

Three new species and two new genera of land snails from the Bonaparte Archipelago in the Kimberley, Western Australia (Pulmonata, Camaenidae).

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Abstract

The present work contains descriptions of new species and new genera of camaenid land snails from islands of the Bonaparte Archipelago in north-western Kimberley, Western Australia. The monotypic *Kimberleydiscus* n. gen., with its type species *Kimberleydiscus fasciatus* n. sp., is described from Bigge Island. The species is characterised by its discoid, banded and smooth shell and a peculiar penial anatomy, which includes dense pustulation of the inner penial wall, presence of a corrugated main pilaster, and a vas deferens that reflexes as an epiphallus and connects with the penial chamber through a pore. *Kimberleymelon* n. gen. is also monotypic. Its type species, *Kimberleymelon tealei* n. sp., is endemic to Middle Osborn Island and characterised by its relatively large, highly turreted, almost trochiform shell with regular axial sculpture. The inner penial wall supports an undulating, corrugated main pilaster and dense pustulation. A new species, *Carinotrachia admirale* is described from Middle and Southwest Osborn Islands. Both islands support distinct morphs that differ slightly but consistently in shell shape and penial wall structure and are considered to form two subspecies, *C. admirale admirale* and *C. a. elevata*.

Key words: Gastropoda, taxonomy, islands, anatomy, morphology, shell

Introduction

Camaenidae is perhaps the most widespread and diverse family of land snails in Australia. This group encompasses 446 currently recognised species in 85 genera according to Smith *et al.* (2002) including taxa recently described by Zhang and Shea (2008), Clark (2009), and Stanisic (2009). In Australia, the diversity of camaenid gastropods is highest in the tropical regions of Western Australia and Queensland. Most taxa from southern, north-western and central Australia have been revised in monographs of Solem (1979, 1981a, 1981b, 1983, 1984, 1985, 1988, 1993, 1997). Accordingly, about 180 species are currently known to occur in the Kimberley and immediately adjacent regions of the Northern Territory, yet many of them are undescribed (Solem 1991, 1998). This renders the region a hotspot of camaenid diversity and evolution. Here, camaenid snails predominantly inhabit rainforest and woodland habitats that provide a heavily fragmented environment, which has facilitated the extensive radiation of the group. Previous works have shown that rainforest patches in the Kimberley usually support unique and mostly endemic assemblages of camaenid species (Solem and McKenzie 1991). However, due to the remoteness of north-western Australia, many areas have not yet been adequately studied. This holds true in particular for many of the islands of the Buccaneer and Bonaparte Archipelagos off the Kimberley coast. For 120 out of the 153 islands with an area larger than 100 hectares, limited biological information is available at best. In order to enhance the knowledge of the flora and fauna of these archipelagos, nineteen of the largest islands have been selected for the Kimberley Island Survey of biological diversity by the Department of Environment and Conservation, Western Australia, which commenced in 2007 and is due to be completed by the end of 2010. Survey work

has resulted in the discovery of a diverse and largely unknown snail fauna on these islands. The object of this paper is to describe a comparatively small part of this fauna.

Material and methods

This study is primarily based on ethanol preserved specimens and supplementary dry shell material collected during the Kimberley Island Survey (KIS) of the Department of Environment and Conservation, Western Australia (DEC) in 2007–2008. Types are deposited in the Western Australian Museum, Perth (WAM) and the Australian Museum, Sydney (AM).

Morphological descriptions focus on characters of the shell, the mantle cavity, the genital organs, and the radula. Morphometric shell parameters, such as height of shell (H), diameter of shell (D), height of last whorl (LW), and width of umbilicus (U) were measured with callipers precise to 0.1 mm. The numbers of whorls of shell (N), including the protoconch, were counted as described by Barker (1999: Fig. 6).

Anatomy of mantle and genital organs was studied using a microscope with drawing mirror. The final inking of drawings was done by Martin Püschel. Radulae and jaws were extracted manually, cleaned by soaking in 10% KOH solution for about six hours followed by rinsing in water and ethanol. They were mounted on carbon specimen tabs for electron scanning microscopy. Radular dentition formula gives the numbers of teeth per row as follows: C (central row of teeth) + number of lateral rows of teeth + number of transitional rows of teeth + number of marginal rows of teeth. If available, the anatomy of up to five specimens per sample was studied in order to ensure that the described morphological features are consistent within taxa.

Systematics

Gastropoda
Heterobranchia
Stylommatophora
Camaenidae Pilsbry, 1895

Carinotrachia Solem, 1985

Type species. *Carinotrachia carsoniana* Solem, 1985, by original designation.

Diagnosis: (Solem 1985). Shell with a diameter of 15.5 to 18.5 cm, with strongly and evenly elevated apex, slightly laterally compressed whorls, body whorl descending just before aperture; umbilicus narrowly open; periphery with protruded keel. Postapical sculpture of prominent radial ribs and extremely fine, anastomosing periostracal folds. Aperture

lip weakly expanded, slightly thickened, parietal wall with distinct callus. Colour yellowish horn. Genitalia typical; vas deferens entering penial sheath apically, reflexing as weakly developed epiphallus, connecting to penial chamber through pore. Penial wall with complex pilasters.

Remarks: This monotypic genus was established by Solem (1985: 857–863) for a species found near the Gibb River-Kalamburu Road on the Kimberley mainland. The combination of a keeled periphery, prominent ribbing, simple lip, and characteristic penial wall structure was stated to be the major differentiating character. The species described herein corresponds well with the diagnosis of this genus as presented by Solem (1985). It represents the second known species of the genus and is likely endemic to the Osborn Islands (Fig. 1), in about 60 to 80 km distance from the type locality of *C. carsoniana*.

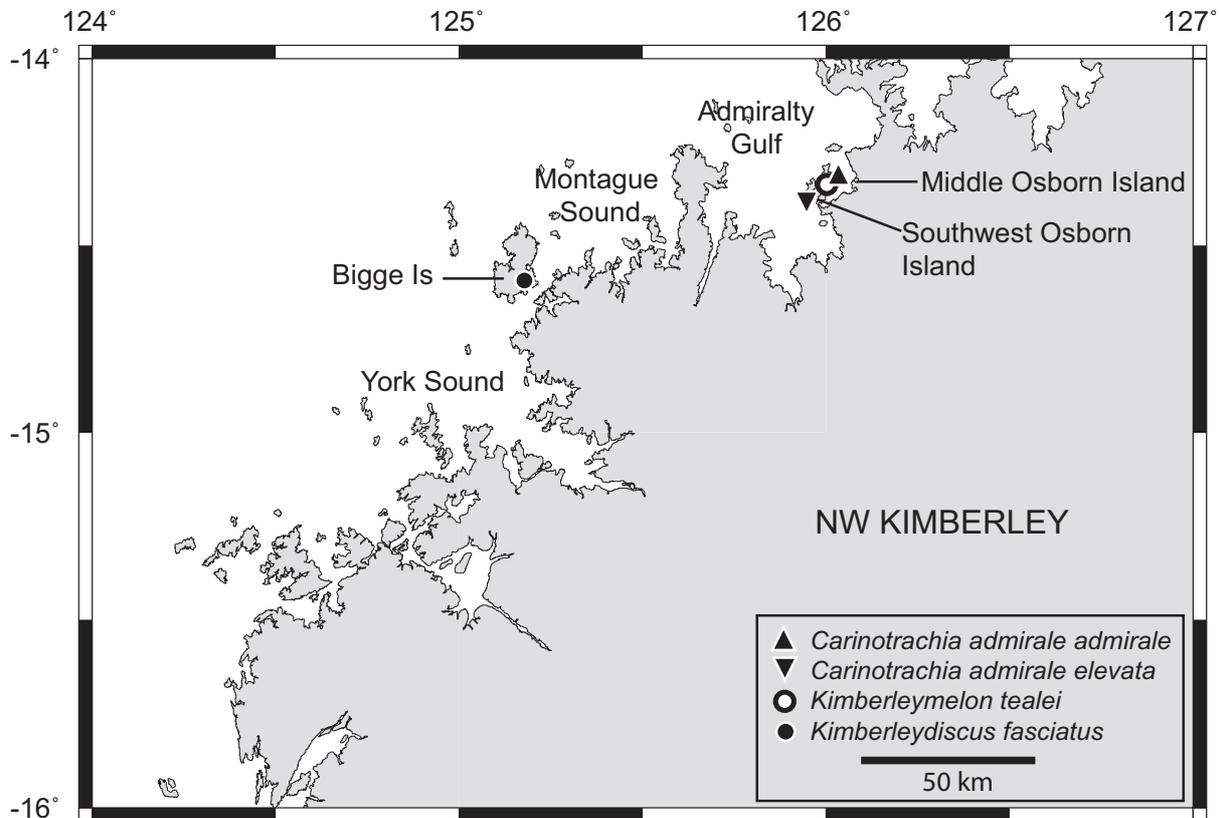


FIGURE 1. Distribution map showing the north-western part of the Kimberley, Western Australia.

Species of *Carinotrachia* differ from other north-western Australian camaenids most conspicuously by their keeled periphery in combination with the presence of well-developed, comparatively broad axial ribs, narrow umbilicus and compressed shell spire. The absence of a main stimulatory pilaster in the penial chamber is another characteristic feature of this group. Solem (1985) stated that *Turgenitubulus pagodula* Solem, 1985 from the Ningbing Ranges is apt to be confused with *Carinotrachia* because of its similar shell. However, it differs most obviously in having finer ribs, a broadly expanded lip and in details of the genital anatomy.

Carinotrachia admirale n. sp.

Two similar morphs were found, one on each of Middle and Southwest Osborn Islands. These forms widely correspond in their shell and genital anatomy by showing only subtle but consistent differentiation with regard to shell shape and anatomy of the inner penial wall. Correspondingly, mitochondrial sequences from two specimens of each island reveal consistent but comparatively low genetic differentiation of the two morphs (3% uncorrected sequence divergence in 16S). The consistency of differences between specimens from each morph suggests that both represent

independent evolutionary entities. On the other hand, the relatively low rates of differentiation imply that reproductive incompatibility might be incomplete. From a taxonomical point of view, the treatment of the two allopatric forms as geographical races of a single species is considered to best reflect their potentially transitional nature as biological species *sensu* Mayr (1942, 1963).

Carinotrachia admirale admirale n. sp. & n. subsp.

Figs 2A, 3–5.

Type locality: Western Australia, NW Kimberley, Bonaparte Archipelago, Admiralty Gulf, Middle Osborn Island, east

coast, 14°18'57.1"S 126°01'59.6"E. *Ficus* grove over large boulders, in rock crevices (coll. R. Teale, 5 Aug. 2007) (Fig. 1).

Type material. Holotype WAM S34628 (preserved specimen) (Fig. 2A). Paratypes AM C.463606 (32 preserved specimens), WAM S36600 (100 preserved specimens).

Etymology. The species epithet 'admirale' (feminine gender) refers to the Admiralty Gulf, in which the Osborn Islands are situated; the word is intended a noun in apposition.

Description: (based on dissection of four specimens).

Shell (Figs 2A, 3A–G). Thin (translucent), of approximately four regularly expanding whorls, shape variable from strongly depressed to broadly conical. Whorls

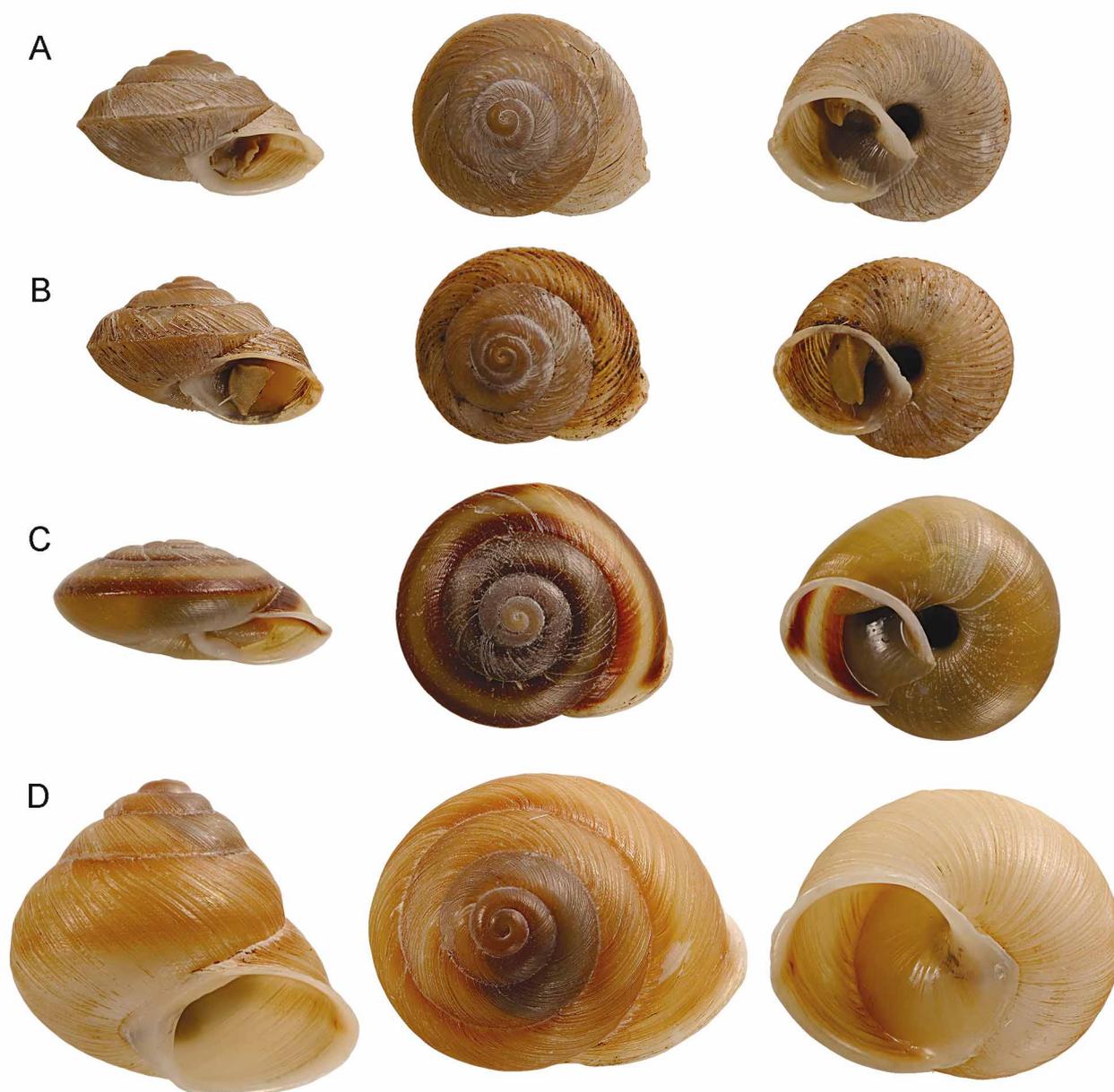


FIGURE 2. Shells in natural size. **A.** *Carinotrachia admirale admirale* n. sp. & n. subsp., holotype WAM S34628. **B.** *Carinotrachia admirale elevata* n. subsp., holotype WAM S34629. **C.** *Kimberleydiscus fasciatus* n. sp., holotype WAM S34630; note that foot of preserved animal protrudes from aperture. **D.** *Kimberleymelon tealei* n. sp., holotype WAM S36877. Scale bar = 10 mm.

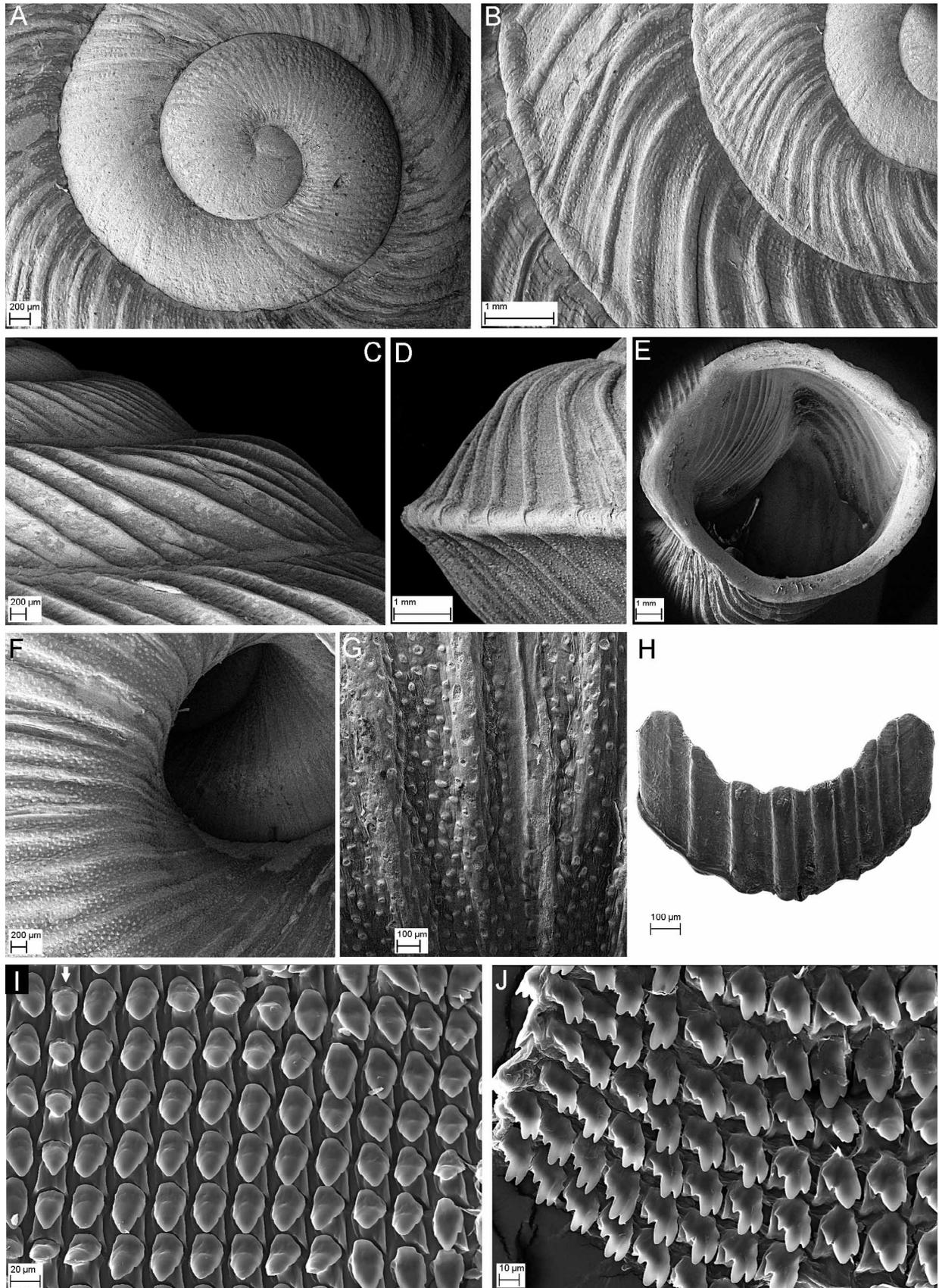


FIGURE 3. SEM photographs of shell, jaw and radula of *Carinotrachia admirale admirale* n. sp. & n. subsp., paratype AM C.463606. **A.** Apical whorls viewed from above (scale bar = 200 μ m). **B.** Second to fourth whorl viewed from above (scale bar = 1 mm). **C.** Lateral view of second to fourth whorl (scale bar = 200 μ m). **D.** Close-up of periphery of last whorl (scale bar = 1 mm). **E.** Close-up of aperture (scale bar = 1 mm). **F.** Umbilicus (scale bar = 200 μ m). **G.** Detail of sculpture of lower portion of shell, near umbilicus (scale bar = 100 μ m). **H.** Jaw (scale bar = 100 μ m). **I.** Central (marked with small arrow) and lateral teeth of radula viewed from above (scale 20 μ m). **J.** Marginal teeth viewed from above (scale bar = 10 μ m).

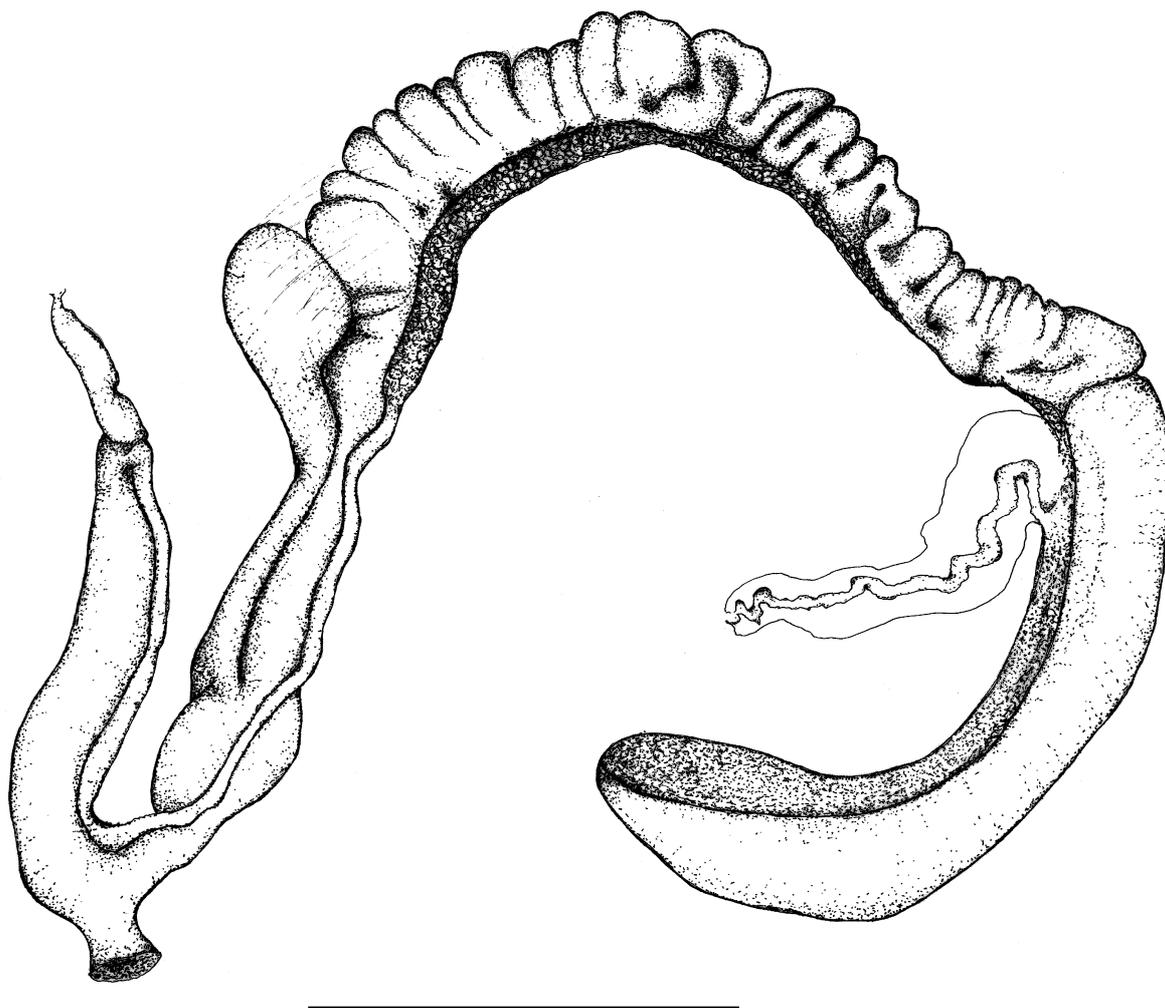


FIGURE 4. Genital anatomy of *Carinotrachia admirale admirale* n. sp. & n. subsp., paratype AM C.463606. Scale bar = 5 mm.

strongly keeled at periphery, upper part slightly shouldered, basal part convexly flattened. Umbilicus narrowly open; umbilical width equivalent to $\sim 1/5$ of shell diameter; 5–20% obscured by columellar reflection. Colour uniform crème-brown to horn; outer lip colour same as shell; inner lip colour whitish. Protoconch about 3.3 mm in diameter with approximately two superficially smooth whorls, covered with dense microscopic pustulation arranged in axial rows. Teleoconch with regularly-spaced, rounded, prosocline axial ribs; evenly distributed across shell surface, reduced in prominence in zone below suture and within umbilicus; spaces between ribs about twice as wide as thickness of the ribs. Minute periostracal nodules sparsely distributed on last one to two whorls, but dense on basal part of shell and within umbilicus; hairs or filaments absent. Aperture forms a 30–45 degree angle relative to horizontal. Outer lip well rounded, sharp, without parietal or basal notch. Upper lip slightly curving into callous parietal wall.

Pallial organs. Pallial cavity deep, extending about one whorl. Mantle pigmented with greyish-brown spots. Kidney extending about half length of pallial cavity.

Genital anatomy (Figs 4–5). Penis rather straight, of

more or less of same length as anterior part of oviduct. Penial retractor muscle very short, stubby; attached to penial apex near entering of vas deferens. Penial sheath well-developed, extending entire length, thin proximally, thick distally. No well-developed epiphallus present. Vas deferens opens to the penial lumen via simple pore; no vergic papillum found. Inner penial wall covered with dense pilasters, arranged in irregular fishbone-pattern; no stimulatory main pilaster differentiated. Vagina moderate to long, tubular to proximally inflated; inner wall with corrugated longitudinal pilasters. Spermatheca short, reaching only to distal base of spermooviduct; duct and head clearly differentiated; duct moderately wide; internally smooth; head globular, internally smooth, with wall of varied thickness. Spermatheca connected with spermooviduct by connective tissue. Free oviduct more or less straight, moderately long, comprising about half of anterior part of oviduct. Male and female gonads fused as spermooviduct. Albumen gland elongate. Talon embedded in albumen gland close to anterior end of albumen gland. Hermaphroditic duct slender, tightly undulating within connective tissue, connects terminally with fertilization chamber.

Digestive system (Figs 3H–J). Jaw consisting of about ten, slender, regularly spaced plates. Radula ribbon elongate-squarish, 4 mm long with 125–130 rows of teeth (~32 rows of teeth/mm) (n=2). Dentition formula C + 12–14 + 3–4 + 13–15. Central teeth with bluntly pointed, slender mesocone that extends to more than half of the basal plate; ectocones absent. Lateral teeth with bluntly pointed, rather ovate mesocone, about as long as base of tooth; endocones and ectocones greatly reduced. Marginal teeth multicuspoid, mesocone and endocone similar in length, ectocone smaller than endocone, occasionally subdivided.

Aestivation. Seals to rocks and other hard substrates when aestivating ('rock sealer').

Comparative remarks. *C. admirale* is similar to the type species of the genus, *C. carsoniana*, with respect to shell shape, size and sculpture (Solem, 1985: 857–862). It differs from the former in presence of small nodules on shell surface, which are largely absent in *C. carsoniana*, a more rounded shape of ribs, comparatively larger distances between ribs, and in that the inner penial wall of *C. carsoniana* is covered by much more irregularly arranged pilasters. A valvular ridge in the opening of the vas deferens into the penial lumen as reported for *C. carsoniana* has not been found in *C. admirale* where the vas deferens forms a simple pore.

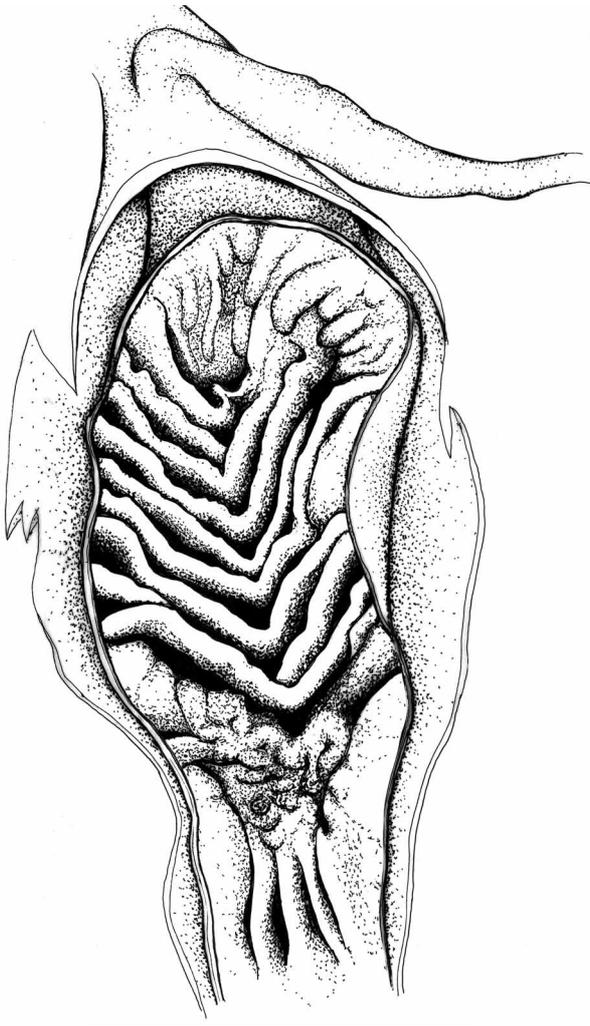


FIGURE 5. Penial anatomy of *Carinotrachia admirale admirale* n. sp. & n. subsp., paratype AM C.463606. Scale bar = 3 mm.

Carinotrachia admirale elevata n. subsp.

Figs 2B, 6–8.

Type locality (Fig. 1). Western Australia, NW Kimberley, Bonaparte Archipelago, Admiralty Gulf, South West Osborne Is., east coast, 14°22'47.3"S 125°56'00.6"E. Rainforest/vine thicket on steep east facing slopes half way between beach and base of cliffs, volcanic scree and boulders. Active on trees (coll. V. Kessner, 8 Feb. 2008).

Type material. Holotype WAM S34629 (preserved specimen) (Fig. 2B). Paratypes AM C.463607 (10 preserved specimens), WAM S36857 (27 preserved specimens).

Etymology. The sub-specific epithet 'elevata' refers to the, in comparison with the nominate form, more elevated shell shape.

Description (based on dissection of two specimens).

Shell (Figs 2B, 6A–G). Corresponding to nominate form except for a more elevated spire, which results in slightly different H/D ratio (Table 1), other than in the nominate form microscopic pustulation is restricted to basal part of shell and umbilicus.

Mantle cavity, genital anatomy, digestive system (Figs 6H–J, 7–8). Generally similar to nominate form; but inner penial wall with a more irregular pattern of pilasters not closely resembling a fishbone-pattern.

Remarks. From the nominate form this subspecies differs by weaker spiral keel, a more elevated spire, and more irregularly arranged pilasters on the inner penial wall. Compared to *C. carsoniana* this taxon differs by more rounded shape of spiral ribs, comparatively larger distance between adjacent ribs, less pronounced spiral keel, different arrangements of pilasters on inner penial wall and absence of valvular ridge in opening of vas deferens into penial lumen.

Kimberleymelon n. gen.

Description. Shell comparatively large, trochiform, with high spire. Whorl widely convex in cross-section, with straight or slightly flattened periphery. Sculpture consists of pronounced, prominent, regularly spaced axial growth lines. Aperture simple, rounded, no traces of nodes, with callused parietal wall. Diffuse, brownish sub-sutural and peripheral bands blending into each other over white background of shell with a light brownish to ochre tone. Vas deferens enters penial complex apically. Epiphallus well developed, tubular, within penial sheath, opening to penial chamber through short, indistinct vergic papillum; small pilaster sitting next and underneath this opening. Penis proper bulbous, within sheath; internally with very fine pustulations in fishbone-pattern and one large, undulating, corrugated main stimulatory pilaster. Radula very long.

Comparative remarks. The highly spired, trochiform shell, widely convex whorls and regular axial sculpture are a characteristic combination of characters unique to this taxon. Overall genital anatomy is similar to other confamilial taxa from the Kimberley. The very fine pustulation of the inner penial wall resembles that found in some species of *Amplirhagada* Iredale, 1933, but which differ by having a

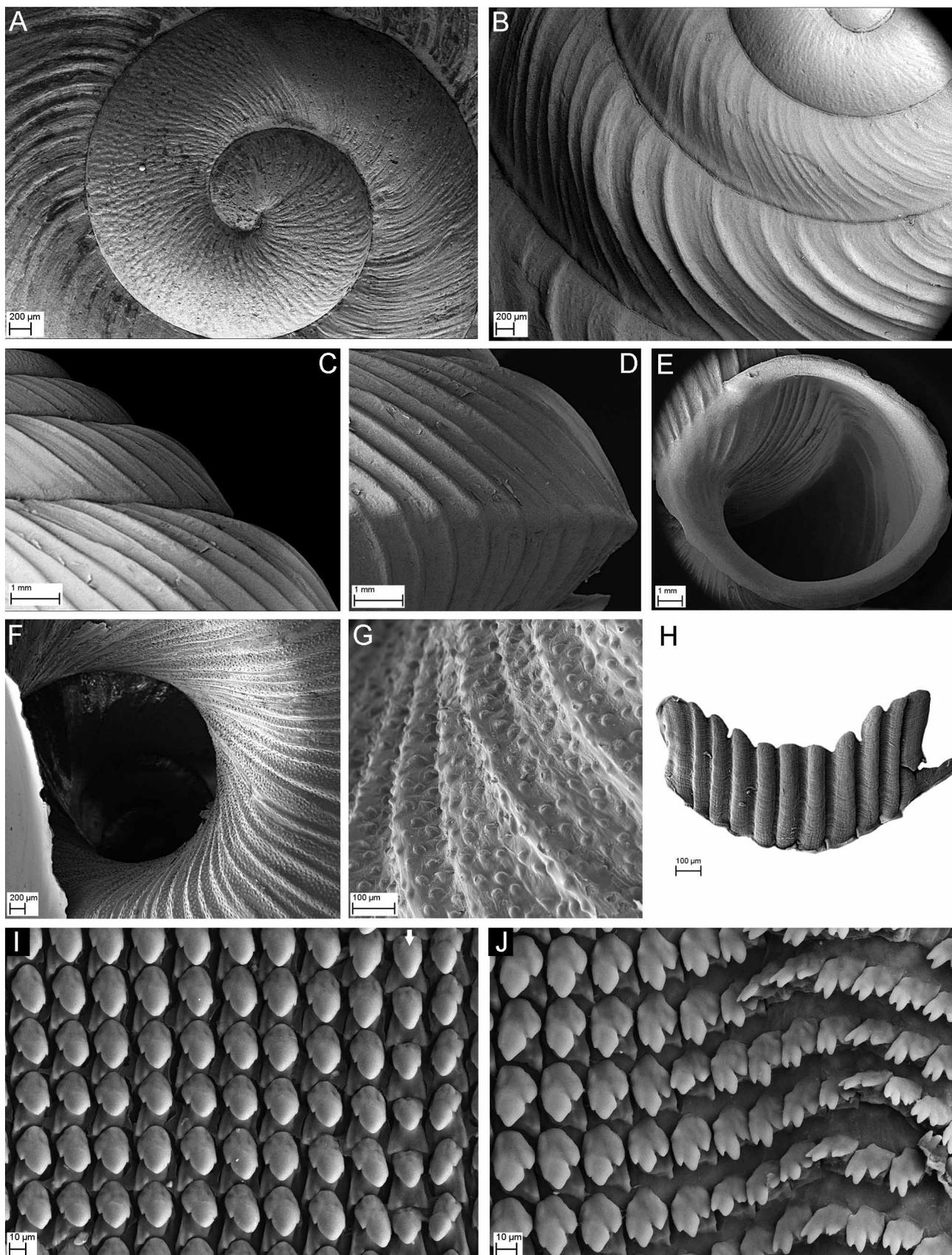


FIGURE 6. SEM photographs of shell, jaw and radula of *Carinotrachia admirale elevata* n. sp. & n. subsp., paratype AM C.463607. **A.** Apical whorls viewed from above (scale bar = 200 μ m). **B.** Second to fourth whorl viewed from above (scale bar = 200 μ m). **C.** Lateral view of second to fourth whorl (scale bar = 1 mm). **D.** Close-up of periphery of last whorl (scale bar = 1 mm). **E.** Close-up of aperture (scale bar = 1 mm). **F.** Umbilicus (scale bar = 200 μ m). **G.** Detail of sculpture of lower portion of shell, near umbilicus (scale bar = 100 μ m). **H.** Jaw (scale bar = 100 μ m). **I.** Central (marked with small arrow) and lateral teeth of radula viewed from above (scale 10 μ m). **J.** Marginal teeth viewed from above (scale bar = 10 μ m).

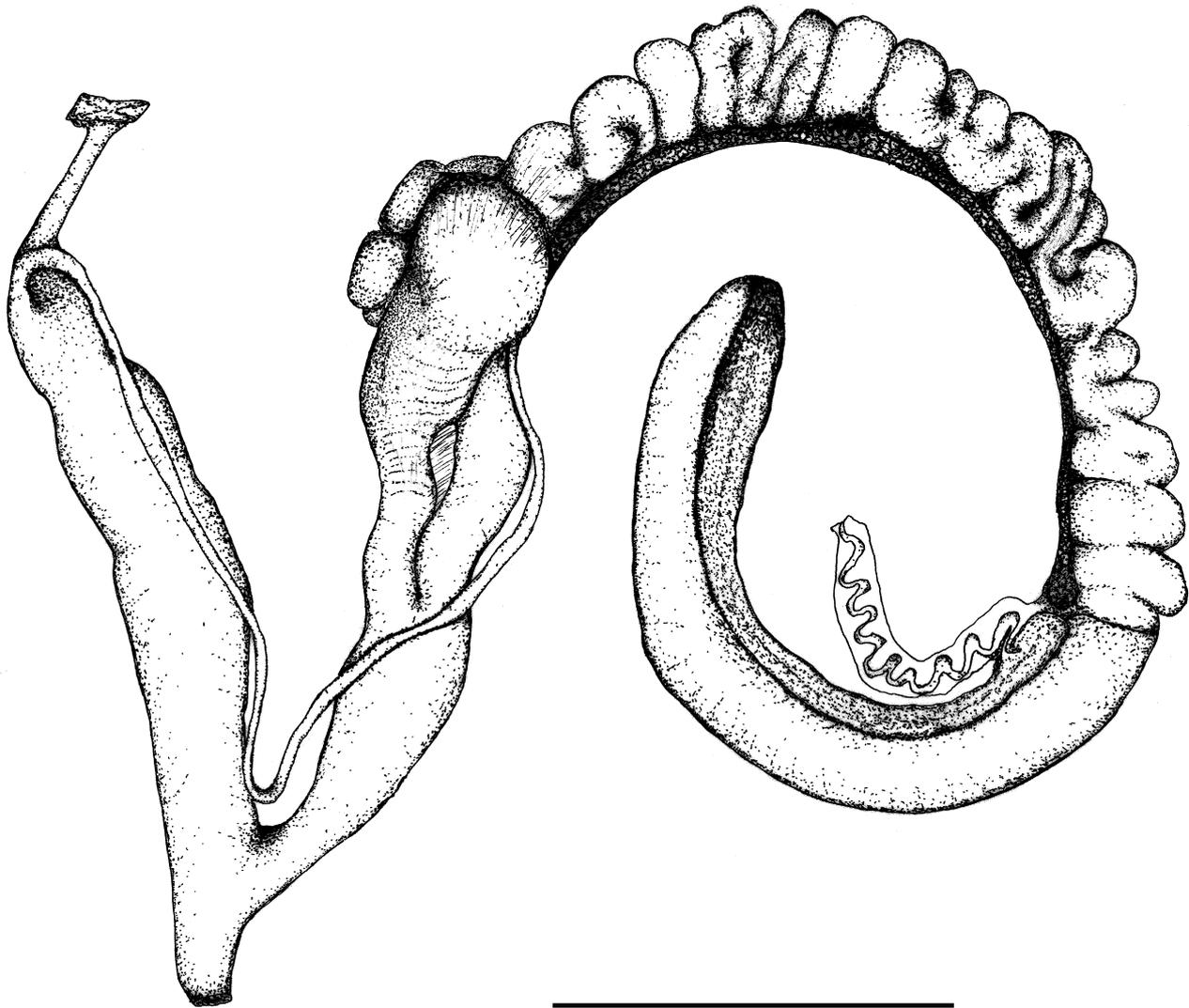


FIGURE 7. Genital anatomy of *Carinotrachia admirale elevata* n. subsp., paratype AM C.463607. Scale bar = 5 mm.

penial verge not found in *Kimberleymelon*. Radula of *Kimberleymelon* longer, with fewer rows of teeth per mm, but more rows of lateral and marginal teeth than in species of *Amplirhagada*, *Carinotrachia* and *Kimberleydiscus* n. gen.

Etymology. Derived from 'Kimberley', the region in NW Australia where this genus occurs, and 'melon' (Latin; derived from melon [Greek] = melon) in reference to the somewhat globular shape of the shell. The Latin suffix '-melon' is of neuter gender.

Type species. *Kimberleymelon tealei* n. sp.

***Kimberleymelon tealei* n. sp.**

Figs 2D, 9–11.

Type locality (Fig. 1). Western Australia, NW Kimberley, Bonaparte Archipelago, Admiralty Gulf, west coast of Middle Osborn Island, 14°18'27.3"S 125°59'24.7"E. Large boulder pile with vine thicket and figs over top, in crevices between boulders (coll. R. Teale, 10 Aug. 2007).

Type material. Holotype WAM S36877 (preserved specimen) (Fig. 2D). Paratypes AM C.463610 (3 dry shells; 14°18'27.3"S 125°59'24.7"E), WAM S36489 (4 dry shells; 14°18'27.3"S 125°59'24.7"E), WAM S36490 (dry shell; 14°18'37.4"S 125°59'18.4"E), WAM S36488 (dry shell; east coast, 14°18'40.0"S 126°01'29.4"E).

Etymology: Named in honour of Roy Teale, collector of the holotype, in recognition of his achievements in malacology.

Description (based on dissection of one specimen).

Shell (Figs 2D, 12A–B). Large (18–26 mm in height, 20–28 in diameter), trochiform, with high spire, solid. Whorls widely convex in cross-section, but slightly compressed at periphery, convex to slightly shouldered above periphery. Umbilical opening occluded by columellar reflection. Background and ventral colour whitish, banded; sub-sutural band diffuse, thin, brownish; peripheral band diffuse, rather thin, brownish; both bands blending into each other rendering upper surface of shell light brown. Outer lip colour whitish. Protoconch with less than 2 whorls, about 4.5

mm in diameter, sculpture almost smooth except for faint axial growth lines. Teleoconch with fine, prominent axial lirae (growth lines), slightly curved when viewed from above, rounded in cross-section, with regular spacing, spaces between lirae wider than thickness of lirae. Axial lirae weak on spire but otherwise almost evenly distributed across whorl surface. Aperture forms a 45 degree angle relative to the horizontal. Lip well rounded, moderately thick, slightly expanded but not reflected. Parietal callus well developed, basal and palatal nodules absent.

Pallial cavity extending about 0.75 whorls. Mantle pigmentation consists of few blackish spots. Kidney extends more than half length of pallial cavity.

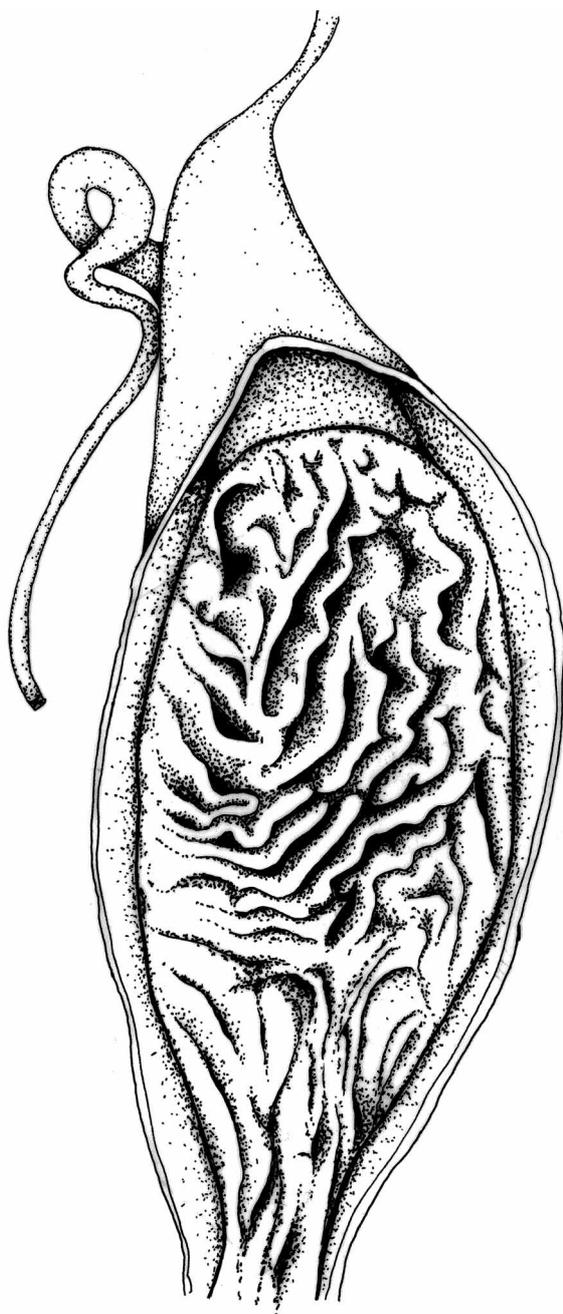


FIGURE 8. Penial anatomy of *Carinotrachia admirale elevata* n. subsp., paratype AM C.463607. Scale bar = 3 mm.

Genital anatomy (Figs 13–14). Penial complex rather straight, longer than anterior part of oviduct. Penial retractor muscle very short, stubby attached at apex of penial complex. Penial sheath well-developed, distal portion strong, reaching below base of penis, proximal portion thin, reaching above entrance of vas deferens. Vas deferens entering penial sheath near apical end of penial complex, continued as epiphallus to enter penial lumen through conspicuously elevated, tubular vergic papilla; small pilaster next and underneath this opening. Inner penial wall supports very fine, dense pustulations arranged in fishbone-pattern, distributed over entire length of inner penial wall, increasing in size towards base. Stimulatory main pilaster well developed, corrugated, undulating, comprising apical to median portion of inner penial wall. Vagina moderately long, tubular. Inner wall of vagina and spermathecal duct with densely packed, corrugated longitudinal pilasters. Spermatheca short, reaching base of spermoviduct; spermathecal duct and head clearly differentiated; duct moderately wide, head elongately inflated, internally smooth, with thin wall. Spermathecal head connected with distal end of spermoviduct by connective tissue. Free oviduct moderately long, comprising about half of anterior part of oviduct; more or less straight. Spermoviduct longer than anterior part of oviduct, contorted. Albumen gland elongate. Talon embedded in albumen gland at junction with spermoviduct. Hermaphroditic duct contorted.

Digestive system (Figs 9C–F). Jaw with 11 plates, which are variable in degree of development and width. Radula ribbon elongate, 7.5 mm long with 180 rows of teeth (24 rows of teeth/mm) ($n=1$). Dentition formula $C + 17 + 2 + 25$. Central teeth with bluntly pointed, ovate mesocone, shorter than base of tooth; with vestigial ectocones. Mesocone of lateral teeth distinctly shorter than basal plate, endocones and ectocones vestigial. Marginal teeth with broadly rounded mesocone, endocones become progressively more vestigial towards the marginal-lateral transition, ectocones prominent, also becoming progressively more vestigial towards the marginal-lateral transition.

Remarks. The holotype was the only preserved specimen of the species available. In addition, several dry shells were found at the type locality or in close proximity. For characteristic features see diagnosis of the genus. Among the Camaenidae in the Kimberley, there are only a few species with similarly large shells, such as *Xanthomelon* (Martens, 1860). Species of this genus differ in that their shell is more globular in shape with lower spire. They also differ greatly in their genital anatomy by having a much longer penial retractor muscle, a not as markedly differentiated epiphallus, and an inner penial wall that lacks a main stimulatory pilaster.

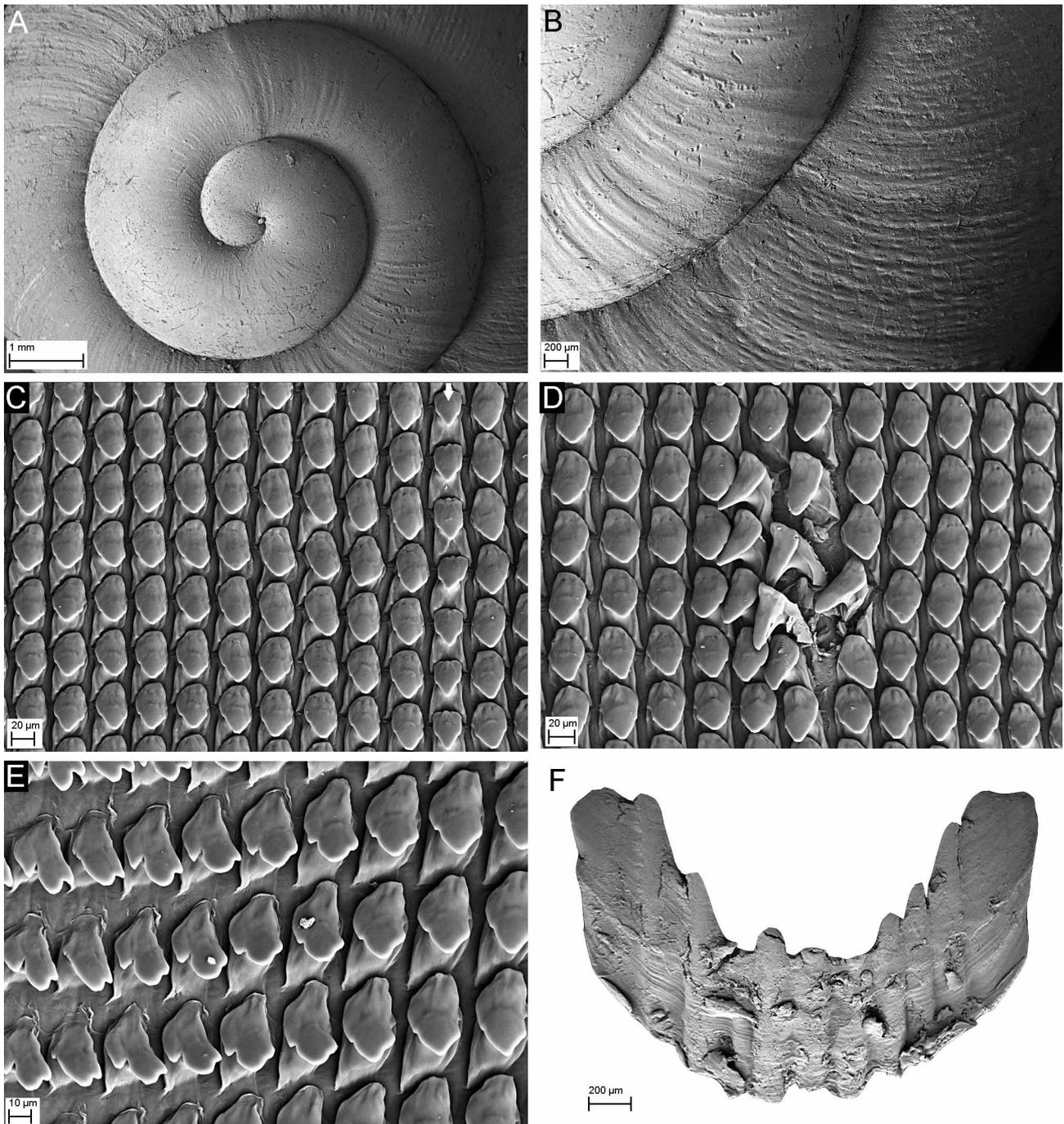


FIGURE 9. SEM photographs of *Kimberleymelon tealei* n. sp. **A, B.** Shell, paratype AM C.463610; **A**, apical whorls viewed from above (scale bar = 200 μ m); **B**, second to fourth whorl viewed from above (scale bar = 200 μ m). **C–E.** Radula, holotype WAM S36877; **C,D**, central (marked with small arrow) and inner lateral teeth of radula viewed from above (scale 20 μ m). **E.** Marginal teeth viewed from above (scale bar = 10 μ m). **F.** Jaw, holotype WAM S36877 (scale bar = 200 μ m).

Kimberleydiscus n. gen.

Description. Shell discoid in shape, with low spire and in cross-section narrow, flattened whorls with markedly convex and keeled periphery; sculpture smooth except for axial growth lines, aperture simple rounded. Penial complex moderately long, about as long as anterior part of oviduct; penial retractor muscle about as long as penial complex, attached to its apex. Penial sheath well-developed, its distal end reaching below base of penis, proximal end above entrance of vas deferens. Vas deferens entering penial sheath

near the apical end of penial complex, continued as epiphallus that enters penial chamber via a simple pore. Inner penial wall with wall pustules of moderate size, arranged in dense, longitudinal rows over entire length of inner penial wall. Main pilaster corrugated, comprising apical to median portion of inner penial wall, additional pilasters shorter, rather indistinct and smooth. Vagina medially inflated. Spermatheca short, reaching to distal part of spermooviduct. Inner wall of vagina and spermatheca with smooth longitudinal pilasters. Free oviduct moderately long, comprising about half of anterior part of oviduct.

TABLE 1. Shell parameters. Given are maxima and minima (average \pm standard deviation) of shell height (H), shell diameter (D), height of last whorl (LW), width of umbilicus (U) [each in mm], number of whorls (N), and height/diameter ratio (H/D) (No. = number of measured shells, HT = holotype).

Taxon	No.	H	D	LW	U	N	H/D
<i>C. admirale admirale</i>	16	9.3 – 10.5	16.1 – 18.2	8.1 – 9.1	2.9 – 3.5	3.7 – 4.2	0.52 – 0.62
		(10.0 \pm 0.4)	(17.5 \pm 0.5)	(8.6 \pm 0.3)	(3.2 \pm 0.2)	(3.9 \pm 0.1)	(0.57 \pm 0.02)
	HT	10.5	17.7	8.9	3.0	4.0	0.59
<i>C. admirale elevata</i>	24	9.5 – 11.5	15.5 – 18.0	8.0 – 9.5	2.7 – 3.5	3.3 – 4.1	0.58 – 0.68
		(10.4 \pm 0.5)	(16.6 \pm 0.6)	(8.6 \pm 0.4)	(3.0 \pm 0.2)	(3.6 \pm 0.2)	(0.63 \pm 0.02)
	HT	10.6	17	8.8	3	3.8	0.62
<i>Kimberlymelon tealei</i>	8	18.3 – 26.4	19.9 – 28.5	12.0 – 15.7	closed	3.3 – 4.0	0.79 – 0.97
		(21.0 \pm 2.6)	(23.3 \pm 2.6)	(13.0 \pm 1.1)		(3.7 \pm 0.2)	(0.90 \pm 0.06)
	HT	23.5	24.4	13.2	closed	4.0	0.97
<i>Kimberleydiscus fasciatus</i>	17	7.9 – 10.5	17.7 – 21.8	5.9 – 7.5	2.4 – 3.8	2.8 – 3.7	0.43 – 0.58
		(9.2 \pm 0.7)	(19.3 \pm 1.1)	(6.4 \pm 0.4)	(3.2 \pm 0.3)	(3.3 \pm 0.2)	(0.48 \pm 0.04)
	HT	9.4	20.0	7.4	3.5	3.2	0.47

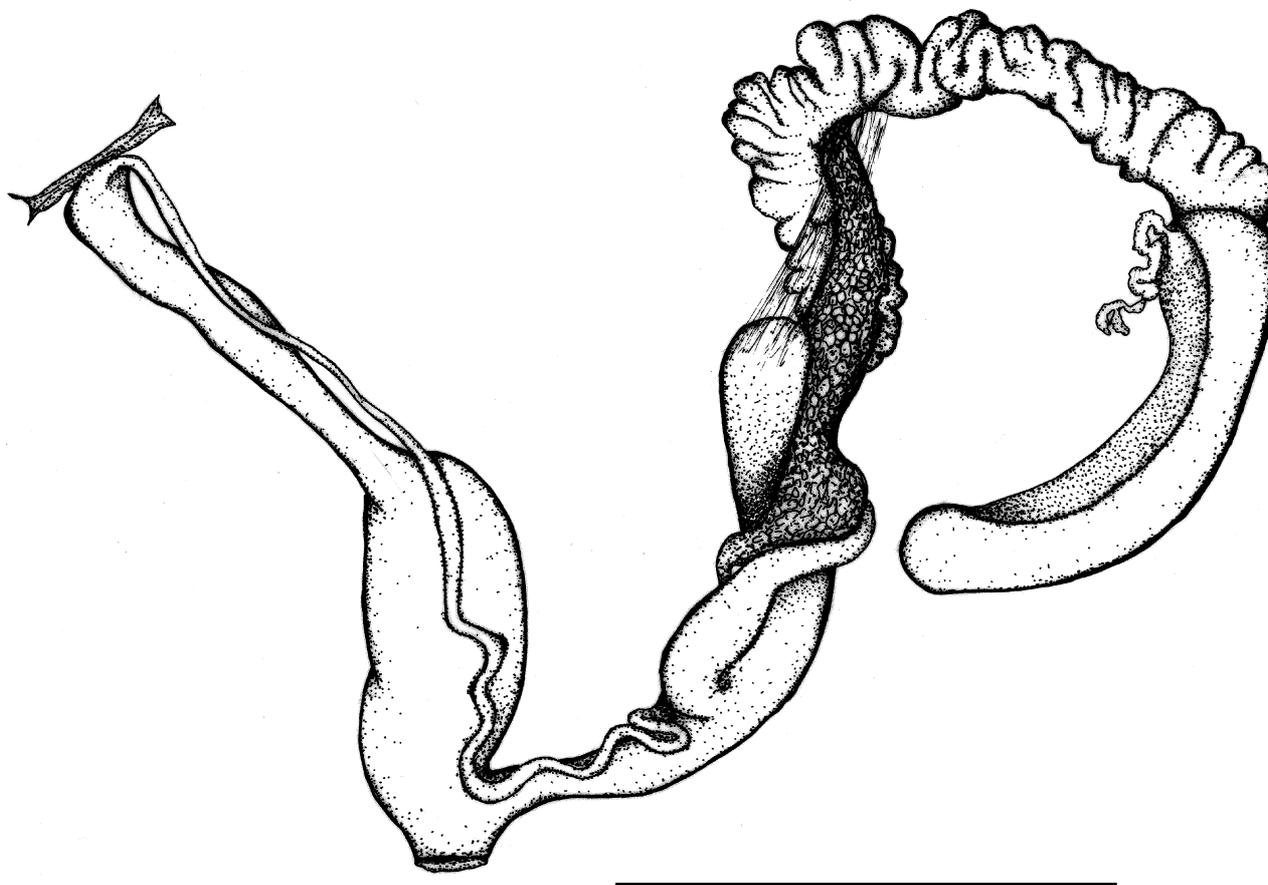


FIGURE 10. Genital anatomy of *Kimberlymelon tealei* n. sp., holotype WAM S36877. Scale bar = 10 mm.

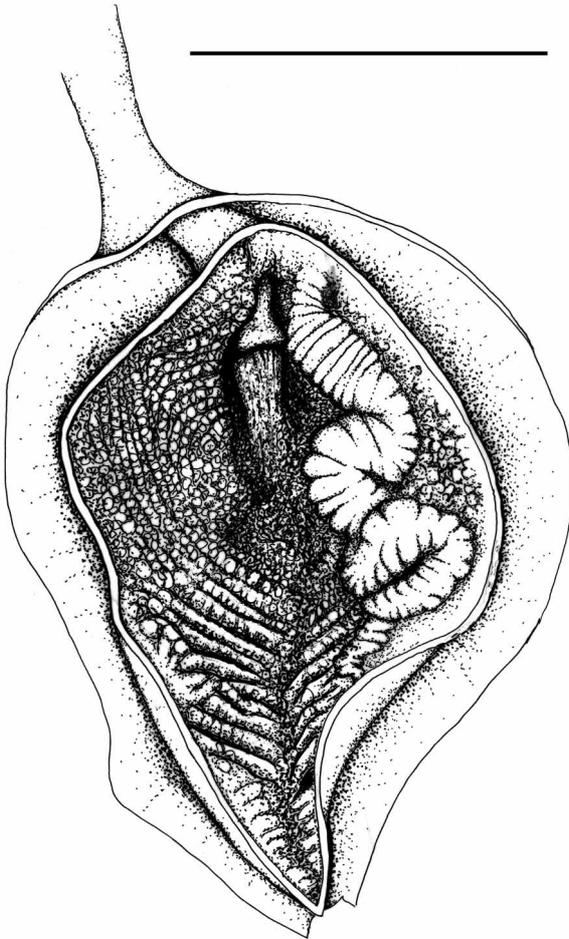


FIGURE 11. Penial anatomy of *Kimberleymelon tealei* n. sp., holotype WAM S36877. Scale bar = 5 mm.

Comparative remarks. The discoid, smooth shell with its low spire, rather flattened and angulate to keeled whorls is characteristic. This combination of characters is not found in any other camaenid in the region. Overall genital anatomy is similar to other confamilial taxa from the Kimberley. The pustulation pattern of inner penial wall resembles that found in several species of *Amplirhagada*, which however have a penial verge. A weakly differentiated epiphallus and presence of apical pilasters of the inner penial wall are further differentiating features.

Etymology: Derived from 'Kimberley', the region in NW Australia where this genus occurs, and 'discus' (Latin; derived from diskos [Greek] = disk, disc) in reference to the discoid shape of the shell. The Latin suffix '-discus' is of masculine gender.

Type species. *Kimberleydiscus fasciatus* n. sp.

***Kimberleydiscus fasciatus* n. sp.**

Figs 2C, 12–14.

Type locality (Fig. 1). Western Australia, NW Kimberley, Bonaparte Archipelago, Bigge Island, 4.4 km NNE of Savage Hill, 14°35'13"S 125°11'10.5"E. Small vine thicket patch, figs at the base of sandstone cliffs, large boulders and

overhangs, in rock crevices (coll. V. Kessner, 17 Aug. 2008). Type material. Holotype WAM S34630 (preserved specimen) (Fig. 2C). Paratypes AM C.463606 (3 preserved specimens, type locality), WAM S36869 (9 preserved specimens, type locality), WAM S36868 (preserved specimen, 4.1 km NNE of Savage Hill, 14°35'20.5"S 125°11'06.8"E), WAM S36630 (preserved specimen, 3.8 km NNE of Savage Hill, 14°35'33"S 125°11'19"E), AM C.463608 (5 dry shells, 3.8 km NNE of Savage Hill, 14°35'33"S 125°11'19"E), WAM S36486 (10 dry shells, 3.8 km NNE of Savage Hill, 14°35'33"S 125°11'19"E).

Etymology. The species epithet 'fasciatus' (Latin = banded) refers to the conspicuously banded colour pattern of the shell.

Description (based on dissection of two specimens).

Shell (Figs 2C, 9A–D). Discoid, with low spire, 18–22 mm in diameter, thin (translucent) to solid; last whorl narrow in cross-section, whorls slightly convex to flattened above periphery, angulate to keeled at periphery, convexly flattened below periphery. Umbilicus open, moderately wide, comprising 13–20 percent of shell diameter, 5–20 percent occluded by columellar reflection. Background and ventral colour horn; sub-sutural and peripheral bands well defined, rather broad, reddish brown; outer lip colour paler than shell. Protoconch about 1.7 whorls, about 4 mm in diameter, rather smooth. Teleoconch smooth except of fine axial growth lines. Aperture forms a 30 degree angle relative to the horizontal. Lip simple, sharp, expanded, slightly reflected; parietal callus thin; no basal or palatal nodules or barriers present.

Pallial cavity extending about 0.75 whorls. No pigmentation on mantle present. Kidney extends about half of length of pallial cavity.

Genital anatomy (Figs 13–14). Penial complex weakly contorted, slightly shorter than anterior part of oviduct. Penial retractor muscle about as long as penial complex, attached to apical part of penial complex. Penial sheath well-developed, distal portion strong, reaching below base of penis, proximal portion thin, reaching above entrance of vas deferens. Vas deferens moderately wide, entering penial sheath near the apical end of penial complex forming a simple loop, continued as epiphallus to enter penial chamber via simple pore. Inner penial wall with conspicuous pustulations; penial wall pustules moderate in size, densely arranged in longitudinal rows over entire length of inner penial wall; apical portion of inner penial wall supporting a corrugated main pilaster and some additional shorter, rather indistinct, rather smooth longitudinal pilasters. Vagina moderately long, medially inflated; inner wall with smooth longitudinal pilasters. Spermatheca short, reaching distal end of spermoviduct; spermathecal duct and head clearly differentiated; duct moderately wide with smooth longitudinal pilasters; head globular to elongately inflated, smooth with delicate wall, connected with oviduct by connective tissue. Free oviduct moderately long, comprising about half of anterior part of oviduct; more or less straight. Spermoviduct shorter than anterior part of oviduct. Albumen gland elongate. Talon embedded in albumen gland close to

anterior end of albumen gland. Hermaphroditic duct weakly contorted within sheath of connective tissue.

Digestive system (Figs 12D–F). Jaw consisting of a solid plate. Radula ribbon elongate-squarish, 3.2–4.5 mm long with 110–140 rows of teeth (31–34 rows of teeth/mm) ($n=2$). Dentition formula $C + 13-14 + 3-4 + 20-21$. Central teeth with sharply pointed, slender mesocone, shorter than base of tooth, ectocones absent. Lateral teeth with sharply pointed, triangular mesocone, about as long as base of tooth, endocones occasional present and vestigial, ectocones vestigial. Marginal teeth with broad mesocone, endocone

present in marginals and marginal-lateral transitional teeth. Ectocones in marginal teeth smaller than endocones, with usually one tip.

Remarks. The discoid shell of this species is characteristic. On Bigge Island, there occurs a yet undescribed species of *Amplirhagada* with a somewhat similar, discoid and keeled shell. This species differs by absence of spiral colour bands, a narrower umbilicus, darker colour of the base, and absence of a parietal wall.

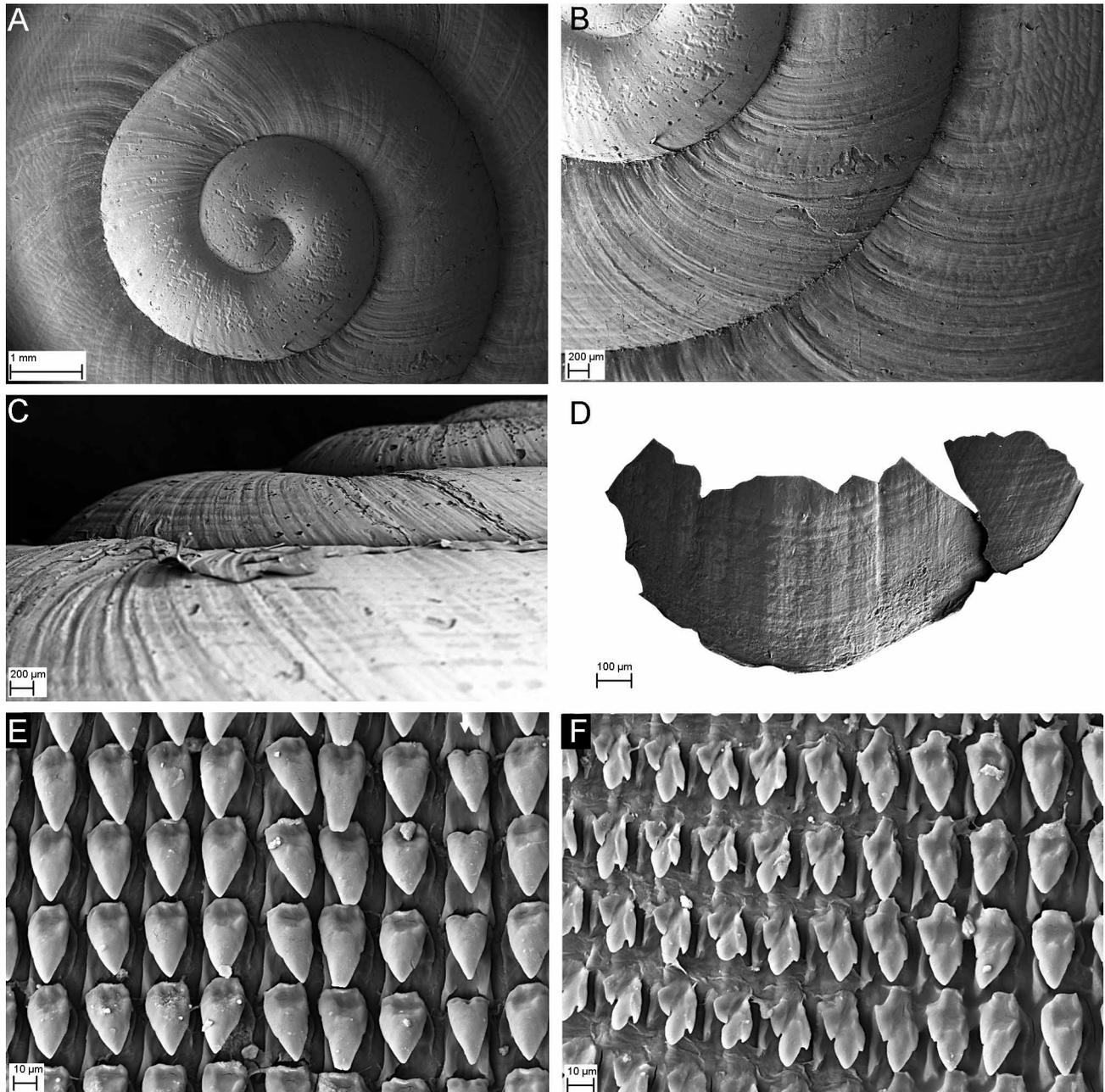


FIGURE 12. SEM photographs of *Kimberleydiscus fasciatus* n. sp. **A–C.** Shell, paratype AM C.463606; **A**, apical whorls viewed from above (scale bar = 200 µm); **B**, second to fourth whorl viewed from above (scale bar = 200 µm); **C**, lateral view of second to fourth whorl (scale bar = 1 mm). **D.** Jaw, paratype WAM S36869 (scale bar = 100 µm). **E,F.** Radula, paratype AM C.463606; **E**, central (marked with small arrow) and inner lateral teeth of radula viewed from above (scale 10 µm); **F**, marginal teeth viewed from above (scale bar = 10 µm).

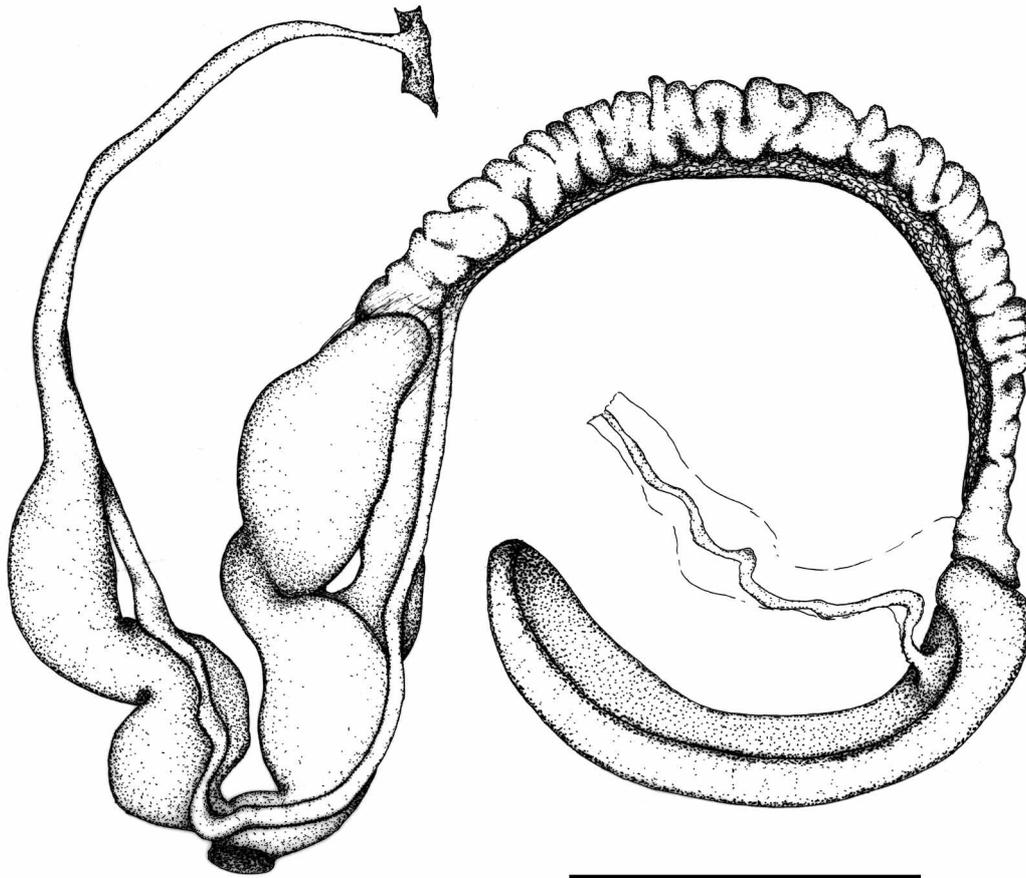


FIGURE 13. Genital anatomy of *Kimberleydiscus fasciatus* n. sp., paratype AM C.463606. Scale bar = 5 mm.

Discussion

Previous workers have established a system that emphasises general features of the shell, such as overall shape, relative size and sculpture, as well as the genital anatomy in the taxonomical classification of Western Australian Camaenidae (Iredale 1933, 1938, 1939; Solem 1979, 1981a, 1981b, 1983, 1984, 1985). By using these characters, it is indeed possible to identify and circumscribe clusters of species that share certain key morphological features. Further, preliminary mitochondrial data (Köhler, 2009) seem to corroborate this procedure. The taxa described herein are all rather distinctive among north-western Australian Camaenidae and readily recognisable by their shells. Each of the genera treated herein is characterised by a peculiar combination of shell features and characteristics of the genital organs, particularly with respect to penial anatomy.

The genera *Carinotrachia*, *Kimberlymelon* n. gen. and *Kimberleydiscus* n. gen. are each known to contain only one or two species, and thus have relatively limited distributions in the Kimberley region. Their limited occurrence corresponds well with the general pattern observed in camaenid land snail assemblages of the Kimberley, according to which suitable habitats comprise

compositionally different sets of very geographically localized endemic species, most of which belong to genera that are endemic to the Kimberley region (Solem and McKenzie 1991). The analysis of patterns of species richness and phylogenetic diversity *sensu* Faith (1992) in the Kimberley Camaenidae awaits the completion of the Kimberley Island Survey.

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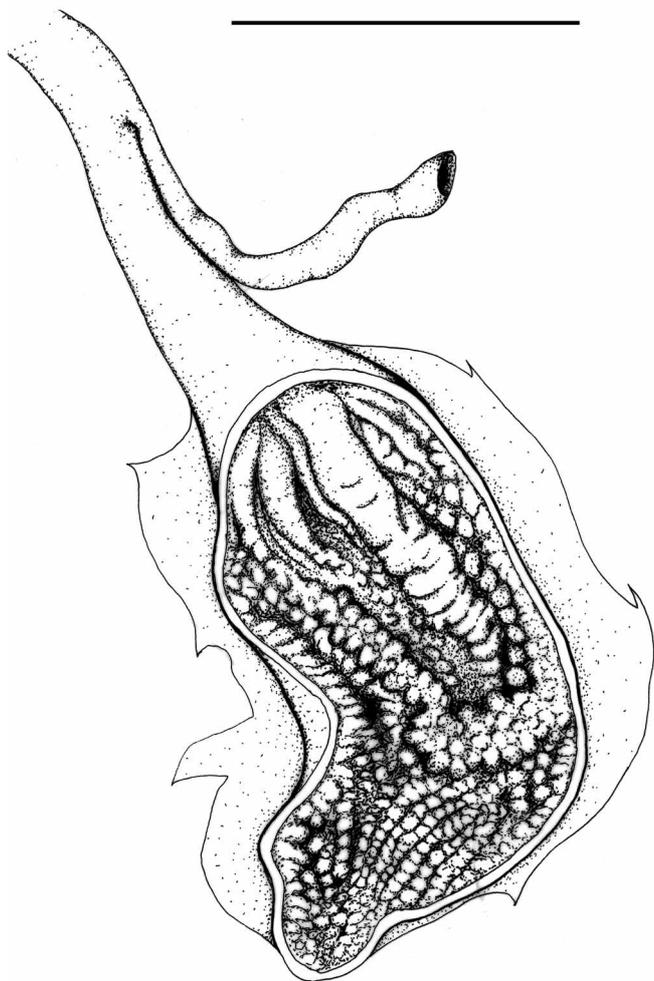


FIGURE 14. Penial anatomy of *Kimberleydiscus fasciatus* n. sp., paratype AM C.463606. Scale bar = 5 mm.

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