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NOTOPUS DORSIPES (LINNAEUS) IN SINGAPORE: FIRST RECORD OF THE BRACHYURAN SUPERFAMILY RANINOIDEA (CRUSTACEA: DECAPODA) ON THE SUNDA SHELF

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INTRODUCTION

Recently, a brachyuran crab identified as *Notopus dorsipes* (Linnaeus, 1758), was found at Changi (north-east Singapore). This represents the first record of the superfamily Raninoidea de Haan, 1839, in Singapore and on the Sunda Shelf (Figs. 1, 2). The superfamily Raninoidea has a worldwide distribution and its members inhabit marine habitats from the intertidal zone to over 300 m deep (reviewed in Ahyong et al., 2009; see also Dawson & Yaldwyn, 1994). Fifty species of raninoids are currently assigned to 12 genera in six subfamilies (Ng et al., 2008).

Notopus dorsipes belongs to a monotypic genus currently assigned to the subfamily Notopodinae Serène & Umali, 1972 (see Ng et al., 2008). Originally described as *Cancer dorsipes* by Linnaeus (1758), this species has had a confused nomenclatural history (see Holthuis, 1962). In order to stabilise the name *Cancer dorsipes* Linnaeus, Holthuis (1962: 55) designated a figure in Rumphius (1705: pl. 10: Fig. 3) as the lectotype of *Notopus dorsipes* (reproduced as Fig. 3). De Haan (1841) established the genus *Notopus* for *Cancer dorsipes* Linnaeus, the type species by monotypy.

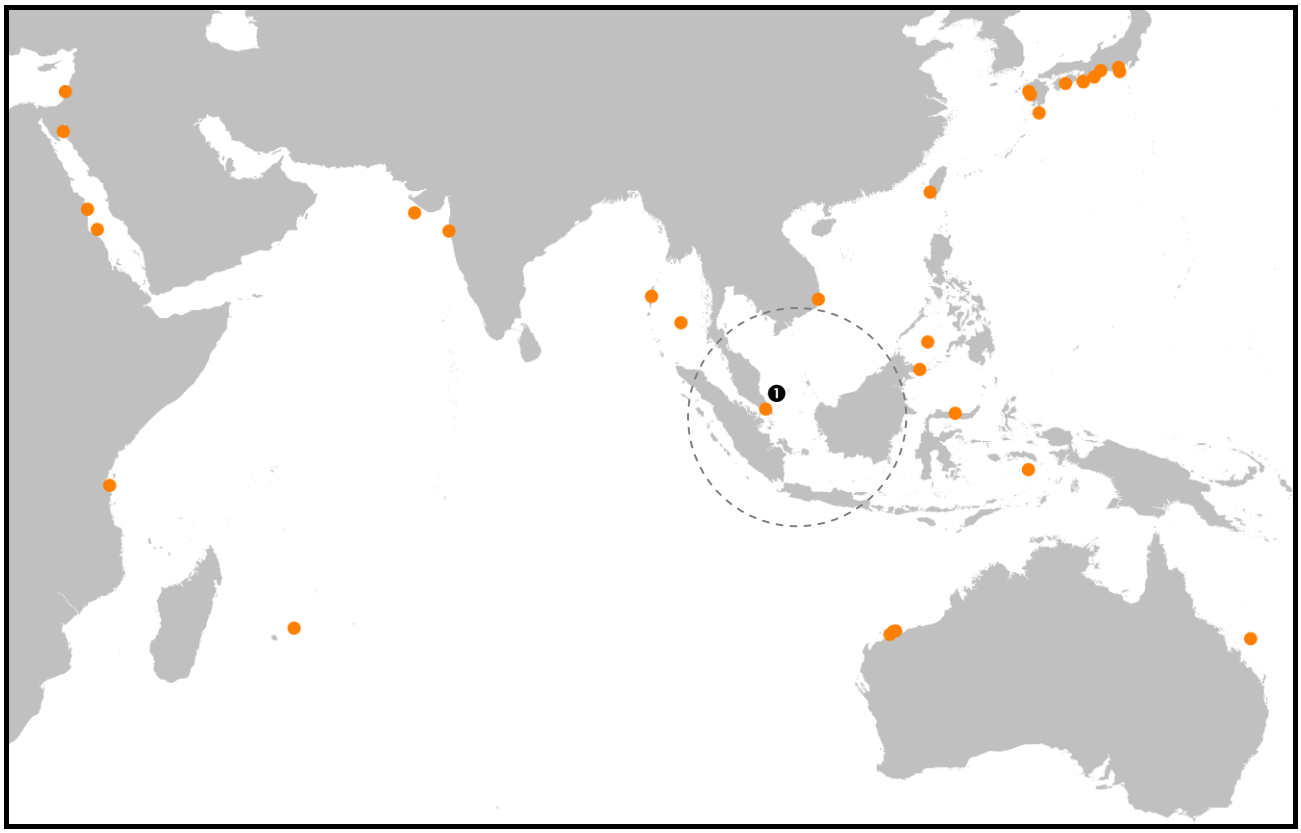

Fig. 1. All known records of *Notopus dorsipes* represented by solid orange circles. The new record from Singapore is marked (❶). Locality data from Table 1. The Sunda Shelf area is encompassed by the circle (see Fig. 2).

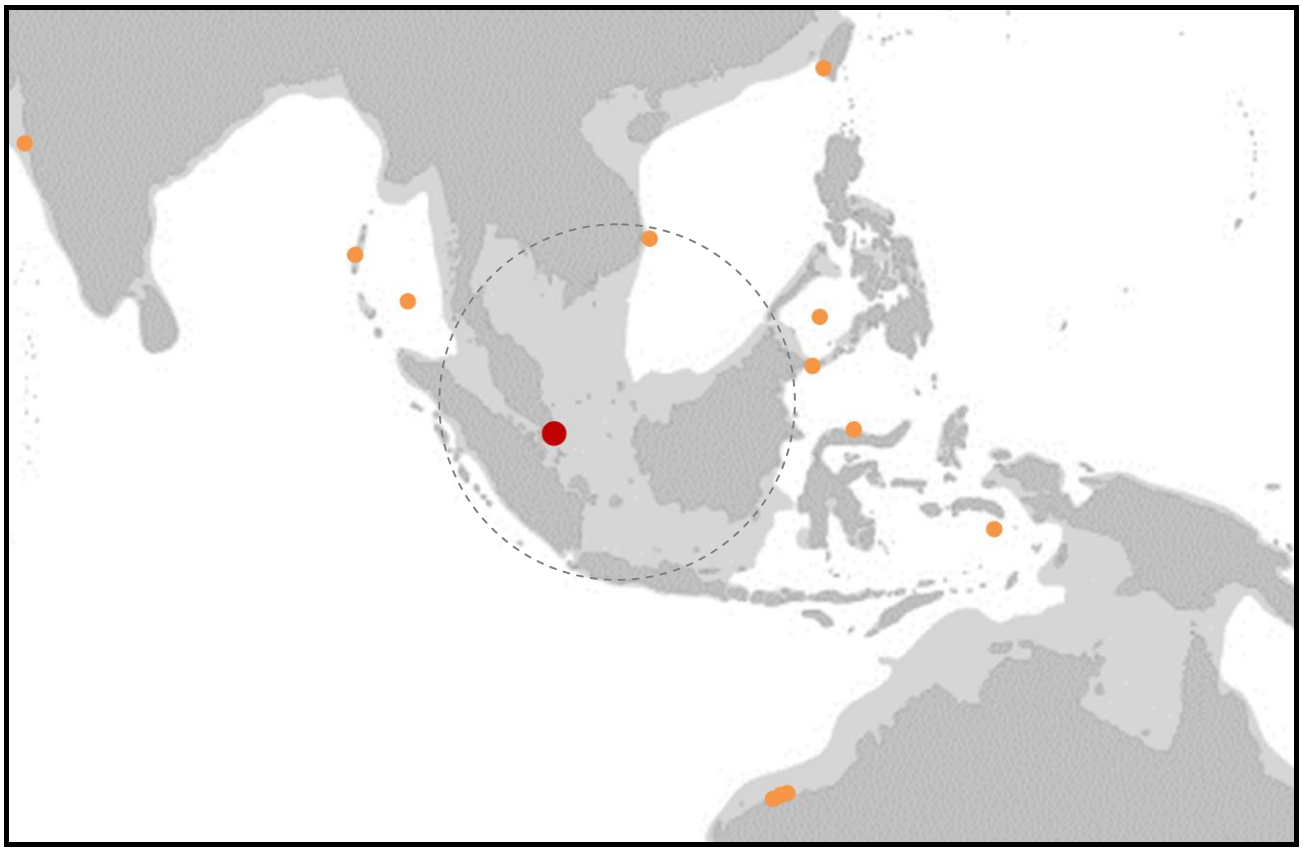

Fig. 2. Records of *Notopus dorsipes* on and around the Sunda Shelf. The Sunda Shelf is enclosed within the circle, and the areas in light grey are the currently submerged areas which would have been exposed ca. 17,000 years ago when sea levels were 120 m below present levels. Present day exposed landmasses are coloured dark grey. Solid orange circles represent all known records in the vicinity. Location of the Singapore record marked with a solid red circle. Map courtesy of Harold K. Voris (Field Museum of Natural History, Chicago; Voris, 2000).

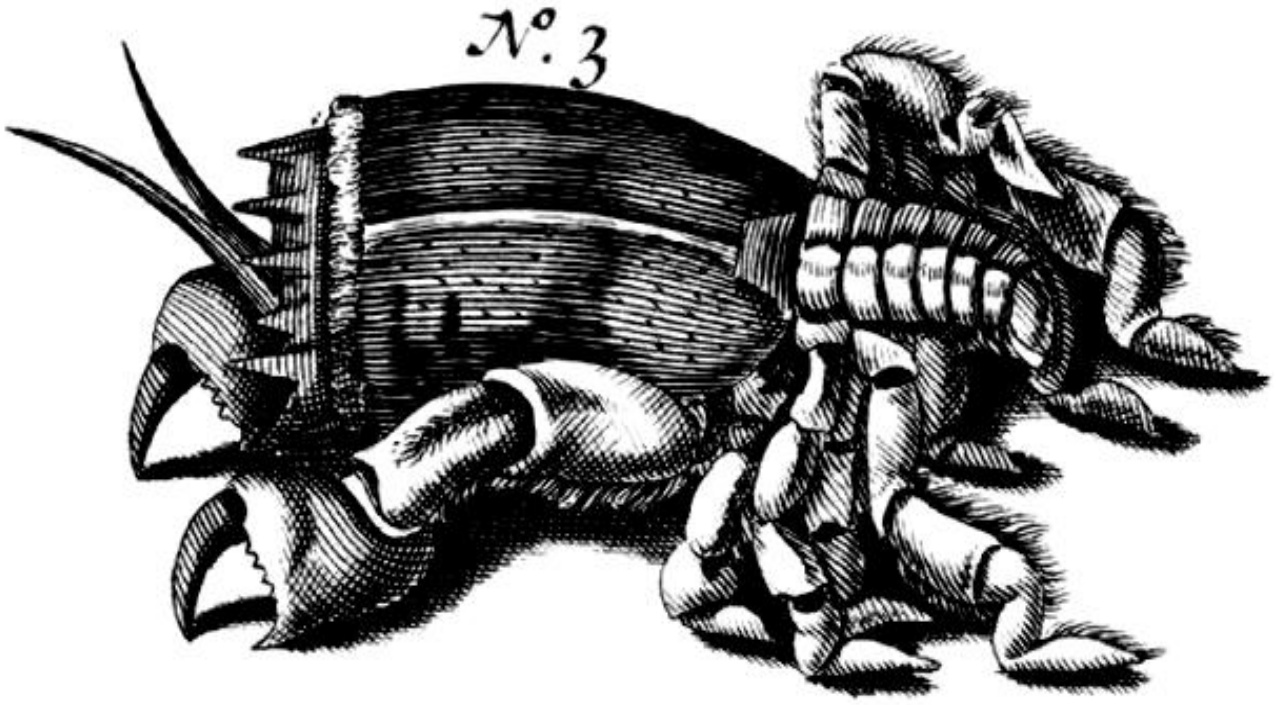

Fig. 3. Lectotype of *Cancer dorsipes*. Figure from Rumphius (1705: pl. 10, Fig. 3).

RECORD AND OBSERVATIONS

A female specimen of *Notopus dorsipes* was found in the intertidal zone of a beach near Carpark 6 at Changi on the north-east coast of Singapore (1.383°N, 104.003°E) on 22 May 2011 (Fig. 4a–c), buried just beneath the fine sandy sediment, on a sand bank exposed at low tide. Removed from the substrate, the animal actively attempted to re-burrow itself and it was subsequently dislodged several times for observations. While burrowing, the anterior end of its body was lifted somewhat by the chelipeds as the animal dug into the sand, entering at an angle, posterior end first. The chelipeds also aided in pushing the animal backwards during the process. Burrowing was rapid, no doubt aided by the flattened and spade-like dactylus of the periopods, and the animal would disappear completely in a matter of seconds (Fig. 5a–d).

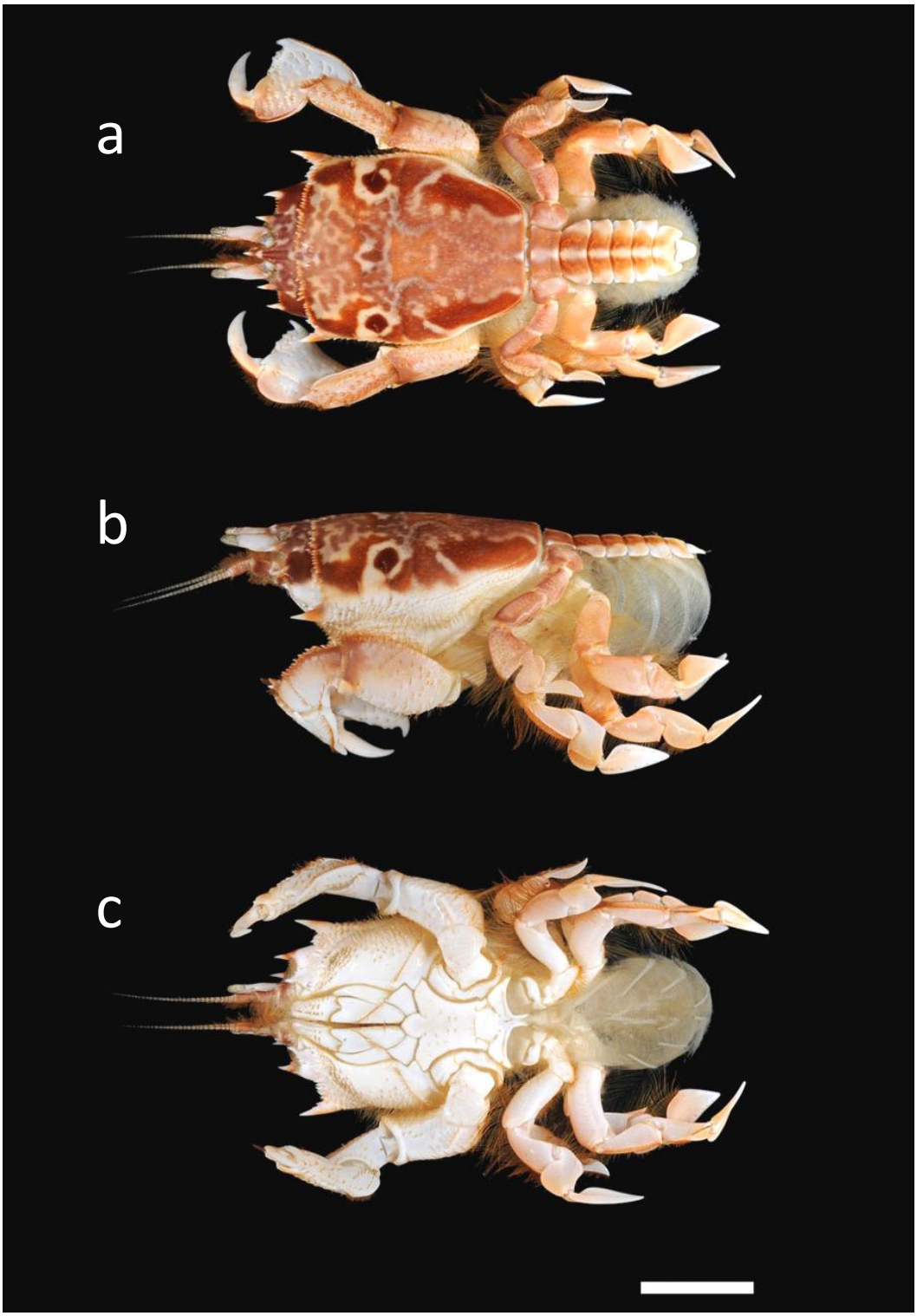

Fig. 4. Female specimen from Singapore of carapace length 25.7 × width 17.7 mm (ZRC 2011.0302): a, dorsal view; b, lateral view; c, ventral view. Scale bar = 10 mm. (Photographs by: Tan Heok Hui).

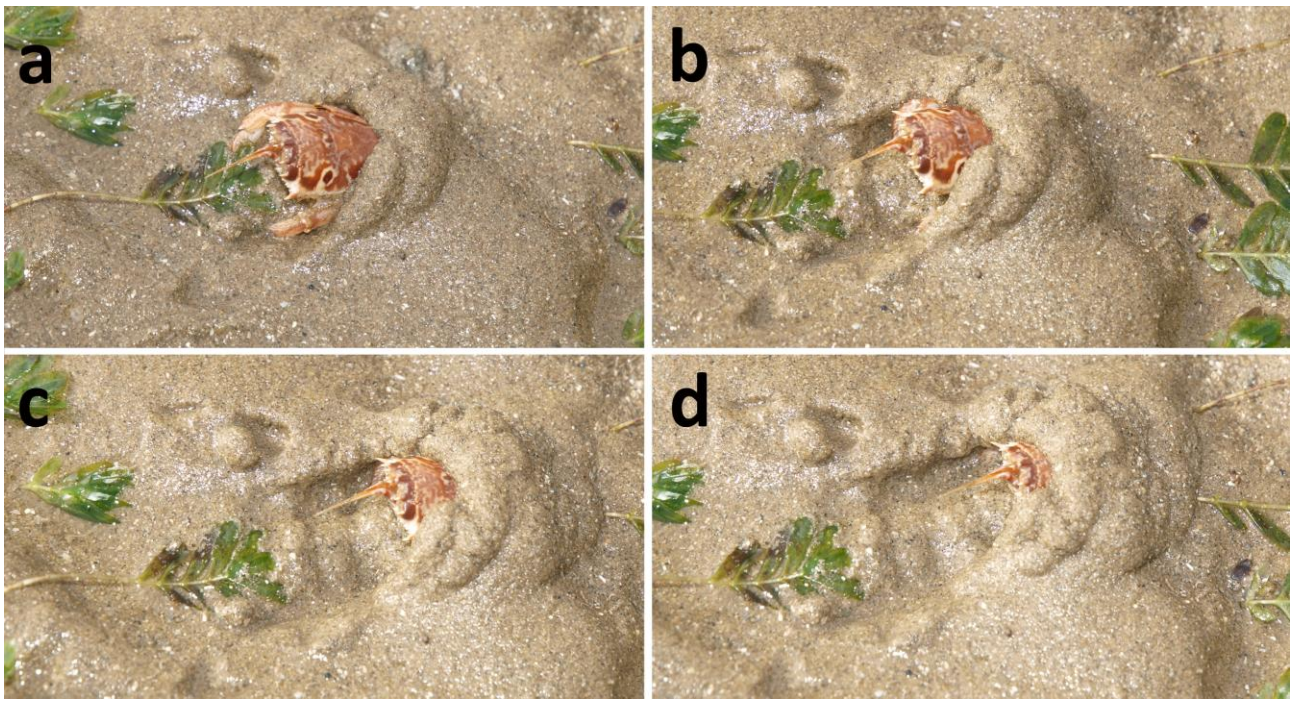

Fig. 5. *Notopus dorsipes* female of carapace length 25.7 × width 17.7 mm: a–d, habitus of the collected individual 'back-burrowing' into sand. (Photographs by: Chan Sow Yan).

This individual measured 25.7 × 17.7 mm (carapace length × width). The carapace was intensely coloured with red-brown and white mottling and has a pair of distinct spots, one on each side of the carapace around the midlength (Fig. 4a–c). It agreed well with the recent diagnosis provided by Ahyong et al. (2009: 149, 150, Fig. 110), apart from being slightly slimmer than the male specimen figured. The presence of the pair of reddish-brown spots, outlined in white, on either side of the carapace is also mentioned as a good species recognition character (Ahyong et al., 2009: 150). The individual was collected as a voucher specimen (ZRC 2011.0302) and was deposited in the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research (RMBR), National University of Singapore.

DISCUSSION

This record from an intertidal sand bank in Changi is remarkable as it has never been found despite extensive dredging and collecting in Singapore which began over a hundred years ago (e.g., Adams & White, 1849; Walker, 1887; Lanchester, 1900). Further collections and studies in Singapore have also not turned up the presence of this species (e.g., Ow Yang, 1963).

Notopus dorsipes is known from throughout the Indo-West Pacific, although prior to this study, it had yet to be recorded from the Sunda Shelf (Table 1, Figs. 1, 2). It is distributed from East Africa, west through to Japan and the Great Barrier Reef to the east (Fig. 1). The present record from Singapore fills in the gap of its distribution on the Sunda Shelf. The Sunda Shelf is a continental shelf that extends from mainland Southeast Asia, and its areas above sea level include the Thai-Malaysian peninsula (including Peninsular Malaysia and Singapore), and the islands of Sumatra, Java, Borneo, and Palawan (Voris, 2000; Sathiamurthy & Voris, 2006; Carpenter et al., 2011; Fig. 2).

As reviewed by Voris (2000), over half of the Sunda Shelf is now covered by shallow seas less than 100 m deep. With sea level fluctuations as a result of global temperature changes (glacials and interglacials), much of this Shelf was exposed at varying degrees and for varying lengths of time (Voris, 2000). It has been estimated that between 11,000 and 17,000 years ago, sea levels would have been between 50 and 120 m below present levels (BPL), respectively, and would have caused the exposure of the Sunda Shelf to such an extent that all the currently inundated Sundaic areas (shaded light grey in Fig. 2) would have been connected as a single expansive landmass (Fig. 2). Molengraaff & Weber (1919) first postulated the existence of this exposed shelf, which would have excluded most forms of marine fauna and flora. Earlier distributional studies of coral reef fishes (Bellwood & Wainwright, 2002), shorefishes (Randall, 1998), brachyuran crabs (Tweedie, 1955), and mangrove forests (MacNae, 1968) lend support to this hypothesis. Population genetic studies using various DNA markers have shown that varying degrees of genetic differentiation exist between populations of amphi-Indo-West Pacific marine taxa such as the false clownfish, *Amphiprion ocellaris* (Nelson et al., 2000) and mangrove forests (Liao et al., 2007, 2009; Tan et al., 2005). Carpenter et al. (2011) provide an excellent review of other marine taxa that also appear to be affected by changing sea levels.

Table 1. All known localities of *Notopus dorsipes* (Linnaeus, 1758), with their geographical coordinates (in decimal degrees). Names of localities have been updated to reflect current spellings.

S/No.	Locality	Latitude	Longitude	References
1.	Australia: Angel Island	−20.483	116.817	Tyndale-Biscoe & George, 1962
2.	Australia: between Point Samson and Onslow	−20.812	116.263	Tyndale-Biscoe & George, 1962
3.	Australia: Dampier Archipelago	−20.533	116.600	Tyndale-Biscoe & George, 1962
4.	Australia: Swain Reefs	−21.239	151.847	Dawson & Yaldwyn, 1994
5.	Borneo: Unsang	5.288	119.199	Adams & White, 1849
6.	India: Andaman Islands	12.500	92.750	Alcock, 1896
7.	India: Malabar coast	18.932	72.779	Alcock, 1896
8.	Indonesia: Banda	−4.583	129.917	Ihle, 1918
9.	Indonesia: Sulu Sea	8.000	120.000	Ihle, 1918
10.	Indonesia: Teluk Kuandang	0.975	122.708	Ihle, 1918
11.	Israel: near Atlit: N've-Yam	32.678	34.931	Lewinsohn & Holthuis, 1964
12.	Japan: Amakusa	32.400	130.117	Yamaguchi et al., 1987
13.	Japan: Kii Minabe	33.708	135.302	Sakai, 1976
14.	Japan: Kii Nagashima	34.139	136.405	Sakai, 1976
15.	Japan: Mikawa-Isshiki	34.752	137.056	Muraoka, 1998
16.	Japan: Nagasaki	32.689	129.955	Sakai, 1940
17.	Japan: Nanki Shirahama	33.648	135.347	Muraoka, 1998
18.	Japan: Sagami Bay: Mitohama near Misaki	35.059	138.819	Balss, 1922
19.	Japan: Shimoda: off the coast of Kisami	34.642	138.925	Sakai, 1935
20.	Japan: Tosa Bay: Mimase	33.492	133.572	Muraoka, 1998
21.	Japan: west of Tanegashima	30.574	130.981	Yokoya, 1933
22.	Mauritius	−20.200	57.500	Studer, 1883
23.	Red Sea: Gulf of Aqaba: Station XXXVII	28.750	34.750	Monod, 1938
24.	Red Sea: Khor Dongonab: islet group	21.083	37.133	Laurie, 1915
25.	Red Sea: Sudan	19.097	38.095	Hartnoll, 1979
26.	Singapore: Changi	1.383	104.003	Present study
27.	Taiwan: Kaoshiung County: Mituo: Nanliao	22.762	120.232	Ng et al., 2000
28.	Tanzania: Zanzibar	−6.133	39.317	Nobili, 1905
29.	Thailand: Andaman Sea: Station 1015-1	9.898	95.663	Serène & Soh, 1976
30.	Vietnam: Cau Da	12.217	109.200	Vo et al., 2002

As sea levels rose to less than 50 m BPL about 11,000 years ago (Voris, 2000), much of the Sunda Shelf was reinundated, and marine habitats suitable for species of Raninoidea would have begun to reappear (and recolonisation of the Sunda Shelf by some marine organisms is likely to have taken place). This is predicated upon the existence of the Raninoidea at that time (an assumption that is not unreasonable as fossils referable to the Raninoidea are known from the Cretaceous; Brösing, 2008). Information on the larval duration of the Raninoidea is scarce, but the duration is 36–62 days in the confamilial *Raninoides benedicti* Rathbun, 1935 (see Knight, 1968), which would theoretically allow for dispersal over long distances. However, modern-day currents within the Sundaland area do not appear to favour dispersal of plankton into the Sundaland area (e.g., see Nelson et al., 2000: Figs. 6, 8; detailed review in Wyrtki, 1961). These currents are likely to explain the absence of the Raninoidea on the Sunda Shelf since it was submerged.

The record of *Notopus dorsipes* from Singapore could thus represent a recent natural colonisation of the Sunda Shelf by this species from adjacent areas since the last glacial period, or the magnitude of the sampling effort that will be required to inventory and catalogue the marine biodiversity that is present in the waters around Singapore.

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