with *Hypselodoris sagamiensis* (Baba, 1949) but this species has pustules on dorsum and yellow spots only on the mantle margin. One record with similar morphology has been mentioned at sea slug forum (see Deomurari, 2007).

Distribution. Mediterranean, Red Sea and Tropical Indo-Pacific. Arabian Sea: Lakshadweep, India (Apte, 2009) and Pakistan.

Family Discodorididae Bergh, 1891

Jorunna funebris (Kelaart, 1859)
(Figure 2B)

Description. Body covered with tiny tubercles, caryophyllidia, giving velvety appearance to mantle. Background color white bearing jet black, partially pigmented, rings of different sizes; larger rings in the middle of dorsum. Rhinophore clubs jet black. Gills white with jet black rachis. Border of mantle with spots and smaller rings of black color.

Distribution. Red Sea and Tropical Indo-west Pacific. Arabian Sea: Lakshadweep, India (Apte, 2009) and Pakistan.

Family Phyllidiidae Rafinesque, 1814

Phyllidia ocellata Cuvier, 1804
(Figure 2C)

Description. Mantle bearing yellow tubercles of different sizes; larger, mostly in mid-dorsum gradually smaller and abundant on margin. Jet-black color bordered in white expand and meander on both sides of mantle forming rings. Surface of tubercles irregular having tiny warts or tubercles. Sides of mantle with small, round black spots. Rhinophores yellow.

Distribution. Red Sea and Tropical Indo-west Pacific (Rudman, 1999b). Arabian Sea: Pakistan.

Phyllidia picta Pruvot-Fol, 1957
(Figure 2D)

Description. Mantle bearing three rows of orange-yellow capped tubercles on mid-dorsum, one medial and two outer; each outer row comprising at least two larger tubercles in middle (see Yonow, 2001b, 2012: fig. 16 A). Dorsum covered with black color which form

transverse rays giving blue-grey scalloped pattern on sides having tubercles. Rhinophores orange-yellow.

Distribution. Indo-west Pacific (Rudman, 2006a; Yonow, 1996, 2012). Arabian Sea: Pakistan. Yonow (2012) documented the species from Socotra which is perhaps the only record from the Western Indian Ocean, so far.

Phyllidia rueppelii (Bergh, 1869)
(Figure 2E, F)

Description. Mantle having three less organized rows of orange-yellow capped tubercles on mid dorsum; one medial and two outer rows, and yellow margin. Ground color blue-grey with black on dorsum; black rays on sides forming blue-grey scalloped pattern provided with tubercles.

Remarks. In *P. rueppelii*, dorsal tubercles among three rows sometimes appear cross connected by blue-grey ground color (see Nithyanandan, 2012: fig. 6). In addition, yellow mantle margin is the most recognizable character of this species.

Distribution. Red Sea, Northwestern Indian Ocean, and Western Australia (Rudman, 2006b). Arabian Sea: Oman (Rudman, 2008) and Pakistan.

Family Polyceridae Alder & Hancock, 1845

Tyrannodoris luteolineata (Baba, 1936)
(Figure 2G)

Description. Body elongate having long, pointed posterior end of foot. Ground color black with four green-yellow lines/stripes on dorsum; two medial passing from mid of rhinophores to base of gills and two outer, each arising from rhinophores. Head bearing two

green-yellow markings between rhinophores and connected with medial lines. Rhinophores black. Gills black with green-yellow rachis (see Rudman, 2001; Pola *et al.* 2005: fig. 6).

Remarks. This species may be confused with *Tambja affinis* known from the Western Indian Ocean which, however, has one milky-green mark between the rhinophores (Yonow, 1990; Rudman, 2005).

Distribution. Central Indo-Pacific and South Africa (see Pola *et al.* 2005). This is possibly, first record of *T. luteolineata* from the Western Indian Ocean.

Suborder Cladobranchia
Family Flabellinidae Bergh, 1889

Coryphellina rubrolineata O'Donoghue, 1929
(Figure 2H)

Description. Body elongate, pale translucent with some white pigments and three magenta lines longitudinally, one medial and two outer. Cerata long, pointed and tinged with magenta near ends and white tips.

Distribution. Red Sea, and Tropical and subtropical Indo-Pacific (Rudman, 1998; Yonow, 2000). Arabian Sea: Pakistan.

Family Tethydidae Rafinesque, 1815

Melibe japonica Eliot, 1913
(Figure 3)

Description. Body elongate, translucent pink with proportionally large oral hood and broad, flat cerata. Body covered with scattered tiny, white-speckled tubercles of different sizes. Dorsum and cerata bearing brown spots/blotches and rose-pink round tubercles, and a row of yellow-speckled tubercles on distal

margin of cerata. Oral hood also bearing transparent, pointed papillae/tubercles on outer surface.

Distribution and Remarks. This species is known from Western Pacific: Japan, Korea and Eastern Australia (Rudman, 2004), and currently exists as uncertain synonym of *M. viridis* based upon Gosliner & Smith (2003, pg. 324; MolluscaBase, 2018). A detail morphological and anatomical study of *M. japonica*, which is lacking in the scientific literature, and comparison of molecular analysis of the two species can resolve its taxonomic status. This is first record of the genus *Melibe* from Pakistan.

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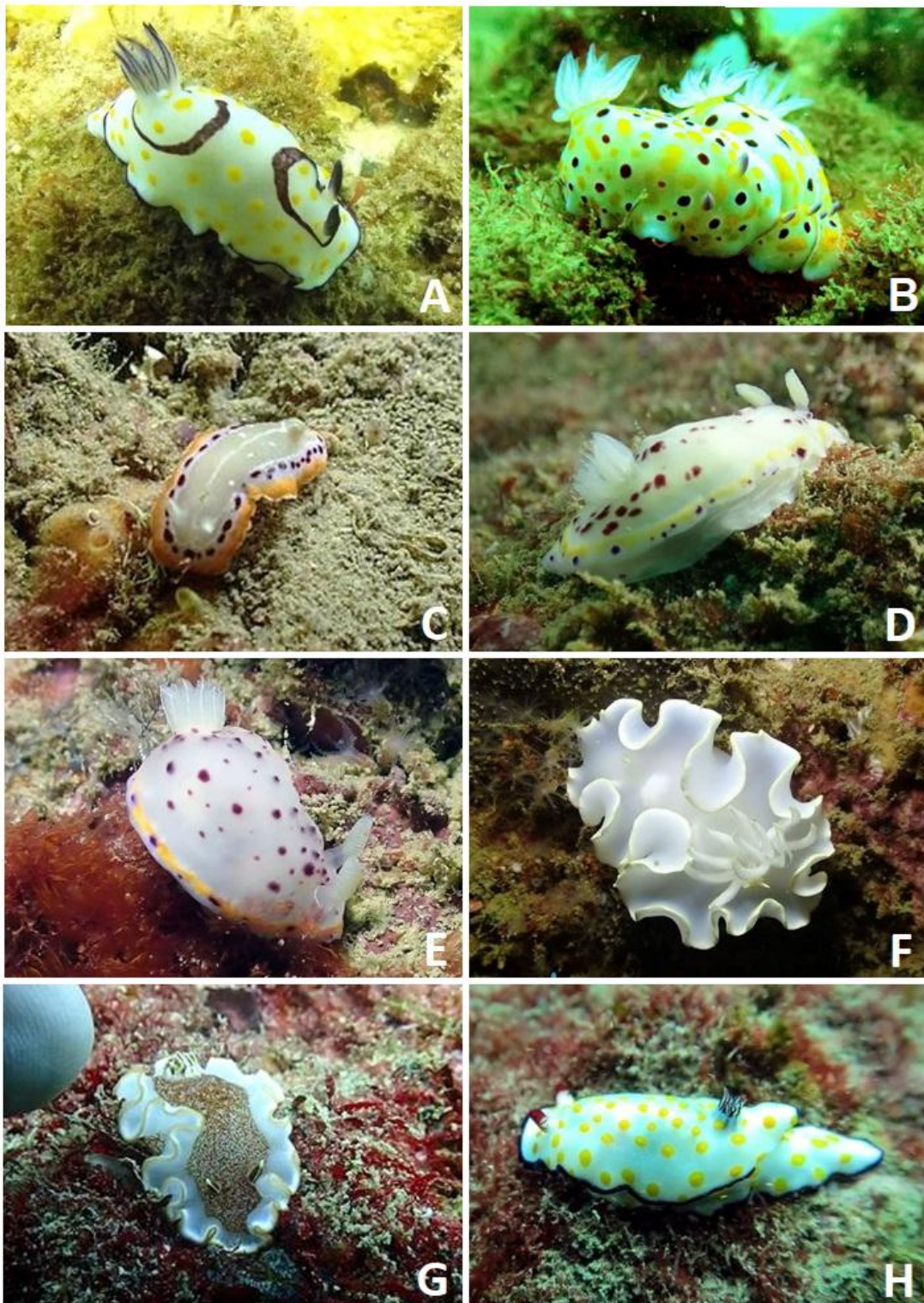


Figure 1. A) *Goniobranchus annulatus*; B) *Goniobranchus cavae*; C) *Goniobranchus decorus*; D, E) *Goniobranchus tumuliferus*; F) *Glossodoris pallida*; G) *Glossodoris rufomarginata*; H) *Hypselodoris ghardaqana*. Photos: A, Karachi Scuba Diving Center; B, Scuba Adventures Pakistan; C, D, E, F, G, Indus Scuba; H, Pakistan Underwater Explorers.

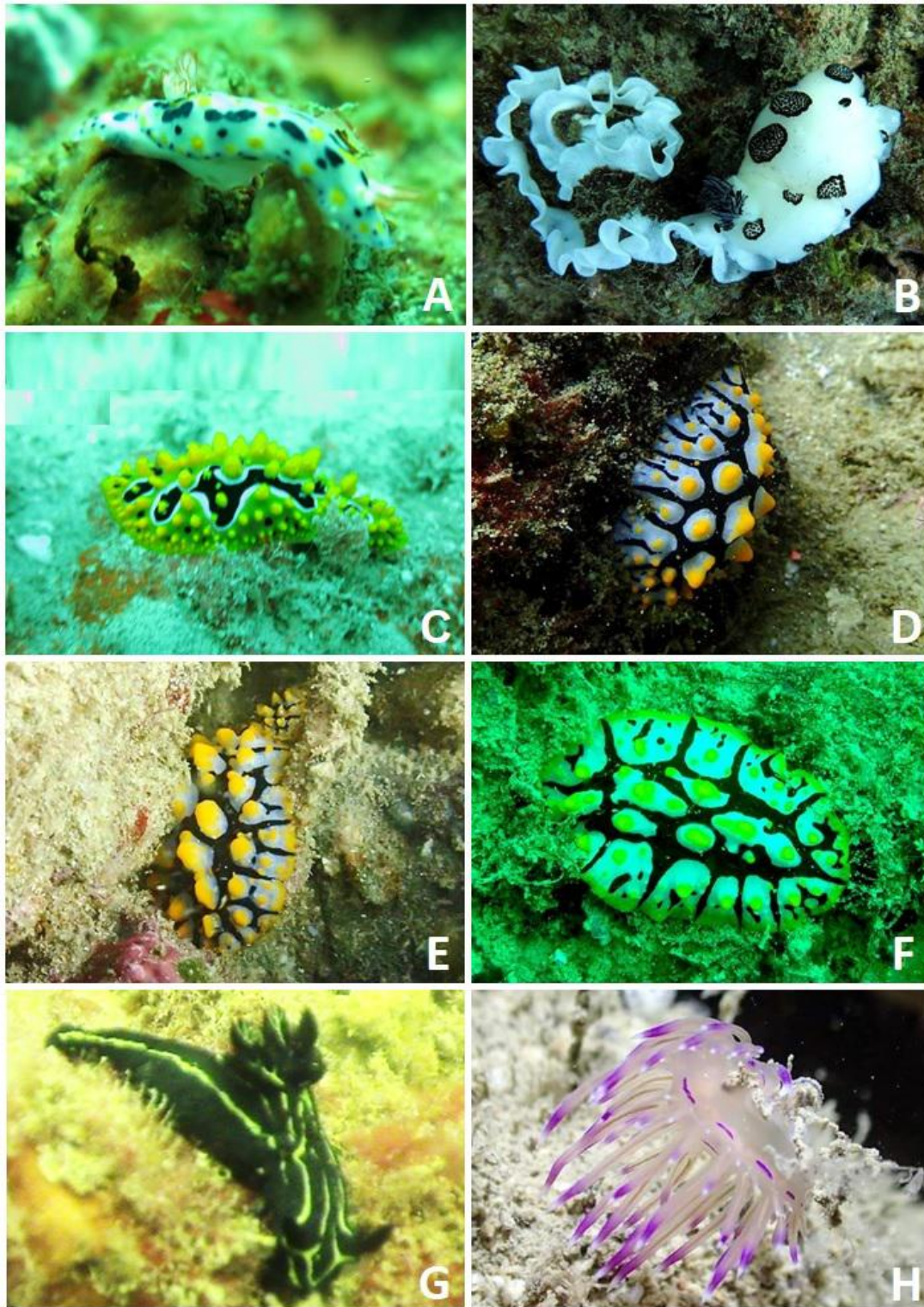


Figure 2. A) *Hypselodoris infucata* B) *Jorunna funebris*; C) *Phyllidia ocellata*; D) *Phyllidia picta*; E, F) *Phyllidia rueppelii*; G) *Tyrannodoris luteolineata*; H) *Coryphellina rubrolineata*. Photos: A, C Scuba Adventures Pakistan; B, D, E, H, Indus Scuba; F, G, Karachi Scuba Diving Centre.



Figure 3. *Melibe japonica* specimen in close up. Photo: Divers Reef Karachi.