

Non-indigenous sea slug *Tenellia adpersa* in the southeast coast of the Arabian Sea, India

Nudibranchs are gastropod molluscs belonging to suborder Opisthobranchia. They are easily identified based on their shell-less bodies and a pair of rhinophores (tentacles) on the dorsal side of the head. These organisms are stunningly colourful, hence are often called ‘butterflies of the ocean’. About 3000 species of Nudibranchs are known globally¹, and 311 species have been reported from India². *Tenellia adpersa* is a tiny nudibranch, commonly known as lagoon sea slug or miniature aeolis. It is a euryhaline aeolid sea slug inhabiting shallow areas from 1 to 34 m depth, and with salinity ranging from 3‰ to 50‰ (ref. 3). Its preferred habitats are estuaries,

brackish water bodies, lagoons and harbours of temperate and tropical regions³. This species was first described by Nordmann⁴ in 1844, based on specimens collected from the Black Sea, Ukraine.

ICAR-Central Marine Fisheries Research Institute (CMFRI), Kochi has been monitoring the benthos in Cochin harbour and the adjacent coastal region from 2010. In the present study, the benthos samples were collected using a sampler (Van Veen Grab) with an area of 0.28 m². The samples (surface layer sediments) were sieved using 2 mm and 500 µm sieves. The benthos retained in the sieves was preserved in 4% buffered formalin stained with Rose Bengal solu-

tion and subsequently identified. During one such investigation, *T. adpersa* was identified on the basis of 17 specimens collected from the bar mouth of Cochin harbour (9°58'N, 76°15'E) at 5 m depth (Figure 1) on 13 September 2013. This is the first record from Indian waters. The collection consisted of juveniles (2.96 mm) and adults (up to 7.80 mm) (Figure 2). Table 1 provides the morphometric details. The benthos sample also contained amphipods, decapod crustaceans, polychaetes (*Nereis* spp., *Malmgrenia* spp.) and Oligochaetes. Table 2 provides the environmental parameters recorded during the sampling period. The specimens have been deposited in the Marine Biodiversity Museum of CMFRI (accession no. DB.1.3.1). It has been reported that *T. adpersa* grows up to 8 mm length and attains maturity at 3.6 mm (ref. 3). Its known longevity is less than one year and it reaches sexually maturity in 20 days (ref. 5). It spawns 3–5 times, with each spawning period lasting for 3–5 days, and lays 25–50 eggs per spawn⁵.

Taxonomical studies on the *T. adpersa* specimens were carried out following Alder and Hancock⁶, and Roginskaya³. This species is known to be pale brown-coloured with tiny black spots.

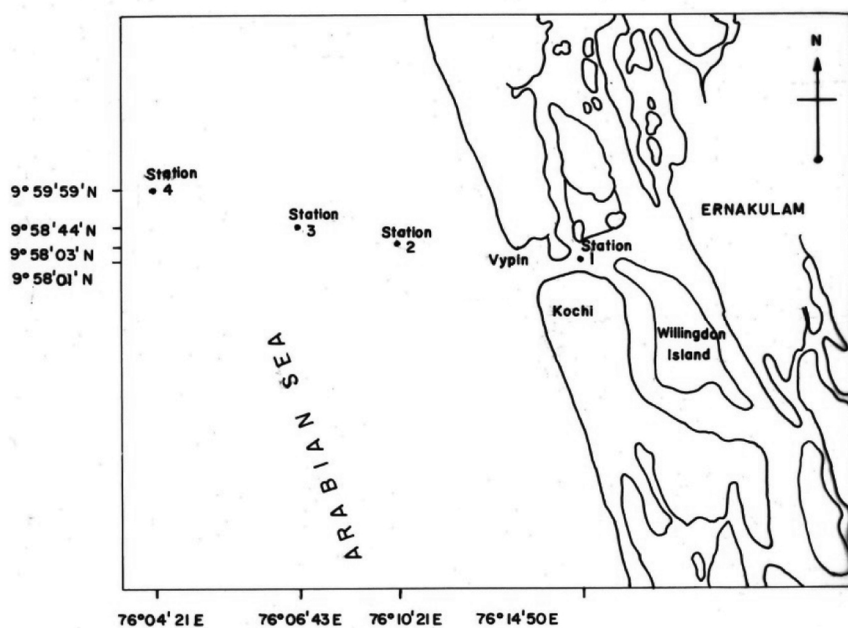


Figure 1. Map showing the sampling point (station-1) at Cochin estuary, Kerala, India.

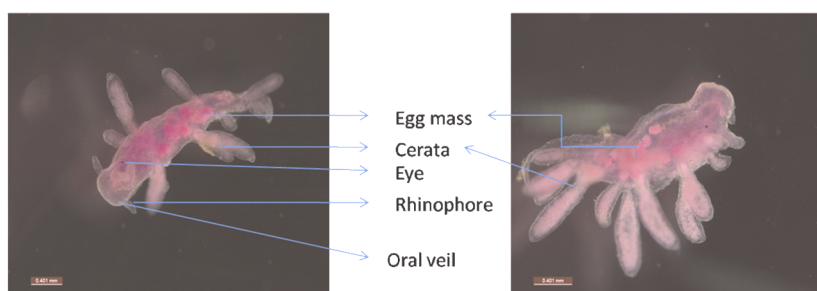


Figure 2. Morphometric characteristics of miniature sea-slug *T. adpersa*.

Table 1. Total length and body width of *Tenellia adpersa* specimens

| Total length (mm) | Body width (mm) |
|-------------------|-----------------|
| 2.96 | 1.16 |
| 3.41 | 1.99 |
| 3.55 | 1.35 |
| 4.13 | 1.85 |
| 4.30 | 2.34 |
| 4.37 | 1.55 |
| 4.44 | 2.18 |
| 5.13 | 2.07 |
| 5.37 | 1.32 |
| 5.46 | 1.96 |
| 5.63 | 2.19 |
| 5.90 | 2.57 |
| 6.37 | 2.74 |
| 6.76 | 2.02 |
| 6.90 | 2.05 |
| 7.07 | 2.39 |
| 7.80 | 2.01 |

However, in the present study the colour of the fresh specimens could not be observed, and identification was based on preserved specimens. It is easily distinguished by its minute slender body tapering behind and two short, cylindrical rhinopores/tentacles or veils on the sides of the head, which serve as chemosensory organs. The tentacle-like dorsal outgrowths called papillae/cerata form 2–6 groups of 1–3 simple cerata each.

T. adpersa is closely associated with hydroids and mainly feeds on them. It mostly prefers to feed on hydroids, *Garveia franciscana*, *Cordylophora caspia*, *Gonothyrea loveni* and *Ectopleura crocea*^{3,7}. Among these, *Garveia franciscana* commonly called rope grass hydroid, has been reported from the Cochin backwaters. Leloup⁸ described *Bimeria franciscana* (a junior synonym of *Garveia franciscana*) for the first time from the west coast of India. Subsequently, Mammen⁹ reported it in large numbers from Cochin, wherein its colonies generally grew up to 15 cm (maximum of 30 cm) and the distance between the branches was 3–10 mm. The rope grass hydroid had been surviving in fresh, brackish and marine water habitats and tolerated salinities varying from 1‰ to 35‰ (ref. 10). It is one of the important prey items for *T. adpersa*¹¹; one *T. adpersa* can devour 100 individuals of *Garveia* species per day³. *Garveia franciscana* provides shelter and habitats to many crustaceans like amphipods, shrimps, crabs and juvenile fishes¹², and is probably helpful in sustaining good fishery. The major impacts of invasive species are the alteration of nutrient cycling, food webs, community structure and shifting of native species^{13,14}. Invasive alien species are the major threats to biodiversity.

To the best of our knowledge, there are no earlier records of this species from the Indian Ocean rim countries. The natural geographical range of the species is from northeastern Atlantic Ocean to the Caspian Sea^{3,7}. More recently, it has been introduced into New Zealand (Table 3). It has also been introduced to the several Pacific Ocean countries through ballast water of ships³. Ballast water is stored in ballast tanks located at the bottom chamber of empty cargo ships to maintain buoyancy. When these ships enter the next port of call to load cargo, the ballast water is discharged. Microscopic marine animals (zooplankton, nekton)

and plants (phytoplankton) are transported along with the ballast water to new biogeographical areas, where they become marine pests. Similarly, benthos may unintentionally enter the ballast tank. Cochin backwater is a tropical estuary along the southwest coast of India, in which the Cochin harbour is situated. The bar mouth of the Cochin estuary is the main entrance of the Cochin harbour and is permanently connected to the Arabian Sea. Cochin port is

a major international transshipment terminal and latest statistics has revealed that it handled 1430 vessels during the year 2013–14 and 1476 vessels in 2014–15 (ref. 15). The intensive international shipping activity could have triggered the invasion of *T. adpersa*. Ship hulls contain several fouling organisms, including hydroids. The adult *T. adpersa* might have got attached to the hydroids on the surface of the ship hull and then transported to Cochin. Another possibility is

Table 2. Hydrological characteristics observed at the sampling site

| Observed parameters | Surface | Bottom |
|--|---------|--------|
| Water temperature (°C) | 29 | 26.2 |
| pH | 6.78 | 7.47 |
| Salinity (PSU) | 4.62 | 31.9 |
| Chlorophyll <i>a</i> (mg m ⁻³) | 1.364 | 0.929 |
| Chlorophyll <i>b</i> (mg m ⁻³) | 0.031 | 0.000 |
| Chlorophyll <i>c</i> (mg m ⁻³) | 0.213 | 0.000 |
| Dissolved oxygen (mg l ⁻¹) | 5.82 | 3.28 |
| SiO ₃ -Si (mg l ⁻¹) | 2.74 | 0.05 |
| PO ₄ -P (mg l ⁻¹) | 0.040 | 0.045 |
| NO ₃ -N (mg l ⁻¹) | 0.002 | 0.000 |
| NO ₂ -N (mg l ⁻¹) | 0.003 | 0.007 |
| Total NH ₃ -N (mg l ⁻¹) | 0.013 | 0.252 |
| GPP (mg C L ⁻¹ h ⁻¹) | 0.038 | – |
| NPP (mg C L ⁻¹ h ⁻¹) | 0.059 | – |

GPP, Gross Primary Productivity; NPP, Net Primary Productivity.

Table 3. First records of *Tenellia adpersa* reported in different countries

| <i>Tenellia adpersa</i> /synonym | Year | Country name | Reference |
|----------------------------------|------|---------------------|-----------|
| <i>Tergipes edwardsii</i> | 1846 | Ukraine | 4 |
| <i>Tergipes lacinulatus</i> | 1849 | Germany | 18 |
| <i>Embletonia pallida</i> | 1881 | Finland | 19 |
| <i>Embletonia pallida</i> | 1907 | Russia | 20 |
| <i>Embletonia pallida</i> | 1907 | Sweden | 20 |
| <i>Embletonia pallida</i> | 1910 | England | 21 |
| <i>Embletonia pallida</i> | 1926 | France | 22 |
| <i>Tenellia pallida</i> | 1944 | Denmark | 23 |
| <i>Embletonia mediterranea</i> | 1953 | Brazil | 24 |
| <i>Tenellia ventilabrum</i> | 1953 | Atlantic Ocean | 25 |
| <i>Embletonia pallida</i> | 1955 | Mediterranean | 26 |
| <i>Embletonia pallida</i> | 1960 | Brazil | 27 |
| <i>Tenellia pallida</i> | 1963 | Japan | 28 |
| <i>Tenellia adpersa</i> | 1970 | Russia | 3 |
| <i>Tenellia adpersa</i> | 1972 | East coast of USA | 29 |
| <i>Tenellia adpersa</i> | 1979 | West coast of USA | 30 |
| <i>Tenellia pallida</i> | 1979 | South Carolina, USA | 31 |
| <i>Tenellia adpersa</i> | 1990 | Russia | 32 |
| <i>Tenellia adpersa</i> | 1996 | Australia | 33 |
| <i>Tenellia adpersa</i> | 2001 | New Zealand | 34 |
| <i>Tenellia adpersa</i> | 2005 | The Netherlands | 35 |
| <i>Tenellia adpersa</i> | 2006 | Hong Kong | 36 |
| <i>Tenellia adpersa</i> | 2013 | Norway | 37 |

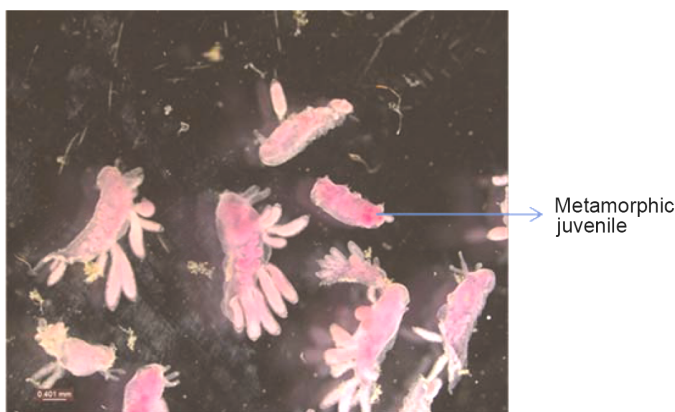


Figure 3. Juvenile and adult specimens of *T. adpersa*.

the transport of egg masses of *T. adpersa* discharged through ballast water, which might have developed into adults. This is corroborated by the occurrence of juveniles as well as adult stages (Figure 3). During the monsoon months (June–September), the Cochin estuary salinity gradients are very low¹⁶, which might have favoured *T. adpersa* development and survival. India is one of the signatories to the Convention on Biological Diversity (CBD)¹⁷. Article 8(h) of the CBD states that, ‘Each contracting Party shall, as far as possible and as appropriate, prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species’. Therefore, continuous monitoring of harbours/ports is essential to prevent the invasion of non-indigenous species.

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