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SHORT COMMUNICATIONS

Report on the association of valviferan isopod *Synidotea variegata* Collinge 1917 and regular sea urchin *Stomopneustes variolaris* Lamarck, 1816 from rocky subtidal regions of Vizhinjam, southwest coast of India

Aneena Yesudas[1] · P. R. Jayachandran[1] · Usha V. Parameswaran[2] · D. Vidyalakshmi[1] · P. Priyaja[1]

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Abstract
Association of the idoteid isopod, *Synidotea variegata* Collinge 1917 with the echinoid sea urchin, *Stomopneustes variolaris* Lamarck, 1816 is reported for the first time from the rocky subtidal region of Vizhinjam coast, southwestern India. Isopods infested the spines and peristome of sea urchins and the intensity of infection increased with the increasing test diameter of the host.

Keywords Association · Isopod · Sea urchin · Kerala · India

1 Introduction

The order Isopoda is a highly diverse group of crustaceans that dwell in a large variety of habitats ranging from the desert to the deep-sea with a wide bathymetric range in the marine realm. They tend to exhibit a wide diversity in body shapes and sizes (Schram 1986; Brusca and Wilson 1991). In the marine realm, they are mostly free-living and found in or on sediments. They display a variety of feeding habitats including detritivores, browsers, carnivores, parasites and filter feeders and exhibit one or more feeding niches (Poore and Bruce 2012). Members of the family Idoteidae generally inhabit in the rocky intertidal coasts around the world. Among these, genus *Calidotea* Richardson, 1899 and *Edotia* Guérin-Méneville, 1843 commonly show an association with echinoderms (Carrasco et al. 2012; Zaixso et al. 2009), while some members of these genera typically reside on brown algae (Stebbins 1989) and molluscs (Gray et al. 1997).

✉ P. Priyaja
priyaja59@gmail.com

[1] Department of Marine Biology, Microbiology and Biochemistry, Cochin University of Science and Technology, Kochi, Kerala 682 016, India

[2] Centre for Marine Living Resources and Ecology, Ministry of Earth Sciences, Kochi, Kerala 682 508, India

Sea urchin species are known to be important ecosystem engineers due to its rock-boring activity and role as active bio-eroders (Chazottes et al. 2004; Glynn and Manzello 2015). Some members in the sea urchin family such as Stomopneustidae excavate pits in the sedimentary rocks into which their body can fit (Asgaard and Bromley 2008; Santos et al. 2015; Yamamori and Kato 2017). Accordingly, they can transform natural rocky substrates into urchin pits, a prominent habitat for a variety of marine organisms like molluscs, crustaceans, sponges, echinoderms and fishes (Ayyagari and Kondamudi 2014a, b; Bronstein and Loya 2015; Britayev et al. 2019). The spines of the sea urchins also offer refuge to associated organisms from their predators. There are few reports on the infestation patterns of sea urchin by endosymbionts (Wells 2013) as well as ectosymbionts (Britayev et al. 2013: Maran et al. 2017). The species *Stomopneustes variolaris* Lamarck, 1816 is an edible sea urchin with a wide distribution in the Indo-west Pacific region (Giese et al. 1964; James 2008; Jayakody 2012). This species is also known to offer refuge to a large array of marine invertebrates (Ayyagari and Kondamudi 2014a, 2014b). This paper reports for the first time an association of valviferan isopod *Synidotea variegata* Collinge, 1917 with the regular echinoid sea urchin, *Stomopneustes variolaris* from the subtidal regions of Vizhinjam coast of southwestern India along with notes on its ecological significance.

2 Materials and methods

Live sea urchins were hand-picked through SCUBA diving from the subtidal rocky shores of Vizhinjam coast (8°22′ 51.6”N, 76°58′59.5″E) at 5 m depth during May 2019 (Fig. 1). Physicochemical parameters of water samples were measured in the field. Water temperature was measured using a mercury thermometer (±0.5 °C ± 1 digit). The conductivity, pH (±0.01 pH ±1 digit), and salinity (±2% of FS ±1 digit) were analyzed using a portable water analyzer (PCS Tester 35, Eutech). The dissolved oxygen concentration was analysed following standard procedures of Winkler (1888).

For the identification of sea urchins, all spines were removed and test diameter was measured along ambitus using a vernier caliper. Sea urchins were identified following the keys of Clark and Rowe (1971). The firmly attached isopods were observed on 11 individuals among the collected sea urchins and they were carefully separated using a tweezer and preserved in 5% formalin prepared in seawater. The enumeration and identification of the isopod specimens were carried out using standard keys and references (Collinge 1917). The images of the specimen were taken using a microscope camera (Model CatCam300) attached to a stereomicroscope (Model: Magnus MSZ Bi). Images of sea urchin were taken using a digital camera. All the specimens were deposited in the museum collections of the Department of Marine Biology, Microbiology and Biochemistry, CUSAT, Kochi, India (MBM/PP/AN/01/2020).

3 Results

3.1 Field observations

Water temperature, salinity, pH and dissolved oxygen of the sampling location were measured as 29 °C, 35.45 psu, 8.06 and 5.4 ml L^{-1} respectively. In total, 11 individuals of sea urchins were collected and all were observed to be infested by isopods. Approximately 185 individual isopods were collected from 11 sea urchins. The intensity of infection by isopods was found to be gradually increasing with the test diameter of sea urchins (5 to 6.5 cm) (Fig. 3). The highest number of isopods (23 individuals) was noticed on sea urchin test with the widest diameter (6.5 cm) and the lowest number of isopod individuals on test with the shortest diameter (5 cm).

The sea urchin collected was identified as *Stomopneustes variolaris* Lamarck, 1816, commonly known as black sea urchin or long-spined sea urchin. This species is widely distributed in the Indo-west Pacific regions with high abundance in shallow rocky shores. This is the only species described under the genus *Stomopneustes* and also it is the only extant species under

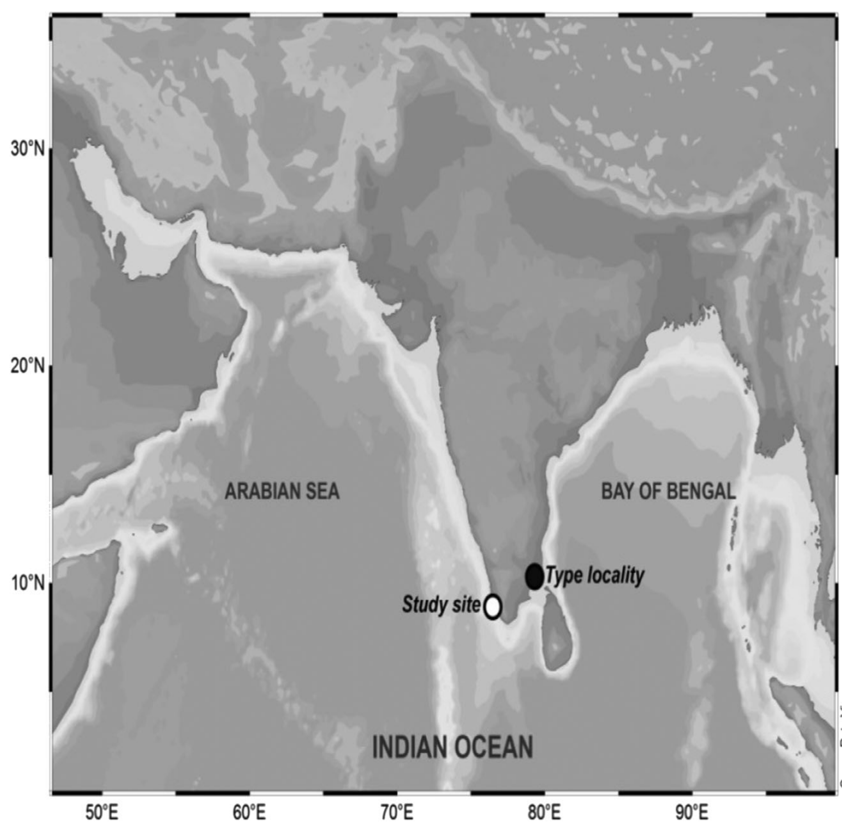

Fig. 1 Study area. White circle represents the study site (Vizhinjam coast) and black circle represents type locality of *S. variegata* (Gulf of Mannar)

family Stomopneustidae (Kroh and Smith 2010). The species identity is confirmed by the doubly compound ambulacral plates, the imperforate and non-crenulate primary tubercles and by the absence of a complete bridge across the upper end of the pyramids constituting the Aristotle's lantern. The specimen is characterized by rigid ovoid test usually covered by erect bristling solid spines. The valviferan ectosymbionts of species, *Synidotea variegata* Collinge, 1917 which were found living in close association with the urchins (Fig. 2) are described below.

3.2 Description of the Symbiont

SYSTEMATICS

Order: Isopoda Latreille, 1817

Suborder: Valvifera Sars, 1882

Family: Idoteidae Samouelle, 1819

Genus: *Synidotea* Harger, 1878

Synidotea variegata Collinge, 1917

Synidotea variegata Collinge, 1917, p.2, pl.1, Figs. 1–10; Monod, 1934, p.6, pls.l & 3; Barnard, 1936, p.185; 1940, p.428; Nierstrasz, I941,p. 278; Pillai, 1954, p.17; nec, *Synidotea variegata* Chilton, 1924, p.891. Pillai, 1963, p.102, Figs. 1 A-G.

Type locality:

Coral reefs of Kilakarai, Ramnad District [Kilakarai, Ramanathapuram district, Tamil Nadu, India].

Distribution:

India (common along the intertidal rocky shores of Kerala and Tamil Nadu coast), Sri Lanka, Indo-china, Suez Canal, Natal, South Africa.

Material examined:

185 isopods collected from 11 sea urchin from the Vizhinjam coast, south-west coast of India (Fig. 2a-c).

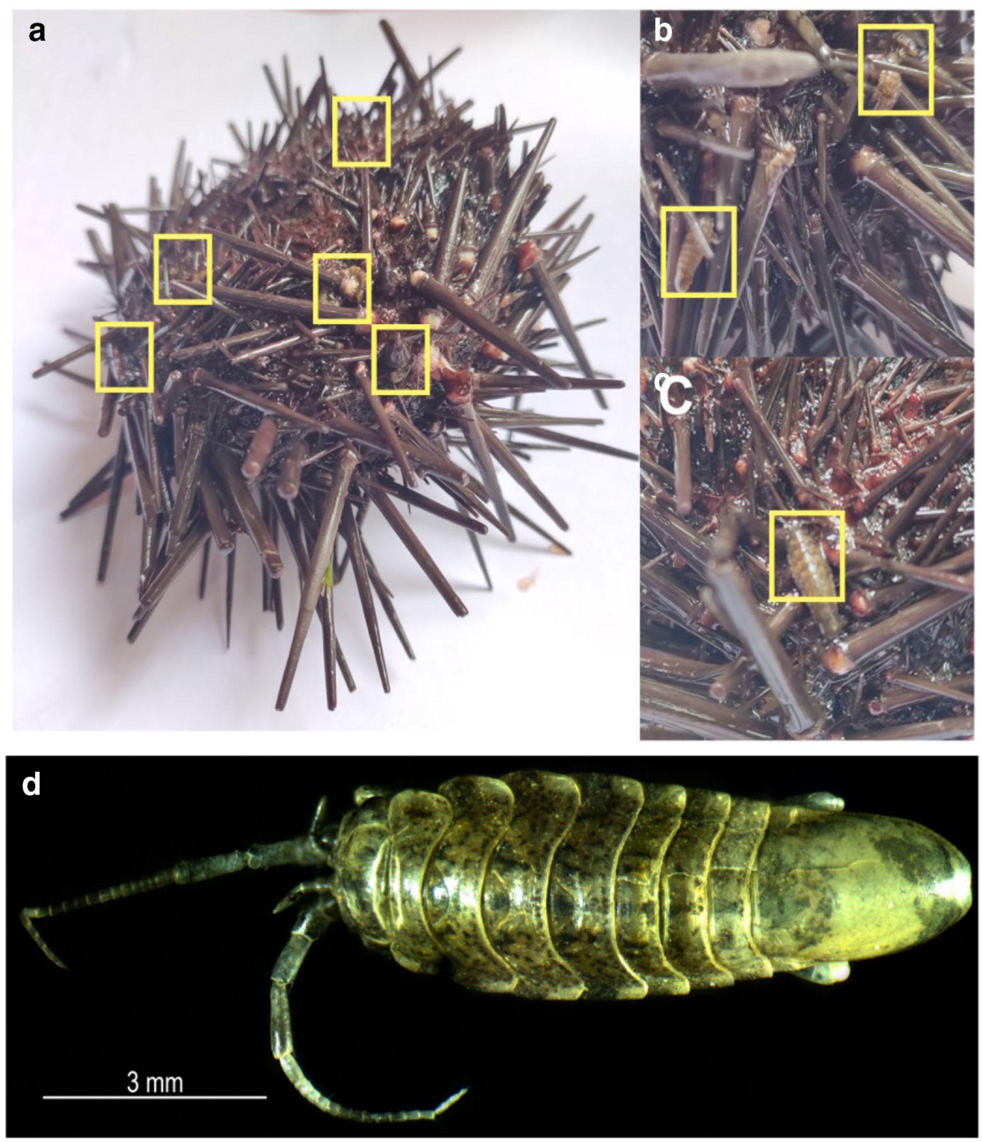

Fig. 2 **a-c** Association of isopod *S.variegata* on sea urchin *S.variolaris*, yellow box showing the isopod on urchin. **d.** Individual specimen of *S. variegata* (Original, Scale bar: 3 mm)

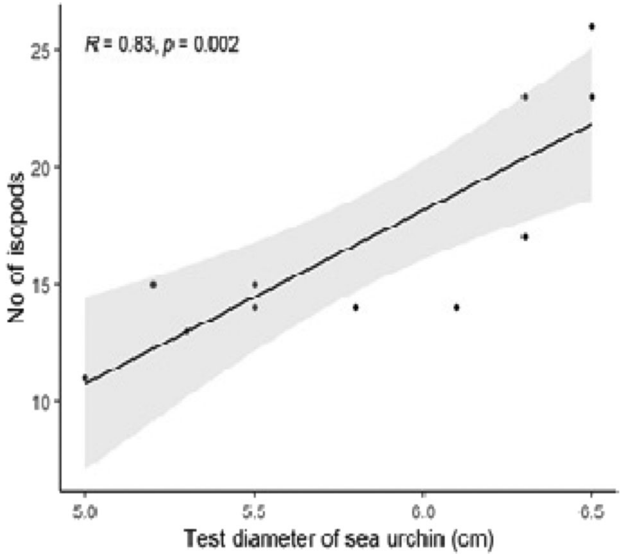

Fig. 3 The relationship between the test diameter of *S. variolaris* and the number isopods *S. variegata* associated with sea urchin (where $n = 11$)

Description:

Body elongate oblong; 2.8 times as long as wide, head is wider than long; frontal margin straight; Perionite 1 lateral margin is straight, approximately 0.8 times as wide as pereionite 2; perionite 2 to 4 are broad and wider; perionite 5 to 7 gradually narrow down. Lateral margin perionite 2 to 7 rounded, eyes large and oval, approximately 0.6 times as long as median head length, bulging laterally. Pleotelson approximately 1.6 times as long as wide with narrow rounded apex. Color golden-yellow in formalin preserved specimens. First 4 perionite with prominent dorso-median arcuate depressions present in the anterior side. The first joint of antennula is expanded, second and third are short and wide, and subequal; flagellum length is 2.5 times longer than last peduncular joint, setae present in bunches. Antennae 1st and 2nd joints subequal, together with equal to the 3rd, 4th rather longer and narrower, 5th half again as long as the 4th; flagellum with 21 articles. Maxillula having outer lobe with 8 denticulate spines, in the inner lobe terminally it has 2 long setose spines and a small setule. Maxillipede is short and wide, palp 3 jointed, basal plate short but prolonged on the inner margin anteriorly, epipodite broad and excavate on the posterior margin, distal inner lobe rounded terminally. Segments of the mesosome 2–4 subequal, 5–7 somewhat shorter, pleural plates of the 1st segment with anterior and posterior angles rounded, in 2–4 anterior angle is produced forward a little and posterior angle rounded, 5–7 truncate, coxal plates not present on the dorsal side. In the middorsal line of segments 2–4 is an arcuate depression towards the anterior margin, thoracic appendages 2–4 small and directed forwards, 5–8 larger and directed narrow lateral structures indicating a further coalesced segment terminal segment with straight lateral margins gradually narrowing posteriorly, posterior margin bluntly rounded with a small median notch, dorsal surface very faintly keeled. Uropod having lateral margins almost straight, excepting at the hinge, rounded anteriorly and setose on the inner margin, on the outer posterior margin is a small denticulate spine; endopodite with straight inner margin and cutaway on the outer side.

4 Discussion

In the present study the association of the isopod, *Synidotea variegata* Collinge, 1917 were noticed with a single species of sea urchin, *Stomopneustes variolaris* Lamarck, 1816. Isopods as a group have established themselves successfully in diverse environments and they have radiated from a free-living marine ancestor to inhabit a variety of habitats and display different lifestyles (Poulin 1995). Since they have poor displacement abilities and are highly vulnerable to predators, they often associate themselves with marine flora and fauna for their protection from predators. Association of isopods been reported with sponges, shrimps, chiton, sea-anemones, bryozoans, barnacles, polychaetes worms and other isopods (Giambiagi 1925; Shen 1929; Pearse 1932; Menzies 1951; Glynn and Manzello 2015).

Symbiotic association of isopods with echinoderms has been reported by Stebbins (1989), who made a detailed study on the commensal *Colidotea rostrata* Benedict, 1898 an idoteid living on and mimicking the color of two northeastern Pacific sea urchins, *Strongylocentrotus purpuratus* Stimpson, 1857 and *Strongylocentrotus franciscanus* Agassiz, 1863. Menzies and Miller (1955) reported the asellote, *Antias unirameus* Menzies, 1951 living in the pits on the skin of the sea cucumber *Stichopus mollis* Hutton, 1872. Potts (1915) observed the association of *Cirolana lineata* Potts, 1915 with the feather star, *Comanthus annulatum* Bell, 1884 from the Torres Strait. Other isopod associates within the echinoderms include the sphaeromid *Exosphaeroma nuttingi* Boone, 1921, collected from the spines of an unidentified sea urchin in Barbados (Boone 1921).

The present study describes a new association between isopod species *Svnidotea variegata* and sea urchin *Stomopneustes variolaris* from the subtidal region of south-west coast of India. It is observed that the intensity of infection by isopod individuals increases with the increasing test diameter of the sea urchins, as reported for polychaetes associated with the same sea urchin by Ayyagari and Kondamudi (2014a).

Nearly all idoteids are common inhabitants of rocky coasts worldwide and show cryptic colouration. The symbionts living on and mimicking the colour of sea urchin might exploit the microhabitat offered by the host (Lee and Miller 1980; Brusca 1984). The well-defined physical defense system of sea urchins (test, spines, pedicellariae) makes them a suitable shelter for other organisms (Baeza and Thiel 2000; Ruppert et al. 2004). As the idoteid *Svnidotea variegata* is a scavenger (Sarma 1974), the symbionts may be taking advantage of feeding currents of the sea urchin or other organic matter settling on the host to obtain food. The brown colour of isopod renders them well camouflaged among the spines of the host urchin.

This newly discovered association warrants further consideration since the boundary among mutualism, commensalism and parasitism is often difficult to identify without proper knowledge. Some idoteids are reported to be commensal or parasitic with marine invertebrates: *Colidotea rostrata,* a sea urchin-dwelling isopod from southern California (Stebbins 1988) and *Edotia doellojuradoi* Giambiagi, 1925 a mussel-dwelling from Argentinean Patagonia and southern Chile (Zaixso et al. 2009). Multi-host use patterns have also been reported in idotied isopods, such as *Edotia magellanica* associated with the bivalves *Mytilus chilensis* (Jaramillo et al. 1981) and *Mulina edulis* (González and Jaramillo 1991) and *E. doellojuradoi* with their hosts, *Mytilus edulis platensis* (Zaixso et al. 2009) and *Mytilus chilensis* (Gray et al. 1997). These ambiguities not withstanding, the present paper reports for the first time an association of the isopod *Synidotea variegata* Collinge, 1917 with the sea urchin *Stomopneustes variolaris* Lamarck, 1816 based on collections from the Vizhinjam coast, southwestern India.

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Code availability Not applicable.

Authors' contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by AneenaYesudas, Jayachandran P. R., Usha V. Parameswaran, Vidyalakshmi D. and Priyaja P. The first draft of the manuscript was written by AneenaYesudas and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability All data generated or analysed during this study are included in this published article.

Declarations

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

Conflicts of interest/competing interests All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

References

Asgaard U, Bromley RG (2008) Echinometrid Sea urchins, their trophic styles and corresponding bioerosion. In: Wisshak M, Tapanila L (eds) Current developments in bioerosion. Erlangen Earth Conference Series. Springer, Berlin, Heidelberg, pp 279–303. https://doi.org/10.1007/978-3-540-77598-0_15

Ayyagari A, Kondamudi RB (2014a) Ecological significance of the association between *Stomopneustes variolaris* (Echinoidea) and *Lumbrineris latreilli* (Polychaeta) from Visakhapatnam coast. India Mar Biol 2014:1–4. https://doi.org/10.1155/2014/640785

Ayyagari A, Kondamudi RB (2014b) Symbiotic association between *Athanas dorsalis* (Alpheidae) and *Stomopneustes variolaris* (Echinoidea) from Visakhapatnam coast, India. Am J Mar Sci 2(3):47–50 http://pubs.sciepub.com/marine/2/3/1

Baeza JA, Thiel M (2000) Host use pattern and life history of *Liopetrolisthes mitra*, a crab associate of the black sea urchin *Tetrapygus niger*. J Mar Biol Assoc UK 80(4):639–645

Benedict JE (1898) Two new isopods of the genus Idothea from the coast of California. Proc Biol Soc Wash 12:53–55

Boone PL (1921) Report on the Tanidacea and Isopoda collected by the Barbados-Antiqua Expedition from the University of Iowa in 1918. University of Iowa Studies in Natural History. 95:91–98

Britayev TA, Bratova OA, Dgebuadze PY (2013) Symbiotic assemblage associated with the tropical sea urchin, *Salmacis bicolor* (Echinoidea:Temnopleuridae) in the an Thoi archipelago. Symbiosis 61:155–161. https://doi.org/10.1007/s13199-013-0263-x

Britayev TA, Bratova O, Mekhova ES, Chernyshev AV (2019) The first record of symbiosis between a palaeonemertean (Nemertea) and echinoderms (Echinodermata). Symbiosis 78(2):135–139. https://doi.org/10.1007/s13199-018-00588-x

Bronstein O, Loya Y (2015) Photoperiod, temperature, and food availability as drivers of the annual reproductive cycle of the sea urchin *Echinometra* sp. from the Gulf of Aqaba (Red Sea). Coral Reefs 34(1):275–289

Brusca RC (1984) Phylogeny, evolution and biogeography of the marine isopod subfamily Idoteinae (Crustacea: Isopoda: Idoteidae). San Diego Soc Nat Hist 20:99–134

Brusca RC, Wilson GDF (1991) A phylogenetic analysis of the Isopoda with some classificatory recommendations. Mem Qnslnd Museum 31:143–204

Carrasco SA, Cerda O, Cifuentes M (2012) New insights into the life-history of the isopod *Edotia dahli* (Valvifera: Idoteidae): report of host-use and distribution records in the central Chilean coast. Rev Biol Mar Oceanogr 47(2):339–343. https://doi.org/10.4067/S0718-19572012000200016

Chazottes V, Chevillotte V, Dufresne A (2004) Caractérisation de la production particulaire par l'oursin *Echinometra mathaei* sur les résifs Indo-Pacifiques: influence des peuplements coralliens et implications sur la dynamique sédimentaire. Geobios 37(1):13–22. https://doi.org/10.1016/j.geobios.2003.01.008

Clark AM, Rowe FEW (1971) Monograph of shallow-water indo-West Pacific echinoderms. Trust Br Mus (Nat Hist) 690:1–238

Collinge WE (1917) Description of a new species of Isopoda of the genus Synidotea, Harger, from the Gulf of Mannar. Records of the Indian Museum 13:1–3

Giambiagi DC (1925) Resultado de la primera expedición a Tierra del Fuego (1921). Enviada por la Facultad de Ciencias Exactas, Físicas y Naturales de la Universidad Nacional de Buenos Aires. Crustáceos, Isópodos. Anales Soc Ci Argent 1925: 229–246

Giese AC, Krishnaswamy S, Vasu BS, Lawrence J (1964) Reproductive and biochemical studies on a sea urchin, *Stomopneustes variolaris,* from Madras Harbor. Comp Biochem Physiol 13(4):367–380

Glynn PW, Manzello DP (2015) Bioerosion and coral reef growth: a dynamic balance. In: Birkeland C (ed) Coral reefs in the Anthropocene. Springer, Dordrecht, pp 67–97. https://doi.org/10.1007/978-94-017-7249-5_4

González M, Jaramillo ED (1991) The association between *Mulinia edulis* (Mollusca, Bivalvia) and *Edotea magellanica* (Crustacea, Isopoda) in southern Chile. Rev Chil Hist Nat 64:37–51

Gray JS (1997) Gradients in marine biodiversity. In: Ormond RF, Gage JD, Angel MV (eds) Marine biodiversity: patterns and processes. Cambridge University Press, Cambridge, pp 18–34

Gray AP, Richardson CA, Seed R (1997) Ecological relationships between the Valviferan isopod *Edotia doellojuradoi* Giambiagi, 1925, and its host *Mytilus edulis chilensis* in the Falkland Islands. Estuar Coast Shelf Sci 44(2):231–239. https://doi.org/10.1006/ecss.1996.9999

James DB (2008) Indian echinoderms their resources biodiversity zoogeography and conservation. Glim Aqu Biol 7:120–132

Jaramillo E, Navarro J, Winter J (1981) The association between *Mytilus chilensis* Hupe (Bivalvia, Mytilidae) and *Edotea magellanica* Cunningham (Isopoda, Valvifera) in southern Chile. Biol Bull 160(1):107–113. https://doi.org/10.2307/1540904

Jayakody S (2012) Provisional checklist of sea urchins (Echinodermata: Echinoidea) of Sri Lanka. In: Weerakoon DK, Wijesundra S (eds) the National red List 2012 of Sri Lanka. Conservation Status of the Fauna and Flora. Ministry of Environment, Colombo, Sri Lanka, pp 370–372

Kroh A, Smith AB (2010) The phylogeny and classification of post-Palaeozoic echinoids. J Syst Palaeontol 8:147–212. https://doi.org/10.1080/14772011003603556

Lee WL, Miller MA (1980) Isopoda and Tanaidacea: the isopods and allies. In: Morris RH, Abbott DP, Haderlie EC (eds) Intertidal invertebrates of California. Stanford University Press, Stanford, pp 536–558

Maran BAV, Kim I-H, Bratova OA, Ivanenko VN (2017) Two new species of poecilostomatoid copepods symbiotic on the venomous echinoid *Toxopneustes pileolus* (Lamarck) (Echinodermata) from Vietnam. Syst Parasitol 94:227–241

Menzies RJ (1951) A new genus and new species of asellote isopod, *Caecijaera horvathi,* from Los Angeles-Long Beach Harbor. Am Mus Novit 1542:1–7

Menzies RJ, Miller MA (1955) Marine asellote isopods of the genus Antias with the description of a new species from New Zealand. Trans Proc R Soc N Z 83(2):383–389

Pearse AS (1932) Inhabitants of certain spollges at Dry Tortugas. Carnegie Inst Wash Publ 435:117–124

Potts FA (1915) The fauna associated with the crinoids of a tropical coral reef: with especial reference to its colour variations. Papers from the Department of Marine Biology of the Carnegie Institution of Washington 8:71–96

Poore GCB, Bruce NL (2012) Global diversity of marine isopods (except asellota and crustacean symbionts). PLoS One 7:e43529

Poulin R (1995) Evolutionary influences on body size in free-living and parasitic isopods. Biol J Linn Soc 54(3):231–244

Ruppert EE, Fox RS, Barnes RD (2004) Invertebrate zoology: a functional evolutionary approach, 7th edn. Thomson-Brooks/Cole, Belmont, p 905

Santos A, Mayoral E, Dumont CP, da Silva CM, Ávila SP, Baarli BG, Ramalho RS (2015) Role of environmental change in rock-boring echinoid trace fossils. Palaeogeogr Palaeoclimatol Palaeoecol 432: 1–14

Sarma AL (1974) Phytal fauna of *Caelerpa taxifolia* and *C. racemosa* off Visakhapatnam coast. Indian J mar Sci 3(2):155–164

Schram F (1986) Remipedia. Part 1. Systematics. San Diego Society of Natural History Memoir. 15: 4-60. Sci bull 47:367–372

Shen CJ (1929) Description of a new isopod, *Dynoides dentisinus,* from the coast of North China. Bull Fan Mem lnst Bio 1:65–75

Stebbins TD (1988) Observation and experiments on the natural history and behavior of the commensal isopod *Colidotea rostrata* (Benedict, 1898) (Isopoda: Idoteidae). J Crustac Biol 8(4):539–547

Stebbins TD (1989) Population dynamics and reproductive biology of the commensal isopod *Colidotea rostrata* (Crustacea: Isopoda: Idoteidae). Mar Biol 101(3):329–337

Stimpson W (1857) On the Crustacea and Echinodermata of the Pacific shores of North America. Boston J. Nat. Hist 6:444–532, Plates 18-23

Wells PG (2013) Observing the entocommensal ciliate fauna of sea urchins, *Strongylocentrotus spp* an exercise that illustrates the wonders of symbiosis Symbiosis 60: 45–47. https://doi.org/10.1007/s13199-013-0238-y

Winkler LW (1888) The determination of dissolved oxygen in water. Berlin Deut Chem Gas 21:2843–2855

Yamamori L, Kato M (2017) The macrobenthic community in intertidal sea urchin pits and an obligate inquilinism of a limpet-shaped trochis gastropod in the pits. Mar Biol 164(3):61

Zaixso HE, Stoyanoff PD, Gil G (2009) Detrimental effects of the isopod, *Edotia doellojuradoi,* on gill morphology and host condition of the mussel, *Mytilus edulis platensis*. Mar Biol 156:2369–2378. https://doi.org/10.1007/s00227-009-1265-3