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# SINGAPORE MOLLUSCA: 9. THE FAMILY ARGONAUTIDAE, WITH A NEW RECORD OF *ARGONAUTA HIANS* (CEPHALOPODA: OCTOPODA: ARGONAUTOIDEA)

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***ABSTRACT.*** — The family Argonautidae is represented in Singapore waters by *Argonauta argo* and *Argonauta hians*. The latter species is a new record for Singapore based on a recent discovery of a shell at the Semakau Landfill. Information on the records of both species in Singapore, taxonomic or nomenclatural, and other related notes of interest are provided.

***KEY WORDS.*** — Argonaut, paper nautilus, historical records, nomenclature, Singapore, taxonomy

## INTRODUCTION

The Argonautidae Tryon, 1879, is a small family of pelagic octopuses, comprising four valid species in a single genus, that is widely distributed in both tropical and temperate waters worldwide (Finn, 2014). The females produce a brittle shell secreted with their dorsal arms, and argonauts are commonly called paper nautiluses because of the superficial similarities of their shells to those of the distantly related chambered nautiluses (family Nautilidae). Shells are washed up on beaches around the world, occasionally in the thousands, and mass gatherings (breeding aggregations) and strandings have been reported (see Norman, 2000: 194). The shell was assumed to serve mainly as a brood case for their eggs, but recent observations by Finn & Norman (2010) have shown that the shell of at least one species is used by the animals to trap air, that is gathered at the sea surface, to attain neutral buoyancy.

The brittle shell secreted by the female is perhaps the most recognisable aspect of the species in the family (Finn, 2013: 143), and was known to Pliny the Elder (see Belon, 1551: 52, 53). However, little or nothing was known about the animal—and even until the middle of the 19th century, it was believed that the animals would float upside down on the surface of the ocean and use their flattened and enlarged first pair of arms as sails (Fig. 1). Finn (2013) provided a brief but well-referenced introduction to the history of the study of this family.

Males are tiny octopuses that never develop a shell and are seldom seen. During mating, the males detach a modified third arm, or hectocotylus, that contains a sperm reservoir, which then crawls into the mantle cavities of the females, often wrapping around their gills or into the egg mass (Norman, 2000; Finn, 2013). Multiple male hectocotyli, each from a different male, are often found in mature females (Norman, 2000; Finn, 2014). It is assumed that the male argonaut dies after mating as no male with a regenerated hectocotylus has ever been collected (Norman, 2000).

In this instalment of a group-by-group treatment of the molluscs found in the Republic of Singapore (see Tan & Low, 2013b, 2014; Ng et al., 2014), the family Argonautidae is reviewed. Two species, *Argonauta argo* Linnaeus, 1758, and *Argonauta hians* Lightfoot, 1786, are herein reported, the latter as a new record. Details of these records and notes of interest are included.

## MATERIAL AND METHODS

Records were collated from the available literature and geographically-relevant material in various collections was examined where available and accessible. Primary synonyms and records that mention Singapore are listed. Abbreviations of the collections from which specimens were examined in the course of this study are: ZRC = Zoological Reference Collection, Lee Kong Chian Natural History Museum, National University of Singapore; and

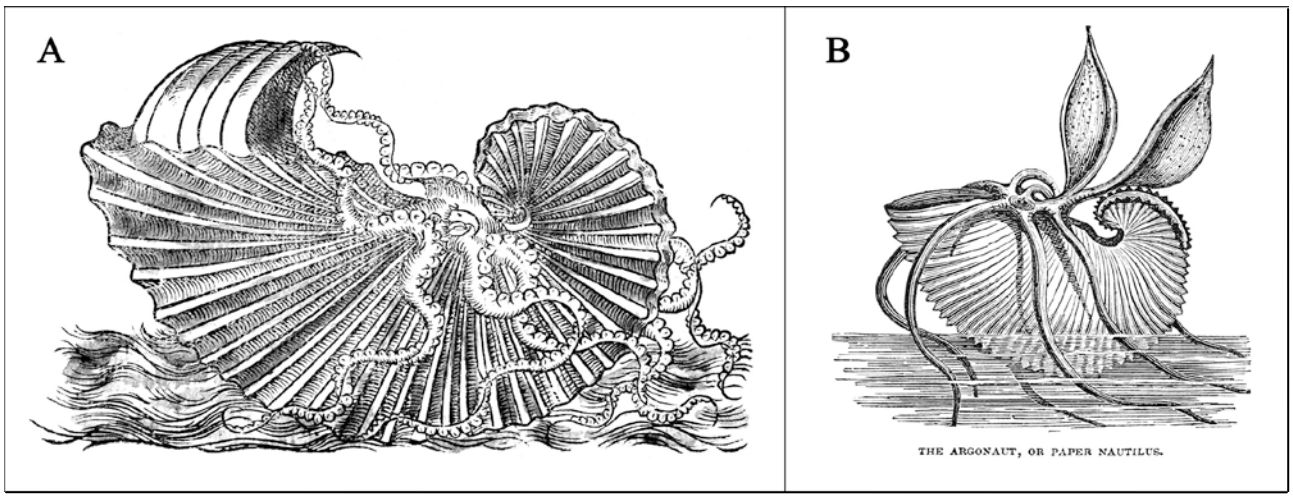


Fig. 1. Historical representations of the species of the genus *Argonauta* Linnaeus, 1758, which were thought to 'sail' on the surface of the ocean using their flattened and enlarged first pair of arms as sails: A, a figure from Belon (1551: 52, unnumbered fig.); B, a figure from Lamarck (1837: 21, unnumbered fig.). Images from works no longer in copyright digitised by and available at the Biodiversity Heritage Library.

TSK = collection of the second author. Measurements are given in the form of shell length (SL) × shell breadth (SB). Standard vertical orientation of the shell was used for illustrations and measurements, and shell length is defined as the maximum length of the shell and shell breadth is the maximum breadth. All measurements are in millimetres (mm).

## SYSTEMATICS

### SUPERFAMILY ARGONAUTOIDEA TRYON, 1879

Argonautidae Tryon, 1879: 133 (type genus *Argonauta* Linnaeus, 1758).

### FAMILY ARGONAUTIDAE TRYON, 1879

Argonautidae Tryon, 1879: 133 (type genus *Argonauta* Linnaeus, 1758).

#### Genus *Argonauta* Linnaeus, 1758

*Argonauta* Linnaeus, 1758: 708 (type species *Argonauta argo* Linnaeus, 1758, by subsequent designation by Children, 1825: 252; gender masculine).

***Remarks.*** — The subsequent designation of *Argonauta argo* Linnaeus, 1758, as the type species of the genus *Argonauta* Linnaeus, 1758, is sometimes attributed to Montfort (1810: 7) (e.g., Dodge, 1953: 11; Finn, 2013: 153). Although Montfort (1810: 7) stated that the type species of the genus was "L'Argonaute papiracé, l'Argonaute à carène enfumée. Argonauta papyracea fusca", and proposed these names to replace *Argonauta argo* Linnaeus, 1758 (which was listed in the synonymy), none of these names is an available name and this action by Montfort (1810: 7) does not qualify as a designation of type species under Article 69.2.2 of the 'International Code of Zoological Nomenclature' (hereafter the Code, ICZN, 1999: 72).

The International Commission on Zoological Nomenclature (ICZN, 1926: 13) ruled in Opinion 94 that the type species of the genus-group name *Argonauta* Linnaeus, 1758, was *Argonauta argo* Linnaeus, 1758. This was further expanded upon in Direction 72 (ICZN, 1957: 164, 184) which determined that designation of *Argonauta argo* Linnaeus, 1758, as the type species of the genus-group name *Argonauta* Linnaeus, 1758, was to be attributed to Children (1824: 252).

Keen (1971: 894) and Finn (2013: 168) have both discussed that the gender of the genus-group name *Argonauta* Linnaeus, 1758, is masculine. The gender of the genus-group name *Argonauta* Linnaeus, 1758, has been accepted by the International Commission on Zoological Nomenclature (Melville & Smith, 1987: 49).

### ***Argonauta argo*** **Linnaeus, 1758**
(Figs. 1, 2)

*Argonauta argo* Linnaeus, 1758: 708, sp. 231 (type localities: Indian Ocean; Mediterranean Sea ["in Pelago, M. Indico, Mediterraneo"]) [see ***Remarks***].
*Argonauta Corrugata* Humphrey, 1797: 6 (type localities: "Mediterranean and East Indies") [not an available name as it is included in a work that has been rejected for nomenclatural purposes (see Melville & Smith, 1987: 318)].
*Argonauta Papyracea* Röding, 1798: 71 (type locality: none stated/traced) [see ***Remarks***].
*Argonauta sulcata* Lamarck, 1801: 99 (type locality: none stated/traced).
*Argonauta papyracea* Link, 1807: 85 (type locality: none stated/traced) [see ***Remarks***].
*Argonauta grandiformis* Perry, 1811: pl. 42, fig. 4, unnumbered caption to pl. (type locality: Cape of Good Hope, South Africa [see Petit (2003: 17)]).
*Argonauta haustrum* Dillwyn, 1817: 335, 336 (type locality: East Indies).
*Ocythoë antiquorum* Leach, 1817b: 139 (type locality: Mediterranean [see Finn, 2013: 195]).
*Ocythoë Argonautae* Blainville, 1825: 366, pls. 1, 1 bis, 1 ter (type locality: none stated/traced).
*Argonauta compressa* Blainville, 1826: 212 (type locality: Indian Seas ["vient de la mer des Indes"]).
*Trichocephalus acetabularis* delle Chiaje, 1827: 225, 226, 244, pl. 16, figs. 1, 2 (type locality: Naples, Italy ["Regno di Napoli"]) [see ***Remarks***].
*Argonauta naviformis* Conrad, 1854: 334.
*Argonauta papyria* Conrad, 1854: 331, 332, pl. 34, fig. 1 (type locality: none stated/traced).
*Argonauta minor* Risso, 1854: 77, pl. 33, figs. 1, 2 (type locality: none stated/traced) [after Finn (2013: 194, 195)].
*Argonauta maxima* Reeve, 1861: pl. 2, unnumbered caption to pl. [nomen nudum and not an available name, published as a synonym and without a diagnosis or description; see ***Remarks***].
*Argonauta argo* forma *agglutinans* von Martens, 1867: 106 (type locality: none stated/traced [see Finn (2013: 195)]).
*Argonauta argo* forma *aurita* von Martens, 1867: 104 (type locality: Seram, Maluku, Indonesia ["Ceram, Moluccas", see Finn (2013: 195)]).
*Argonauta argo* forma *obtusangula* von Martens, 1867: 104 (type locality: none stated/traced [see Finn (2013: 195)]).
*Argonauta pacifica* Dall, 1869: 237 (type locality: none stated/traced) [nomen nudum].
*Argonauta maxima* Dall, 1871: 96 (type locality: "Indo-Pacific") [nomen nudum, not accompanied by a diagnosis; see ***Remarks***].
*Argonauta pacifica* Dall, 1871: 95, 96 (type locality: California).
*Argonauta bulleri* Kirk, 1886: 138, 139, pl. 4 (type locality: Portland Island, New Zealand).
*Argonauta argo* var. *americana* Dall, 1889: 174, 190, pl. 43, fig. 1, 1a, 1b, pl. 64, fig. 142b, pl. 67, fig. 63, 63a, 63b (type locality: Long Island, New York [see Finn (2013: 195)]).
*Argonauta cygnus* Monterosato, 1889: 120 (type locality: none stated/traced).
*Argonauta argo* var. *mediterranea* Monterosato, 1914: 387, pl. 10, fig. 2 (type localities: Adriatic Sea; Mediterranean Sea; Atlantic Ocean ["Méditerranée, Mer Adriatique et Océan Atlantique"; see also Finn (2013: 196)]).
*Argonauta Ferussaci* Monterosato, 1914: 389, pl. 13 (type locality: Sicily, Italy ["Sicile"]).
*Argonauta Sebae* Monterosato, 1914: 387, 388, pl. 11, fig. 1 (type locality: Adriatic Sea ["Adriatique"]).
*Argonauta Monterosatoi* Monterosato, 1914: 388, 389, pl. 12, figs. 1, 2 (type locality: Viesti, Gargano, Italy [see Finn (2013: 196)] [after Mienis (1994: 3); Finn (2013: 194)].
*Argonauta Monterosati* [sic] Coen, 1914: 23, pl. 1, fig. 2 [after Mienis (1994: 3); Finn (2013: 194)] [junior primary homonym and junior synonym of *Argonauta monterosatoi* Monterosato, 1914].
*Argonauta Monterosatoi* Coen, 1915: 272, 273, pl. 5, fig. 1 [after Mienis (1994: 3); Finn (2013: 194)] [junior primary homonym and junior synonym of *Argonauta monterosatoi* Monterosato, 1914].
*Argonauta cigno* D'Angelo & Gargiullo, 1987: 216, unnumbered fig. (bottom row, centre) (type locality: Island of Elba, Italy) [after Finn (2013: 196)]).

**Singapore records:**
*Argonanta* [sic] *argo* – Traill, 1847: 241 [first record].
*Argonauta argo* – Traill, 1858: 175 (after Traill, 1858). — Balfour, 1858: 342 (? after Traill, 1847).

***Material examined.*** — **Philippines.** Sulu Sea (ZRC.MOL.5726; ex TSK), 1990s.

***Distribution in Singapore.*** — Data unavailable.

***Habitat.*** — Pelagic in oceanic waters (Finn, 2014)

***Description.*** — The following diagnosis of the shell is adapted from Finn (2013). Shell thin, rather compressed laterally; to more than 260 mm in shell length; lateral ribs smooth, continuous; keel thin, of consistent width; keel tubercles relatively small and pointed, consistent in size and shape throughout.

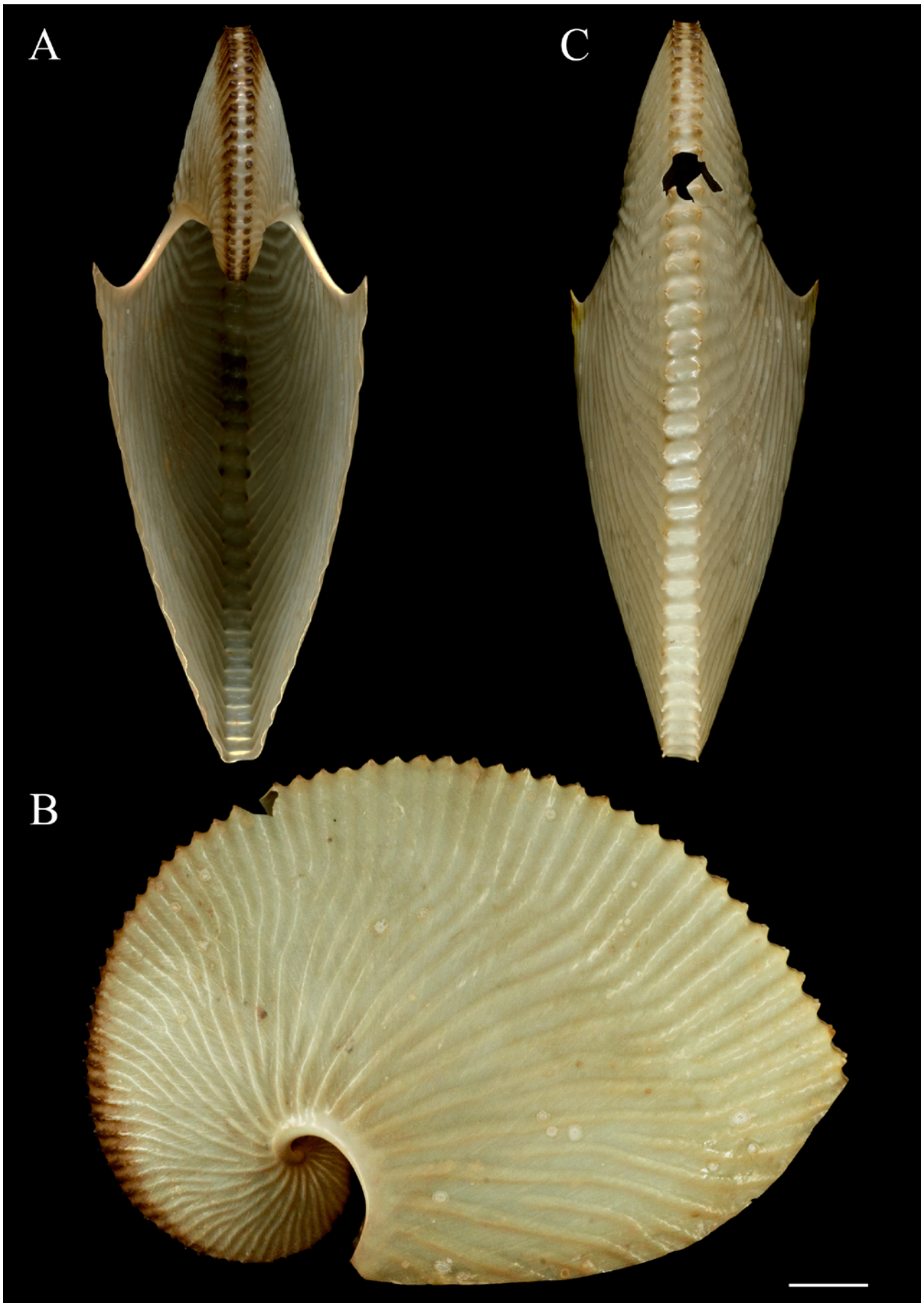


Fig. 2. *Argonauta argo* Linnaeus, 1758: A–C, Sulu Sea, Philippines (ZRC.MOL.5726 [ex TSK]; SL 185.0 × SB 127.7 mm). Views: A, apertural; B, lateral; C, abapertural. Scale bar = 20 mm.

***Remarks.*** — Shells of this species can be easily recognised by the narrow keel of consistent width and being rather laterally compressed. It is the largest living species of *Argonauta*. The taxonomy and biology of this species has been treated recently by Finn (2013). No specimen of this species from Singapore could be located and this species is tentatively included as a valid record for the local malacofauna (see **DISCUSSION**). A shell from the Philippines is herein figured for illustrative purposes (Fig. 2).

The type localities of *Argonauta argo* Linnaeus, 1758, were stated to be the Indian Ocean and Mediterranean ("in Pelago, M. Indico, Mediterraneo"). Moolenbeek (2008: 26) designated a specimen at the Museum of Evolution, Uppsala Univesity (UUZM) as the lectotype of *Argonauta argo* Linnaeus, 1758. Although clearly of the "Mediterranean form" (see Dodge, 1953: 11), there is no additional locality information relating to the specimen, and as such, the type localities of *Argonauta argo* Linnaeus, 1758, remain as the Indian Ocean and Mediterranean Sea.

The species-group name *Argonauta papyracea* was first made available by Röding (1798: 71) and was based on "sp. I" of *Argonauta argo* Linnaeus, 1758, as used by Gmelin (1791: 3367, 3368), which is a composite species which includes *Argonauta argo* Linnaeus, 1758 (see Finn, 2013: 190). Gmelin (1791: 3368) also included five other infrasubspecific varieties (listed as β, beta; γ, gamma; δ, delta; ε, epsilon; ζ, zeta), with various figures by Martini (1769) being referred to each variety. Gmelin (1791: 3368) referred two figures by Martini (1769: pl. 17, figs. 158, 159) to the δ (delta) variety. These figures agree well with the current definition of *Argonauta argo* Linnaeus, 1758 (see also Finn, 2013: 177, 179). Link (1807: 85) proposed the name *Argonauta papyracea* for the variety δ (delta) of Gmelin (1791: 3368), to which he referred a figure by Martini (1769: pl. 17, figs. 158, 159 [as "459"]). *Argonauta papyracea* Link, 1807, was proposed independently of *Argonauta papyracea* Röding, 1798, and is junior primary homonym of the latter, and both names are junior subjective synonyms of *Argonauta argo* Linnaeus, 1758.

Robson (1932: 200) doubtfully considered *Argonauta striata* Perry, 1811 (pl. 42, fig. 3, unnumbered caption to pl.; type locality: East Indies), to be a "small example of *argo*". Petit (2003: 51) considered *Argonauta striata* Perry, 1811, to be a nomen dubium.

*Trichocephalus acetabularis* delle Chiaje, 1827 (pp. 225, 226, 244, pl. 16, figs. 1, 2; type locality: Naples, Italy ["Regno di Napoli"]), was described based on the heterocotylus of a male found inside the shell of a female individual, and was described as a parasite of the latter (see Duchamps, 2004: 107, as "*Microchephalus acetabularis*"). As *Argonauta argo* Linnaeus, 1758, is the only species of this genus confirmed to inhabit the Mediterranean Sea (see Finn, 2013: 192, fig. 35), *Trichocephalus acetabularis* delle Chiaje, 1827, is almost certainly synonymous with this species.

*Argonauta fragilis* Parkinson, 1856 (p. 387, 388; no type locality stated), was listed as synonym of *Argonauta argo* Linnaeus, 1758, by Dodge (1953: 11, footnote). Robson (1932: 200) followed Dodge's (1953: 11) opinion with doubt. The description appears to be too brief and lacking in diagnostic characters for the name to be identified with a known species.

The name "*Argonauta maxima*", with authorship attributed to Blainville, has been used by early authors (e.g., Reeve, 1861: pl. 2, unnumbered caption to pl.; see also Dall, 1908: 227). As far as we can ascertain, the name was never used by Blainville, and remains an unavailable name, as it has never been published with a diagnosis (e.g., Dall, 1871: 96).

Monterosato (1914) proposed several species-group names in the genus *Argonauta* Linnaeus, 1758, which were based on the manuscript names of earlier authors: "*Argonauta Ferussaci* Valenciennes mss." (p. 389), "*Argonauta Monterosatoi* Coen mss." (pp. 388, 389), and "*Argonauta Sebae* Valenciennes mss." (pp. 387, 388). As it is clear that Monterosato (1914) was simply using these manuscript names, authorship of the name should be attributed only to Monterosato (1914) (Article 50 of the Code, ICZN, 1999: 52). In the case of *Argonauta monterosatoi*, Monterosato (1914: 389, 390) was the first author to make this name available, and the two subsequent proposals of this name by Coen (1914: 23, pl. 1, fig. 2; 1915: 272, 273, pl. 5, fig. 1) are junior primary homonyms and junior synonyms of Monterosato's (1914) name (see Mienis, 1994: 3; Finn, 2013: 194, 196).

### ***Argonauta hians* Lightfoot, 1786**

(Figs. 3, 4)

*Argonauta hians* Lightfoot, 1786: 44, 139, 174 (type locality: Ambon, Indonesia [see ***Remarks***]).
*Ocythoë Cranchii* Leach, 1817a: 295, 296, pl. 12, figs. 1–6 (type locality: Gulf of Guinea, West Africa).
*Argonauta nitida* Lamarck, 1822: 653 (type localities: Indian Ocean; Maluku, Indonesia ["l'Océan des grandes Indes et des Moluques"]).
*Argonauta crassicosta* Blainville, 1826: 213 (type locality: Australia ["Nouvelle-Hollande"; see also Finn (2013: 179)]).

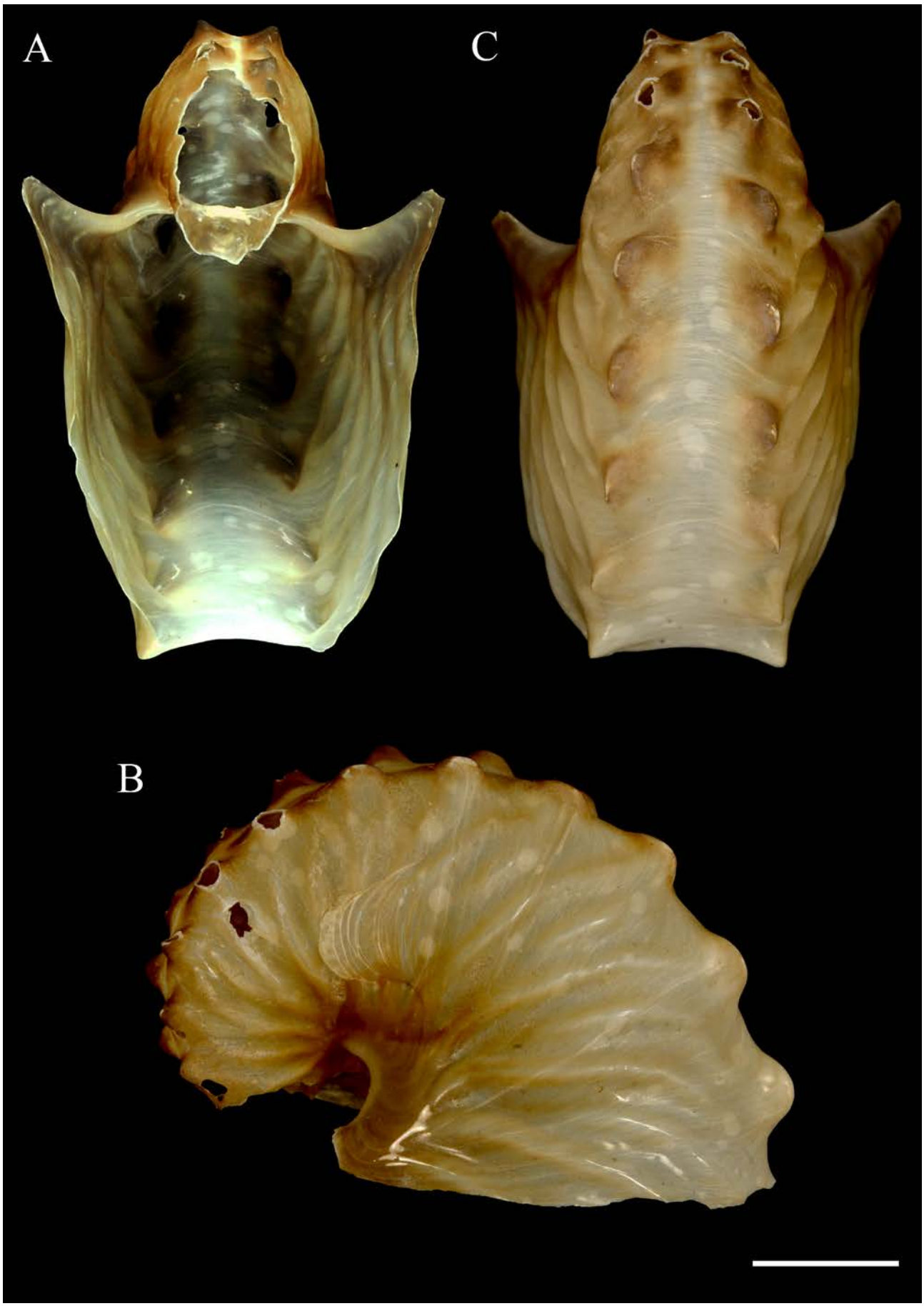


Fig. 3. *Argonauta hians* Lightfoot, 1786: A–C, Pulau Semakau, Singapore (ZRC.MOL.5725; SL 43.4 × SB 27.3). Views: A, apertural; B, lateral; C, abapertural. Scale bar = 10 mm.

*Argonauta raricosta* Blainville, 1826: 213 [replacement name and junior objective synonym of *Ocythoe cranchii* Leach, 1817].
*Argonauta Owenii* Adams & Reeve, 1848: 4–6, pl. 3, fig. 1a–d (type locality: South Atlantic Ocean).
*Argonauta Kochiana* Dunker 1852: 49, 50 (type locality: China Seas ["Mari Chinensi"]).
*Argonauta polita* Conrad, 1854: 333, pl. 34, fig. 4 (type locality: none stated/traced).
*Argonauta hians* forma *aurita* von Martens, 1867: 105 (type locality: Bacan, Maluku, Indonesia ["Batjan, Moluccas", see Finn (2013: 179)]) [in part].
*Argonauta hians* forma *mutica* von Martens, 1867: 105 (type locality: none stated/traced [see Finn (2013: 179)]).
*Argonauta hians* forma *obtusangula* von Martens, 1867: 105 (type locality: Seram, Maluku, Indonesia ["Ceram, Moluccas", see Finn (2013: 179)]) [in part].
*Argonauta Böttgeri* Maltzan, 1881: 163, pl. 6, fig. 7 (type locality: none stated/traced).

***Material examined*.** — **Singapore.** Station RF231, Phase II lagoon, at the southern part of Semakau Landfill, Singapore Straits (ZRC.MOL.5725 [CMBS INT-0284]), 4 November 2013.

***Distribution in Singapore*.** — To date, known only from a single shell found at Semakau Landfill (see Fig. 4).

***Habitat*.** — Pelagic in oceanic waters, females have been observed 'riding' on jellyfish (Norman, 2000; Finn, 2014).

***Description*.** — The following diagnosis of the shell is adapted from Finn (2013). Shell thin, rather wide and somewhat boxy; to about 100 mm in shell length; lateral ribs smooth, continuous; keel tubercles rounded and relatively large; keel width and size of keel tubercles increase with shell growth.

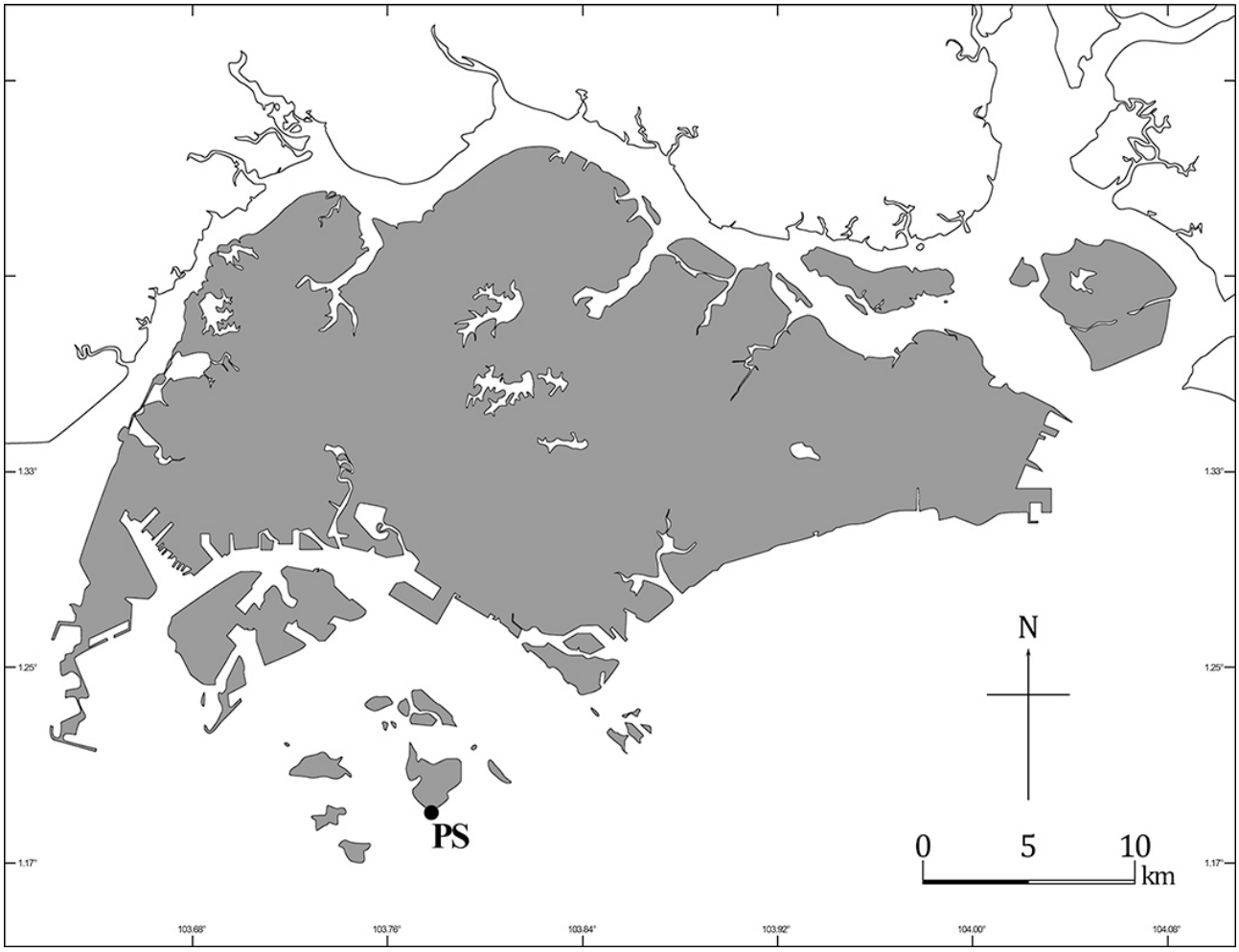


Fig. 4. Distribution of the family Argonautidae Tryon, 1879, in Singapore. Detailed locality information is currently only known for a single record of *Argonauta hians* Lightfoot, 1786, which was found on Pulau Semakau (PS).

***Remarks.*** — Shells of this species can be recognised by the wide keel and boxy shape. It is the smallest species of *Argonauta*. The taxonomy and biology of this species have been treated recently by Finn (2013).

Moolenbeek (2008: 26) designated a drawing by Rumphius (1705: pl. 18, fig. B) to represent illustration of the lectotype of *Argonauta hians* Lightfoot, 1786. This action changes the type locality of *Argonauta hians* Lightfoot, 1786, from "China" (Lightfoot, 1786: 174) to Ambon, Indonesia (see also Finn, 2013: 177).

## DISCUSSION

Both *Argonauta argo* Linnaeus, 1758, and *Argonauta hians* Lightfoot, 1786, are known to occur in the South China Sea and Southeast Asia (Norman & Lu, 2000; Finn, 2013, 2014). However, no specimen of *Argonauta argo* Linnaeus, 1758, from Singapore could be located and it has not been reported since Traill (1847, 1858). It should be noted that the list compiled by Traill (1847) includes species from the vicinity of Singapore as well, and it is therefore uncertain if the *Argonauta argo* originated from the territorial waters of Singapore. The record of *Argonauta argo* is thus herein only tentatively included as part of the malacofauna of Singapore, and will require confirmation by the way of future samplings or records (e.g., Tan & Low, 2013a).

## ACKNOWLEDGEMENTS

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