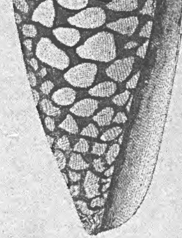

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From the Editor

Owing to a string of unforseen circumstances only one part of Volume 20 was published in 1999. This issue completes Volume 20 and it is hoped that from now on there will be one volume per year published in two numbered parts.

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Two new living species of *Loxotaphrus* (Gastropoda: Cancellariidae: Plesiotritoninae) from Queensland, Australia and Mozambique, East Africa

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Abstract

Until now, the only living species assigned to the cancellariid genus *Loxotaphrus* Harris, 1897 was the West African species *L. deshayesii* (Duval, 1841). Two new living species are described here, *L. limpusi* n. sp., from the Swain Reefs, Queensland, and *L. rosadoi* n. sp., from off southern Mozambique. *L. limpusi* most closely resembles the type species of the genus, *L. variciferus* (Tate, 1888) (Miocene, southern Australia). Although *L. rosadoi* resembles *L. variciferus* and *L. limpusi* more closely than it does *L. deshayesii*, it differs from all other species assigned to *Loxotaphrus* in having weak sculpture, apart from the prominent, sharp nodules around the peripheral keel.

Key words: Cancellariidae, Plesiotritoninae, taxonomy, Australia, Mozambique, SE Africa.

Introduction

Loxotaphrus is a genus of unusual gastropods with a moderately tall spire, strongly angled whorls, axial ridges inclined at a slight angle to the outer lip, and therefore a general resemblance to many genera of the Cancellariidae, except that it lacks columellar plates. Previously, it was classified in the Family Buccinidae. Beu & Maxwell (1987) significantly increased the content and diversity of the gastropod family Cancellariidae by including *Loxotaphrus* and several other genera in the new Subfamily Plesiotritoninae. Major characters uniting the members of the subfamily are the moderately tall to very tall, narrow shape, so that varicate species resemble the buccinid genus *Colubraria*, and the non-collabral axial sculpture, which is opisthocline and inclined at a low angle (c. 10-20° in most species) to the varices and growth lines. Living species of the subfamily are still quite poorly known, and undescribed Recent species of *Tritonoharpa*, in particular, continue to be found (e.g., Verhecken, 1997, p. 319; others in the collection of Richard E. Petit). Beu & Maxwell (1987) included the following genera in Plesiotritoninae:

Turehua Marwick, 1943, containing species with weakly angled or weakly rounded whorls, with only a terminal varix, and with several prominent columellar plaits; formerly classified in the Fasciolariidae.

Plesiotriton Fischer, 1884, with evenly inflated whorls, with prominent varices all down the teleoconch, and with 3 or more prominent columellar plaits;

formerly classified in the Ranellidae (or its synonyms Cymatiidae and Tritonidae).

Tritonoharpa Dall, 1908, resembling *Plesiotriton* but lacking columellar plaits; formerly classified as a subgenus of *Colubraria,* in the Colubrariidae (+ Buccinidae).

Africotriton Beu & Maxwell, 1987, resembling *Tritonoharpa* but including smaller, more simply sculptured shells with only 1 or 2 weak columellar plaits.

Kapuatriton Beu & Maxwell, 1987, containing a single New Zealand Eocene species resembling *Loxotaphrus,* but having coarser sculpture, only a thin terminal varix, and prominent columellar plaits.

Varicohilda Eames, 1957, containing a single species from the Eocene of Nigeria, with an unusually short, wide, thick shell and numerous wide, thick varices, and with prominent columellar plaits; formerly classified in the Ranellidae.

Loxotaphrus Harris, 1897, having the final possible combination of weakly to quite strongly angled whorls, with no columellar plaits, and with only the terminal varix developed (at least, in the great majority of specimens; a few aberrant individuals may have more than one varix, as in almost all varicate gastropods). Formerly classified in the Buccinidae.

Loxotaphrus is the least easily recognisable as a member of the Cancellariidae of all these genera, but is likely to belong in this subfamily because of its non-collabral axial costae. Examination of the anatomy and radula is needed to confirm its familial position. It also is one of the smallest genera of the subfamily, in number of species. Of the six species included by Beu & Maxwell (1987), the only living one was the West African species *L. deshayesii* (Duval, 1841). Two undescribed living species referable to *Loxotaphrus* have been brought to our attention separately in recent years, and we have combined to name them both here. In all probability, more species of *Loxotaphrus* and other Plesiotritoninae will be discovered in the tropical Indo-West Pacific as sampling intensity increases in remote areas and in deeper water.

A further fossil species to be referred to *Loxotaphrus,* but not included by Beu & Maxwell (1987), is *Morum (Oniscidia) quilonicum* Dey (1962: 70, pl. 5, figs. 24, 25), from the Middle or Late Miocene Quilon Limestone at Padappakara, near Quilon in southwestern India. The nine species now referred to *Loxotaphrus* are:

Loxotaphrus aturensis (Peyrot, 1926), Late Oligocene, SW France.
L. deshayesii (Duval, 1841), Recent, West Africa (Fig. 2 E-F).
L. limpusi n. sp., Recent, SE Queensland, Australia (Fig. 1 B-I).
L. minbuensis (Noetling, 1895), Oligocene, Irrawaddi River, Burma [Myanmar].

L. quilonicus (Dey, 1962), Miocene, SW India.
L. rosadoi n. sp., Recent, southern Mozambique, East Africa (Fig. 2 A-D).
L. subtaurinensis (Vergneau, 1965), Middle Oligocene, SW France.
L. taurinensis (Bellardi, 1873), Miocene, Torino, Italy.
L. variciferus (Tate, 1888), Mid. Miocene, Victoria & South Australia (Fig. 1 A).

Materials and Methods

We have tried to examine all Recent material of the two new *Loxotaphrus* species available in both private and museum collections. Almost all originally was in private collections. Unfortunately for the confirmation of the taxonomic position of this strange genus, all material consists of empty shells. One of the specimens of *L. limpusi* n. sp. (paratype 2) was coated with gold and examined by SEM (a Philips PSEM 500) in the Institute of Geological & Nuclear Sciences. Other specimens are illustrated by light photography, and in some cases were coated with ammonium chloride sublimate or magnesium oxide before photography, to enhance the sculpture.

Abbreviations

The following abbreviations are used through the text for Malacology collections of the institutions housing the material referred to:

AMS, Australian Museum, Sydney, Australia;
IGNS, Institute of Geological & Nuclear Sciences, Lower Hutt, New Zealand;
IRSNB, Institut Royal d'Histoire Naturelle de Belgique, Brussels, Belgium;
NM, Natal Museum, Pietermaritzburg, South Africa.

Systematics

Superfamily **CANCELLARIOIDEA** Forbes & Hanley, 1851
Family **CANCELLARIIDAE** Forbes & Hanley, 1851
Subfamily **Plesiotritoninae** Beu & Maxwell, 1987
Genus ***Loxotaphrus*** Harris, 1897

Loxotaphrus Harris, 1897: 165.
Type species (by original designation): *Phos (?) variciferus* Tate, 1888, Middle Miocene of Victoria and South Australia (Fig. 1 A).

Loxotaphrus limpusi n. sp.
(Fig. 1 B-I.)

Type material: Holotype: AMS, C 367433, trawled by fisherman in 188-192 m, southeast of Hixson Cay, Swain Reefs, E Queensland, Australia, October 1994, presented by A. Limpus; one of four empty shells.
Paratypes 1-3, all from same lot as holotype; paratype 1 in collection of Allan Limpus, Bundaberg, Queensland (Fig. 1 G); paratype 2, IGNS, TM 7871 (Fig. 1 B, E, H-I); paratype 3, presented to IRSNB, IG 28797.

Distribution: At present, known only from the type locality.

Description: Shell biconical, moderately tall-spired, aperture 49% of shell height, spire 34% of shell height; whorls moderately strongly angled, with sharp, narrow carina at half whorl height on early spire whorls, ascending gradually to upper third of whorl height on penultimate whorl; exterior pale fawn to pale brown, finely but very irregularly maculated with many small, darker red-brown spots, forming vague, moderately wide, darker brown axial bands on sutural ramp and upper third of last whorl below shoulder angle, 7-8 bands on last whorl; bands continuing on base and canal but broken by 2 vague, paler spiral peribasal bands. Aperture pale fawn to white. Protoconch pale brown, paucispiral, of 1.25 smooth, inflated whorls, maximum diameter 1.5 mm, exposed height 1.5 mm, with large, hemispherical initiation, last quarter-whorl weakly keeled; similar to but smaller than that of *L. rosadoi* n. sp. Transition to teleoconch very abrupt, orthocline, marked by sudden initiation of fine spiral and axial sculpture and of narrower and sharper median spiral keel. Teleoconch of 5.5-6.0 narrowly keeled whorls, sutural ramp relatively narrow over last 2 whorls, moderately steeply sloping, weakly concave; below keel, whorl weakly convex, contracting again to suture. Last whorl moderately long, contracting moderately sharply to neck and strongly recurved siphonal canal, forming narrow, weakly bulging, evenly convex fasciole. Axial sculpture of many low, narrow, well-defined ridges over whole whorl height on early spire whorls, forming small, narrowly rounded nodules at peripheral keel, 30 and 26 on penultimate and antepenultimate whorls of holotype, respectively; weakening gradually down shell to be represented only by shoulder nodules on last 1.0-1.5 whorls; judging from weak nodules and from alignment of colour bands on last whorl, axial ridges opisthocline, at c. 10-15^0 to terminal varix. Spiral sculpture of several orders of very low, wide, weakly convex, closely spaced cords covering entire teleoconch surface, 7-9 relative narrow cords on sutural ramp, 5 major cords on spire whorls below keel and 12 on last whorl, each interspace with one central, narrower secondary cord, with one still lower and narrower, tertiary cord filling each secondary interspace; a further 12-15 low, closely spaced cords on canal and fasciole, decreasing in width anteriorly. Terminal varix coloured as remainder of shell surface, low and wide (wide in spiral direction, i.e., parallel to whorl surface), demarcated by narrow posterior groove, with strongly convex outer surface, contracting gradually to aperture, forming narrow, weakly flared, polished, almost smooth outer lip, faintly grooved at outer margin in conformity with exterior spiral interspaces. Aperture narrowly oval. Inner lip thick, smooth, without parietal or columellar ridges, moderately wide, raised into thick, smooth collar extending widely from whorl surface at prominent angle over fasciole and neck, partly hiding fasciole in apertural view and forming narrow pseudumbilical chink. Surface of apertural lips and collar microscopically nodulous, as in all other Plesiotritoninae examined by SEM (Beu & Maxwell, 1987).

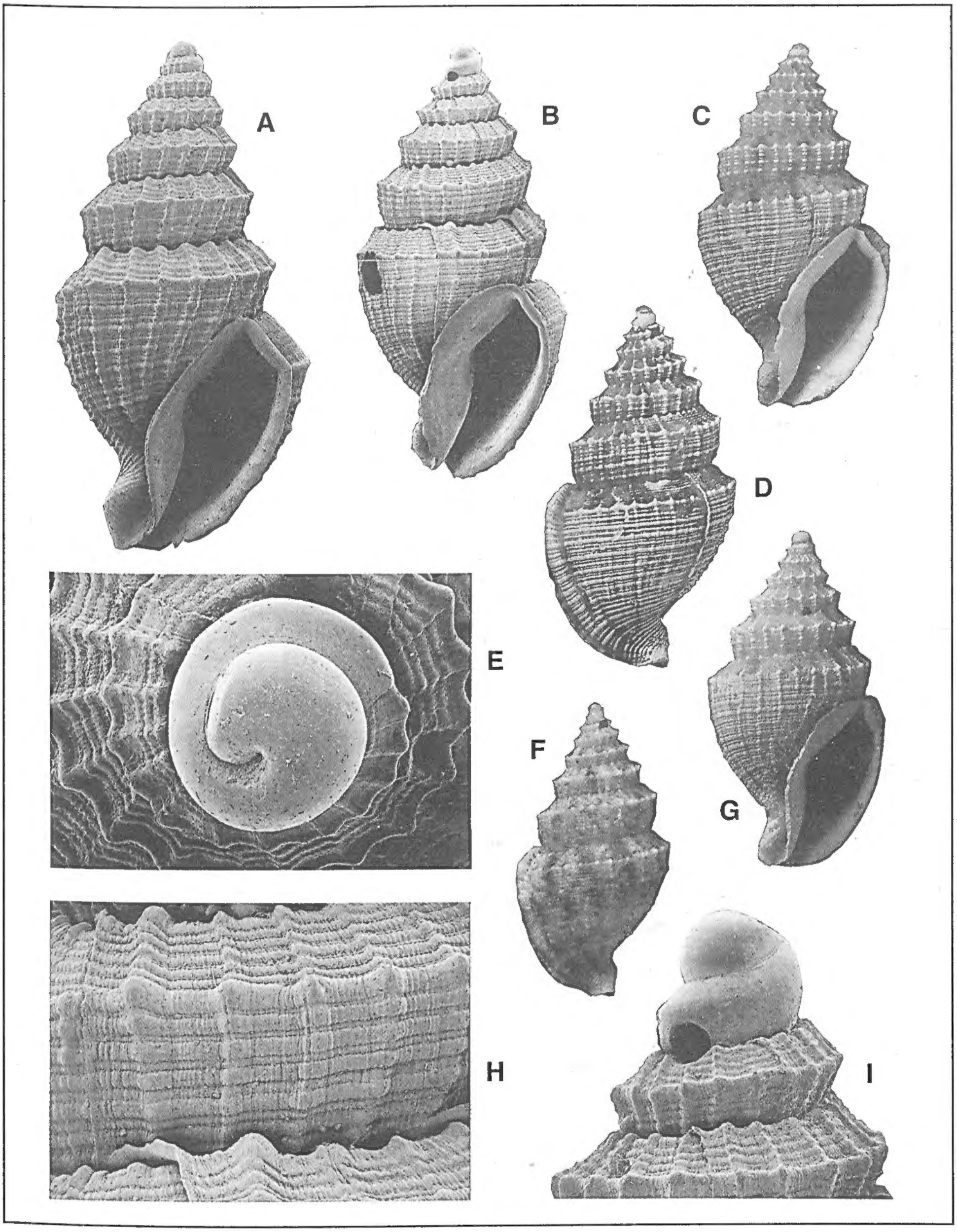

Figure 1
A *Loxotaphrus variciferus* (Tate), type species of *Loxotaphrus* Harris, 1897; Balcombian (Middle Miocene), `Clifton bank', Muddy Creek, near Hamilton, western Victoria; H 18.0 mm; IGNS, WM 11334. **B-I** *Loxotaphrus limpusi* n. sp., 188-192 m, SE of Hixson Cay, Swain Reefs, SE Queensland, October 1994. **B, E, H-I** Paratype 2, SEM micrographs; H 20.7 mm; IGNS, TM 7871; (B) Whole shell, montage; (E) Protoconch, apical view; (H) Sculpture of venter of penultimate whorl; (I) Protoconch, ventral view. **C-D, F** Holotype; H 24.0 mm; AMS, C 367433; (C-D) Ventral and dorsal views, coated with magnesium oxide; (F) Dorsal view, uncoated, to show colour pattern. **G** Paratype 1, coated with magnesium oxide; H 22.2 mm; in collection of Allan Limpus.

Dimensions:

	Height (mm)	Diameter (mm)
Holotype	24.0	12.7
Paratype 1	22.2	12.0
Paratype 2	20.7	10.3
Paratype 3	18.6	9.8

Remarks: Loxotaphrus limpusi is similar to the type species, the Australian Miocene species *L. variciferus* (Tate) (Fig. 1 A), differing in its much finer and more numerous axial ridges, which fade out over the last 1.0-1.5 whorls rather than remaining strongly over the whole shell as in *L. variciferus,* in its slightly less obviously keeled whorls, in its slightly lower, wider and more closely spaced spiral cords, and in its lower fasciole than in *L. variciferus*. From *L. rosadoi* n. sp., *L. limpusi* differs in its smaller size, its much less prominent peripheral nodules, its taller spire, its markedly smaller protoconch, its very much stronger sculpture other than the peripheral nodules, and in particular in its much more obvious spiral sculpture. From the living West African species *L. deshayesii* (Duval) (Fig. 2 E-F), *L. limpusi* differs in its smaller size, its narrower shape, its thinner shell, its much weaker sculpture, its axial ridges inclined at a markedly lower angle to the varix, its lower varix, and its smooth rather than prominently ridged apertural lips.

It seems likely that *L. limpusi* is a direct descendant of *L. variciferus*, and it provides another example of the retreat to Queensland, presumably as a result of late Cenozoic temperature decline, of taxa that occur also as Cenozoic fossils in Victoria and South Australia. Other examples of this northern occurrence of species related to southern Australian fossils include the cowry *Umbilia capricornica* Lorenz, 1989 (Wilson, 1993: 192, pl. 30, figs. 1-6, 8), the volutes *Athleta (Ternivoluta), Notovoluta* and *Nannamoria* (Darragh, 1979, 1983), the ranellid *Sassia (Austrotriton)* cf. *garrardi* (Beu) (AGB, unpublished data), species of *Columbarium*, and the pseudolivid *Zemira bodalla* Garrard (Ponder & Darragh, 1975: 103).

Etymology: The new species is named for the well known collector Allan Limpus, of Bundaberg, Queensland, who provided all the material.

Loxotaphrus rosadoi n. sp.

(Fig. 2 A-D.)

Type material: Holotype: NM, L4843/ T1719, off southern Mozambique, 150 m, in lobster trap, collected by J. Rosado, 1998.

Paratypes 1-2, southern Mozambique, 150 m; paratype 1 in collection of M. Amorim, Lisbon, Portugal; paratype 2 in collection of P. Granja, Sobral Monte Agraco, Portugal.

Paratypes 3-4, *ex pisce,* off Quissico, southern Mozambique, 120-160 m, September 1997, in collection of J. Rosado, Maputo, Mozambique.

Type locality: southern Mozambique, 150 m, in lobster trap, 1998.

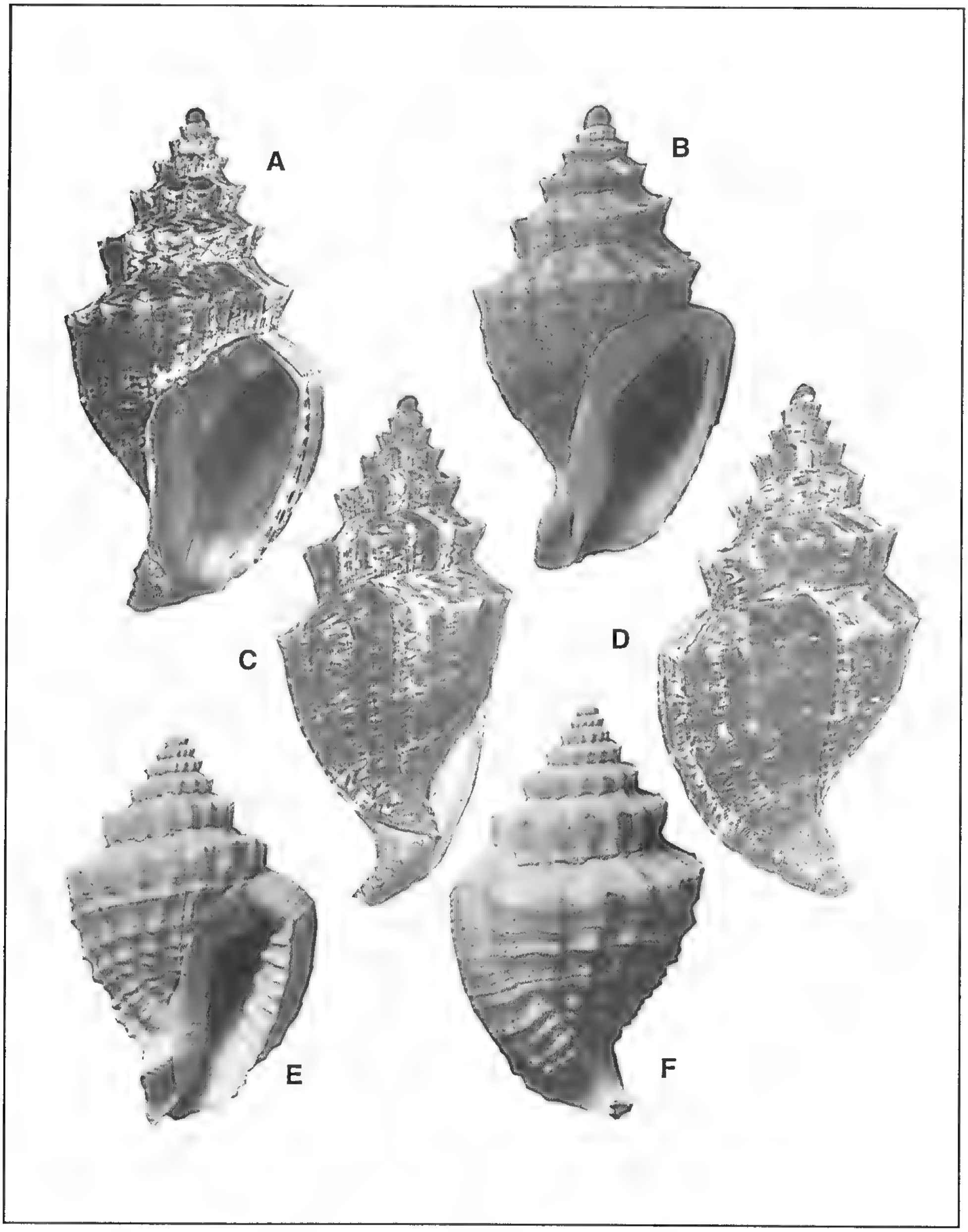

Figure 2
A-D *Loxotaphrus rosadoi* n. sp., off southern Mozambique, East Africa. **A, C-D** Holotype, from lobster trap in 150 m, coll. M. Amorim, 1998; H 30.9 mm; Natal Museum, Pietermaritzburg, L4843/ T1719; ventral, left-lateral and dorsal views. **B** Specimen attached by its dorsum to *Xenophora pallidula* (Reeve), trawled off southern Mozambique, February 1986; H 30.1 mm; in collection of Dawn Brink. **E-F** *Loxotaphrus deshayesii* (Duval), off Dakar, Sénégal, West Africa; large specimen, coated with ammonium chloride; H 26 mm; formerly in collection of the late Marcel Pin (from Beu & Maxwell, 1987: pl. 26 g, i); ventral view (E), and oblique right dorso-lateral view (F) showing axial ridges truncated by terminal varix.

Material studied: the types; a damaged shell also from off Quissico (in collection of J. Rosado); and four further shells from off southern Mozambique - one poorly localised empty shell, from a South African trawler (probably, like all the other material, from southern Mozambique; presented to AGB by The Abbey Specimen Shells), now in IRSNB, IG 28798, and three empty shells, trawled off southern Mozambique in ca. 200-300 m, in South African private collections (in collection of Val van der Walt, Westville, 2 specimens, collected in 1982 and 1988; in collection of Dawn Brink, Westville, one specimen, February 1986, attached to a specimen of *Xenophora pallidula* Reeve; Fig. 2 B).

Distribution: This species is known at present only from off southern Mozambique, in depths between 120 and 300 m.

Description: The holotype is described, but the variability in dimensions of the type lot is indicated in brackets.

Shell biconical, thin-walled, with relatively long recurved siphonal canal; colour brown with pale fawn V-shaped markings. Spire angle 62° (60°-70°), spire height 28.8% of total shell height (27.4-30.5%). Protoconch very much like that of *L. limpusi* n. sp. (Fig. 1 E, I), dark brown, paucispiral, with 1.25 smooth whorls, slightly deviated from teleoconch coiling axis; maximum diameter 1.7 mm (1.6-1.9 mm), exposed height 1.6 mm (1.5-1.8 mm). Transition to teleoconch forms an opisthocline line, further indicated by start of carinate teleoconch whorl. Teleoconch with 6 strongly shouldered whorls, sides straight, sutural ramp sloping outwards moderately gently. Axial sculpture of smooth ribs, only slightly developed on sutural ramp, more obvious on abapical part of whorl near shoulder but fading anteriorly, and at peripheral carina forming broad-based whitish pointed spines directed upwards, parallel to abapical whorl side, forming distinct coronation. Number of axial ribs: on first teleoconch whorl: 14 (14-20), visible with difficulty on first half-whorl; on second to fifth whorls: 14 (13-17), 13 (13-16); 14 (14-18), 17 (14-17) respectively. On last whorl, axial costae on sides clearly marked only near carina, where they form ridges on some specimens. On rest of last whorl, each axial indicated only by two rather strong nodules and two very weak ones. Between axial ribs, vaguely indicated growth-lines form narrow angle to axial ribs. Temporary growth-stops at regular intervals of about 1/3 of a whorl are indicated weakly by thin line on spire whorls; indicated more prominently on last whorl by slight reflection of former outer lip, showing banded pigmentation like that on reflected rim of outer lip. Last whorl ending in varix composed of two close-set axial ribs (paratype 3 has 2 varices), forming a broad, flattened, whitish spine at periphery, reflected away from aperture; varix with same colour pattern as whorl surface. Spiral sculpture commencing at protoconch rim, consisting of tiny, close-set, smooth, flat cords over entire teleoconch surface. Number on adapical and abapical sides of first to fifth whorl respectively: 4, 10; 8, 10; 13, 12; 19, 17; 27, 37; and 36, 140 on last whorl. On base of last whorl, nodules weakly indicated at sculptural intersections, those near periphery most prominent. Aperture oblongly oval, height 58.6 % of total shell height (55.6-62.0 %). Outer lip smooth within; inner lip smooth, without columellar folds; one weak, rounded tooth (parietal ridge) near adapical corner of parietal callus, and another still weaker one at base of siphonal canal. Large collar present on inner lip, at adapical part of aperture attached to previous whorl, but free-standing below over neck, and attached again to curved siphonal canal (Fig. 2 C). Surface of callus and collar microscopically nodulous (visible at 30 x enlargement), as in all Plesiotritoninae (Beu & Maxwell, 1987). Pseudumbilical chink present, partly covered by collar. Siphonal canal relatively long, narrow, twisted dorsally. Traces of thin fawn periostracum remain on abapertural side of parietal shield. Last whorl with three narrow, pale, spiral colour bands: one near periphery, and two close to each other near lower third of base, coinciding with weakly nodulous spiral cords.

Dimensions:

	Height (mm)	Diameter (mm)
Holotype	30.9	16.0
Paratype 1	25.7	14.5
Paratype 2	22.4	13.0
Paratype 3	23.6	13.1
Paratype 4	22.4	13.6
IRSNB, IG 28798	24.2	13.5
V. Van der Walt colln., 1	20.5	11.3
V. Van der Walt colln., 2	23.1	13.1
D. Brink colln.	30.1	17.2

Remarks: Most of the type specimens were taken in lobster traps; paratype 1 had the top attached to a shell of *Xenophora pallidula*, and another in a South African private collection is still attached by its dorsum to the same species of *Xenophora*. Other material in South African private collections was taken by commercial fish trawlers.

The holotype was collected alive, but only traces of soft parts remained when it was studied. Paratype 2, and obviously paratype 1, were collected as empty shells and this may explain why their colour is paler than that of the other types. The general colour of fresh shells varies from medium brown to yellowish brown. Paratypes 2 to 4 have some holes in the shell, probably due to predation by fish; the same applies to a fifth, non-type shell (coll. Rosado), the complete last whorl of which is missing. The presence of the varices suggests that all types of both *L. limpusi* and *L. rosadoi* are fully grown.

Within the genus *Loxotaphrus*, *L. rosadoi* is the first Recent species found in the Indian Ocean. Until now, there has been no similar material in the collection of the Natal Museum, Pietermaritzburg, South Africa (D. Herbert and R. N. Kilburn, NM, pers. comm.). This new species is easily distinguished from *L. deshayesii* from off West Africa in having a relatively thin shell. For a slightly smaller number of protoconch whorls, it has a larger protoconch: maximum diameter 1.6-1.9 mm, exposed height 1.5-2.1 mm (protoconch dimensions of the unlocalised non-type shell are respectively 1.9 and 2.1 mm), versus respectively 1.3-1.4 mm and 1.1-1.5 mm for *L. deshayesii*. The pointed coronation of the whorls is absent in *L. deshayesii*, which has only rounded nodules instead of narrowly pointed nodules at the shoulder carina. Surface sculpture is much stronger in *L. deshayesii*, which also has lirae inside the outer lip and may have transverse ridges (but not true spiral plaits) on the inner lip. The free-standing collar also is absent in *L. deshayesii*. The differences from *L. limpusi* n. sp. are given above.

In general form, *L. rosadoi* resembles the Middle Miocene *L. variciferus* from western Victoria, Australia (Fig. 1 A), but the latter can easily be distinguished by its stronger sculpture and by the absence of prominent, narrowly rounded nodules on the carina.

Etymology: This new species is named for José Rosado of Maputo, Mozambique, who collected and made available for study the first shells of this species.

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The donation of the material of *Loxotaphrus limpusi* by Allan Limpus, of the holotype of *L. rosadoi* by Manuel Amorim, and of a specimen of *L. rosadoi* by Bob Foster, The Abbey Specimen Shells, Santa Barbara, are gratefully acknowledged. The study of *L. rosadoi* was possible only thanks to Christa and Jens Hemmen (Wiesbaden, Germany), Manuel Amorim, José Rosado, C. P. Fernandes (Cascais, Portugal), and Paulo Granja, all of whom who made material available for study. Dawn Brink and Val van der Walt (Westville, South Africa) also loaned us specimens of *L. rosadoi*. Wendy St George (IGNS) is thanked for photography and for SEM maintenance, operation and printing, and Dr Philippe Bouchet and Virginie Héros (Laboratoire de Malacologie, Muséum national d'Histoire naturelle, Paris) for bibliographic assistance on the French author André Duval. We also are grateful to Dr Thomas Darragh (Museum of Victoria), Dr Winston Ponder (AMS) and an anonymous referee for suggesting improvements to the manuscript.

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A new living scallop
(Bivalvia: Pectinidae) from the southwestern Pacific

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Abstract

Palliolum minutulum n. sp. is described from New Caledonia, northern Queensland (Australia), the Solomon Islands, Fiji and Kiribati. This is the first living *Palliolum* known from the Indo-Pacific.

Key words: Mollusca: Bivalvia: Pectinidae, *Palliolum minutulum* n. sp., southwestern Pacific.

Introduction

During the *Montrouzier* Expedition to the Touho and Koumac areas of New Caledonia from August 23rd to 5 November 5th 1993 (Bouchet, 1994) a new small pallioline pectinid was collected alive, mainly by algae washings. Additional material from northern Queensland was collected alive amongst algae attached to submerged nets at a depth of 6 m.

The type material is housed at the Muséum national d'Histoire naturelle, Paris (MNHN). Other studied material is kept in the AMS, HD, MNHN, NMNZ, and PS.

Abbreviations

AMS, Australian Museum, Sydney
HD, H.H. Dijkstra collection, Sneek
PS, P.C. Southgate collection, Townsville
MNHN, Muséum national d'Histoire naturelle, Paris
NMNZ, Museum of New Zealand Te Papa Tongarewa, Wellington
db, articulated valves
lv, left valve
rv, right valve

Systematics

Superfamily **PECTINOIDEA** Wilkes, 1810
Family **PECTINIDAE** Wilkes, 1810
Subfamily **Pectininae** Wilkes, 1810
Tribe **Palliolini** Korbkov in Eberzin, 1960
Genus ***Palliolum*** Monterosato, 1884

Palliolum Monterosato, 1884: 5 [Proposed as a section of *Pecten*].
Type species (by subsequent designation [Crosse, 1885]): *Pecten incomparabilis* Monterosato, 1828; living, Mediterranean Sea.

Diagnosis: Palliolini with prominent antimarginal microsculpture, antimarginal macrosculpture nearly absent, no shagreen microsculpture or commarginal macrosculpture, foliated calcite (uniformly oriented laths) outside of pallial line, byssal notch and sinus shallow throughout ontogeny, a weak ctenolium with closely spaced teeth, small auricular crura.

Distribution: Eocene-Recent (Hertlein, 1969: N354). Boreal Atlantic (Waller, 1991: 35) and southwestern Pacific; shallow to deep water.

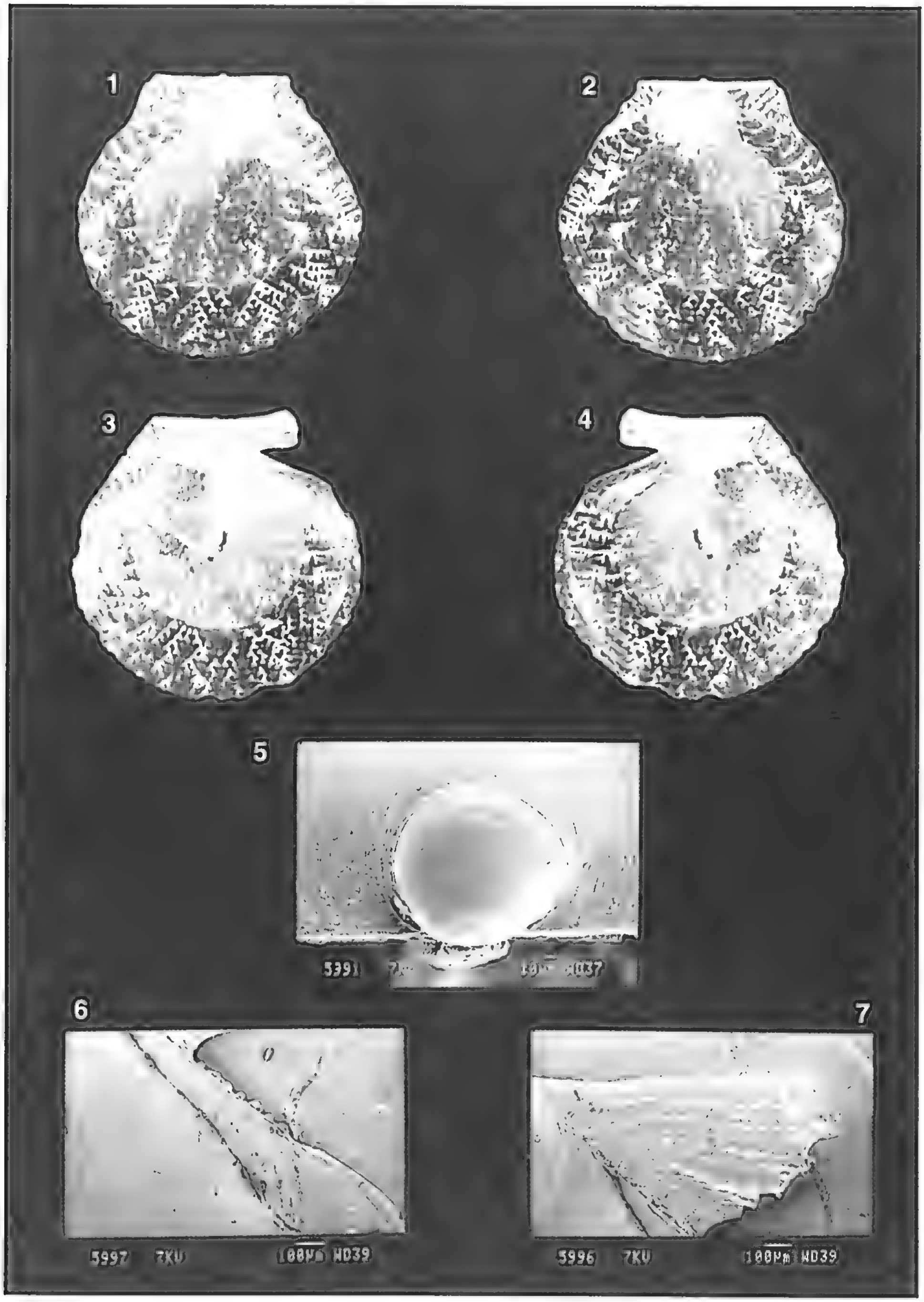
Discussion: So far the present species is the only living *Palliolum* from the Indo-Pacific region. Representative genera of Palliolini, mainly fossil, are enumerated by Beu (1995: 19) and Beu & Darragh (in prep.) from New Zealand and southern Australia.

For phylogeny and stratigraphy see Waller (1991: 35; 1993: 198), Waller & Marincovich (1992: 219), Beu (1995: 19) and Beu & Darragh (in prep.). It differs from *Delectopecten* by a more depressed and less circular shell (*Delectopecten* is more convex and circular of shape), by absence of scales on intersections on left valve (generally present in *Delectopecten*), by a declined hinge line of the right valve (hinge line straight in *Delectopecten*), and a less demarcating byssal fasciole with anterior auricle (strongly demarcating in *Delectopecten*), and a more colourfull shell (*Delectopecten* only whitish). *Delectopecten* is also living in deeper water (bathyal to abyssal depths), *Palliolum* littorally to sublittorally.

Palliolum minutulum n. sp.

(Figs 1-7)

Description: Shell small, orbicular, equiconvex, equilateral, translucent, up to ca. 9 mm high, auricles nearly equal in size, umbonal angle about 90°. Prodissoconch ca. 110 µm in height. Left valve smooth, glossy, with minuscule antimarginal scratches and commarginal lirae near anterior margins of auricle and disc. Microscopic sculpture lacking near posterior and ventral margins. Anterior and posterior auricles gradually transitionally developed into disc without demarcating disc flanks. Hinge line nearly straight, antero-dorsal margin slightly raised. Auricular crura without dorsal and intermediate teeth. Resilifer wide triangular. Right valve with similar microsculpture to that of left valve. Anterior auricle prominent, somewhat curved, with four irregularly arranged radial riblets bearing fine gemmae where they are crossed by the fine commarginal lirae. Byssal fasciole rather broad; byssal notch weakly indented; ctenolium well developed on suture, functional segment with 10 small teeth (active ctenolium). Exterior translucent cream, with white tent-shaped maculations; soft parts dark brown.



Figures:

Figures 1-7. *Palliolum minutulum* n. sp. **1-4.** Holotype (MNHN), 6.8 x 6.6 mm (db). 1. Left valve, exterior. 2. Left valve, interior. 3. Right valve, exterior. 4. Right valve, interior. **5-7.** Paratypes (MNHN). 5. Left valve, prodissoconch. 6. Right valve, exterior, active ctenolium. 7. Right valve, exterior, anterior auricle.

Dimensions of the holotype:
Height 6.8 mm, Length 6.6 mm, Depth (diameter) 1.0 mm.

Type material:
Holotype (db) MNHN and 6 paratypes (db) (MNHN, 5 db; HD 6691, 1 db).

Type locality:
New Caledonia, coral reef lagoon off Koumac, between mainland and Infernet reef, 20°34.4'S, 164°13.0'E, 12-14 m, bottom of flat slabs with gorgonians and ooze, live, *Montrouzier* stn 1299, Oct. 1993.

Other material examined:
New Caledonia. MNHN, 3 lv, 2 rv, HD 6692 (1 lv, 1 rv), NW New Caledonia, 20°34'S, 164°16'E, 0-2 m, dead, *Montrouzier* stn 1277, Oct. 1993; MNHN, 2 lv, NW New Caledonia, 20°34.5'S, 164°15.5'E, 3-7 m, dead, *Montrouzier* stn 1297, Oct. 1993; MNHN, 1 lv, NW New Caledonia, 20°35.8'S, 164°12.7'E, 9-10 m, dead, *Montrouzier* stn 1302, Oct. 1993; MNHN, 1 rv, NW New Caledonia, 20°40'S, 164°11.2'E, 12 m, dead, *Montrouzier* stn 1316, Oct. 1993.
Australia. AMS C.165165, 2 rv, Queensland, Lizard Island, Granite Bluff, in 23 m, sandy mud bottom, many forams, some green mixed algae & *Caulerpa* spp., leg. W.F. Ponder, 7 Dec. 1974; AMS C.165166, 1 rv, Queensland, Lizard Island, off East Face, ca. 20 m, foraminiferous, leg. W.F. Ponder, P.H. Colman, I. Loch, 11 Dec. 1974; AMS C.165167, 1 rv, Queensland, Endeavour Reef, 14°57'S, 145°35'E, 8-10 m, rubble wash on outer reef slope, leg. I. Loch, 9 Dec. 1984; HD 6733, 11 db, 7 lv, N Queensland, Pioneer Bay, Orpheus Island, 18°35'S, 146°29'E, from submerged nets, live, 6 m, leg. P. Southgate.
Solomon Islands. AMS C.165168, 2 lv, 2 rv, W Malaita Island, Aoki Harbour, on sheltered side of reef on slopes, 3-7.5 m, coral & rubble bottom, brown algae washings, leg. P.H. Colman, 18 Aug. 1973; NMNZ MF.30460, 8 lv, 6 rv, Vangunu Island, Marovo Lagoon, between Telina Island and Mbareki Peninsula, amongst shell grit & rubble, 9 m, 6 Oct. 1965; NMNZ MF.59756 and NMNZ MF.59756, 4 lv, 4 rv, Vangunu Island, Marovo Lagoon, off Telina Island, amongst shell grit & rubble, 11 m, 26 Oct. 1965; PS P.1314, 4 db, Nusa Tupe Island, Gizo, attached to submerged nets, live, 6-10 m, leg. K. Friedman.
Fiji. PS P.1315, 1 db, off Savusavu on the island of Vanua Levu, 16°34'S, 179°15'E, attached to submerged nets, live, 8-10 m, leg. P. Southgate.
Kiribati. PS P.1332, 7 db, lagoon of Abaiang atoll, off Taburao, 0°59'N, 172°59'E, attached to submerged nets, live, 6-8 m, leg. A. Beer.

Distribution: Solomon Islands, northern Queensland (Australia), New Caledonia, Fiji and Kiribati, 0-14 m, living in 6-14 m amongst algae on soft sediments.

Discussion

Palliolum minutulum is closest in outline to *Palliolum incomparabile* (Risso, 1826), known from the Mediterranean Sea and the adjacent area of the eastern Atlantic. Both species are almost circular in shape, fragile, usually transparent and highly coloured. However, *P. incomparabile* is larger (up to ca. 13 mm high) with prominent antimarginal microsculpture; *P. minutulum* is smaller (up to ca. 10 mm high, usually smaller to 8 mm) with minuscule antimarginal scratches or smooth.

Remarks

The present species is live collected amongst algae in shallow water. The size attained by live specimens held under culture conditions for up to 8 months was 6-8 mm in height. The largest specimen examined, from Gizo in the Solomon Islands, was 9.2 mm in height.

Etymology

The species is named after its small dimension (Latin minutulus, adj. = very small).

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Molluscan Research **20(2)**: 19-24 *(2000)*

Diet of olives: *Oliva tigridella* Duclos, 1835 in Queensland

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Abstract

Field observations of *Oliva tigridella* in Queensland revealed a diet of small gastropods, bivalves, echinoids and holothurians. Foraging animals were observed carrying prey attached to the rear of the foot. Up to seven prey items were recorded on the foot. Analysis of gut contents showed a high frequency of holothurian spicules although these were rare amongst items found on the foot. This study reveals a previously unrecorded catholic diet of olives although small gastropods and bivalves are important components.

Key words: Gastropoda, Olividae, diet

Introduction

Species of the neogastropod family Olividae are often abundant in shallow water, sandy habitats of the tropics and subtropics. They have many adaptations for sand burrowing - including the shiny, unornamented, cylindrical shell, foot with parapodia and large crescent-shaped propodium and a long siphon. Despite the attention given to the family by shell collectors, little is known of their biology including their feeding habits. Olsson & Crovo (1968) observed the feeding of *Oliva sayana* from Florida in an aquarium, where it took live bivalves, *Donax* and *Laevicardium*, as well as pieces of fish, shrimp and steak and placed them in a pocket at the posterior ventral end of the foot. The gastropod then retreated into the sand and consumed the prey. This foot pocket, or pouch, is a ventral down-folding of the posterior end of the foot and is present in several, perhaps all, *Oliva* species including *Oliva tigridella*, the subject of this paper (Kantor & Tursch, 1998 plates 3 & 7). More is known about the ecology of Olivellidae but species in this family differ significantly in anatomy from Olividae (Kantor, 1991) and likely also in feeding biology. Some olivellid species are known to be deposit feeders (Edwards, 1969; Kantor, 1991), suspension feeders (Seilacher, 1959), predators of foraminiferans (Hickman & Lipps, 1983) and of bivalves (Marcus & Marcus, 1959).

In November 1997, near Cairns, we observed a small population of *Oliva tigridella* foraging across low intertidal sand flats. Closer examination revealed that some of these gastropods were carrying prey in sticky mucus adhering to the posterior of the foot. This observation initiated a three day study (7-9 November 1997) of the population to obtain quantitative data on the natural diet of the gastropod.

Taxonomic note

Oliva tigridella Duclos, 1835 has usually been considered a synonym of *Oliva oliva* (Linnaeus, 1758) which has been regarded as a highly variable taxon but is more likely a complex of several closely similar species (Kantor & Tursch, 1998). However, Tursch & Kantor (unpublished observations) have recently recognised that the two species differ not only in shell characters but also in penis shape and radular tooth morphology. Many published and museum records of *O. oliva* from Queensland (e.g. Wilson, 1994; Jansen 1996) are likely to be *Oliva tigridella* (pers. comm. B. Tursch).

Methods

The study site was located at the south end of Yorkeys Knob beach, 12 km north of Cairns, Queensland, Australia (145°43' E, 16º48.8' S). *Oliva tigridella* was abundant in an area up to 40-50 m from the base of the beach and protected to the seaward by low sand bars. Standing water of 10-20 cm was retained behind the sand bars at low water spring tides. The substrate comprised uniform medium-coarse quartz sand. Observations were made on 7-9 November on a falling tide between 0630-1100 h each day. Foraging *O. tigridella* were located by following trails and the gastropods examined. Prey were found adhering to the rear of the foot, loosely held in a mucus mass. Normally prey are held in the foot pouch but this is likely to be everted when the animal is handled. The mucus may be important in keeping prey within the pouch. Those carrying prey were measured with calipers in the field, and the prey removed and placed in individual plastic bags for measurement and identification in the laboratory. A sample of 11 *Oliva* was collected for gut content analysis; this sample was boiled soon after collection and preserved in 80% ethanol. These olives were subsequently dissected and food remains extracted from the stomach and rectum. These were mounted on glass slides in "Aquamount" and the items identified from skeletal remains by microscopic examination. Abundance of *Oliva tigridella* was estimated by 50 x 50 cm randomly thrown quadrats with the sand washed through a 2 mm mesh sieve. Voucher material of *Oliva tigridella* is deposited in the collection of the Natural History Museum, London.

Results

Individuals of *Oliva tigridella* were actively foraging on the falling tide from early to mid-morning with trails extending for several metres in length. The olives moved rapidly and occasionally were seen chasing small *Cadella semen* and *Donax verninus*. By mid-morning most olives had ceased foraging and lay buried in the crests of the rippled sand.

A total of 32 quadrats, representing 8m^2, yielded 15 *O. tigridella*, a density of 1.9/m^2. The only other significant macrofaunal animal recorded in the quadrats was the sand dollar *Arachnoides placenta* with a density of 2/m^2.

Sixty-four individual *O. trigridella* (mean shell height 20.4±2.8 mm, range 16.9-30 mm) were located carrying prey with a combined total of 104 prey items (Table 1). The most commonly recorded prey (71% of items) were the small umbonine gastropod *Isanda coronata* (mean height 2.9±0.54 mm) and the tellinoidean bivalve *Cadella semen* (shell length 4.6±1.08 mm) (18.4% of items). Other prey, including small mactrid and donacid bivalves, crustaceans, a juvenile (4.0 mm) echinoid *Arachnoides placenta*, a small holothurian (*Trochodota maculata*), and an echiuroid were much less frequent (Table 1). Most *O. tigridella* (62.5%) carried single prey items (Table 2), 28% had two items, but one carried seven *Isanda*. Usually when *Oliva* was carrying multiple prey items these comprised solely *Isanda* (Table 3). Although *Cadella semen* are larger than *Isanda*, there was no significant difference in the size of *O. tigridella* taking these two prey (mean 20.8 mm versus 20.4 mm). Prey animals carried by *O. tigridella* were found in various stages of consumption. For example, some *Isanda* were intact, others were partially eaten and others had shells empty except for the operculum. This suggests that shelled prey are held in the foot pouch during feeding by the proboscis and not swallowed whole. No predation damage was detected on any of the shelled prey.

Table 1. Prey items recovered from the foot of *Oliva tigridella*.
Total number with food = 64.

	Numbers of prey	Numbers of *Oliva* with prey type	Mean height (mm)	S.dev	Range
Gastropoda					
Isanda coronata Adams, 1854	74	43	2.9	0.54	1.7-4.0
Bivalvia					
Cadella semen (Hanley, 1845)	19	18	4.6	1.08	3.0-6.1
Paphies elongata (Reeve, 1854)	1	1	_	_	6
Notospisula sp.	2	1	_	_	2.9, 3.5
Donax verninus Hedley, 1913	1	1	_	_	2.5
Mactra cf *olorina* Philippi, 1846	1	1	_	_	5
unidentified bivalve fragment	1	1	_	_	_
Crustacea - amphipod	1	1	_	_	_
Crustacea - isopod	1	1	_	_	_
Echiuroida - skin	1	1	_	_	_
Echinoidea					
Arachnoides placenta (L., 1758)	1	1	_	_	_
Holothuroidea					
Trochodota maculata Clark, 1921	1	1	_	_	_
TOTAL PREY	**104**	**71**			
Height of *Oliva tigridella* (n=64)			20.4	2.8	16.9-30.0

Out of eleven animals dissected for gut content analysis, six contained food remains. All six individuals contained spicules (sigmoids and wheels) from the small, chiridotan holothurian *Trochodota maculata* (identified from Cannon & Silver, 1986); additionally, two individuals also contained crustacean fragments, one of these also had vetigastropod radular teeth (probably *Isanda*) and a further *Oliva* also contained setae of a nereid polychaete.

Table 2. Number of prey items held in foot by individual olives.

Number of prey items	1	2	3	4	5	6	7
Oliva with all prey	40	18	2	2	0	1	1
Oliva with *Isanda*	23	12	1	2	0	1	1
Oliva with *Cadella*	16	1	0	0	0	0	0

Table 3. Prey combinations held in foot by individual olives.

	N
Isanda only	40
Cadella only	14
Isanda / *Cadella*	2
Isanda / *Arachnoides*	1
Notospisula / *Paphies*	1
Cadella / *Donax*	1
Cadella / Amphipod	1
Other items	3

Sieving of sand (ca1500 cm^2) for potential prey items in the area where olives were foraging yielded 16 *Isanda*, 2 *Cadella semen*, 1 *Donax verninus*, 2 *Mactra* juveniles and one naticid *Neverita didyma*. Hand sorting of a sand sample of 315 cm^2 yielded one prawn, one *Trochodota maculata*, and one *Isanda*.

Discusssion

Our results for *Oliva tigridella* confirm previous observations (Olsson & Crovo, 1968; Kantor & Tursch, unpublished) that olives capture prey whilst foraging and then store the items in the pouch at the posterior ventral end of the foot. Captured prey are passed to the foot pouch by the proboscis. Feeding on these prey items takes place when the olives are buried in the sand and the varying states of digestion of the shelled prey indicates that the shelled prey, at least, are consumed within the foot pouch rather than being swallowed whole. Smaller, soft-bodied prey may be swallowed entire. Olives have two potential sources of toxic secretions which may be involved in prey capture and immobilization although there have been no direct tests. Choline esters capable of causing paralysis of prey have been have recorded from the hypobranchial gland of seven species of *Oliva* (Roseghini et al. 1996). Additionally, olives possess accessory salivary glands with the ducts opening at the proboscis tip. These glands have a histology similar to those found in Muricidae which have been shown to produce serotonin, a muscle relaxant (West et al. 1994).

The habit of carrying prey in the foot pouch may be a strategy enabling olives to maximise foraging time with the consumption of the food taking place later whilst the olives are buried beneath the sand. Available prey in the habitat, such as *Isanda* and *Cadella*, are probably individually too small to meet the metabolic requirements of the olive and capture of several prey items is needed on each foraging excursion. In our study the *O. tigridella* were foraging in the early morning on a falling tide later becoming buried and quiescent on the incoming tide. Foraging on the surface exposes the olives to risk from predation (crabs, fish) and environmental factors such as heat stress and the consumption of prey beneath the sand can be viewed as a behaviour to minimize this risk.

Species of a few other gastropod families are known to carry prey on their foot; Coleman (1981 p.50) illustrates the volute *Melo miltonis* (Gray, 1834) from southern Australian carrying a captured *Turbo pulcher* in a "tail pouch". Also Branch & Branch (1981 figs 107-9) illustrate *Marginella rosea* capturing a *Gibbula zonata* and attaching it to the posterior tip of the foot "...where it carries it around until hungry." Many Volutidae hold and manipulate large gastropod prey in the foot (Morton, 1986) and the development of the foot pouch for prey carrying in *Oliva* could be a modification of this behaviour for life in unstable sandy substrates.

In conclusion, it should be emphasized that this is a very short term study and there may be seasonal changes in diet. Also the prey collected and identified may be those which take longest to consume and are therefore retained for longer in the foot pouch. This problem is highlighted by the high frequency of holothurian spicules recorded in the gut content samples compared with the single record of a holothurian from the foot pouch. Nevertheless, there is little information available on the diet of any *Oliva* species and the data presented here indicate that although *Oliva tigridella* feeds upon a range of prey species, small gastropods and bivalves and a holothurian are important components of the natural diet.

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Outbreak of *Mytilopsis sallei* (Récluz, 1849) (Bivalvia: Dreissenidae) in Australia

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Chronology

Darwin is the largest port on the tropical northern Australian coast. On 27th March 1999, during the wet season phase of the Port of Darwin Survey for adventive marine species, divers discovered dense (23,650 individuals m^{-2}) aggregations of a thin shelled "mussel" on floating pontoons, concrete piles, retaining walls, ship's hulls and mooring ropes (Fig. 1) inside Cullen Bay Marina, the largest of three marinas within Darwin Harbour. Early the following morning RCW observed specimens attached to the hull of a motor yacht that was in the lock leaving the Marina. Because of the great extent of tidal rise and fall around Darwin (approx. 8 metres on springs), all three marinas have systems of lock gates separating the waters of the marina from the sea.

RCW identified the "mussels" on 29th March as *Congeria (Mytilopsis) sallei* (Récluz, 1849) based on their exact conchological and anatomical agreement with descriptions in the recent literature (Morton, 1981, 1989; Marelli & Gray, 1983). The reasons behind the choice of this particular scientific name are given in the section on nomenclature below. The identification was verified the following day by Shirley Slack-Smith on the basis of preserved specimens. This represents the first record of a species from the family Dreissenidae and superfamily Dreissenoidea for Australia (Prezant, 1998).

The extent of the Darwin outbreak was revealed during intensive searches by rapid response teams over the next week. One team discovered a population of small individuals (6 individuals m^{-2}) in the second marina (Tipperary Waters Marina) and a lightly fouled vessel in the third marina (Frances Bay Marina). Other teams discovered three moderately to heavily fouled vessels moored at different locations outside the marinas, but still within Darwin Harbour. Checking revealed that these five secondary infestations could all be confidently traced back to Cullen Bay Marina. Extensive searches failed to discover any individuals elsewhere in Darwin Harbour itself. As the previous dry season phase of the Port of Darwin Survey in August 1998 had also failed to reveal a single *M. sallei*, live or dead, anywhere within Darwin Harbour, we concluded the outbreak in Cullen Bay Marina must have taken place during the previous six months.

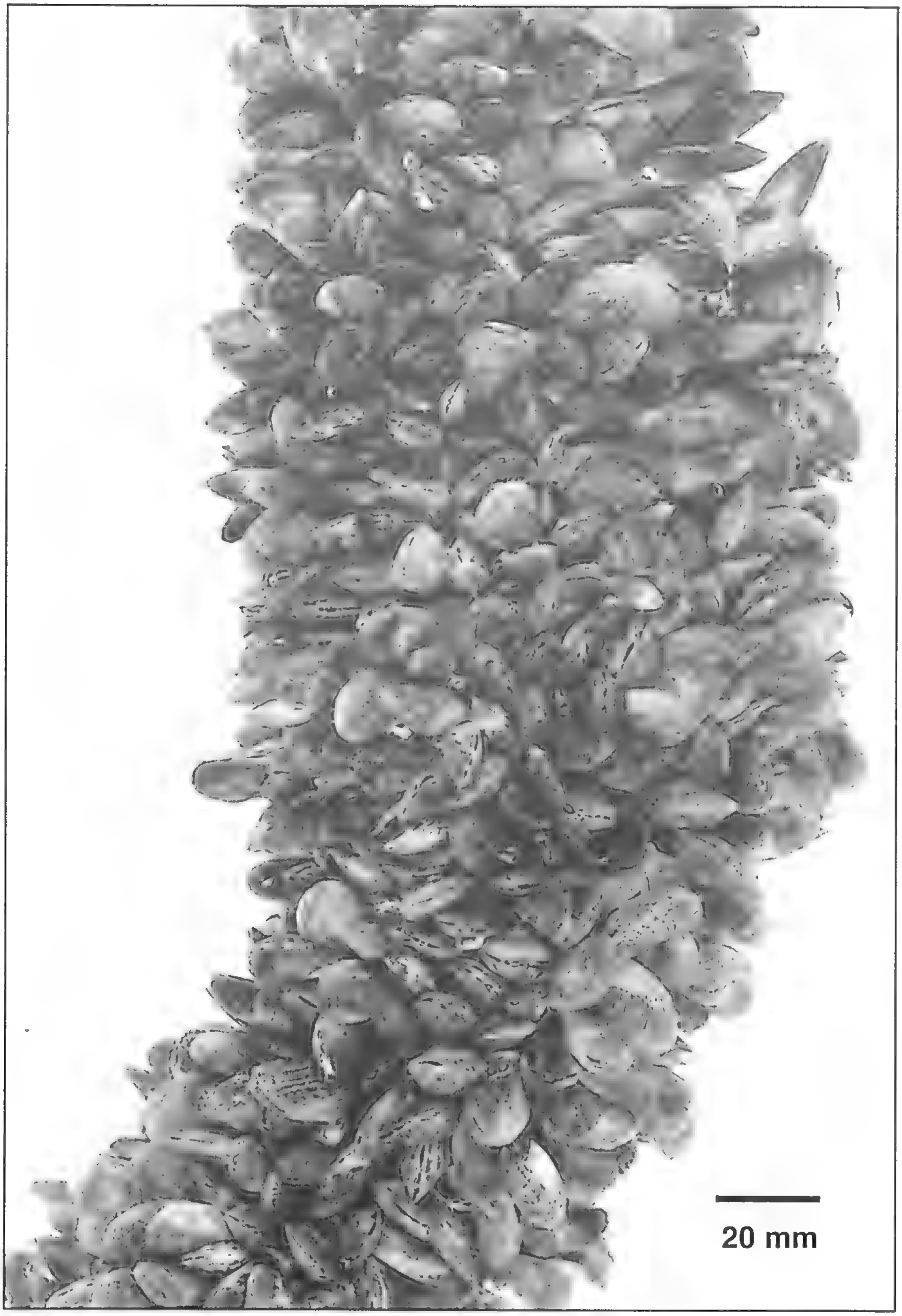

Figure 1.
Section of 10 mm diameter polypropylene rope from Cullen Bay Marina heavily fouled with *Mytilopsis sallei*.

The presence of *Mytilopsis sallei* in Darwin posed a threat to the pearl farming and aquaculture industries in addition to both commercial and recreational fisheries throughout tropical and warm temperate Australia because of its propensity to cause severe fouling on marine structures (Ramachandra et al, 1975; Morton, 1981, 1989). *M. sallei* is an opportunist with very fast growth, early maturity, high fecundity and wide tolerance to salinity, oxygen and pollution levels (Ramachandra et al, 1975; Morton, 1981). In a commendable response to the threat, the Northern Territory Government declared a state of Natural Disaster on 1st April, closed and quarantined all three marinas, and instigated an eradication campaign. Under this campaign Cullen Bay Marina and its lock was treated with a total of 163,040 kg liquid sodium hypochlorite (i.e., a volume yielding a final concentration of 12% chlorine in solution) plus 4,325 kg powdered copper sulphate (i.e., a volume yielding a maximum final, 0.45 μm filtered, concentration of 0.5 mg litre^{-1} copper in solution) between 3rd and 22nd April (S. Sly pers. comm., 25 May 1999 and D. Parry pers. comm., 8 June 1999). Tipperary Waters Marina and Frances Bay Marina and their locks were treated similarly (1,980 kg sodium hypochlorite plus 1,050 kg copper sulphate, and 21,980 kg chlorine plus 2,075 kg copper sulphate respectively) (S. Sly pers. comm., 25 May 1999). The maximum final, 0.45 μm filtered, concentration of copper in solution reached 0.8 mg litre^{-1} in both Tipperary Waters Marina and Frances Bay Marina (D. Parry pers. comm., 8 June 1999). Fouled vessels outside the marinas were recalled into the nearest marina prior to treatment, or lifted from the water, or, in the case of the bamboo raft *Nale Tasih* that had drifted/sailed from Kupang and become heavily fouled in Cullen Bay whilst on display there between 8th January and 28th March, burnt above high water mark.

The chemical treatments of all three marinas were effective in killing *Mytilopsis sallei*. The last known living individual of *M. sallei* was detected in Cullen Bay Marina on 18th April. There was also considerable, but not complete, mortality of other marine life (RCW pers. obs.). As of 31st May, levels of copper remained high but the toxicity to marine life had decreased due to formation of non-toxic, organic copper compounds (D. Parry pers. comm., 8 June 1999). As of this same date, regular post-eradication surveys had found no live *M. sallei* inside any marina and no settlement had been detected in Darwin Harbour. Ongoing surveys for *M. sallei* will monitor the re-establishment of the (largely adventive) fouling community dominated by the barnacle *Balanus amphitrite* Darwin, 1854 and the serpulid tubeworm *Ficopomatus uschakovi* (Pillai, 1960) within the marinas, and check for settlement of *M. sallei* in the Harbour itself.

The possibility of residual populations of *Mytilopsis sallei* remains of great concern. In addition, the risk of reinvasion by *M. sallei* or the introduction of other marine organisms continues (Carlton & Geiler, 1993). Under the protocols put in place since the outbreak, masters of suspect incoming international vessels are requested to undergo an inspection of their vessel's hull (by divers) plus treatment of seawater intake systems and such inspections are strongly recommended for all such vessels intending to enter one of the marinas. No incoming (recreational or commercial) vessel is subject to mandatory inspection. Neither are protocols in place to survey the ballast water tanks of vessels, but an

Australia-wide Code of Practice for commercial shipping recommends against discharge of ballast in ports and it is illegal to discharge ballast water inside the Darwin marinas. This outbreak should reinforce the need for thorough quarantine inspections of hulls and ballast tanks of all vessels arriving at ports in the minds of legislators (Willan, 1987).

Details of the pre-eradication surveys, the eradication program and post-eradication monitoring will be reported elsewhere.

Nomenclature

The difficulties experienced in selecting a scientific name for this invading bivalve have reflected underlying taxonomic uncertainties at both generic and specific levels. Considering: (i) diversity in the present day, global, dreissenid fauna is small (i.e., there are only six - probably fewer - obligate marine and brackish water species (Marelli & Gray, 1983), plus one - possibly more - obligate freshwater species (Morton et al, 1998)), (ii) some dreissenids, most notoriously the freshwater *Dreissena polymorpha* (Pallas, 1771) (Nalepa & Schloesser, 1993), can be serious pests and occur in enormous densities in readily accessible habitats, and (iii) nomenclatural stability is essential for legislators, we are very surprised that the only comparative taxonomic study anywhere in the world reviews just two species in the northwestern Atlantic Ocean (Marelli & Gray, 1983).

The third requirement listed above has dictated our choice of the name *Mytilopsis sallei* in this note because of its exclusive usage in the marine pest literature. But that name may not necessarily be nomenclaturally correct. Schütt (1992) has emphasised the homology of shell structures in the umbonal region between *Mytilopsis* Conrad, 1858 and the chronologically older genus *Congeria* Partsch, 1835, in that the anterior byssal retractor muscle is attached to an apophysis postero-dorsal to the septum in both genera. Therefore Schütt has concluded the names should be synonymous, with *Congeria* being used for all the (fossil and living) species or, at the very least, with *Mytilopsis* being accorded subgeneric status under *Congeria*. In a recent paper on the extant, subterranean, cave-dwelling *Congeria kusceri* Bole, 1962, Morton et al. (1998) have continued to advocate the separation of *Mytilopsis* from *Congeria* as genera, but they have not segregated those characters that are adaptations to the unique habitat from potential generic apomorphies; it is unlikely that Morton would consider that all fossil *Congeria* species had been subterranean or cavernicolous. Cladistics-based phylogenetic research presents a more objective technique to solve the disagreement over the generic name.

Uncertainty will also surround the "correct" specific name until further research is undertaken. Although the name *sallei* Récluz, 1849 is in general usage relating to western Atlantic (Marelli & Gray, 1983) and Indo-Pacific (Marelli & Gray, 1983; Morton, 1989) Ocean populations of this bivalve, their conspecificity has only once been confirmed (Marelli & Gray, 1983), and that on shell characters alone. Anatomical and genetic studies are now urgently needed to test this hypothesis and, simultaneously, to evaluate the five other nominal species. For instance, if *africana* van Beneden, 1835 is also conspecific, as has been speculated (Nuttall, 1990), that name should automatically take precedence over *sallei.* [But that synonymy would cause such enormous instability we would not hesitate to present a case to the International Commission on Zoological Nomenclature to invoke its plenary powers to suppress *africana.*] Only when this research is published will it be possible to speculate on where the founders of the Darwin population originated because there is now no possibility of identifying the offending vessel.

Acknowledgements

Were it not for the mammoth concerted effort at eradication by scientists, government, industry and the public, *Mytilopsis sallei* had the potential to become established in ports throughout (tropical and warm temperate) Australia. Shirley Slack-Smith (Western Australian Museum) is thanked for confirming the identification of *M. sallei* and for commenting on the draft for this note. We also thank the following senior managers for their corrections to the draft: Rex Pyne (Deputy Director of Fisheries, Northern Territory Department of Primary Industry and Fisheries), Andria Marshall (Project Leader, Northern Territory Aquatic Pests Program), Patrick Filmer-Sankey (Director, MAGNT) and Ron Thresher (Head, CRIMP). We are grateful to Steve Sly (Northern Territory Aquatic Pests Program) for providing the statistics on the quantities of chemicals used to treat the Darwin marinas, David Parry (Northern Territory University) for their final concentrations, and Charlotte Watson-Russell (MAGNT) for the name of the tubeworm.

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Note added in proof

Two further incidents have highlighted Australia's vulnerability to reinvasion by *Mytilopsis sallei.* On 5th September 2000, divers undertaking monitoring surveys for *M. sallei* discovered a moderate infestation of this bivalve on the keel and hull of a vessel moored at the quarantine buoy in Darwin Harbour. The vessel, a 22 metre long, wooden, Indonesian fishing boat, had been intercepted by the Australian Navy thirteen days previously fishing in Australian territorial waters and escorted to Darwin. The skipper admitted the offence and was fined, and the vessel was ordered to leave Australian waters for its home port in Probalinggo, northeastern Java, which it did on 6thSeptember. A second, similar vessel from the same part of Indonesia, that had been escorted to the same site in Darwin Harbour on 8th September for the same alleged offence, was found to be heavily infested with *M. sallei.* It was ordered to leave Australian waters that same day without any prosecution being effected.

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Specific gravity and dropping speed in eggs of *Oncomelania hupensis*, a snail intermediate host of Schistosomiasis

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Abstract

Oncomelania hupensis (Gredler, 1881) is an intermediate host of *Schistosomiasis japonica* in China. In order to understand the factors controlling sedimentation and drifting of adult snails and snail eggs in rivers, three aspects were investigated by experiment. Firstly, the specific gravity of the snail eggs was found to be 2.29 g/cm^3; secondly, the range of dropping speed of the snail eggs through a water column was found to be 1.19 to 3.77 cm/s; thirdly, a formula for dropping speed of the eggs was established. The formula was statistically validated by comparison with observed values. The results are relevant to both the development and design of irrigation schemes, and also to river management, where dispersal of snails and their eggs needs to be controlled.

Key words: *Oncomelania hupensis*, snail eggs, specific gravity, dropping speed.

Introduction

Schistosomiasis is now endemic in 74 countries and territories of the world and *Schistosoma japonica* is mainly distributed in south-east Asian and the Western Pacific region (WHO 1991). One of the most difficult problems for schistosomiasis control is the dispersal of the snail intermediate host along rivers and irrigation schemes. This dispersal expands the endemic areas of schistosomiasis and increases the prevalence of the disease (Hunter, 1993; Mott, 1990). It is important, therefore, to explore methods for controlling the snail host. The ecology of the water snails in relation to water flow has been well-researched and some effective models have been proposed (Dussart,1987; Yin, *et al.*,1987, Bolton, 1988; Xu & Fang, 1989; Yang, *et al.*, 1992; & Green, *et al.*, 1992).

S. japonica is mainly distributed in eight provinces in the southern part of China, with foci in five provinces along the middle and lower reaches of the Yangtze River (MPH,1991; Mao, 1990). *Oncomelania hupensis,* the intermediate snail host of *S . japonica,* is mainly distributed on banksides of rivers, ditches and irrigation schemes throughout the flood plain; snail habitats are increasing year by year. The disease seriously threatens farming and the daily life of local people, and also affects the socio-economic development of these areas (MPH, 1989; Chen, 1989; Xu & Fang, 1990). Thus, snail control is a one of the most important factors for disease control. To understand the parameters which might control the drifting and dropping of snails and their eggs in rivers, experiments on specific gravity and dropping speed for the adult snails have been carried out (Xu, *et al.* 1996). The aim of present study was, therefore, to make similar measurement on the specific gravity and dropping speed for the eggs of *O. hupensis*, to contribute to the development of a scientific basis for the prevention of snail dispersal.

Materials and Methods

Snail eggs. Snail eggs were obtained from snail habitats in Han Yang county in Hubei province at the end of April 1997. Adult snails were collected and put in a bowl of mud at 25 ºC for 15 days. After two weeks, the snails were removed and snail eggs were washed from the surface of the mud in the bowl. All eggs selected for measurement were in the primitive gut embryonic stage. A 25 ml specific gravity flask was used to determined specific gravity. Dropping speed was measured in a water-filled glass tube of 160 cm length and 4.5 internal diameter, in which a water column length of 130 cm was available to observe the eggs dropping.

Measurement of the specific gravity of the snail eggs was carried out in accordance with the routine measurement method for the determination of specific gravity of river silt in China. (Sha, 1963).

The snail eggs washed from the mud bowl were collected by suction tube in a tissue culture dish of 9 cm diameter. The snail eggs were weighed and separated on Whatman's No.4 filter paper for 8 h to absorb excess surface water from the eggs. The flask containing the eggs was put into a desiccator for 8 h to continue the drying process. The snail eggs were weighed, placed in a graduated flask and made up to 25 ml; the flask was then filled distilled water and shaken gently before being weighed on a balance. Thus the weight included graduated flask, the snail eggs and distilled water. The distilled water and snail eggs were then discarded from the flask. The flask was dried inside and outside, distilled water was added to the level of 25 ml and the flask was weighed again; thus the weight included only graduated flask and distilled water.

The following formula was used to calculate the specific gravity of the snail eggs:

$$SGe = g_e / g_e + g_1 - g_2 \times SG_{H2O}$$

Where:

SGe : specific gravity of the snail eggs. (g/cm^3)
g_e: weight of the snail eggs (g)
g_1: weight of flask plus distilled water (g)
g_2: weight of the snail eggs plus flask and distilled water (g)
SG_{H2O}: specific gravity of distilled water at 4 ºC (g/cm^3)

Measurement of dropping speed of snail eggs in stable water. The diameter of each snail egg was measured under the microscope. The egg was put into the 160 cm glass tube and dropping speed was measured directly (MWE 1965).

Establishment and deduction of the formula for dropping speed of snail eggs. The formula for snail eggs dropping speed in stable water was based on the established principle for measuring the dropping speed of a round object (Qia & Wan, 1983). The difference between the theoretically predicted and the measured values was statistically investigated.

Results

Specific gravity of snail eggs. The mean specific gravity was 2.29 g/cm^3, minimum of 2.25 g /cm^3, maximum of 2.33 g /cm^3 and standard deviation of 0.0162.

Dropping speed of the snail eggs. The diameter of each of 84 snail eggs was measured; 74 eggs had shapes which resembled a spherical pill. The range of diameter of the snail eggs was 0.43 to 0.83 mm; the dropping speed of the snail eggs was mean 2.48 cm/s, minimum of 1.19 cm/s, maximum of 3.77 cm/s and standard deviation of 0.2614.

The establishment and deduction of formula for dropping speed of the snail eggs. A snail egg drops with uniform acceleration when water resistance and the specific gravity of the egg become balanced. Because the shape of the snail-eggs is similar to spherical pill, the force (G) acting on the eggs in stable water is given by:

$$G = \pi/6 \times d^3(\gamma_1 - \gamma_0) \text{ .... (1) (Qian \& Wan, 1983).}$$

Where:

G:	Gravitational force acting on the snail eggs in water (g)
F:	Water resistance.
W:	Dropping speed of the snail eggs in stable water. (cm/s)
Ca:	Resistance coefficient.
γ_1:	Specific gravity of the snail eggs (g/cm^3)
γ_0:	Specific gravity of water. (g/cm^3)
g:	Gravity plus speed. (cm/s)
d:	Diameter of the snail eggs (mm)

Snail eggs which drop in water meet water resistance. The resistance equation of the snail eggs in stable water is:

$$F = Ca \times \gamma_0 \times \pi/4 \times d^2 \times w^2/2g \text{ ....(2)}$$

When G = F, the resistance of the snail eggs drops with uniform acceleration. The equation is therefore

$$Ca = 4/3\ (\gamma_1 - \gamma_0)/\gamma_0 \times gd/w^2 \text{ ....(3)}$$

Based on a general principle of silt motion, there is a resistance coefficient (Rd) (also called circumflow). The function of the relationship is given by :

$$Ca = f(Rd) \ldots\ldots\ldots\ldots(4)$$

in which $Rd = wd/v$, where w = dropping speed of the snail eggs; d = diameter of the snail eggs and v = flow rate. When a correlation was made with the experimental data, the result was

$$Ca = 250/Rd \ldots\ldots\ldots\ldots(5)$$

Therefore, the dropping speed formula of the snail eggs in stable water can be formed from equation (3) and (5), and is:

$$w = 4/750v \times (\gamma_1 - \gamma_0/\gamma_0) \times gd^2 \ldots\ldots\ldots\ldots(6)$$

The unit of each symbol in the formula is:

w = cm/s
d = cm
γ_1 = 2.29 g/cm^3
γ_0 = 1g/cm^3
g = 981 cm/s^2, which can change with the water temperature.

A *t* test was used to investigate the difference between the practical measured value and the predicted value of the dropping speed. The *t* value is 0.677, ($t_{0.05} = 1.994$) $P > 0.05$, there was no significant difference between the predicted and measured value.

Discussion

Oncomelania hupensis is distributed mainly in marshland and lakes in southern China. The peak egg laying period is spring and autumn of every year. The snail eggs are light and small, so they drift easily in the flood season. Once the eggs settle in suitable hatching sites, new snail populations develop. Therefore, it is important to try to control the dispersal of snails and their eggs in irrigation schemes in endemic areas.

The snails lay eggs at the edge of lakes and rivers. When eggs are laid on moist mud, the eggs become covered with soft mud so that they have the appearance of a small mud pill. It has been observed that if the mud layer comes off at the first development stage of the eggs, the eggs do not develop into a juvenile snail (Guo, 1983). Thus, the mud layer seems to plays an important role in the growth phase of the snail eggs. Microscopic observation showed that the drying procedures used here did not damage the internal or external physical and biological characteristics of the eggs. The measured values would therefore appear to be reliable.

The specific gravity of the eggs of *O. hupensis* is an indispensable basic physical parameter in the calculation of dropping speed and drift distance for snail eggs in still- and running-water. This information may contribute to a theoretical basis for the prevention of snail dispersal in the field.

Based on the dropping speed of snail eggs measured in this study, the drifting style of the snail eggs can be compared with the dropping speed of silt in rivers. Usually, 0.5 mm diameter silt particles are suspended in flowing water but drop at a rate of 5.67cm/s in still water. Our results show the dropping speed for snail eggs to be 1.19 to 3.77 cm/s, which is lower than the result for silt that is suspended as drift in rivers. Therefore, it can be inferred that snail egg dispersal will at least conform with the drift of silt in the rivers. These observations may have practical value for developing engineering measures to control and mitigate the dispersal of snails and their eggs.

Conclusion

Investigations were carried out into specific gravity and dropping speed of snail eggs and an appropriate formula has been devised to link these parameters. Statistical analysis showed no significant difference between measured values and the values predicted from a formula for dropping speed based on Newtonian principles. The result could be used as a basic parameter in the control of *Oncomelania hupensis* when water conservation facilities are designed or rebuilt in areas in which schistosomiasis is endemic.

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Nine new species of Mascarene land snails (Mollusca: Gastropoda)

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Abstract

Survey work carried out in the Mascarene Islands of Réunion, Mauritius and Rodrigues in the S.W Indian Ocean over the last 10 years have yielded at least 14 new species, 9 of which are described here:- Assimineidae: *Omphalotropis stevanovitchi* ; Pomatiasidae: *Tropidophora vincentflorensi;* Helicarionidae: *Ctenophila aigretteianum; Erepta wendystrahmi; Pachystyla waynepagei; Dupontia affouchensis;* Streptaxidae: *Gonospira jacobsi; Gulella mamellensis: Gulella argoudi.*

Key words: Mascarene, land snails

Introduction

The land snail fauna of the Mascarene Islands (Réunion, Mauritius and Rodrigues) is relatively well known and consists of at least 146 species of which 132 are endemic (Griffiths,1996).

However field work over the last 10 years has yielded a number of new species some of which are described here. These new species come from areas hitherto poorly surveyed and from newly discovered subfossil deposits.

The subfossil sites include Limekiln Cave on Ile aux Aigrettes in the south east of Mauritius where deposits yielded shells from 53 species of non marine molluscs (Griffiths,1991) and those of Snail Rock in the mountains east of Port Louis (Griffiths,1990). These deposits were dated by the amino acid racemization dating method (Goodfriend and Mitterer, 1987; Goodfriend, 1990). The dating for snail shells from Limekiln Cave was between the end of the Pleistocene and the first half of the present Holocene warm phase i.e. 15,000-5,000 years old, while shells from Snail Rock are 2,500-1,000 years old (Goodfriend, personal communication 1992). Snail shells from the other subfossil sites on Réunion, Mauritius and Rodrigues were not dated but are believed by the author, on the basis of the state of the shells collected and the associated vertebrate remains, to date from the time of native forest clearance most at 150 years ago.

The leaflitter samples taken were in areas of remnant middle altitude and upland forest in a number of sites on Réunion and Mauritius.

The species described are readily assignable to families occurring on the Mascarene Islands and again highlight the remarkable molluscan radiation on these isolated volcanic islands.

Higher classification used herein follows Smith (1992). All type material has been lodged with the Australian Museum, Sydney. The SEM and normal photos of the types were all done at the Australian Museum

Systematics

Superfamily **RISIOOIDEA**
Family **ASSIMINEIDAE**
Subfamily **Ophalotropinae**

This subfamily is confined to southeast Asia, the southwest Pacific and the islands of the Indian Ocean. In the Mascarenes it is represented by 1 genus.

Omphalotropis Pfeiffer, 1851

This genus has the same distribution as the Subfamily. In the Mascarenes this genus is represented by 20 species including that described below.

Omphalotropis stevanovitchi sp.n.

(Plate 1, Figs. A, I)

Type material:

Holotype: Dead adult in leaflitter sample in moist upland native forest just below trig station at summit of Piton de la Petite Rivière Noire, S.W.Mauritius, alt: 828 m, coll O.Griffiths (O.G), Jan 1992 (AMS C202885).

Paratypes: three adult and subadult shells from the type locality (AMS C202863); one dead shell in leaf litter from moist native upland forest at Bassin Blanc, Mauritius, coll V. Florens Dec 1994 (AMS C202865); one worn juvenile collected in subfossil deposits at Snail Rock S.of Port Louis (20°11.4'S; 57°30.8'E). Coll. O.G June 1990. These deposits were estimated at 2,500-1,000 BP (AMS C202864). Also collected in Réunion at St Philippe; Tremblet and Takamaka, (Stévanovitch,1994). Specimens viewed before being lodged at the Paris Museum.

Description: Shell small, conical, thin for genus, covered in thin, light horny brown periostracum. Whorls 5, regularly increasing, convex, last whorl with very fine keel on the periphery. Sutures moderately impressed. Aperture oval, except along columellar where it is almost straight. Umbilicus narrow. Lip thin along lower part of the columella where it is slightly reflected outwards, otherwise unreflected. Protoconch and embryonic whorls malleated. Subsequent whorls covered by prominent, equally-spaced spiral ridges cut by irregular growth lines. Paratype from Bassin Blanc is smaller than the holotype with slightly more angulate whorls.

Dimensions of holotype: Height: 2.26mm; Diameter: 1.65mm.

Animal: Fresh dead animal uniformly dark, operculum thin horny with malleated appearance.

Remarks: This species is readily distinguished from all other Mascarene *Omphalotropis* by its distinctive spiral sculpture and very small size. *O.antelmei*, the only other *Omphalotropis* of similar size, lacks spiral sculpture, while the only other *Omphalotropis* with a sculpture of spiral ridges – *O.multilirata*, lacks the intersecting growth lines present on *O.stevanovitchi* and is 8.5mm high. Described from fresh dead specimens collected with a leaflitter sample in native forest.

Etymology: Named for Colette Stévanovitch who has worked on Réunion land snails and first recorded this species on Réunion.

Superfamily **LITTORINOIDEA**
Family **POMATIASIDAE**

This family occurs in Europe, Africa and the southwest Indian Ocean. In the Mascarenes it is represented by 2 genera.

Tropidophora Troschel.1847

This genus occurs in Africa and the south west Indian Ocean. In the Mascarenes there are 14 species including that described below.

Tropidophora vincentflorensi sp.n.

(Plate 3, Figs. A, B, C).

Type material:
Holotype: Subfossil adult in scree under basaltic rock overhang in degraded forest S. of eastern most peak of Trois Mamelles Mountain, Mauritius. Alt: 490 m. 20°18′31″S; 57°26′43″E, coll Vincent Florens 23.5.1996 (AMS C202875).
Paratypes: Five adult and subadults from the type locality, (AMS C202878).

Description: Shell depressed, planispiral, thin. Whorls 4, the first 2 raising markedly above the plane of the shell which is formed by the last 2 whorls. On the edge of the shell there are 2 prominent spiral keels, 1 forming the shoulder of the shell, the other the periphery. The first one and a half whorls are embryonic with a sculpture of irregular dendritic lines giving way to a malleated appearance. Subsequent whorls above and below have a sculpture of low spiral ridges crossing fine radial growth lines, giving the shell a trellised appearance under magnification. On the upper part of the shell on the last whorl these spiral ridges number 10 between the suture and the first keel. The underside has a deep, wide umbilicus edged by a strong spiral ridge. The lower spiral ridges on the underside are stronger inside the umbilicus.

Lip thin very slightly reflected. Shell pale horn coloured except the 2 keels which have an alternate dashing of brown and horn. From inside the aperture these 2 keels appear solid brown.

Dimensions of holotype: Height: 7mm ; Diameter: 13mm

Remarks: Based on the shell sculpture and form, this species clearly belongs to the genus *Tropidophora*. It is readily distinguished from all other Mascarene *Tropidophora* as it is the only one that is planispiral. While planispiral *Tropidophora* occur in Madagascar, all have very different sculpture and thus this species is very different to the described Madagascan *Tropidophora* (Fischer-

Piette *et al*, 1993). This species is only known from subfossil deposits at its type locality. Despite considerable survey effort it has not been found living and is thus considered extinct.

Etymology: Named for its discoverer, Vincent Florens.

Order **STYLOMMATOPHORA**
Superfamily **HELICARIONOIDEA**
Family **HELICARIONIDAE**
Subfamily **Ereptinae**

This subfamily is endemic to the Mascarenes and Madagascar, where it is represented by nine genera.

Ctenophila Ancey, 1882

This genus occurs in Madagascar where there are two described species (Emberton, 1994) and the Mascarenes, where there are 3 species including that described below.

Ctenophila aigretteianum sp.n.

(Plate 2, Figs A, B, C).

Type material:
Holotype: Subfossil adult in limestone scree with large numbers of other snails from Limekiln Cave on Ile aux Aigrettes, Grand Port, east Mauritius, coll O.G and Carl Jones, Feb 1989 (AMS C202886).
Paratypes: 19 adult and subadult shells from the tyope locality, (AMS C202861).

Description: Shell discoidal, flat, pale glossy white. Whorls 4, regularly increasing. Sutures moderately impressed. Aperture oval and depressed, being slightly below the plane of the shell. Umbilicus very wide. Outer lip thin, sharp, unreflected except along the lower part of the columella where it is slightly reflected outwards. Embryonic whorls 2, smooth. Subsequent whorls with irregular colabral growth lines often more prominent above at the suture and margin of the shell.

Dimensions of holotype: Height: 1.55mm; Diameter: 2.4mm.

Remarks: The only Mascarene snail that resembles this species is *Ctenophila vorticella* with which it shares the same general shell structure and shape. However *C. vorticella* has very prominent radial ribs on both the upper and lower sides of the shell. Such ribs remain on subfossil specimens that have lost their periostracum. Such ribs are totally absent on *C. aegretteianum*. This species is only know from the subfossil deposits at its type locality. These subfossil deposits have been dated at 15,000 - 5,000 BP. It has never been found on the mainland of Mauritius and despite considerable survey effort has not been found living on Ile aux Aigrettes and is thus considered extinct.

Etymology: Named for its type locality.

Erepta Albers, 1850

This genus is endemic to Mauritius and Reunion, where there are five species including that described below.

Erepta wendystrahmi sp.n.

(Plate 2, Figs D, E, F)

Type material:

Holotype: Subfossil adult in limestone scree with large numbers of other snails, from Limekiln Cave on Ile aux Aigrettes, Grand Port, east Mauritius, coll O.G and Carl Jones, Feb 1989 (AMS C202877).

Paratypes: 43 adult and subadult shells from the type locality (AMS C202857); one adult subfossil shell in basalt scree under rock overhang, S edge of Bassin Blanc, coll V.Florens, April 1998 (AMS C202858); one adult subfossil shell in basalt scree in lava pit, 750m SE of Bassin Blanc. 20°27.3′S; 57°28.5′E, coll O.G. Jan 1997 (AMS C202859); nine adult subfossil shells in concretions on roof of Lion Mountain Cave number 2, Treize Cantons, Grand Port, east Mauritius, 20°22.73′S; 57°42.89′E, coll. O.G. and J.Hauchler Nov 1997 (AMS C202860).

Description: Shell depressed-conic, solid, periphery angular, pale glossy white. Whorls 5, regularly increasing. Sutures moderately impressed. Umbilicus minutely open or completely closed by reflected columella. About 20 distinct, low, broad, irregular, radial ridges flare out in a curved spoke-like form from the umbilicus and disappear near periphery. Outer lip thin, slightly reflected except along columella where thickened and reflected outwards. Slight callosity of columella near umbilicus. Embryonic whorls with fine spiral lines. Subsequent whorls with fine spiral lines cut by fine, closely-spaced radial lines giving shell decussate appearance under magnification. Paratypes from Lion Mountain Cave are more conical than the type.

Dimensions of holotype: Height: 4.5mm; Diameter: 8.5mm.

Remarks: E.wendystrahmi is the fifth species of *Erepta* in Mauritius. Of these, four occur in the subfossil deposits of Limekiln Cave. *E. stylodon* and *E. odontina* are globose and lack the decussate sculpture of *E. wendystrahmi. E. setiliris,* although similar in shape to *E. wendystahmi,* has a broad, deeply excavated umbilicus. *E. thirouxi* the only *Erepta* not found in Limekiln Cave is conical and also lacks a decussate sculpture. In addition to the above differences, *E. wendystahmi* is the only *Erepta* with the distinctive broad spoke-like ridges on the underside of the shell. *Erepta wendystrahmi* is only known from subfossil deposits. Despite considerable survey effort has not been found living on Mauritius or Ile aux Aigrettes and is thus considered extinct.

Etymology: Named for Wendy Strahm who was responsible for the establishment of Ile aux Aigrettes as a properly managed nature reserve.

Pachystyla Morch,1852

This genus is endemic to Reunion and Mauritius where there are 3 species including that described below.

Pachystyla waynepagei sp.n.

(Plate 3, Figs. D, E, F).

Type material:

Holotype: Subfossil adult, unique specimen, in limestone scree with large numbers of other snails, from Limekiln Cave on Ile aux Aigrettes, Grand Port, east Mauritius, coll Wayne Page, June 1996 (AMS C 202871).

Description: Shell large, solid, globose with rounded periphery, white on upper whorls, last whorl orange to horn with 5 mm wide white band just above periphery. Whorls 7, regularly increasing. The suture is not impressed in the first 4 whorls and is slightly margined. In subsequent whorls the suture is deeply impressed as a result of damage which was repaired by the snail at that point. Umbilicus closed, columela broad with slight excavation down middle. Lip thin not reflected. Shell smooth with faint growth striae visible under high magnification.

Dimensions of holotype: Height 28mm; Diameter 39mm.

Remarks: The deposits at Limekiln Cave yielded only one specimen of *P. waynepagei* and many specimens of *Pachystyla bicolor*. All *P. bicolor* were very large (max diam: 48mm) with a very sharp keel. All retained evidence of the decussate sculpture that is a feature of the species. All were either bleached white or retained their complete brown colour. *P. waynepagei* by contrast completely lacks these features. Even allowing for the effect of the injury, the type's form is very distinct. The orange last whorl with its peripheral white band is also a feature absent on *P. bicolor. P. waynepagei* has never been found on the mainland of Mauritius and despite considerable survey effort has not been found living on Ile aux Aigrettes and is thus considered extinct.

Etymology: Named for Wayne Page of the Mauritian Wildlife Foundation who discovered the unique specimen of this species.

Dupontia Godwin-Austen, 1908

This genus is endemic to Madagascar and the Mascarenes. In the Mascarenes there are 8 species, including that described below.

Dupontia affouchensis sp.n.

(Plate 3, Figs. G, H, I)

Type material:

Holotype: Subfossil adult shell, in limestone scree with tortoise and solitaire bones, below day-light hole, Caverne L'Affouche, just east of Anse Quittor

Reserve, Plaine Corail, Rodrigues. 19°45.40′S; 63°22.12′E, coll OG and Carl Jones, Dec 1997 (AMS C202887).
Paratypes: one adult shell from the type locality (AMS C202872); one adult shell in limestone scree, Caverne Patate, Plaine Corail, Rodrigues, coll OG and Carl Jones June 1989 (AMS C 202873); 18 adult and subadult shells; in limestone scree below day-light hole, Caverne Bambara no 3, just east of Anse Quittor Reserve, Plaine Corail, Rodrigues. 19°45.36′S; 63°22′E, coll OG and Carl Jones, Dec 1997 (AMS C 202874).

Description: Shell depressed, thin, periphery rounded, pale glossy white with a thin brown band bordering the suture and continuing on the last whorl just above the periphery. Whorls 4, regularly increasing. Sutures distinctly margined Umbilicus narrow, partially closed by reflected upper part of the culumella. Outer lip thin, sharp with no peristome. Aperture broader than high, lunate descending slightly below the plane of the shell. Shell appears smooth with fine spiral lines apparent under high magnification. In many specimens the brown band is absent.

Dimensions of holotype: Height: 5.5mm; Diameter: 11mm.

Remarks: This species has only ever been found in the limestone (Calcarinite) deposits of the South West of Rodrigues, an area of palm savannah that was completely burnt over and cleared in the 1830′s. While there is an extensive radiation of *Dupontia* on Mauritius and Réunion, this is the only known *Dupontia* from Rodrigues. It differs from all other Mascarene *Dupontia* by it′s slightly larger size, more globose shape and glossy white colour. It is also the only described *Dupontia* with a peripheral band. Despite considerable survey effort has not been found living on Rodrigues and is thus considered extinct.

Etymology: Named for its type locality.

Superfamily **STREPTAXOIDEA**
Family **STREPTAXIDAE**

This family is widely distributed throughout the tropical and subtropical regions of the world. In the Mascarenes there are 6 genera. The extensive radiation of Streptaxidae in the Mascarenes is one of the features of the fauna, with at least 39 species already described (Griffiths,1996). While Madge (1938) considered that *Gonospira* is "already overcrowded with numerous very polymorphic species", the species described here are very distinct and cannot be assigned to any existing species.

Gonospira Swainson, 1840

This genus is endemic to the Mascarenes, where it is represented by 32 species including that described below.

Subgenus ***Microstrophia*** Möllendorff, 1887

Gonospira (Microstrophia) jacobsi sp.n.

(Plate 1, Figs. H, K)

Type material:
Holotype: Live collected adult, in dried leaflitter sample collected at base of tree in degraded moist upland native forest just below the summit on the eastern side of Mt Brise Fer, W. Mauritius at 622 m, coll O.G and Vincent Florens June 1994 (AMS C202883).
Paratypes: three adult and eight subadult or juvenile shells collected at the type locality (AMS C202866); one adult and one subadult subfossil shell, under deep rock piles below the scarp on the northern side of Snail Rock, south of Port Louis Mauritius, 20°11.4'S; 57°30.8'E, coll by O.G, June 1990 (AMS C 202867), snails from this site have been dated at 2,500 - 1,000 BP; one old dead adult shell, under rock at base of scarp, SW side of Le Morne, SW Mauritius, coll O.G May 1991 (AMS C 202868); one adult subfossil shell, under rock pile, Mt Brise Fer, coll Vincent Florens, 1997 (AMS C 202869).

Description: Shell cylindrical, but slightly broader near apex, spire flattened, translucent horn to white. Aperture elongate, set to one side and projecting tube-like away from plane of shell. Lip thickened, well reflected. Upper third of aperture nearly separated by strong protruding parietal lamina which almost touches thickening within peristome on right side of aperture. Umbilicus very narrow, slit-like in adults, extremely broad in juveniles. Whorls 7, regularly increasing. Embryonic whorl with a malleated appearance. Subsequent whorls covered with regular, prominent, backward reflected growth ridges. The subfossil paratype from Mt Brise Fer is very elongate: Height: 4 mm and has 9 whorls.

Dimensions of holotype: Height: 2.8 mm; Diameter: 1.4 mm. Aperture height: 0.9 mm; width: 0.5 mm.

Animal: Unrecorded.

Remarks: While there are six Mascarene streptaxids less than 4mm in length none of them have the flattened spire and cylindrical shape, together with the bold growth ridges, that characterise this species. The species is assigned to the subgenus *Microstrophia* because of its very widely umbilicate discoidal juvenile stage. Juveniles with their broad umbilicus and discoid shape appear at first glance to be very different to adults. *Gonospira s.s.* in comparison, have a very narrow umbilicus in the juvenile and adult stage. The 3 other species of the subgenus *Microstrophia* are also figured for comparison. (Plate 1, Figs E, F,G).
This snail has been found living only at one small site on the summit of Mt Brise Fer, which is also the only place where the large endemic helicarionid *Erepta stylodon* still lives. Given its extremely limited range this species must be considered (following the IUCN classification) as threatened. Its occurrence in subfossil deposits at Snail Rock in the N.W and at Le Morne in the SW of Mauritius indicates it previously had a much broader range.

Etymology: Named for Jacob Griffiths, the eldest son of its discoverer.

Gulella Pfeiffer,1856

This genus occurs in Africa and the south west Indian Ocean. In the Mascarenes there are two species already described as well as *G.mamellensis* and *G.argoudi* described below.

Gulella mamellensis sp.n.
(Plate 1, Figs. B, C)

Type material:
Holotype: Subfossil adult shell in scree under basaltic rock overhang in degraded forest at base of northern scarp of Trois Mamelles Mountain, coll Vincent Florens 2.I.1995 (AMS C202884).
Paratypes: four adult and subadult shells from the type locality (AMS C202870).

Description: Shell cylindrical, 7 whorls, with shell widest at level of third and forth whorls. Protoconch with faint malleations, rest of shell smooth. Aperture elongate, set to one side and projecting tube-like away from plane of shell. Lip thickened, reflected, projecting further from aperture along columela and base. Much of aperture filled by one strong protruding parietal lamina which extends from deep inside aperture to beyond plane of lip. Parietal lamina curves along most of its length towards outer lip, which it nearly joins at point of a strong labral thickening within peristome on lower right. Subadults finely perforate.

Dimensions of the holotype: Height 2.6mm; diameter:1.3mm

Remarks: The form of the aperture suggests that it might be placed in *Gonospira* (*Microstrophia*). However the absence of a broadly umbilicate juvenile stage, the smooth shell and nature of the apertural lamina and thickening place it in the genus *Gulella*. It differs from *G. antelmeana* (the only Mascarene *Gulella* with which it could be confused) which has a broad rounded aperture and a simple small parietal lamina. Despite considerable survey effort this species has not been found elsewhere and must be considered extinct.

Etymology: Named for its type locality.

Gulella argoudi sp.n.
(Plate 1, Figs. D, J)

Type material:
Holotype: Subfossil adult shell, buried 10 cm deep in dry soil under basaltic rock overhang on edge of ravine cutting the old part of Chemin Bruniquel, E. of La Saline Les Bains, Réunion, at 250 m. 21°4.8'S; 55°15.8'E, coll O.G., C.Stevanovitch and J.J.Argoud, Dec 1992 (AMS C202876).
Paratypes: One adult and one subadult shell from the type locality, (AMS C202862).

Description: Shell cylindrical, 5 whorls, with conical apex. Protoconch faintly maleated. Rest of shell with strong closely spaced, wavy, slightly oblique costulae. Aperture rounded at base. Lip thickened, well reflected. Upper part of aperture with a thickened short parietal lamina, almost meeting a blunt labral denticle about half way down labrum, which corresponds to a small external pit. Upper part of columellar has small flat process inside aperture. Umbilicus slit-like in adults, rounded and faintly perforate in juveniles.

Dimensions of holotype: Height: 3.7mm; Diameter: 1.8mm.

Remarks: The strong costulate sculpture combined with the distinctive apertural dentition seperates this readily from all other Mascarene streptaxids. However the features of the shell are characteristic of the *Gulella infans* group of Southern Africa (Dr van Bruggen pers comm 1995). According to Dr van Bruggen " in the case of Réunion, occurrence of a species of the *Gulella infans* group widely distributed in southern Africa is at least remote thus we might surmise a shared ancestry of both species". *G.argoudi* is distinguished from the South African members of the *G.infans* group by its smaller size- 3.7mm vs 4.8-6.7mm high for members of the *G.infans* group (from Connolly,M.,1939). The whorls of *G.argoudi* are also more rounded. This species is thus readily distinguished from *G.infans*. *G.argoudi* forms a completely new element in the Mascarene streptaxid fauna and represents a separate, much more recent and unradiated invasion. Although described from subfossil specimens, the presence of a *Gulella* shell fragment (possibly belonging to this species) collected in leaflitter at Cap Noire, Dos-d'Ane Réunion, at 1300m, in 1992, suggests this species may still survive.

Etymology: Named for its co-discoverer, Jean-Jaques Argoud of Réunion.

Acknowledgements

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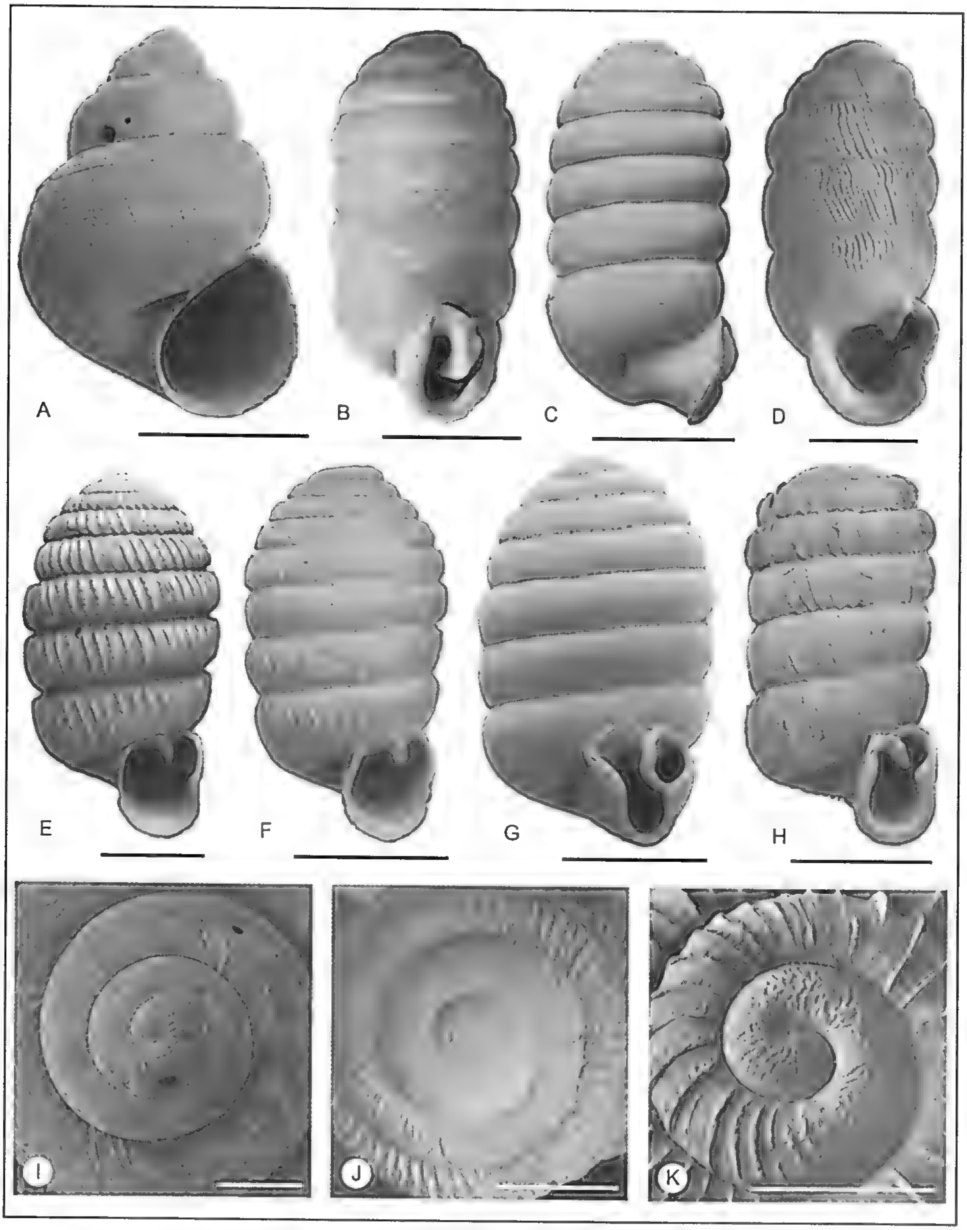

Plate 1

A. *Omphalotropis stevanovitchi* sp. n. Holotype. **B.***Gulella mamellensis* sp.n. Holotype. **C.** *Gulella mamellensis* sp.n. Holotype. **D.** *Gulella argoudi* sp.n. Holotype. E. *Gonospira (Microstrophia) clavulata* (AMS C202880) Piton de la Petite Rivière Noire. **F.** *Gonospira (Microstrophia) modesta* (AMS C202881) Piton de la Petite Rivière Noire. **G.** *Gonospira (Microstrophia) nana* (AMS C202882) Nouvelle France, Mauritius. **H.** *Gonospira (Microstrophia) jacobsi* sp.n. Holotype. **I.** *Omphalotropis stevanovitchi* sp.n. protoconch. Holotype. J. *Gulella argoudi* sp.n. protoconch. Holotype. K. *Gonospira (Microstrophia) jacobsi* sp.n. protoconch. Holotype.

Scale Bars: **A, B, C, D, G, H:** 1mm; **E, F:** 2mm; I: 200µm; **J, K:** 500µm

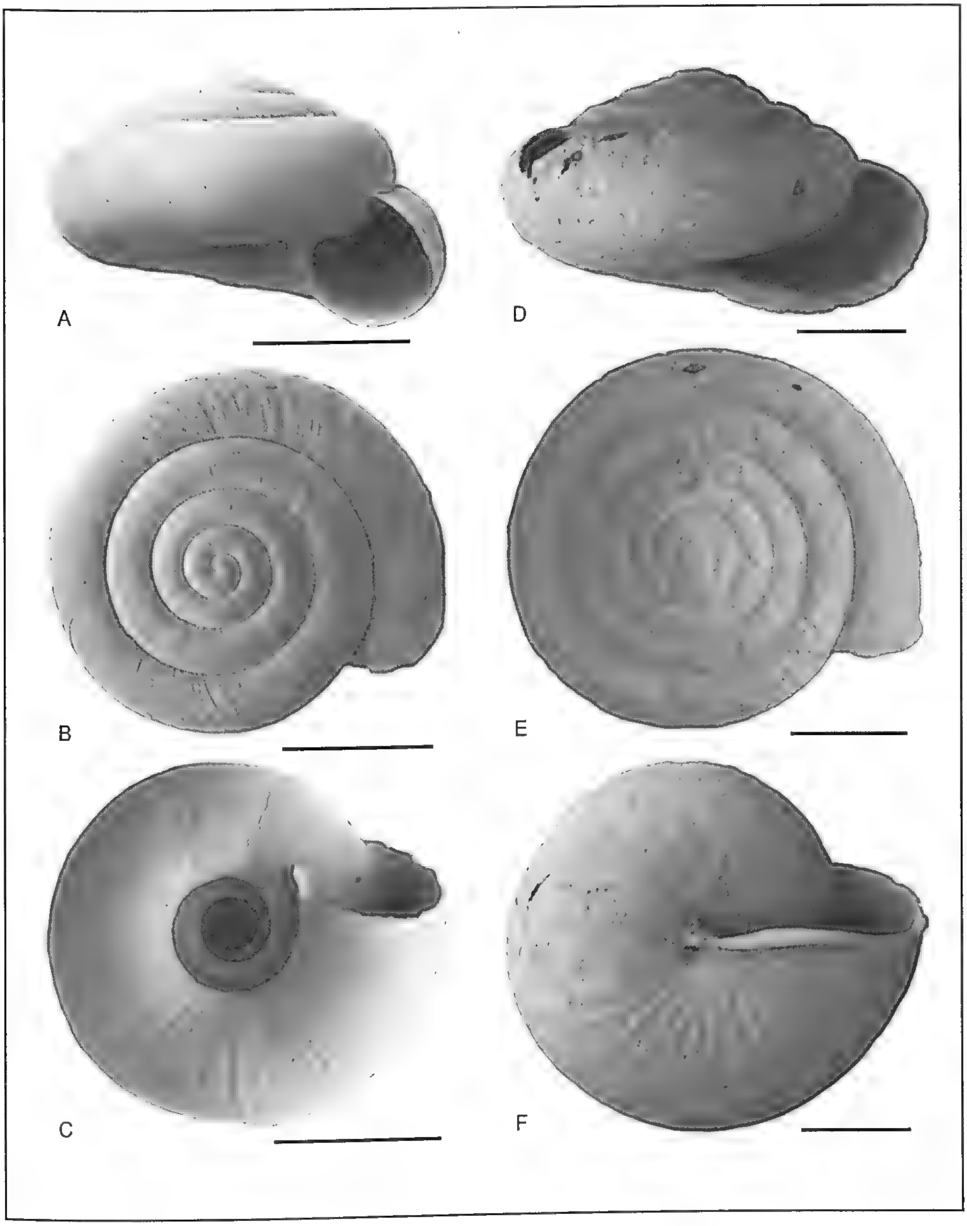

Plate 2
A, B, C. *Ctenophila aigretteianum* sp.n Holotype. **D, E, F.** *Erepta wendystrahmi* sp.n. Holotype.
Scale Bars: **A, B, C:** 1mm; **D, E, F:** 2mm

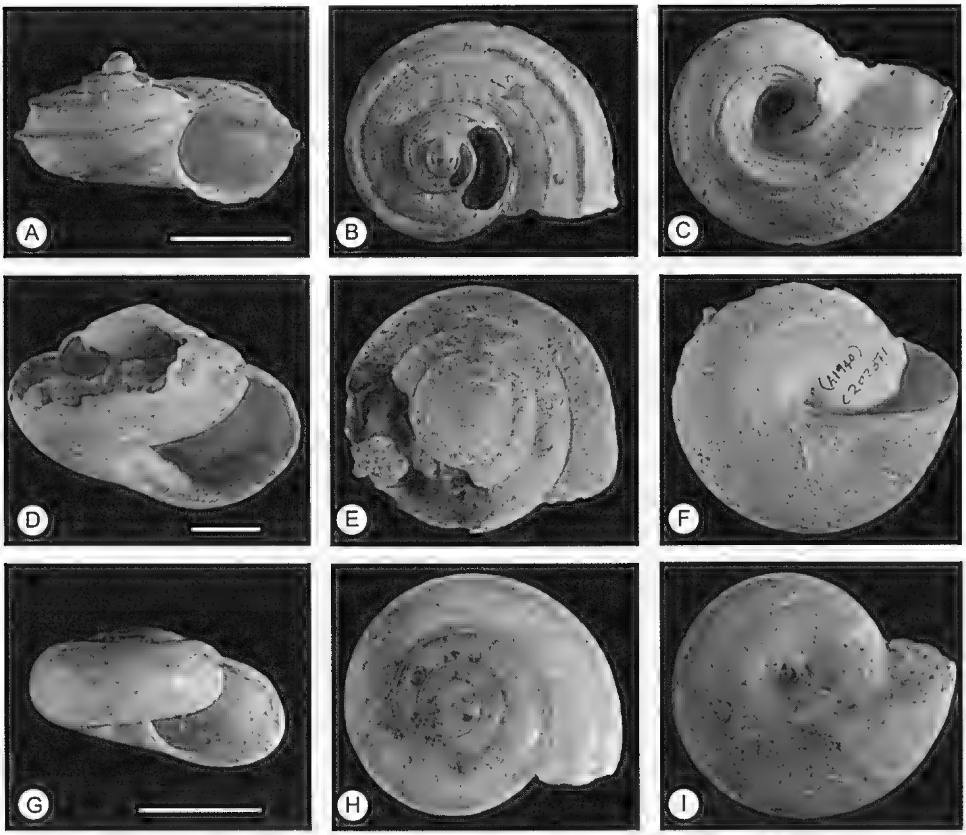

Plate 3
A,B, C. *Tropidophora vincentflorensi* sp.n. Holotype. **D, E, F.** *Pachystyla waynepagei* sp. n. Holotype. **G, H, I.** *Dupontia affouchensis* sp.n. Holotype.
Scale Bars: **A,G:** 5.3mm; **D:** 8.9mm

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Lack of imposex in the muricid *Morula granulata* from Rowley Shoals, northwestern Australia

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Abstract

Dissection of 197 specimens of the thaid *Morula granulata* from Rowley Shoals, on the outer continental shelf 300 km west of Broome, northwestern Australia, revealed that none were affected by imposex. While imposex is known to be caused by tributyltin (TBT), there are also other possible causes such as copper, paint matrix and environmental factors. In addition to the relatively low TBT levels in their tissue, the other environmental factors which can cause imposex may also be missing from Bedwell Island.

Key words: imposex, muricid, *Morula granulata*, Australia

Introduction

Beginning in the late 1960s tributyltin came into widespread use as an antifoulant added to boat paints. The chemical is extremely potent, and concentrations as low as 1 ng TBT l^{-1} of seawater have been demonstrated to affect a wide variety of animal phyla. Goldberg (1986) described TBT as "the most toxic substance ever deliberately introduced into natural waters". The best known effect of TBT is the masculinisation of females of dioecious marine gastropods. Blaber (1970) first reported imposex, the phenomenon in which TBT causes the females to begin to develop a penis and/or a vas deferens, in the thaid *Nucella lapillus* (Linnaeus, 1758), in the United Kingdom. In extreme circumstances, the female genital pore becomes occluded and the animal is unable to spawn. This causes considerable population consequences, including the localised extinction of populations (Bryan *et al.*, 1987; Gibbs *et al.*, 1991; Evans *et al.*, 1994). Worldwide, imposex has been reported in over 120 species of marine gastropods (Oehlmann *et al.*, 1996). Many of these species are intertidal muricids. In Western Australia, imposex has been reported in six species of *Conus* (Kohn & Almasi, 1993; Kohn *et al.*, 1999), *Thais orbita* (Gmelin, 1791) (Field, 1993) and *Morula granulata* (Duclos, 1832) (Reitsema & Spickett, 1999; Wells, unpublished).

Rowley Shoals is a series of three isolated oceanic atolls located on the outer continental shelf 300 km west of Broome, northwestern Australia (Figure 1). The atolls are well away from international shipping, and are visited only by a small number of charter vessels and private yachts (Environment Australia, 1999). Passages into the shoals are small and vessels able to navigate the passages are smaller than 25 m in length; use of TBT in boats of this size was banned in Western Australia in 1991. There should be no TBT present at Rowley Shoals, and accordingly no imposex in marine snails caused by TBT.

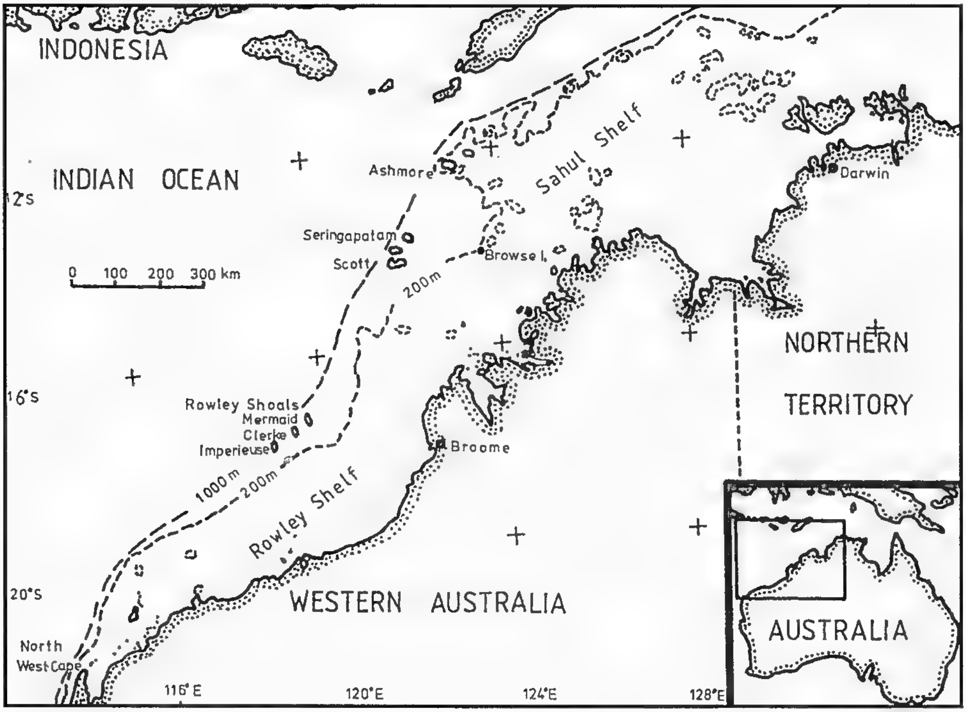

Figure 1.
Map of northwestern Australia showing the location of Rowley Shoals.

Materials and Methods

To verify this hypothesis, 197 *Morula granulata* were collected from intertidal beachrock at Bedwell Island, Clerke Reef, Rowley Shoals (17°20′S; 119°20′E) on 13 September 1999. Individuals were collected as they were encountered; there was no size selection of the specimens. Animals were frozen until they could be dissected at the Western Australian Museum. Specimens were sorted into adults, with a thickened outer lip and teeth inside the lip, and juveniles. Shell length was measured with Vernier callipers then the shells were cracked off using a bench vice. Sex was determined using the presence or absence of a penis. As development of the penis began to be obvious only at a shell length of 17 mm, only animals of 17 mm or more were sexed. Determination of the presence of imposex was based on the anatomical criteria of Oehlmann *et al.* (1996). A sample of tissue was analysed for TBT by the CSIRO Centre for Advanced Analytical Chemistry using atomic absorption spectrometry.

Results

Morula granulata at Bedwell Island ranged in size from 9 to 25 mm with a mean length of 18.9 ± 3.2 mm (S.D.) (Figure 2). The 67 males averaged 19.6 ± 1.8 mm and the 100 females averaged 20.2 ± 2.0 mm. The difference between mean length of males and females was not statistically significant (*t* test, $p > 0.05$), but females were significantly more abundant than males (χ^2 test, $p < 0.05$). None of the animals was affected by imposex.

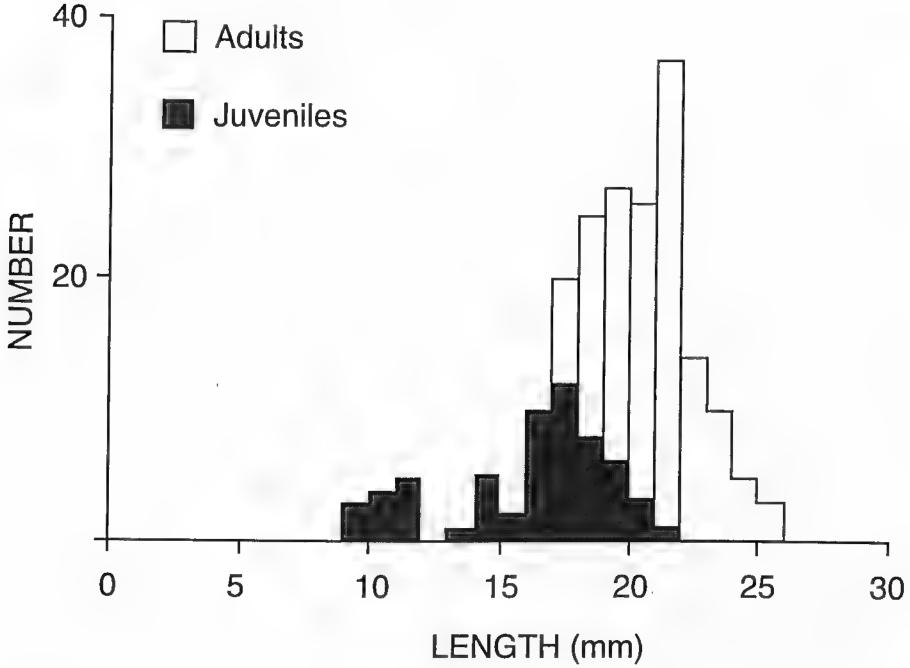

Figure 2.
Size-frequency histogram of *Morula granulata* collected at Rowley Shoals.

The TBT tissue sample was analysed twice by CSIRO. The measured concentration of TBT in the tissues was 30 and 31 ng Sn g^{-1}.

Discussion

Morula granulata is known to be affected by imposex in the ports of Dampier and Port Hedland, Western Australia (Reitsema & Spickett, 1999; Wells, unpublished). The two ports are the largest in Australia in terms of tonnage, and both are heavily utilised by vessels >25 m on which the use of tribtuyltin is still permitted. Reitsema & Spickett (1999) recorded from 0 to 57% of animals at Dampier were affected by imposex, and they found a significant correlation with distance to vessel activity. The highest levels of imposex were found in snails with the highest levels of tributyltin (33 ng Sn g^{-1}) in their tissues. The level of TBT in *M. granulata* tissues in Dampier is similar to that recorded at Rowley Shoals, but no imposex was found at Rowley Shoals. Wells (unpublished) found 96% and 100% of *M. granulata* at two sites adjacent to wharves in Port Hedland had moderate levels of imposex. In contrast, only 83% of the animals on the Port Hedland foreshore were affected. In contrast to the Western Australian results, Liu *et al.* (1997) reported no imposex in *M. granulata* in Taiwan even though combined tissue concentrations of tributyltin and triphenyltin were as high as 243 ng Sn g^{-1}. The mixed results obtained for *M. granulata* in different areas raises the possibility that different populations react in different ways to TBT.

In discussing the population level effects of high TBT concentrations, Evans *et al.* (1994) recorded three major effects:

- reduced recruitment leading to smaller proportions of juveniles to adults;
- reduced abundance; and
- alteration of sex ratios toward male bias.

Juveniles <9 mm were absent and there were few individuals <15 mm of *M. granulata* at Rowley Shoals. This might be taken as evidence that the population is not reproducing. However, the size frequency curve is consistent with data presented by Taylor (1975) for *M. granulata* at several sites at Aldabra Atoll in the Indian Ocean. No data on abundance were collected at Rowley Shoals, and there appear to be no published data on the abundance of *M. granulata* in other localities. However, the fact that 197 individuals could be collected in a single hour at Bedwell Island is evidence that the population density has not been adversely affected by TBT. While the sex ratio of *M. granulata* at Rowley Shoals differs significantly from 50:50, it is biased towards females rather than males. In addition to the lack of imposex, there are thus no characteristics in the population of the type which Evans *et al.* (1994) found to be associated with high levels of TBT.

While TBT has been demonstrated to cause imposex in neogastropods, it is not the only cause. For example, Nias *et al.* (1993) used laboratory experiments to demonstrate that copper, paint matrix and environmental factors may also cause the deformity. The sample of *M. granulata* from the Rowley Shoals is from the only area in the region where the animals are known to occur. In addition to the relatively low TBT levels in their tissues, the other environmental factors which can cause imposex may also be missing from Bedwell Island.

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Index to *Molluscan Research*

(formerly *Journal of the Malacological Society of Australia*)

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Molluscan Research (formerly *Journal of the Malacological Society of Australia*) has been published for 43 years. The volume and part numbering has changed several times over the years. The first 12 issues of the journal (1957-1969) were initially numbered separately but were then considered to be parts of Volume 1 (instructions for binding with part 12, 1969). A summary of the years and volume and part numbering is given below:

J. Malac. Soc. Aust.
1957 vol. 1/1
1958 vol. 1/2
1959 vol. 1/3
1960 vol. 1/4
1961 vol. 1/5
1962 no issue
1963 vol. 1/6, 1/7
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1967 no issue
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Apart from an index to the first 10 numbers of Volume 1 (in No. 10, 1966) no further index has been available for the journal. To overcome this, for personal use, an interactive computer index to Volumes 1-20 has been compiled. Following suggestions from the Editor of the journal, the Author Index, which follows below, has been extracted from this file, and the entire Excel file will be made available on disk.

The interactive index, in Excel 97 for Windows 95, can be searched by author, year, volume number or, by using numerous key-words, to access related articles on regions, environment, genera, family groupings etc. It would be possible to add extra key-words to individualize the searches if needed.

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BOOK REVIEW

Atlas of the Land and Freshwater Molluscs of Britain and Ireland
by **Michael Kerney**

published by Harley Books in association with the Conchological Society of Great Britain and Ireland. 1999; 264pp. Hardback; price 25 Pounds Sterling.

This is a book for the enthusiast; anyone who is seriously into non-marine molluscs would value this work, It would also make an ideal format to which those documenting a regional non-marine mollusc fauna in Australia could aspire.

The atlas is a compilation of interesting facts about each species with a line drawing of the shell or animal, habitat and distributional information and a dot-map showing the known records of each species throughout Great Britain and Ireland based on the 10 km square survey grid. This atlas information was completed in 1998 and was an update of the earlier atlas published by the Conchological Society in 1976. Three symbols are used on the dot-maps, records made in or after 1965; records made prior to 1965 only and fossil occurrences (Lateglacial and Postglacial) lying outside modern ranges. These clearly illustrate where a species is in decline with local population extinctions. Page reference is also made to the full descriptions and identification notes for each species given in the Field Guide to the Land Snails of Great Britain and north-west Europe published by Kerney & Cameron in 1979, and the census published by Ellis in 1951 or the bivalves by Ellis in 1978.

The running head of these map pages gives the family and genus of the species depicted on each page. The whole page design and choice of font, the choice of paper and the quality of the printing, all give the feeling of a "class" production. In all, 211 species are treated including 20 species of prosobranchs in 9 families, 30 species of bivalves in 4 families and 161 species of pulmonates in 29 families. This is really the definitive report on the status of the non-marine molluscan fauna of the British Isles and as such is the model for the world on how to carry out and compile a detailed statement on the current conservation position of this important group of invertebrate animals. But it is also very much a working text and research tool. The book starts with an early history of recording of distributional data of non-marine molluscs in Britain and the history of the Conchological Society Census. This again is a lesson to the many other countries around the world that have local societies or shell clubs about how to harness that pool of enthusiasts to further the knowledge of conservation science in that country or region. The mapping scheme is described and some of the philosophy behind the choice of procedures is given; with the reader well aware that the author of this final work was also involved in those early discussions and decisions nearly 40 years or more ago.

Two short chapters on the Factors Influencing Distribution and a History of the British Fauna set out very clearly how the results of all the survey work which enabled the species maps to be contructed, are also used to make authoritative statements about the fauna in general. Again people may think that these are only of interest to those working on the minutiae or the British fauna and are of little interest to workers in other parts of the world. But a number of species from Britain and Western Europe have become world travellers and worldwide pest species, so any insights into the factors which might limit their populations in their native settings are of immense value to workers around the world trying to understand their population dynamics as introduced aliens.

The work is furnished with a comprehensive bibliography and a well ordered index. All in all, a very pleasing and useful work, well designed and presented with one of D.G. Rands high quality colour photograhs as a cover illustration. This book is the fitting product of over 40 years diligent research, is an example to the rest of the world and is a must for all workers of non-marine mollusc population research and snail enthusiasts.

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Launceston, Tasmania

INSTRUCTIONS TO AUTHORS

General and theoretical papers relating to molluscs are welcome. Papers concerning specific geographical areas or new taxa should normally focus on the Indo-West Pacific region, as well as Australasia and the southern oceans. Papers received will be considered for publication at any time. Long papers and monographs may be published as special issues of *Molluscan Research.*

Papers are considered on the understanding they have not been published elsewhere and if accepted for publication in *Molluscan Research* will not be subsequently submitted elsewhere. All manuscripts must be submitted in English.

1. Papers submitted for publication shall be prepared following the format of the current issue of *Molluscan Research.* All papers will be peer reviewed by two referees before acceptance by the Editor, and upon acceptance all copyright will become the property of the Society.

2. Manuscripts, three copies of which should be submitted, should be double-spaced throughout, typewritten on one side of A4 paper, leaving top, bottom and margins of at least 3 cm. Right margins should not be justified. The first page of the manuscript should have the title, author's name and address, and a running head. The remainder of the manuscript should normally be arranged with the following components: abstract, materials and methods, results, discussion, literature cited, tables and figures.

Manuscripts of 6 manuscript pages or less can be presented in a Shorter Contributions format, with the headings eliminated.

3. Latin names of genera and species and Latin words and abbreviations (et al, e.g., etc.) should be in italics, but nothing else. Symbols and abbreviations should conform with those recommended in the Royal Society's General Notes on the Preparation of scientific Papers (London, Cambridge University Press). The first mention in the text of the scientific name of a species should be accompanied by the author and date. Metric and Celsius units must be used.

4. Text figures should be of good contrast, mounted, and of such size that they can be reduced satisfactorily to a maximum width of 14 cm. Black & white photographs for reproduction as halftone plates should be mounted, glossy prints showing good detail and moderate contrast; full plate size will be 22 by 14 cm. A size measurement should be included on the photograph;

magnifications cannot be given in the figure heading. Colour photographs can be published at author's expense. Figures must be submitted in final form, ready for publication.

5. References should be listed alphabetically at the end of the paper in the form:

Habe, T. 1951. Donacidae and Myidae in Japan, in *'Illustrated catalogue of Japanese shells'*. Kuroda, T. (ed.), (Kyoto, Japan), pp. 71-78.
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Titles of periodicals should not be abbreviated. In the text references should be cited with the year of publication, e.g. Shepherd and Cannon (1988).

6. Papers describing new species and subspecies will not be accepted for publication unless primary type material, and preferably paratypes, are deposited in a recognized public research or natural history museum and the museum registration numbers quoted. Type localities should be defined as accurately as possible. Descriptions must conform with the International Code of Zoological Nomenclature.

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