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Studies in *Canarium urceus* (Linné, 1758) Part 4: *Canarium* (*Canarium*) *orrae* (Abbott, 1960) (Gastropoda: Neostromboidae: Strombidae) and a new species from the Northern Territory, Australia

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ABSTRACT This part of the *Canarium* (*Canarium*) *urceus* (Linné, 1758) after Abbott (1960) revision examines the Australian species of that complex. Currently, there is one recognised species, *Canarium* (*Canarium*) *orrae* (Abbott, 1960), which is divided herein into two species, with the description of *Canarium* (*Canarium*) *darwinense* n. sp. from the Van Diemen Gulf and Darwin surrounds. The *C.* (*C.*) *darwinense* is distinguished from *C.* (*C.*) *orrae* in morphological form. The southern range of *C.* (*C.*) *orrae* is extended to Monkey Mia, Shark Bay. Examples of *C.* (*C.*) *orrae* were also noted from the North Coast of Sumbawa, Indonesia, and Port Moresby, Papua New Guinea. While there is a geographic break in the distribution of *C.* (*C.*) *orrae* creating two populations, Western Australian and Gulf of Carpentaria, populations from these two ranges could not be distinguished using morphology. Future research will likely show genetic differences as a consequence of drift caused by isolation, thus leading to the potential recognition of two cryptic subspecies.

KEYWORDS *Canarium*, *C. orrae*, *C. darwinense*, Northern Territory, *Strombus*, Western Australia

INTRODUCTION

Recent studies of the *Canarium* (*Canarium*) *urceus* (Linné, 1758) complex (Abbott 1960) have led to a significant recognition of species that have either been buried within the synonymy of that species (Dodge 1946, 1956; Abbott 1960; Maxwell *et al.* 2020a), or aggregated to form an oversimplified taxonomy (Maxwell *et al.* 2020b; Dekkers & Maxwell 2020a, b). Abbott (1960, p. 63) described *Strombus* (*C.*) *urceus* with a focus of not distinguishing those taxa, which "in addition to size, sculptural and color variations that appear within a single colony, there are other geographical clines and groups of morphological variations limited to certain rather discrete geographical areas", a mindset that does not give taxonomic justice to the recognition of potential diversity within the *urceus* complex.

The distribution of *Canarium* examined in this study falls within the Damperian Province, which ranges from Shark Bay in Western Australia north to the Gulf of Carpentaria (Wilson 2013; Petuch & Berschauer 2020). The Damperian Province is further divided into several distinctive mesoscale biogeographical regions (Thackway & Cresswell 1998; Petuch & Berschauer 2020), each of which reflect localised species distributions; one example of *Canarium* from Darwin shows distinctive regional consistency in form that distinguishes this population from other areas in the province and justifies species recognition.

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ABBREVIATIONS

AM Australian Museum, Sydney, New South Wales, Australia.
AMD Aart M. Dekkers Collection, Purmerend, The Netherlands.
CC Barbra Collins Collection, Cairns, Queensland, Australia.
LC Lesley Colliver Collection, Geraldton, Western Australia, Australia.
NMV Museums Victoria, Melbourne, Victoria, Australia.
QM Queensland Museum, Brisbane, Queensland, Australia.
SMC Stephen Maxwell Collection, Cairns, Queensland, Australia.
VC Valda Cantamessa Collection, Proserpine, Queensland, Australia.
WAM Western Australian Museum, Perth, Western Australia, Australia.
YC Trevor and Margarette Young Collection, Townsville, Queensland, Australia.

METHODS

Three hundred specimens were examined, and Australian specimens were divided into three distinctive bioregions, with two external Australian examples: first, North Western Biotone, the Van Diemen Gulf and area surrounding Darwin, containing the new species (Figure 1, yellow enclosed area, n = 109); second, the The Exmouthian Subprovince contains most of the western Damperian Province and contains the western population of *C.* (*C.*) *orrae* (Figure 1, green enclosed area, n = 167); third, the Groote biogeographical region, containing the eastern population of *C.* (*C.*) *orrae* (Figure 1, red enclosed area n = 22); and two specimens were observed outside of Australia, one each from Indonesia and Papua New Guinea (see Figure 1). The Arnhem-Wessel region (Figure 1, pink enclosed area) has not been included in this study as material was not made available to the authors by the Museum and Art Gallery of the Northern Territory when requested.

Locality records were divided into three categories: first, material at hand; second, literary records; and third institutional records (QM, NMV, WAM) taken from the Atlas of Living Australia (ALA 2021). However, there are two limitations on the use of digital and literary historical records without accompanying illustrations: first, the correctness of the species identification underpinning each record has not been confirmed; and second, there is a reliance on the accuracy of the data provided with each specimen. For the purposes of this study, locality records were listed under the species that share a similar range. This assumes that each species has a defined geographical boundary. Locality data were divided by Country or Australian state/territory and listed under the distributional records for each species and then mapped (Figure 1).

We provide a redescription of the morphological characteristics of comparative species to provide clarity and to assist the discernment of the novel taxon. The decision to use the rank of species or subspecies is based on Maxwell and Dekkers (2019) and Maxwell *et al.* (2021). Under this system, the subspecies rank should be restricted to those taxa where there are no other forms of discrimination other than phenetic differences in genetic sequences.

SYSTEMATIC PART

Superfamily	Stromboidea Rafinesque, 1815
Epifamily	Neostromboidae Maxwell, Dekkers, Rymer & Congdon, 2019
Family	Strombidae Rafinesque, 1815
Subfamily	Neostrombinae Maxwell & Rymer, 2021

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Tribe	Neostrombini Liverani, Dekkers & Maxwell, 2021
Genus	*Canarium* Schumacher, 1817
Subgenus	*Canarium* Schumacher, 1817

Canarium (*Canarium*) *orrae* (Abbott, 1960)
(Figures 2-3 and 5E-O)

Synonymy.

1960 *Strombus* (*Canarium*) *urceus orrae* Abbott, p. 66, pl. 41, fig. 5. Wilson and Gillett 1971, p. 40, p. 18, figs. 2a-b. Wilson and Gillett 1974, p. 40, pl. 18, figs. 2a-b. Wilson and Gillett 1979, p. 73, pl. 14, figs. 2a-b. Coleman 1975, p. 90. Walls 1980, p. 109, fig. 110. Kreipl *et al.* 1999, pp. 12 and 40, pl. 77.
= *Strombus orrae* Abbott – Dekkers and Maxwell 2020b, fig. 5.
= *Strombus* (*Canarium*) *orrae* Abbott – Liverani *et al.* 2021, p. 30, fig. 2.

Strombus urceus Wilson 1993, p. 156, pl. 21, figs. 5 a-c.

Original Description. "This new subspecies is characterised and distinguished from the southwest Pacific typical *urceus* by its heavier, more quadrate, less coloured shell, its stronger and fewer nodules and its shorter siphonal canal. Its penultimate whorl bears 7-11 knobs (instead of as many as 10 to 16 as in typical *urceus*). The top of the outer lip is square and thickened; the columella is always white and the inner aperture with sparse brown lirae. Body whorl with 7 to 9 nodules at the shoulder, the first one of two at the shoulder being large, swollen and prominent. The young show a narrow, broken spiral band of brownish black on the body whorl. Nuclear whorls 2.5, translucent yellowish and glossy" (Abbott 1960, p. 66).

Type Material. Holotype – ANSP no. 247756. Paratypes – ANSP no. 232673; 233409; 240131; 240137.

Type Locality. Augustus Island, Western Australia (Abbott 1960).

Supplementary Diagnosis. The shell is elongated and fusiform. The teleoconch is high and strongly plicated with large regular shoulder knobs. The ventral body whorl is axially plicated and these from regular knobs on the angulate shoulder, and continue to the mid-whorl; these plications may be strong to weak. The colour of the ventral body whorl is variable and not typically restricted to the lower third. The top of the outer lip is square and thickened; the stromboid sinus is well developed and the flange is not strongly developed. The columella is always white and the inner aperture has sparse brown lirae. The outer lip typically joins below the shoulder.

Locality Records. ***Literary Records*****:** *Western Australia* – Augustus Island (Abbott 1960); Broome (Abbott 1960); Cape Leveque (Abbott 1960); Dampier Archipelago (Slack-Smith and Bryce 2004); Gantheaume Point, Broome (Abbott 1960); La Grange Bay (Abbott 1960). *Northern Territory* – Groot Eylandt (Abbott 1960); Bickerton Island (Abbott 1960). ***Institutional Records*****:** *Western Australia* – 22 km South of Exmouth (NMV F152000); 80 mile Beach south end, Cape Keraudren (F233792); Adele Island (WAM S46615, S46635); Augustus Island, Bonaparte Archipelago (NMV F28768); Back Beach, Dampier (NMV F233795; QM MO83450); Barred Creek (NMV F28786); Black Ledge area, Broome (QM MO83449); Brecknock Island, Bonaparte Archipelago (WAM S46618, S46619); Broome (NMV F28949, F233790; WAM S46588; QM DM11576073); Bundgei Reef (NMV F151685); Cambridge Gulf

(F28875); Camden Sound (WAM S46599); Cape Leveque (AM 77745; QM MO67999; NMV F233800, F28763); Cassini Island, Bonaparte Archipelago (WAM S46591, S46592); Cleaverville, Dampier (NMV F152005, F233717); Cockatoo Island, Buccaneer Archipelago (NMV F19849; WAM S46598, S46633); Corneille Island, Bonaparte Archipelago (WAM S46594); Coronation Island, Bonaparte Archipelago (WAM S46617); East Monalivet Island (WAM S46602); Finucane Island (NMV F151687); Jones Island (WAM S46828l; QM MO56772); Karratha (NMV F233716); Lesueur Island (WAM S46601); Long Island, Buccaneer Archipelago (WAM S46614); Montgomery Reef (WAM S46646); One Arm Point (NMV F233719); Pender Bay (NMV F28779); Scorpion Island, Sir Graham Moore Islands (S46596); Sunday Island, Buccaneer Archipelago (WAM S46631, S46590); Troughton Island (WAM S46616); Turtle Bay (NMV F233798); Yampi Sound, Buccaneer Archipelago (NVM F28784). *Northern Territory* – Groote Eylandt Island (QM MO38297; MO38332).

***Material Examined*:** *Western Australia* – Augereau Island (VC x 2); Back Beach, Dampier (VC x 5); Broome (AMD x 2, SMC x 46); Bundeyi Beach (SMC x 3); Cape Leveque (AMD x 3); Cassini Island (SMC x 1, VC x 4); Dampier (AMD x 1); Dixon Island, Wickham (VC x 4); East Moore Island, Balla Balla (VC x 5); Exmouth (SMC x 1, VC x 2, YC x 1); Forty Mile Beach (SMC x 8, VC x 6); Gnoorea (AMD x 1); Intercourse Island, Dampier (SMC x 12, YC x 1); King Sound (SMC x 2, YC x 1); Middle Mangrove Island, Onslow (AMD x 2); Monkey Mia, Shark Bay (BC x 4); Onslow (SMC x 6, VC x 8); Port Smith, Broome (VC x 4); Pretty Pool, Port Headland (SMC x 7, VC x 9); Roebuck Bay (VC x 10); Walcott Inlet, Kimberley (SMC x 4, VC x 2); *Northern Territory* – Bing Bong (AMD x 8); Drimmie Head, Gove (BC x 4); Hardy Island (AMD x 1); Wallaby Beach, Gove (BC x 8); and Wessel Island (SMC x 1). *Indonesia* – North Coast of Sumbawa (LC x 1). *Papua New Guinea* – Port Moresby (AMD x 1).

Comparison and Remarks. It is expected that the two geographically isolated populations of *C.* (*C.*) *orrae* will be taxonomically separated by genetic evidence, a consequence of drift effects from the separation of the populations, and these will be divided at the subspecies level (Maxwell & Dekkers 2019; Maxwell *et al.* 2021). *Canarium* (*C.*) *orrae* stands out from other species in the *C.* (*C.*) *urceus* complex by the relatively stable morphology and large size, the high teleoconch that is strongly knobbed, the strong axial ribbing on the ventral side (although that is not always the case, and smooth ventral sides do occur), and the simple whitish colour.

Canarium (*Canarium*) *darwinense* Maxwell & Dekkers, new species
(Figures 4 and 5A-D)

Synonymy.

1960 *Strombus* (*Canarium*) *urceus orrae* Abbott, pl. 20, fig. 28.
1980 *Strombus* (*Canarium*) *urceus incisus* Wood – Walls, p. 107.
1987 *Strombus* (*Canarium*) *urceus* Linné – Short and Potter, p. 34, pl. 16, fig. 10.

Description. The shell is strongly bitriangulate with the body whorl being much wider than the final whorl of the spire. The teleoconch is low and the plications are fine, triangulate and regular, not forming distinct nodules at the shoulder. The posterior of the outer lip is square and thickened, causing a strong contraction of the aperture. The outer lip protrudes forming a strong callused knob, the mid-outer lip is thickened and the stromboid sinus is narrow,

with a large flange give the impression of a 'U" shape between the posterior callus and the sinus; the columella is always white and the inner aperture has sparse brown lirae. The ventral body whorl is not axially plicated, and the rounded angulate shoulder has knobs that are blunt, becoming stronger dorsally. Ventral body whorl colouration is typically restricted to the lower third of the body whorl, this colour being a brown stain. The outer lip typically joins at or just below the shoulder.

Type Material. Holotype – Lee Point, Darwin, 42 mm, 2020 (QM MO 85658); Paratype 1 – Lee Point, Darwin, 28 mm, 2020 (SMC 20a.001a); Paratype 2 – Lee Point, Darwin, 32 mm, 2020 (SMC 20a.001b); Paratype 3 – Lee Point, Darwin, 42 mm, 2020 (SMC 20a.001c); Paratype 4 – Lee Point, Darwin, 42 mm, 2020 (SMC 20a.001d); Paratype 5 – Lee Point, 40 mm, 2000 (SMC 20a.002a); Paratype 6 – Lee Point, 38 mm, 2000 (SMC 20a.002b); Paratype 7 – Casuarina, 43 mm, 1970 (AMD STR0782); Paratype 8 – Casuarina Beach, 40 mm, 1970 (AMD STR0782).

Type Locality. We designate Lee Point, Darwin.

Etymology. Named after the Darwin region were the species is well established.

Locality Records. ***Literary Records:*** *Northern Territory* – Shell Island, Darwin (Abbott 1960); East Point, Darwin (Abbott 1960); Port Darwin, Darwin (Abbott 1960); Quail Island, 35 miles west of Darwin, (Abbott 1960); and Nightcliff Point, Darwin (Abbott 1960). ***Institutional Records*****:** *Northern Territory* – Gunn Point Beach, Darwin (NMV F151986); Tree Point, Darwin (QM MO46855); Shoal Bay, Darwin (NMV F233793); Port Darwin, Darwin (NMV F28765); Vesteys Beach, Darwin (QM MO28495). ***Material Examined:*** *Northern Territory* – Darwin (AMD x 1; VC x 5; YC x 1); Casuarina, Darwin (AMD x 2); Lee Point, Darwin (AMD x 4; SMC x 81; VC x 1); Dripstone Cliffs, Darwin (SMC x 7); One Arm Point (VC x 2); Timor Sea (VC x 3); Vesteys Beach, Darwin (SMC x 2).

Comparison and Remarks. *Canarium* (*C.*) *darwinense* is a geographically isolated form that forms a number of colonies, with current evidence having the species restricted to the Darwin region. The strongly calloused outer lip, strong stromboid flange and narrow stromboid sinus, coupled with the bitriangulate shell distinguish *C.* (*C.*) *darwinense* from *C.* (*C.*) *orrae*. The new species *C.* (*C.*) *darwinense* should first be compared with *C.* (*C.*) *orrae* with which it has been confused for so many years until this part of the *C.* (*C.*) *urceus* complex revision. Compared to *C.* (*C.*) *orrae*, the new species has a shorter spire, more cone-like form of the shell with a broader shoulder, a wrinkled upper part of the aperture and a large extension beside the very shallow strombid notch ("strombid lobe" in Dekkers, 2021). In addition, it bears a brown colour stain on the anterior channel, which is lacking in *C.* (*C.*) *orrae*. The new species shares the more cone-like form of *C.* (*C.*) *manintveldi* Dekkers & Maxwell, 2020 from Vanuatu and the New Hebrides. However, that species is mostly much smaller (around 25 to 30 mm) and smoother on the body whorl, with an even shorter spire, the posterior ending of the aperture is raised high towards the apex, and lacks the elongation of the strombid lobe.

DISCUSSION

This paper erects a geographically consistent species from the North Western Biotone containing the Van Diemen Gulf and area surrounding Darwin. The localised range of *C.* (*C.*) *darwinense* is characterised by diverse tropical environments including large estuarine drainage systems, mangrove flats, localised

intermittent fringing reefs and rocky headlands (Thackway & Cresswell 1998). The Exmouthian Subprovince contains most of the western Damperian Province and the western range of *C.* (*C.*) *orrae*, and may contain *C.* (*C.*) *darwinense* in the Kimberly Region. The Northern Region contains the Groote biogeographical region, which contains the most easterly records of *C.* (*C.*) *orrae*. This region has well developed localised fringing coral reefs, and extensive seagrass beds separated by narrow fringing mangrove stands (Thackway & Cresswell 1998). There is no record of *C.* (*C.*) *darwinense* found in this region. The western Northern Biozone, the Arnhem-Wessel region, is relatively unexplored in terms of its biodiversity; reefs tend to the eastern border regions with the Groote Biogeographical region, and there are sporadic records of *Canarium* in that region (ALA 2021), but the form of these is unknown at present to the authors. It is likely that the Arnhem-Wessel region will contain both *C.* (*C.*) *orrae* and *C.* (*C.*) *darwinense* due to veliger dispersal.

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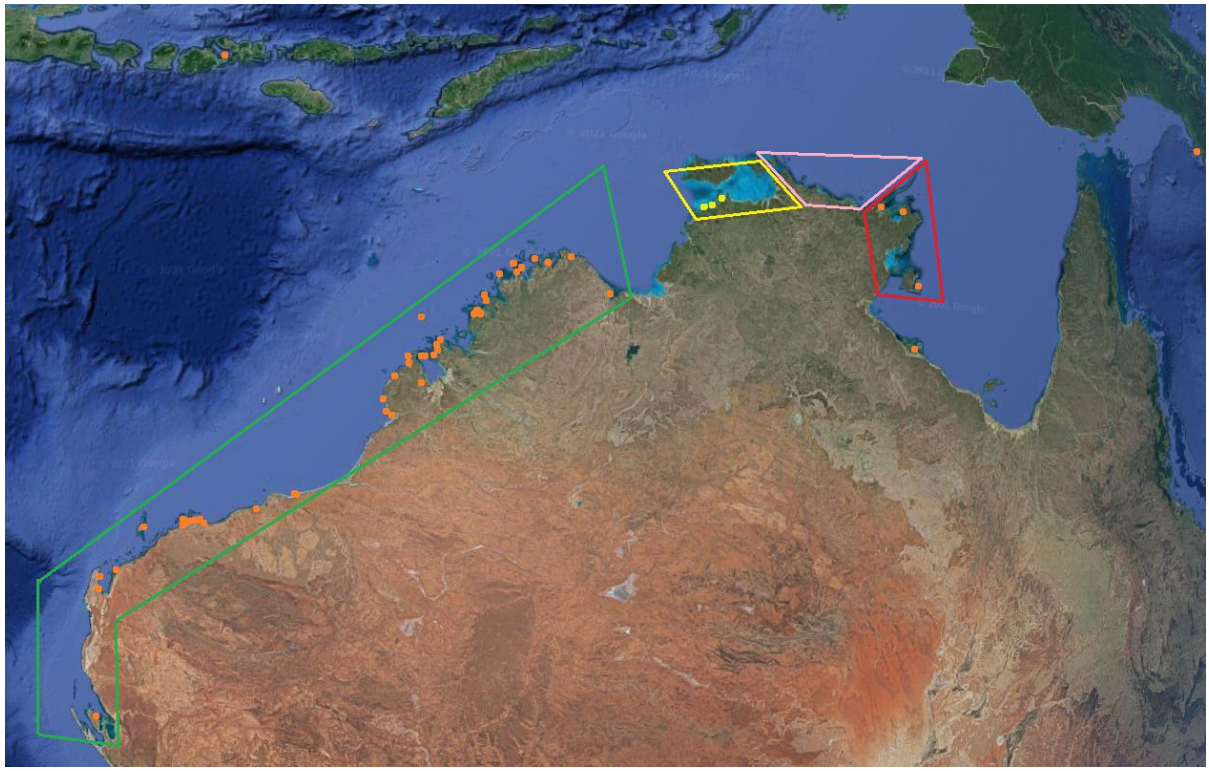

Figure 1. Distribution of *Canarium* (*Canarium*) *orrae* (orange dots) and *Canarium* (*Canarium*) *darwinense* (yellow dots): The Exmouthian Subprovince (Green bordered region – *C.* (*C.*) *orrae*); The Arnhem-Wessel Region (Pink bordered region – material from this region was not seen); The Van Diemen Gulf and Darwin (Yellow bordered region – *C.* (*C.*) *darwinense*); and The Groote Biogeographical Region (Red bordered region – *C.* (*C.*) *orrae*). Outliers from the Damperian Province shown include: Bing Bong, Northern Territory; Port Moresby, PNG; and the North Coast of Sumbawa, Indonesia.

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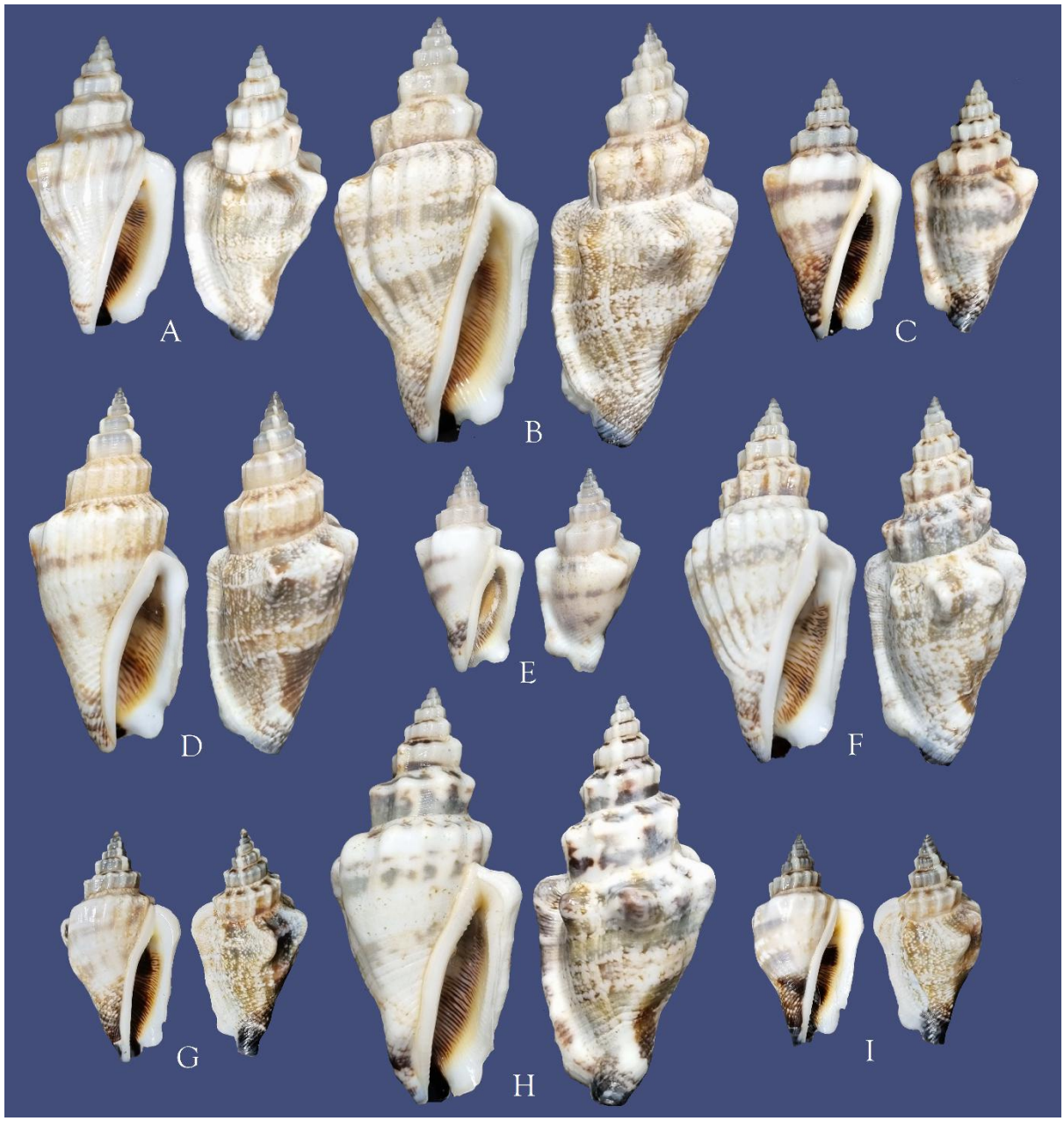

Figure 2. *Canarium* (*Canarium*) *orrae* (Abbott 1960) from The Exmouthian Subprovince: A) King Sound, 36 mm, 1976 (SMC 20.001a); B) Bundeyi Beach, 52 mm, 1983 (SMC 20.007b); C) Forty Mile Beach, 31 mm, 2017 (SMC 20.010a); D) Pretty Pool, Port Headland, 44 mm, 2017 (SMC 20.013a); E) Cassini Island, 24.3 mm, 2013 (SMC 20.002); F) Exmouth, 45 mm, 1989 (SMC 20.009); G) Dampier, 28 mm, 2011 (SMC 20.008a); H) Bundeyi Beach, 51 mm, 1983 (SMC 20.007a); I) Dampier, 26 mm, 2011 (SMC 20.008a).

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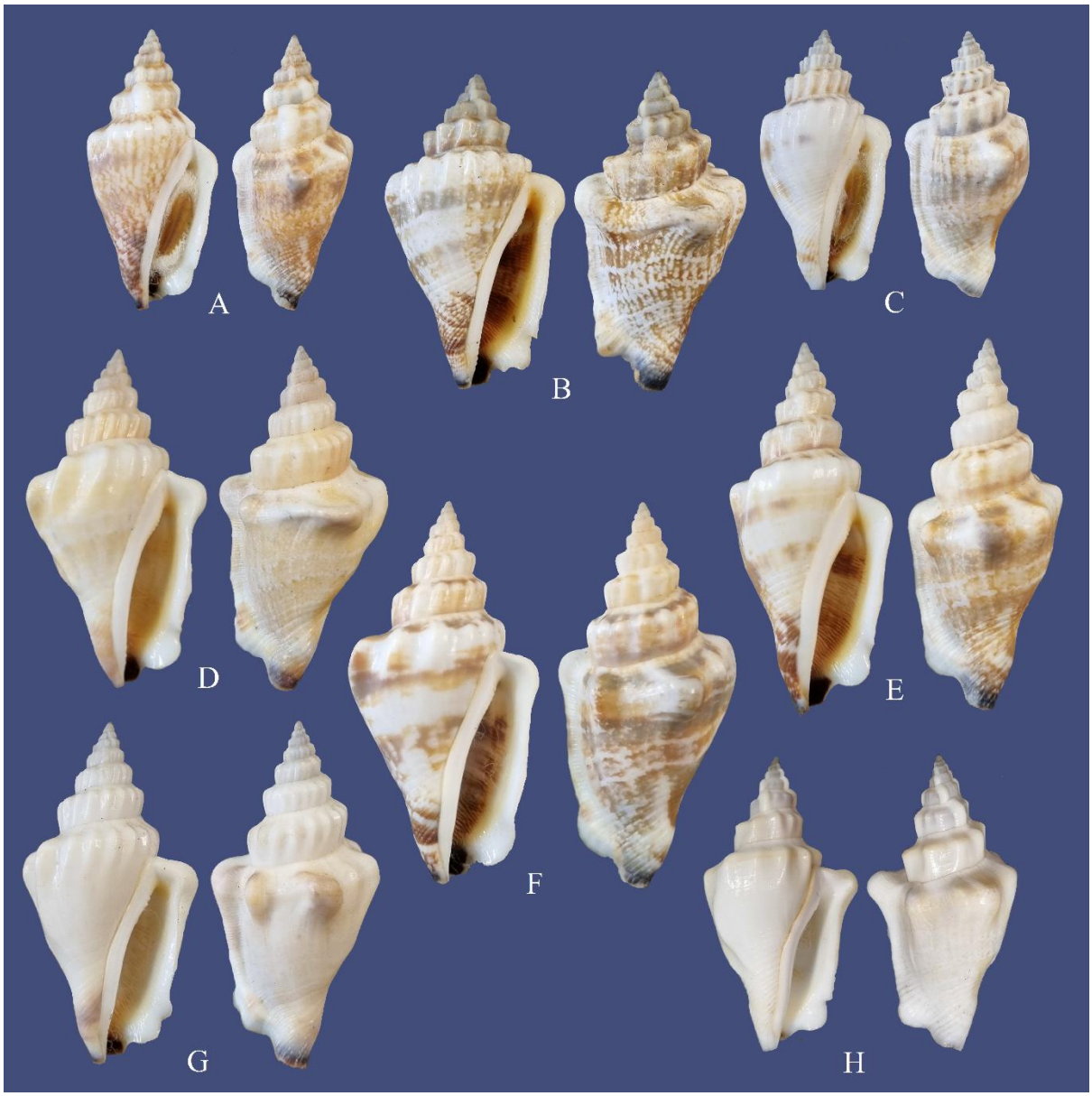

Figure 3. *Canarium* (*Canarium*) *orrae* (Abbott 1960) from The Carpentarian Subprovince – Groote Biogeographical Region: A) Drimmie Head, Gove, 37 mm (BC); B) Drimmie Head, Gove, 40 mm (BC); C) Drimmie Head, Gove, 34 mm (BC); D) Wallaby Beach, Gove, 45 mm (BC); E) Wallaby Beach, Gove, 48 mm (BC); F) Wallaby Beach, Gove, 50 mm (BC); G) Wallaby Beach, Gove, 45 mm (BC); H) Wessel Island, Northern Territory, 1996, 37 mm (SMC 20.003).

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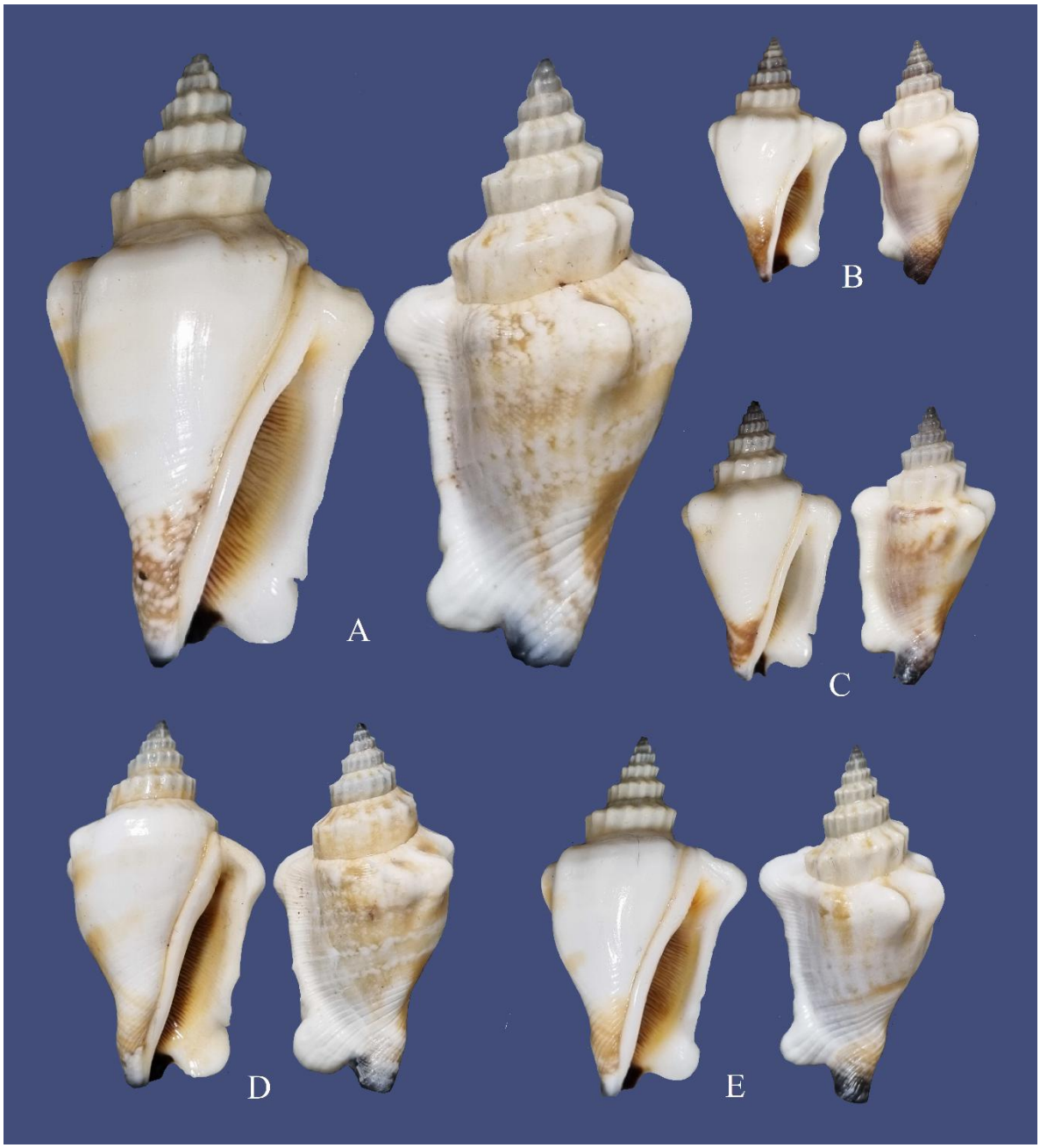

Figure 4. *Canarium* (*Canarium*) *darwinense* n. sp. from Van Diemen Gulf and Darwin: A) Holotype – Lee Point, Darwin, 42 mm, 2020 (QM MO 85658); B) Paratype 1 – Lee Point, Darwin, 28 mm, 2020 (SMC 20a.001a); C) Paratype 2 – Lee Point, Darwin, 32 mm, 2020 (SMC 20a.001b); D) Paratype 3 – Lee Point, Darwin, 42 mm, 2020 (SMC 20a.001c); and E) Paratype 4 – Lee Point, Darwin, 42 mm, 2020 (SMC 20a.001d).

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Figure 5. *Canarium* (*Canarium*) *darwinense* n. sp.: A) Paratype 5 – Lee Point, 40 mm, 2000 (SMC 20a.002a); B) Paratype 6 – Lee Point, 38 mm, 2000 (SMC 20a.002b); C) Paratype 7 – Casuarina, 43 mm, 1970 (AMD STR0782); D) Paratype 8 – Casuarina Beach, 40 mm, 1970 (AMD STR0782). *Canarium* (*Canarium*) *orrae* (Abbott 1960): E) Walcott Inlet, 38 mm, 2013 (SMC 20.011a); F) Walcott Inlet, 37 mm, 2013 (SMC 20.011b); G) Walcott Inlet, 40 mm, 2013 (SMC 20.011c); H) Broome, 47 mm, 2013 (SMC 20.005a); I) Broome, 42 mm, 2013 (SMC 20.005b); J) Broome, 47 mm, 2013 (SMC 20.005c); K) Broome, 45 mm, 2013 (SMC 20.005d); L) Onslow, 41 mm, 2013 (SMC 20.006a); M) Onslow, 41 mm, 2013 (SMC 20.006b); N) Onslow, 40 mm, 2013 (SMC 20.006c); O) Onslow, 38 mm, 2013 (SMC 20.006d).