Four New Records of *Astropecten* Seastar (Asteroidea: Astropectinidae) from Brunei

David J.W. Lane[1] and David J. Marshall[2]*

[1]Lee Kong Chian Natural History Museum, Faculty of Science, National University of Singapore, 2 Conservatory Drive, Singapore 117377
[2]Environmental and Life Sciences Programme, Faculty of Science, Universiti Brunei Darussalam, Jalan Tungku Link, BE1410, Brunei Darussalam

**corresponding author email: david_jwlane@hotmail.com*

Abstract

Establishing definitive regional species records is crucial to understand how marine faunas change under anthropogenic stresses. Other than reef corals, the marine invertebrate species diversity of Brunei Darussalam and in fact the entire Palawan-North Borneo ecoregion is relatively poorly known. The present study reports the first records of the occurrence of four species of the seastar genus, *Astropecten,* from muddy/sandy, intertidal and benthic ecosystems in Brunei. We briefly describe the species, showing key distinguishing features, and discuss their distributions in modified coastal ecosystems and natural embayments in Brunei. Finally we discuss the geographical distributions of these species within the South China Sea and elsewhere.

Index Terms: Asteroidea, biodiversity, Brunei Darussalam, South China Sea

1. Introduction

Brunei falls within the megadiverse Indo-Pacific seas and Indian Ocean biogeographic realm, which, for all marine taxa, has a high specific endemicity (31%).[1] Regionally, the country lies at the centre of the Palawan/North Borneo (PNB) ecoregion, which extends along the north-west Bornean seafront, including Sarawak and Sabah (Malaysia) to Palawan (the Philippines),[2-3] and differs faunistically from the other described ecoregions of the South China Sea (SCS).[2] Despite its unique contemporary fauna, contributed by interconnection with the southerly diversity hotspot, the Western Coral Triangle province,[2] and the northerly SCS ecoregions (Vietnam and China)[2] via the Sunda shelf peripheral current system, the marine faunal diversity of Brunei other than reef corals[4-8] and reef fish[9] is poorly reported in the formal literature. Other taxonomic groups that have received some consideration include foraminiferans,[10] sponges,[11] gastropod molluscs,[12-14] crustaceans,[15-16] and echinoderms.[3,17]

This study reports new species records for the shallow-water seastar genus, *Astropecten*. The inventory for shallow-water seastars of the Brunei continental shelf, an extensive area of some 9980 km^2, suggests a rich diversity (> 45 species), comparable with that of the fauna in the neighboring centre of global Maximum Marine Biodiversity, the Coral Triangle (unpublished records, David J.W. Lane). This unpublished inventory includes members of the genus *Astropecten,* one of the most species rich seastar genera with more than 150 species described[18] and currently at least 130 of these species names accepted as being valid.[19] Although there are some deep-sea forms, astropectinids generally occur in shallow tropical and temperate waters worldwide, on or in sandy/silty substrates where they typically ingest and feed on small molluscs and other infaunal invertebrates.[20]

This study was motivated by the discovery of *Astropecten* seastars in the low intertidal zone sediments of an anthropogenically modified

sandy beach. Extensive breakwater construction along this coast, and at this particular sandy beach ecosystem, has altered wave energy dynamics and benthic sediment properties, creating embayments and sheltered habitats suitable for infaunal intertidal and near-shore sublittoral species. Six *Astropecten* individuals of several distinct morphotypes were observed and collected from around a breakwater at Pantai Tungku (N 4.975189, E 114.87331; Appendix 1). Microscope photographs of preserved, dried specimens were taken with an Olympus SZX10 microscope fitted with a DP-28 Olympus digital camera and, for some images, photostacking was executed using Helicon Focus 8.2.2 software. Sediment samples were also collected from this site for particle size analysis. Other *Astropecten* specimens have been collected previously from Pantai Muara (N 5.038111, E 115.076917), the north side of Pulau Muara Besar (N 5.020417, E 115.078667), Pantai Serasa (N 4.989778, E 115.067000), and Pulau Bedukang (N 4.977417, E 115.063139). Museum collections where the specimens are deposited are indicated by their accession code letters (UBDM refers to the UBD Life Sciences Museum; ZRC refers to the Zoological Reference Collection of the Lee Kong Chian Natural History Museum (LKCNHM) in Singapore).

2. Taxonomic descriptions

Order: Paxillosida
Family: Astropectinidae Gray, 1840

2.1 *Astropecten monacanthus* Sladen, 1883[21]

2.1.1 Material collected

UBDM.10.00047: one wet specimen, R:r = 27.5:8 mm (R/r = 3.44), DJM, Pantai Tungku (North), sandy sediment near unattached breakwater, 06/VI/2024
ZRC.ECH.2461 (BDSTAR 039): one specimen, dried, R:r = 48:13 mm (R/r = 3.69) DJWL, North side of Pulau Muara Besar, sand/mud flats, low tide, 21/II/2004
ZRC.ECH.2462 (BDSTAR 038): one specimen, dried, R:r = 37:10 mm (R/r = 3.7) DJWL, Pulau Bedukang , silty sand, low tide, 20/II/2004

2.1.2 Diagnostic characters

Five-armed seastar with tapering arms; paxillar area two thirds of arm width at marginal plate 5, to nearly three quarters of the width at the arm base. Superomarginal plates, viewed from above, are narrow at the interradius and diminish in size towards the arm tip but at the mid-arm they broaden noticeably; superomaginals lack spines and are covered with granules (see ***Figure 1C***). Paxillae range from small with a single central spinelet at the arm extremities to large ones on the disc with increased numbers of central and fringing spinelets. The madreporite is obscured by paxillae.

Row of robust, pointed spines, one at the upper edge of each infermarginal (IM) plate, that tend to be curved distally (see ***Figure 1***); spines on the interradial pair of IM plates are much reduced in size (see ***Figure 1C***); one or more subsidiary IM spinelets below each main spine, the smallest of which tends to grade into the scale-like armament of the plate. Adambucral plates bear 3 narrow, blunt furrow spines, the middle one being longest, and three subambulacral spines the middle of which is broader than the other two, flattened and round-ended (see ***Figure 1D***).

2.1.3 Further distribution

Originally described from the Philippines, this species is widely distributed in the tropical Indo-West Pacific from East Africa and the Red Sea to the Bay of Bengal, southern areas of Japan and China and to northern areas of Australia.[22-24] In Brunei, in addition to Pantai Tungku on the South China Sea coast, it has also been found intertidally within Brunei Bay at Pulau Bedukang and the north shore of Pulau Muara Besar and subtidally at a depth of about 20 m offshore, on sand near the coral reef patch of Littledale Shoal.

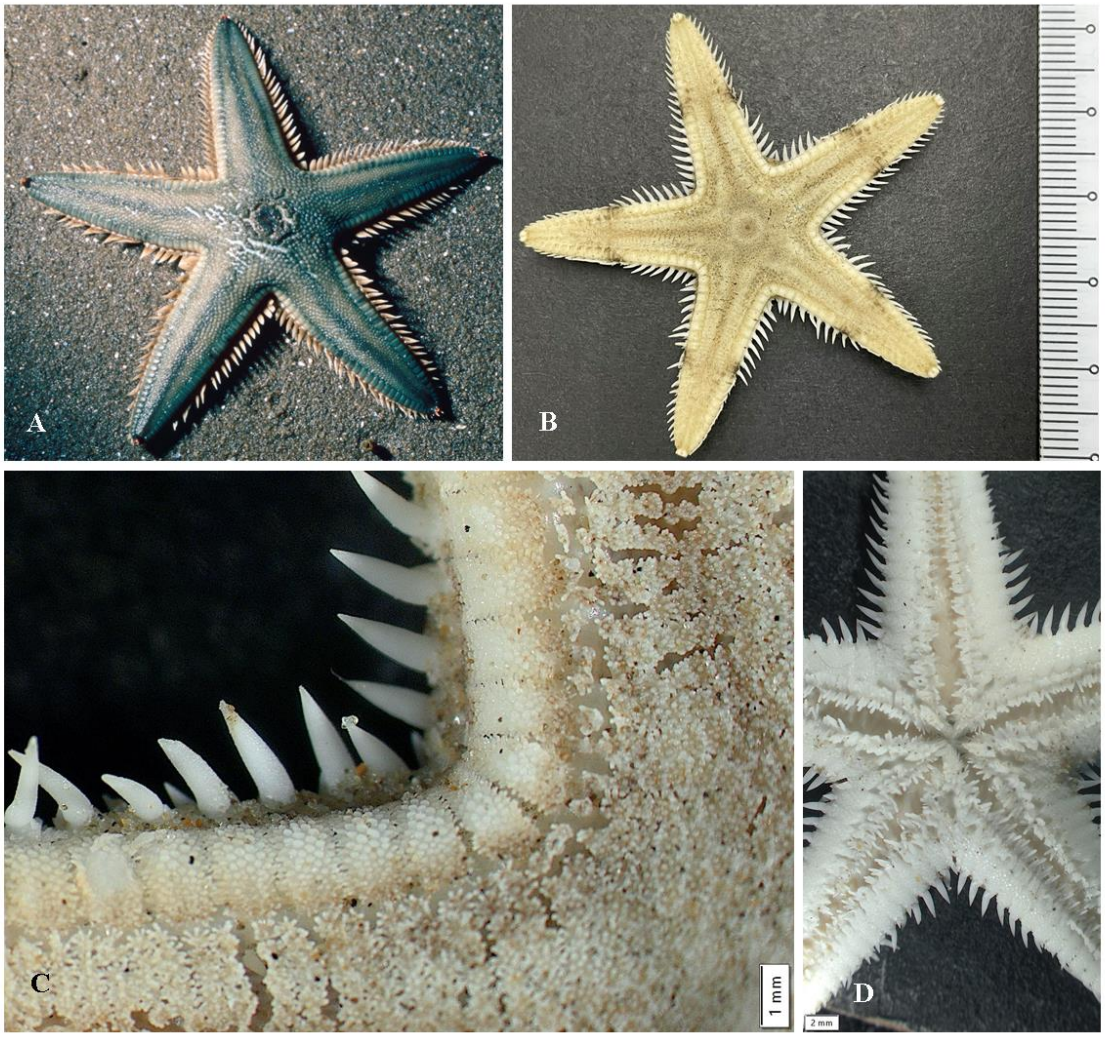


Figure 1. *Astropecten monacanthus*. A. Live seastar (ZRC.ECH.2461 (BDSTAR 039), R = 48 mm) on the northern shore of Pulau Muara Besar; B-D. Preserved, air-dried specimen (UBDM.10.00047) from Pantai Tungku; B. Abactinal view; C. Closer view of abactinal interradial area showing paxillae, some with a single central spinelet, the superomarginal plates covered with granules and robust conical spines arising from the upper edge of each inferomarginal plate; D. Actinal view showing the furrow spines.

2.2 *Astropecten orientalis* Döderlein, 1917[25]

2.2.1 Material collected

UBDM.10.00048: one wet specimen, R:r = 38:12 mm, DJM, Pantai Tungku (North), sandy sediment near unattached breakwater, 06/VI/2024

ZRC.ECH.2463 (BDSTAR 004): one specimen, dried, R:r = 41:11 mm, DJWL, Pantai Tungku, sand, low tide, 27/I/2002

2.2.2 Diagnostic characters:

Stellate seastar with 5 slightly obovate, tapering arms (see ***Figures 2A*** and ***2B***). R:r ratio 3.17 to 3.73; width of paxillar area between half to two thirds of arm width; up to 12 central spines on some paxillae. Superomarginal (SM) plates number 23-24 at R = 38mm to 27 at R = 41 mm and are about twice as broad as long (see ***Figure 2C***); SM plates without spines and covered with prominent granules, about 100 µm in diameter, that are minutely echinate (see ***Figure 2D***). Inferomarginal (IM) plates bear up to 4, occasionally 5, slender, cylindrical spines in an oblique series from upper adoral edge to lower

aboral edge, the upper two often being of similar size (see ***Figure 2E***); interradial IM plate spines are shorter, tend to be flattened and are either emarginated or pointed, some with extended, lanceolate points. Apart from spines, the armament on IM plates is scale-like (see ***Figure 2F***). Adambulacral plates each bear three rod-shaped furrow spines, the central one being longer, and 3 similar ones located abradially (see ***Figure 2G***). Oral plates with a fringe of blunt-ended oral spines decreasing in length on either side of the plate away from the mouth; the middle 6 (3 pairs) project towards the mouth (see ***Figure 2H***); ventral to these, a pair of stout spines, directed towards the mouth, are followed by a series of 9 pairs of radially aligned, downwardly directed spines.

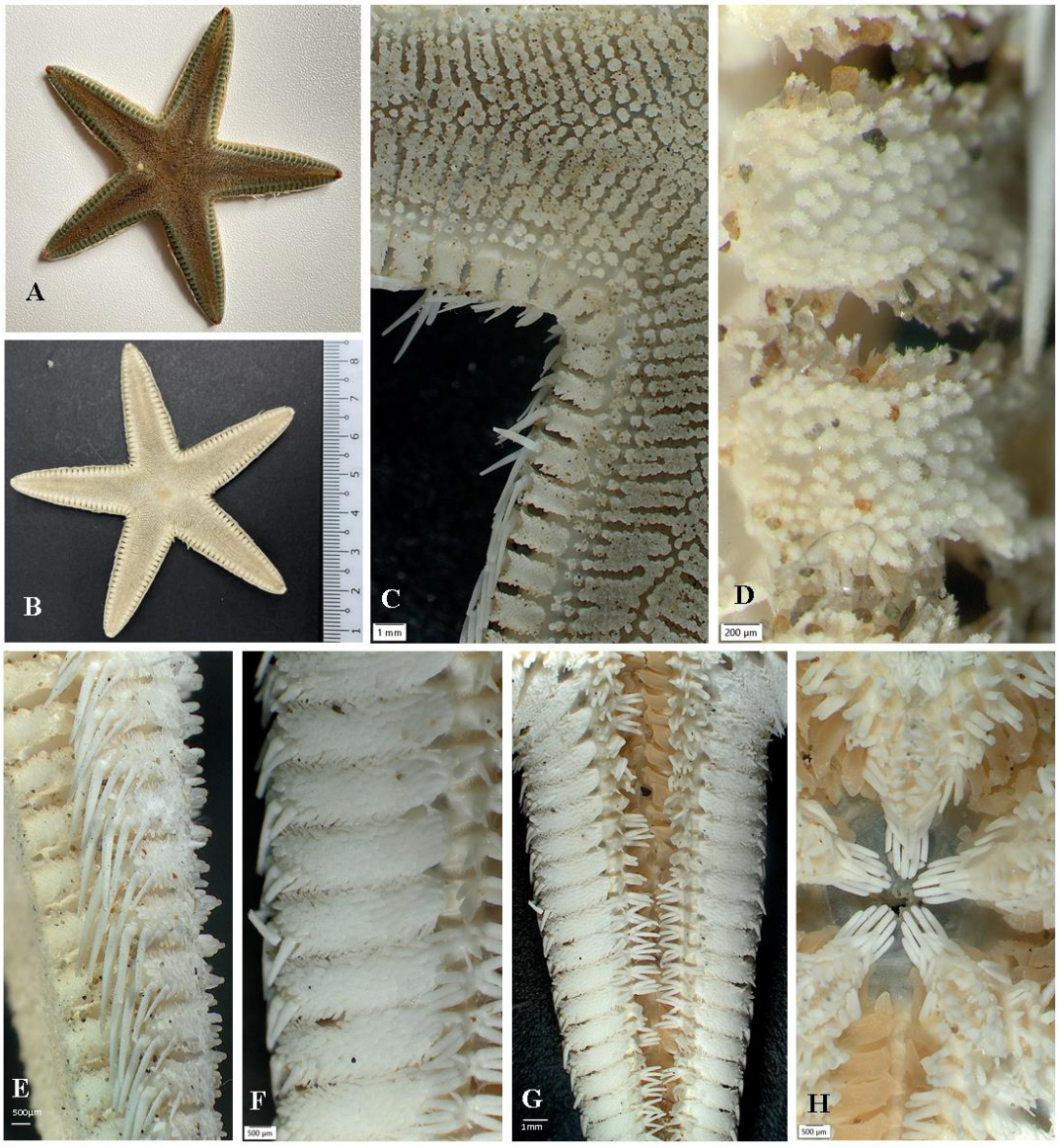


Figure 2. *Astropecten orientalis*. A. Live specimen (UBDM.10.00048); B-H. Photomicroscope views of the same specimen after air-drying; B. Abactinal view of whole animal; C. Abactinal view of interradial area; D. Close view of superomarginal plates covered with minutely echinate granules; E. Side view of an arm (photostacked image) showing details of inferomarginal spines; F. Lower (actinal) surface of inferomarginal plates showing scale-like granulation; G. Ambulacral groove (photostacked image) showing furrow spines; H. Mouth area and oral plate spines.

2.2.3 Further distribution and remarks

The identification of this taxon is tentative. The Brunei specimens are very close to *A. orientalis* Doderlein, 1917[25] in terms of their spination and other armament but differ in paxillar area width to arm width (smaller at about 1/3 in Döderlein's holotype). There are also similarities with *A.granulatus* Müller & Troschel, 1842[26] but the inferomarginal plate spination is much more developed in the Brunei material (more and longer spines below the main one). The distribution of *A. orientalis* (originally described from a single specimen from the Bay of Bengal), based on interpretation of the present material, may now be considered to extend to the South China Sea.

2.3 *Astropecten indicus* Döderlein, 1888[27]

2.3.1 Material collected:

UBDM.10.00049: one wet specimen, R:r = 34:7 mm, DJM, Pantai Tungku, sandy sediment, 01/XI/2019

ZRC.ECH.2464 (BDSTAR 090): one specimen, dried, R:r = 35:9 mm, DJWL, Pantai Serasa, Brunei Bay, low tide, 13/XII/2004

2.3.2 Diagnostic characters

Stellate seastar with 5 pointed arms that taper evenly (see ***Figure 3A***), principally due to an even decrease in paxillar field width along the arm, this width being about about two thirds (64%) of arm width at the fifth marginal plate. Paxillae crowned with a 7–12 fringing spinelets and a single central spinelet for most paxillae, or up to 4 for others; outer 3 or 4 paxillae at the side of each arm aligned in transverse rows while those in the centre of the ray are irregularly arranged (see ***Figure 3B***); superomarginal (SM) plates, slightly broader than long, number 23 at R = 32mm; each SM plate bears an upwardly directed short conical spine (see ***Figure 3B***); interradial SM spines not conspicuously larger than their neighbours and the size decreases gradually towards the arm tip; SM spine location on the upper plate surface gradually shifts from the inner edge for interradial plates towards the plate centre for more distal ones; other armament on upper SM plate surfaces comprises spinules similar in size to those of the paxillae, with finer ones at the plate edges.

Two ventrolateral (actinal) plates; upper edge of each inferomarginal (IM) plate bears a long, subcylindrical pointed spine, longer than the plate width, with another similar shorter one immediately below it (see ***Figures 3C*** and ***3D***); additional much smaller spines (up to 4) in the series confined to interradial IM plates only. Adambulacral furrow spines number 3 with the central one being longer and more robust, plus an inner adambulacral pair, the aboral one being large, robust and bluntly conical, the adoral one being much smaller and narrower (see ***Figure 3D***).

2.3.3 Further distribution and remarks:

Originally described from Sri Lanka, this species is known previously from the South China Sea[3] and elsewhere in the tropical Indo-West Pacific.[22] Morphologically, *Astropecten. indicus* Döderlein, 1888[27] is very similar to *Astropecten andersoni* Sladen, 1888[28] in general body shape, in the arrangement of furrow and other adambulacral spines and in superomarginal and inferomarginal spination. The two species may need reexamination, particularly given that molecular phylogeny reveals distinct regional genetic distances within *A. indicus* that possibly indicate cryptic speciation.[18]

2.4 *Astropecten javanicus* Lutken, 1871[29]

2.4.1 Material collected

UBDM.10.00050: one wet specimen, R:r = 29:8 mm, DJM, Pulau Bedukang, mudflat sediment, 2019-2024 (precise date not recorded).

UBDM.10.00051: one wet specimen, R:r = 32:7 mm DJM, Pantai Tungku, mudflat sediment, 01/XI/2019

UBDM.10.00052: one wet specimen, R:r = 22:6 mm DJM, Pantai Tungku, mudflat sediment, 01/XI/2019

ZRC.ECH.2465 (BDSTAR 018): one specimen, dried, R:r = 41:11 mm, DJWL, Pantai Muara, sand, low tide, 16/VI/2003

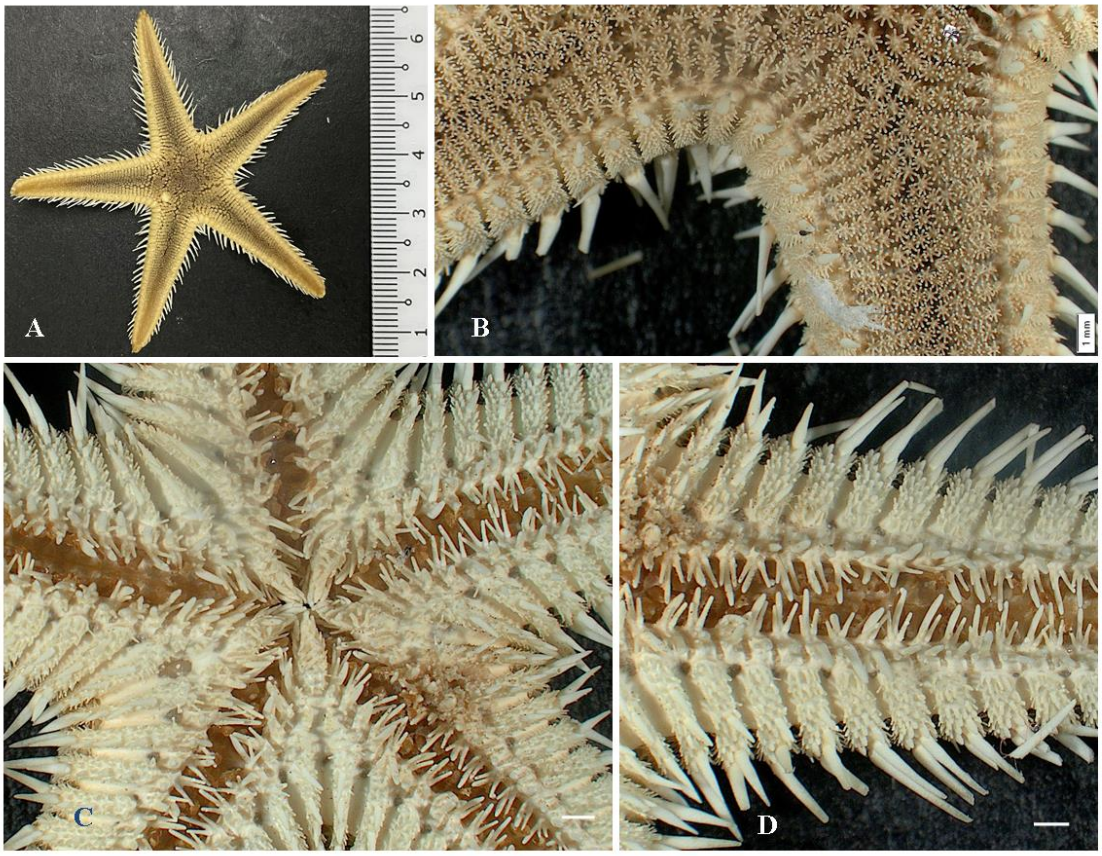


Figure 3. *Astropecten indicus*. A. Abactinal view of preserved, dried seastar (UBDM.10.00049); B. Close-up abactinal view of arm base and interradial region showing positions of superomarginal spines; C. Actinal view of the disc region; D. Close-up actinal view of proximal region of arm showing inferomarginal spines and furrow spines.

2.4.2 Diagnostic characters:

Stellate sea star with 5 narrow, evenly tapering arms (see ***Figure 4A***); abactinal paxillae on arms aligned in transverse rows; arms bordered by superomarginal (SM) plates, each bearing a short, upwardly-directed spine positioned near the inner SM edge basally but towards the arm tip transitioning gradually to the SM middle/outer edge; spines of SM plates adjacent to the interradius usually slightly taller and more robust than the others (see ***Figure 4B***). SM plate number size-dependent, ranging for example from 36 (at R = 34mm) to 25 (at R= 22 mm). Each inferomaginal (IM) plate bears a single flattened, parallel-sided spine (see ***Figure 4B***, ims) at its upper edge, the series forming a horizontal fringe around the sea star (see ***Figures 4A*** and ***4C***); spine tips truncated or emarginated giving the spine a spatulate appearance with, in some cases, the upper face of the outer blade being concave; primary spines on interradial pair of IM plates also flattened but are about half the length of their neighbours and pointed (see ***Figure 4B***); small, cylindrical, pointed spines, usually 3 sometimes 2, are aligned radially immediately below the spatulate spines and others continue in a lateral series ventrally, close to the distal edge on more distal IM plates. Adambulacral plates each bear 3 bristle-like furrow spines, the middle one being longest; medial to these, among a cluster of smaller spinelets, a prominent ventrally directed conical spine arises (see ***Figure 4D***, arrow). The ossicle

pair of each jaw has a double row of 6 to 7 radially aligned, ventrally directed spines and a fringe of at least 8 spines of which the central more robust ones, directed towards the mouth, form the oral spines.

2.4.3 Further distribution:

In addition to Pantai Tungku, other Brunei intertidal locations where this sea star is commonly found include the beaches of Pantai Meragang, Pantai Muara and, in Inner Brunei Bay, Pantai Serasa and Pulau Muara Besar. Described originally from Indonesian material collected from Cirebon (formerly Cheribon in English) on the northern Java coast.[29] Not previously listed for the South China Sea,[3] this species has been reported previously in Brunei from Inner Brunei Bay[18] based on a specimen supplied by the first author. It may be more widely distributed in the Indo-West Pacific but claims of this, based on Google/AI sources, are thus far unsubstantiated. The earlier literature merely indicates an East Indes or Sonde (Sunda) Islands distribution[22,30].

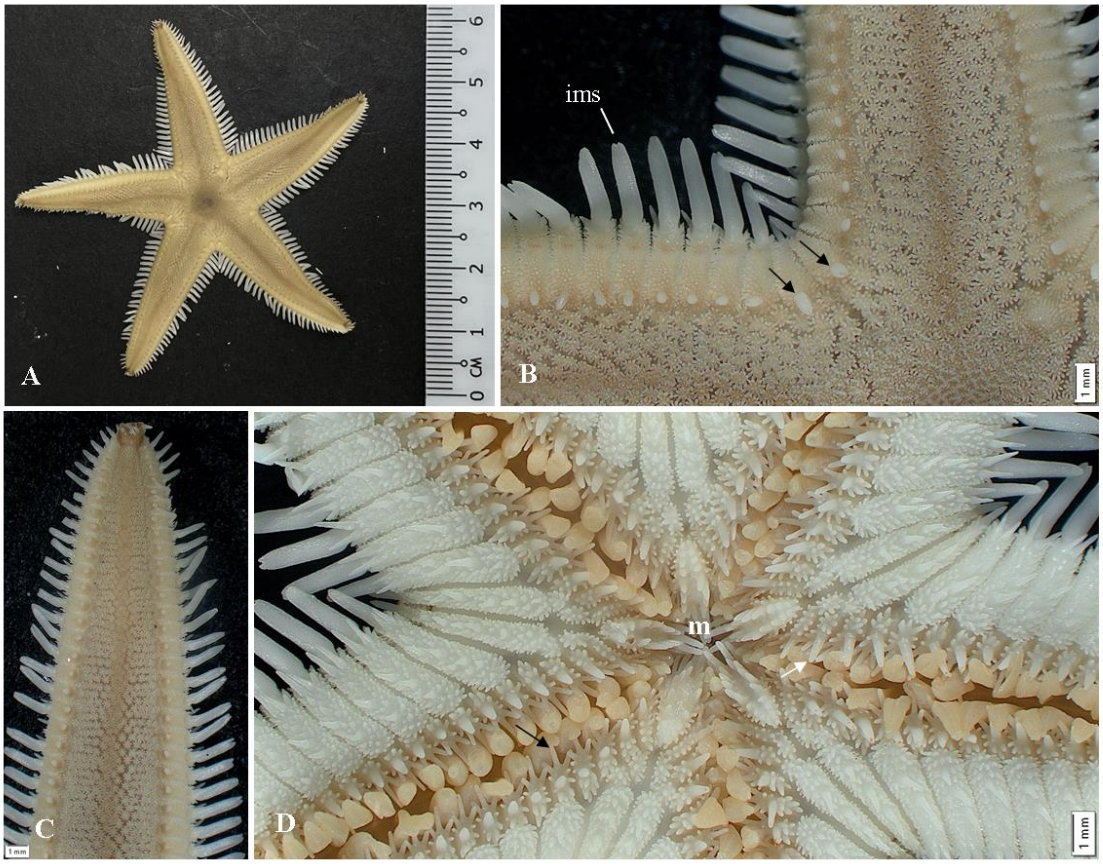


Figure 4. *Astropecten javanicus*. A. Abactinal view of preserved, air-dried specimen (UBDM.10.00050) showing comb-like array of spatulate, fringing inferomarginal spines; B. Closer view of inferomarginal spines (ims). Superomarginal plate spines, one per plate, directed upwards, the interradial pair (black arrows) being slightly larger than the others; C. Abactinal view of arm tip. Paxillae aligned in transverse rows; D. Actinal view, showing the lower spines series on IM plates and, for each adambulacral plate, a furrow spine triplet with a longer middle spine (black arrow) and, lateral to that, a prominent, conical spine directed downwards (white arrow). m = mouth.

2.4.4 Remarks

The phylogenetic relationship of *A. javanicus* with other *Astropecten* species remains unclear as Döderlein's early morphological classification[25] places it within the *Polyacanthus* group whereas molecular data based on mitochondrial DNA markers places it in the *Velitaris* clade.[18] This seastar, like many other intertidal astropectinids, tends to emerge or partly emerge from sandy/silty sediments at dusk. The spatulate,

often scoop-ended spines fringing this sea star are seemingly an adaptation for the efficient, rapid burrowing behaviour of this 'sand star'.

3. Conclusion

The present study reports the first records of the occurrence of four species of the seastar genus, *Astropecten*, from intertidal ecosystems in Brunei, including an anthropogenically modified beach system at Pantai Tungku. As such, this contributes to the important need to build inventories of the marine species of the country and ecoregion.

Of the four *Astropecten* species reported here for Bruneian shores, two of them, *A. indicus* and *A. monacanthus*, known previously from the SCS,[3] are widely distributed in the tropical Indo-West Pacific,[22,23] although the former may be a species complex.[18] *A. orientalis* has only been recorded once before as a single specimen from the Bay of Bengal.[25] Its distribution and indeed the validity of this rare form warrants further investigation. *A. javanicus* is quite common in natural embayments in Brunei and, although recorded only once before more than 150 years ago in the nearby Java Sea,[29] it is likely to be more widely distributed, in the SCS at least. Further surveys, reviews of museum collections and molecular studies will likely reveal more *Astropecten* seastar taxa for Brunei, particularly as this genus is highly speciose[18,19] and given the fact that most members have a long-lived planktonic larval stage that might be expected to result in wide geographic distributions for many taxa.[18]

Furthermore, the occurrence of four *Astropecten* species in sediments on this wave-exposed coast, behind a nearshore breakwater, demonstrates how such man-made coastal structures can alter the sediment properties of sandy beaches in ways that support species and communities more commonly associated with natural embayments or sublittoral environments. Coastal zone sediments along Bruneian SCS-facing beaches are reported as being typically coarse to fine grained sands with a particle size range of the order of 100-300 μm[31] whereas the particle size distribution for sediments at the seastar collection site (sheltered by the breakwater) is strongly skewed towards smaller sizes in this range (see Appendix 1C) and characteristic of more silty sediments of sheltered shores.

Acknowledgements

This study was supported by a UBD research grant to DJM (UBD/RSCH/1.4/FICBF/2025/004). Natasha Khairul is thanked for assisting with the formatting of the manuscript and Bert Hoeksema is thanked for comments and suggestions that materially improved the manuscript.

References

[1] M. J. Costello *et al.*, "Marine biogeographic realms and species endemicity," *Nature Communications*, 8, 1057, 2017.

[2] M. D. Spalding *et al.*, "Marine ecoregions of the world: a bioregionalization of coastal and shelf areas," *BioScience*, 57, 573-583, 2007.

[3] D. J. W. Lane *et al.*, "Echinoderm fauna of the South China Sea: an inventory and analysis of distribution patterns", *The Raffles Bulletin of Zoology*, 48, 459-493, 2000.

[4] E. Turak and L. M. DeVantier, *Field guide to reef-building corals of Brunei Darussalam*. Fisheries Department, Ministry of Industry and Primary Resources, Government of Brunei Darussalam, 256 pp, 2011.

[5] D.J.W. Lane and G. P. C. Lim, "Reef corals in a high sedimentation environment on the 'mainland' coast of Brunei, Northwest Borneo" *Galaxea, Journal of Coral Reef Studies.* Proceedings of the 2nd Asia Pacific Coral Reef Symposium (Special Issue), 166-177, 2013.

[6] B. W. Hoeksema and D. J. W. Lane "The mushroom coral fauna (Scleractinia: Fungiidae) of Brunei Darussalam (South

China Sea) and its relation to the Coral Triangle" *Raffles Bulletin of Zoology*, 62, 566-580, 2014.

[7] D. Huang *et al.*, "Extraordinary diversity of reef corals in the South China Sea" *Marine Biodiversity*, 45, 157-168, 2015.

[8] D. J. W. Lane and B. W. Hoeksema, "Mesophotic mushroom corals at Brunei Darussalam support westward extension of the Coral Triangle to the South China Sea waters of Northwest Borneo" *Raffles Bulletin of Zoology*, 64, 204-212, 2016.

[9] G. R. Allen, *Reef fishes of Brunei Darussalam*, Department of Fisheries, Ministry of Industry and Primary Resources, Government of Brunei Darussalam, 280 pp, 2009.

[10] S. Goeting *et al.*, "Diversity and distribution of the benthic foraminifera on the Brunei Shelf (northwest Borneo): effect of seawater depth," *Diversity*, 15, 937, 2023.

[11] E. Setiawan *et al.*, "Shallow-water sponges from a high-sedimentation estuarine bay (Brunei, Northwest Borneo, Southeast Asia)" *Journal of Tropical Biodiversity and Biotechnology*, 6, Issue 03, 2021.

[12] D. J. Marshall and H. Taha, "An evolutionary estuarine incursion: molecular differentiation and niche separation in *Bornean Indothais* snails (Rapaninae, Muricidae)," *Journal of the Marine Biological Association of the United Kingdom*, 101, 319-329, 2021.

[13] N. Mustapha *et al.*, "The neritid snails of Brunei Darussalam: their geographical, ecological and conservation significance," *Ecologica Montenegrina*, 42, 45-61, 2021.

[14] B. Dayrat *et al.*, "A new species and new records of *Onchidium* slugs (Gastropoda, Euthyneura, Pulmonata, Onchidiidae) in Southeast Asia," *ZooKeys*, 892, 27-57, 2019.

[15] S. C. Choy, "The crustacean fauna of Negara Brunei Darussalam," *Brunei Museum Journal*, 7, 117-163, 1991.

[16] L. Ribero *et al.*, "Assemblage structure, distribution and habitat type of the grapsoid crabs (Brachyura: Grapsoidea) of the coastal forested swamps of northern Borneo," *Regional Studies in Marine Science*, 37, 101323, 2020.

[17] D. J. W. Lane, "Sea cucumber diversity and resources in Brunei, Borneo Island" In: Heinzeller & Nebelsick (eds), *Echinoderms Munchen* pp. 231-237, 2014.

[18] D. E. Zulliger and H. A. Lessios, "Phylogenetic relationships in the genus Astropecten Gray (Paxillosida: Astropectinidae) on a global scale: molecular evidence for morphological convergence, species-complexes and possible cryptic speciation," *Zootaxa*, 2504, 1-19, 2010.

[19] C. L. Mah, *World Asteroidea Database*, 2025. https://www.marinespecies.org/asteroidea (accessed Dec. 27, 2025).

[20] E. Tortonese, Echinodermata. *Fauna d'Italia VI*, Calderini, Bologna, 422 pp, 1965.

[21] W. P. Sladen, "The Asteroidea of H.M.S. Challenger Expedition, Part II," *Journal of the Linnean Society of London, Zoology*, 17, 214-269, 1883.

[22] A. M. Clark and F. W. E. Rowe, *Monograph of Shallow-Water Indo-West Pacific Echinoderms*, The British Museum (Natural History), London, 238 pp. + 31 pls., 1971.

[23] L. M. Marsh and J. Fromont, *Field Guide to the Shallow Water Seastars of Australia*, Western Australian Museum, 543 pp., 2020.

[24] F. W. E. Rowe and J. Gates, "Echinodermata," in *Zoological Catalogue of Australia*, Vol. 33, A. Wells (ed.), CSIRO Australia, Melbourne, xiii + 510 pp, 1995.

[25] L. Döderlein, "Die Asteriden der Siboga-Expedition. I. Die Gattung Astropecten und ihre Stammesgeschichte," in *Siboga-Expeditie. Uitkomsten op zoölogisch, botanisch, ozeanographisch en geologisch gebied verzameld in Nederlandsch Oost-Indie 1899–1900 aan boord H.M. "Siboga"*, Vol. 46(a), E. J. Brill (ed.), Leiden, pp. 1 - 191, 1917.

[26] J. Müller and F. H. Troschel, *System der Asteriden. 1. Asteriae. 2. Ophiuridae*, Vieweg: Braunschweig, xxx+134 pp. 12 pls, 1842.

[27] L. Döderlein, "Echinodermen von Ceylon. Bericht über die von den Herren Dres Sarasin gesammelten Asteroidea, Ophiuroidea und Echinoidea," *Zoologische Jahrbücher*, 3, 821-846, 1888.

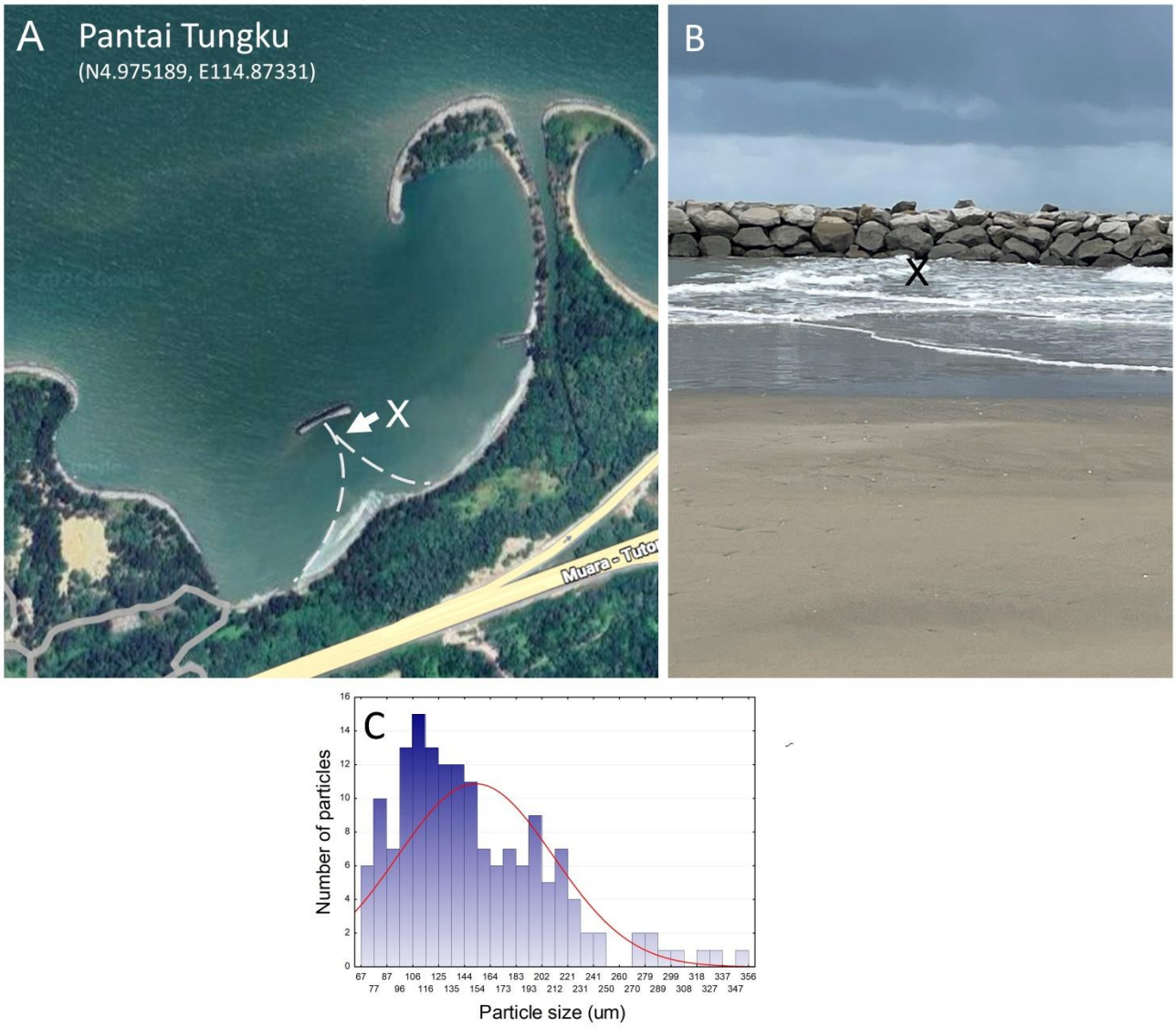
[28] W. P. Sladen, "On the Asteroidea of the Mergui Archipelago, collected for the Trustees of the Indian Museum, Calcutta, by Dr. John Anderson, F.R.S., Superintendent of the Museum," *Journal of the Linnean Society of London, Zoology*, 21, 319-331, 1889.

[29] C. Lütken, "Fortasatte kritiske og beskrivende Bidrag til Kundskab om Søstjernerne (Asteriderne)," *Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening*, 227-304, 1871.

[30] E. Perrier, "Étude sur la repartition géographique des Astérides". *Nouvelles Archives du Muséum d'Histoire Naturelle, Paris.* Deuxième Série, Vol. 1, 1-108. 1878.

[31] C. Schluter and I. Gnanachandran, "Numerical modelling of the Brunei coastal zone" *WIT Transactions on the Built Environment*, 78, 169-178, 2005.

Appendix 1



Appendix 1.
A: Satellite image during high tide at Pantai Tungku showing breakwaters and the sea star collection site (X). The dashed white lines indicate the position of a sand berm during low tide.
B: Collection site photographed during mid-tide and rough sea conditions, showing the unattached breakwater in background and the benthic sediment berm in the foreground.
C: Frequency distribution of sediment particle size at X where specimens were collected (see ***B***). There is a high proportion of fine sand/silt particles (according to the Udden-Wentworth scale, sand particles vary in size between 62.5 µm and 2 mm). The organic content of the sediment by weight was 1.3%.