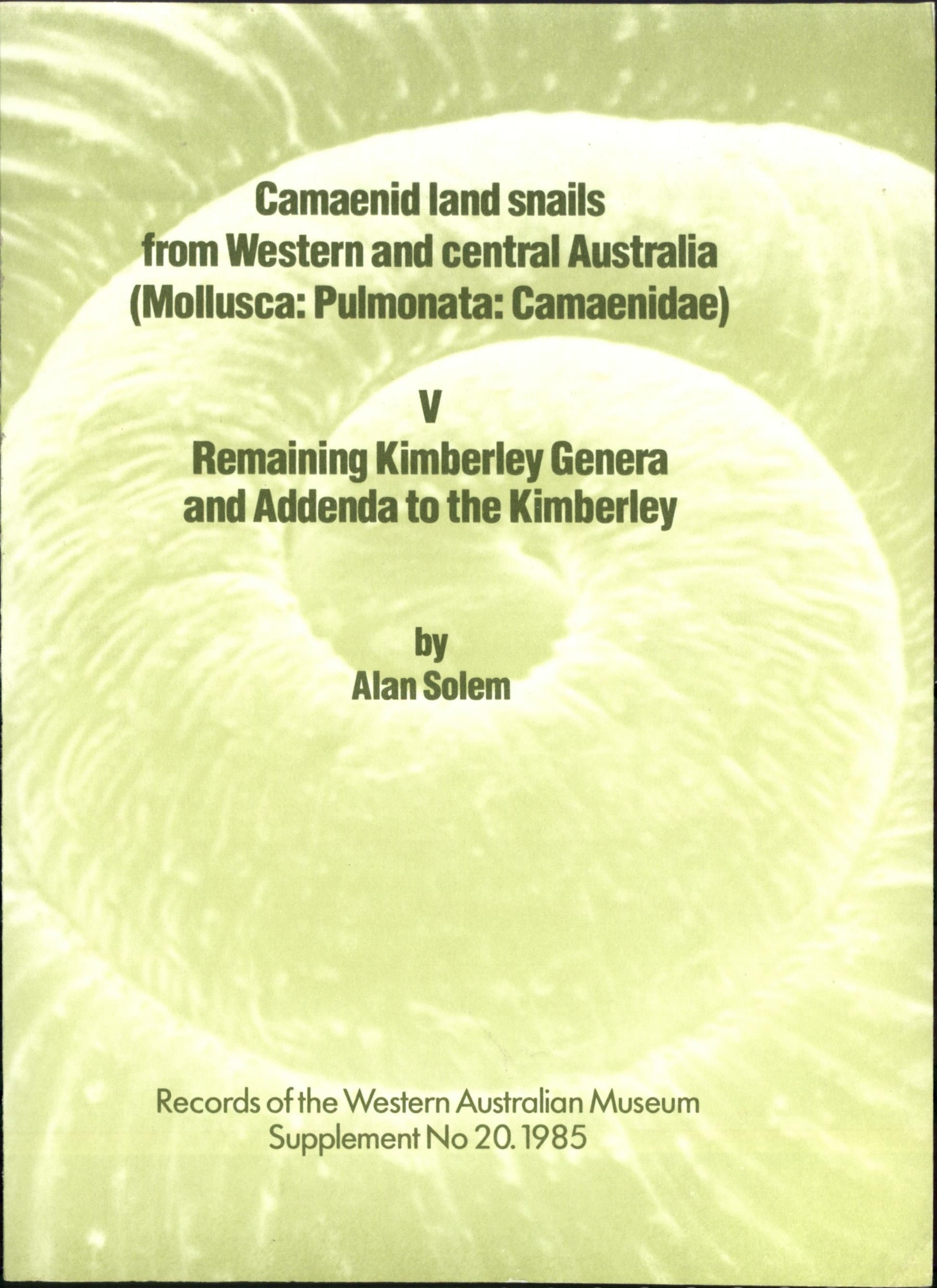

Camaenid land snails from Western and central Australia (Mollusca: Pulmonata: Camaenidae)

V

Remaining Kimberley Genera and Addenda to the Kimberley

by

Alan Solem

Records of the Western Australian Museum
Supplement No 20. 1985

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REMAINING KIMBERLEY GENERA AND ADDENDA TO THE KIMBERLEY

ALAN SOLEM*

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INTRODUCTION

This is the fifth report on the semi-arid zone dominant land snails of Western and central Australia, which belong to the Camaenidae, *sensu lato*. The review of 44 species level taxa, 32 of them new, and four new genera, is based upon study of 7,431 adult specimens, and completes the systematic description of taxa from the Kimberley and adjacent portions of the Northern Territory. Discussion of phylogeny must wait until several related taxa from the Red Centre have been monographed.

There are two parts to this report. The first reviews 34 species from the Kimberley and Northern Territory belonging to the genera *Setobaudinia* Iredale, 1933, *Baudinella* Thiele, 1931, *Retroterra* new genus, *Kendrickia* new genus, *Kimboraga* Iredale, 1939, *Quistrachia* Iredale, 1939, *Carinotrachia* new genus, *Mesodontrachia* new genus, and *Rhagada* Albers, 1860. Both *Quistrachia* and *Rhagada* have their centres of diversity in the Pilbara to Carnarvon area; species of these genera from the Dampierland area south to Carnarvon will be treated subsequently.

The second part involves significant collections made by the author, Laurie Price, Fred and Jan Aslin, and Barbara Duckworth in 1980 from the Napier and Oscar Ranges; East Kimberley; Ningbing Ranges north of Kununurra; and along the Victoria Highway between Kununurra and Katherine, Northern Territory. It was not possible to include this material in Parts II and III (Solem 1981a, 1981b), but specimens from these collections were incorporated into Part IV (Solem 1984). Thus an addenda to the Kimberley taxa is included to supplement the coverage provided in Parts I-III. It is based mainly on the 1980 field work, but also includes significant material from other sources located in various museum collections. Records

*Field Museum of Natural History, Chicago, Illinois 60605-2496, U.S.A.

are given for species whenever this gives more precision to species boundaries, but the main function of this Addenda is to describe 10 additional new species from the Ningbing area, Carson River near Kalumburu, Old Theda Station, and the Prince Regent River Reserve. These descriptions are based on about 3,000 measured adults.

With this monograph, the basic generic and species level review of Kimberley camaenids is completed, in so far as available material permits. Possibly only half of the extant taxa are known. Vast areas of the Kimberley have not been sampled for land snails. Many of the inland areas may have low diversity, but coastal regions such as the area between Kimbolton and the Prince Regent River Reserve (Wilson and Smith 1975), from north of there to the Mitchell Plateau, and the multitude of off-shore islands between the Buccaneer Archipelago and Napier-Broome Bay, can be expected to yield large numbers of new species. The entire north coast between Kalumburu and Wyndham also is malacologically unknown.

Investigation of these areas will substantially change the number of species, produce additional genera, and enable a much better understanding of land snail biogeography for the Kimberley. Difficulty and expense of access will make any such study prolonged at best, improbable in the near future. Thus preliminary biogeographic analyses will be presented elsewhere, using the data base compiled in Parts I-V.

Part I (Solem 1979) covered genera with trans-Australian distributions (*Hadra* Albers, 1860; *Xanthomelon* von Martens, 1860; *Damochlora* Iredale, 1938; *Torresitrachia* Iredale, 1939, plus related *Chloritis*-like genera from eastern Australia). Part II (Solem 1981a) monographed 28 species-level taxa of *Amplirhagada* Iredale, 1933. Part III (Solem 1981b) described 19 new species-level taxa in four new genera (*Ningbingia, Turgenitubulus, Cristilabrum* and *Prymnbriareus*) from the Ningbing Ranges north of Kununurra and near Wyndham. Part IV (Solem 1984) reviewed 29 species-level taxa in five genera ancestral to or derived from *Westraltrachia* Iredale, 1933.

Sufficient data has now been published that some discussions of general biological problems can be presented concerning the Kimberley camaenids. Separate publications on the basic reproductive cycle and shell growth patterns (Solem and Christensen 1984); a remarkable pattern of simultaneous convergence in shell features and divergence in jaw and radular morphology between species of *Amplirhagada* and *Westraltrachia* where they become sympatric in the Napier Ranges (Solem, in press); an in depth study of the remarkable Ningbing radiation (Solem and Emberton, in preparation); are general interest studies derived from the basic systematic reviews.

Part VI will review the camaenids from the Red Centre - that vast area between Warburton on the west and the Dulcie Range north-east of Alice Springs, Northern Territory on the east, Reynolds Range, Northern Territory to the north, and as far south as the fringes of the Everard Range, South Australia. Part VII should complete this series by reviewing those camaenids that range from Dampierland south to Geraldton along the west coast of Western Australia, then inland to Fields Find and through the wheatbelt and goldfields region to Norseman, and finally east into South Australia. Separate monographs on the camaenids of the Flinders Ranges and adjacent areas of South Australia, and various small radiations of taxa around Katherine, Northern Territory and in western New South Wales between Lake Cargelligo and Cobar will provide additional coverage.

Major financial sponsorship of this co-operative project between the Western Australian Museum, Perth (hereafter WAM) and Field Museum of Natural History, Chicago (hereafter FMNH) has been provided by National Science Foundation grants DEB 75-20113, DEB 78-21444, and DEB 81-19208 to FMNH for field work and subsequent study of collected materials, and National Science Foundation grant BMS 72-02149 that established a scanning electron microscope laboratory at FMNH. Grateful acknowledgement is made of this support.

Continuing contributions by Mrs Arthur T. Moulding that permitted extending field time, reaching new areas to collect, and in aiding measurement of specimens and statistical analysis of this data have been recognised in the dedication of the genus *Mouldingia* Solem (1984).

The generosity of the late Frederick K. Leisch in providing the micro-computer facilities on which this report was composed and on which the statistical work was accomplished has been crucial to its timely completion.

Most of the anatomical and nearly all of the shell drawings are by Linnea Lahlum, Illustrator, Division of Invertebrates. Additional illustrations are by Elizabeth A. Liebman and Marjorie M. Connors, formerly Illustrators, Division of Invertebrates. Maps of collecting localities were drafted by Linnea Lahlum and Elizabeth Lizzio, volunteer Illustrator, Division of Invertebrates. For mounting and labelling the many plates and figures, we are all deeply indebted to Dorothy Karall, Associate, Division of Invertebrates. Beth Morris, Division of Invertebrates, patiently and carefully measured much of the shell material and did basic statistical analyses. Margaret Baker, Collection Manager, Division of Invertebrates, assisted in many ways with specimen processing, cataloguing, preparation of material for final deposition at WAM, and many aspects of data handling. Patricia Johnson, Secretary, Division of Invertebrates, helped immeasurably with report preparations, manuscript duplication, and praised everybody for the micro-computer that spared her fingers the typing and retyping of manuscript - although not her careful final rendition of tabular materials.

For field assistance in the several surveys, I am indebted to Laurie Price, Field Associate, Division of Invertebrates; Carl C. Christensen, formerly University of Arizona, now Bernice P. Bishop Museum; Fred and Jan Aslin, Mount Gambier, South Australia; and Barbara Duckworth, Australian Museum, Sydney. The pioneering land snail collections made in the Kimberley

by George W. Kendrick and A.M. Douglas, WAM, in the 1960's, then by Barry R. Wilson and Shirley Slack-Smith, WAM, in the early 1970's, were of great value, as in the other Parts of this series.

Kendrickia ignivenatus recognises the contribution of the first two workers.

SYSTEMATIC REVIEW

The genera reviewed here are not, for the most part, closely related to each other. Discussion of their phylogeny is dependent upon data to be presented in Parts VI and VII, and thus must be deferred. Data on patterns of shell and anatomical variation are presented separately for each genus below.

Any key to the genera of Kimberley camaenids must include anatomical data to be meaningful, since shell convergences are so striking. It is recognised that most specimens taken by non-malacologically trained collectors will consist of dead shells found lying upon open ground. Generally these are worn and bleached to the point that identification characters cannot be observed. Certainly, material collected from a previously unsampled area of the Kimberley will have a high probability of containing new species or genera. These would not key out under the best of circumstances. Thus I have opted to present a key to the described genera based primarily upon anatomical features (p. 977). This is an artificial key to permit identification, not reflect phylogeny.

LIST OF THE TAXA

GENUS *SETOBAUDINIA* IREDALE, 1933

Setobaudinia Iredale, 1933, Rec. Australian Mus., **19**: 55 – type species *Helix (Gonostoma) collingii* Smith, 1893 by original designation; Iredale, 1938, Australian Zool., 9(2): 109 – listing in check list; Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 49-50 – copy of original species description.

Diagnosis

Shell very small, diameter 5.35-9.8 mm, whorl count reduced to 3-5/8 to 4-3/4. Spire slightly (**Fig. 187f**) to moderately (**Fig. 184b**) elevated, often rounded above. Umbilicus widely open, decoiling pattern ranging from normal (**Fig. 182c**), somewhat more rapidly (**Fig. 184g**), to extremely rapidly (**Figs 190c, 192c**). Apical whorls generally 1-3/8 to 1-1/2, sculpture (**Plates 64a, 65a-b, 66a, d, 67a, d, e, 68a, b**) of ovoid to elongated triangular tubercles arranged in vertical and diagonal rows, tubercles largest in mid-section, becoming reduced and irregular near end of apex. Postapical whorls without radial ribbing except for weak irregular growth lines (**Plate 67a**), but with a complex and varied microsculpture composed of periostracal setal rows and microscopic surface ridging. Periostracal setae short and densely distributed (**Plate 67b, c**), to long and widely spaced (**Plates 65a, c, 66b, c**), generally reduced in size and with different form near suture (**Plates 67e, 68a, b**). Tip of setae bluntly rounded (**Plates 67b, c**) to sharply pointed (**Plate 66f**). Base of setae simple (**Plate 66f**) in most species, some with base slightly broadened (**Plate 64d, e**), lateral buttresses well developed (**Plate 69b**), to almost triangular in appearance (**Plate 68b-f**). Size and shape of setae vary with position on whorl (**Plate 68b-f**). Microsculpture ranging from separated protrusions (**Plate 66f**) to anastomosing ridges (**Plate 67b, c**), extent of surface coverage and density variable on individual shells. Periostracal sculpture often obscured by mucoid deposits, worn off, or dirt and fibre encrusted (**Plates 65c, 66d, e, 69a**). Base of shell with reduced sculpture. Body whorl not (**Figs 182b, 187b**), slightly (**Fig. 181b**), moderately (**Fig. 184f**), strongly (**Figs 184b, 187f**), or sharply (**Fig. 192b**) deflected behind lip. Considerable age and species variation in lip size and configurations. Parietal wall with raised edge only in *victoriana* (**Fig. 192**), otherwise at most a thickened callus. Palatal and basal lips age variable in degree of expansion, species and age variable in basal and palatal node prominence. Only *victoriana* (**Figs 192b, c**) without palatal node trace. Interior of lip with microprojections (**Plate 69d**) in all species. Shell periphery rounded (**Fig. 181b**) to weakly angulated (**Figs 184b, 187f**), rarely (**Fig. 192b**) laterally compressed. Periostracal colour brownish horn, rather dark, lip white. Genitalia with marked seasonal size variation. Spermatheca (S) with long shaft, expanded head reaching almost to (**Fig. 189b**) or to (**Fig. 191a**) base of albumen gland (GG). Talon (**Fig. 186a**, GT) short, with lateral entry of hermaphroditic duct (GD). Free oviduct (UV) generally much shorter than vagina (**Figs 183a, c, 185a, 189a, b**), a shortened vagina present in *hirsuta* (**Fig. 186a**), and very short vaginae in *pagoana* (**Fig. 188a**), *anatispretia* (**Fig. 191**), and *victoriana* (**Fig. 193a**). Vas deferens (VD) and ascending portion of epiphallus bound to penis by fibres. Epiphallus (E) normally with both a caecum (EC) and a lobe (EL), former absent in *victoriana* (**Fig. 193a**). Penial retractor muscle (PR) originating on diaphragm, attaching to epiphallus where it reflexes anteriorly and expands before entering vergic or vergic papillae complex. Penis (P) with a long sheath, internally with variable wall sculpture and apical structures ranging from an almost tubular verge (**Figs 185b, 186b, 188b, 189d, e, 193b**) to simple apical pilasters (**Figs 183b, 191b**). Jaw (**Plate 70**) with prominent vertical ribs that vary greatly in number and width, no species differences recognised. Radular teeth (**Plates 71-75**) typical in structure, laterals few in number, blunt tipped and curved, small ectocone present. Lateromarginal transition typical, marginals typical in both number and great variability.

Type species: *Helix (Gonostoma) collingii* Smith, 1893 by original designation.

Comparative remarks

Specimens of *Setobaudinia* Iredale, 1933 and *Baudinella* Thiele, 1931, especially if they are dirt encrusted, can easily be confused. They are sympatric in the Prince Regent River area, and most museum lots were mixtures. Cleaned shells are easily separated in that *Setobaudinia* lacks radial ribs on the shell and has comparatively small apertural barriers. Both species of *Baudinella* (**Figs 194a-f**) have prominent radial ribs and the apertural barriers are much larger. The only other Kimberley genus that might be confused with *Setobaudinia* is *Mouldingia* Solem, 1984 from the Napier Range and near Lake Argyle. These species have a keeled periphery, very prominent radial ribs, a very different microsculpture, and lack the lip nodes (Solem 1984: 639-645, **figs 163a-f, Plates 52-53**). All three genera differ greatly in anatomy, and their similarities are based on size and convergence.

Previous studies and nomenclature

The original description of *Setobaudinia collingii* (Smith, 1893) was based on material collected by J.J. Walker, chief engineer of H.M.S. 'Penguin' during its survey operations off the north-west Australian coast in 1890. Its type locality was mistakenly cited as Baudin Island. Labelled museum specimens, including the types, indicate that Parry Island is the correct locality. Since recent collecting on Baudin Island by WAM staff failed to discover any material of *Setobaudinia,* although locating many examples of *Baudinella baudinensis* (Smith, 1893), restriction of the type locality to conform with the Parry Island labels is proposed. The original description and figures were copied by Pilsbry (1893). Iredale (1933), who apparently never saw any examples of this species, used the original description in proposing the genus *Setobaudinia* and later (Iredale 1939) copied the original information. Thus all subsequent references are based on Smith's very detailed original observations, without any information based on new material or re-examination of types.

Distribution and basic ecology

Setobaudinia has a basically near coastal distribution extending from Stewart River, Kimbolton (16°36'S, 123°31'E), north of Derby to near Kalumburu Mission, including scattered sites in the Drysdale National Park, and then two isolated Northern Territory localities between Timber Creek Police Station and about 86 km west of Katherine. No specimens have been taken from the extensive limestone outcrops around Katherine, in any of the East Kimberley limestone areas near Lake Argyle, the Ningbing Ranges north of Kununurra, nor in the South Kimberley limestone arc extending from the Lawford Ranges through the Napier Ranges, east of Derby. There are no records from the King Leopold Ranges, or from the inland ranges near Beverley Springs.

The above combination of positive and negative data suggests that *Setobaudinia* is an inhabitant of the heavier forested areas of the north-west Kimberley. The actual distribution of species is not known, as each cluster of collecting localities has produced another taxon. The unsampled areas between clusters provide a transition to the next species, but actual species boundaries are unknown. I anticipate that several more species will be discovered, in addition to the two listed below as being represented by too little material for description (p. 774).

The Kimbolton to Kalumburu records are not limestone associated. Specimens have been taken live in leaf litter, under boulders, in vine thickets, open grassy eucalypt woodlands, and under figs. In contrast, both Northern Territory collections are from isolated patches of limestone, snail oases surrounded by apparently snail-free plains and hill systems.

Local distribution of *Setobaudinia* is distinctly patchy. Several live individuals will be encountered in one spot, then no specimens found in equally promising looking litter or boulder piles until another patch is located a few meters away. Sample size in collections usually is small. During aestivation, specimens lie free within the litter, secreting a thick, calcified epiphragm across the aperture. It is the typical epiphragm for a Kimberley camaenid in that the lip protrusions rarely are incorporated into the plane of the epiphragm. Inclusion of the nodes in the plane of the epiphragm would reduce the area to be covered, but for unknown reasons has not been utilized by any Australian camaenids.

The only situation of potential congeneric micro-sympatry involves *Setobaudinia calvitia* and *S. hirsuta* on the Mitchell Plateau. Two lots collected during WAM surveys have labels suggesting that the two species might have been collected within a short distance of each other (see p. 758). All material from the FMNH surveys had either one or the other species at a single station. Unlike some of the Mitchell Plateau *Amplirhagada,* which show vegetation preferences (Solem 1981a: 151), both species of *Setobaudinia* have been taken in vine thicket and open eucalypt forests. I cannot indicate an obvious ecological difference between them. They have distinctive verges and different patterns of penis chamber wall sculpture (compare **Figs 185b** and **186b**), suggesting species recognition adaptations. Presumably there are places in which they become sympatric at least occasionally.

Patterns of shell variation

Two features of the shell makes it difficult to present much analysis of size and shape differences among species. First, they are small camaenids, and the standard measurements used could be recorded only to the nearest 0.1 mm. When applied to a shell height of only 3-4 mm and an umbilical width of about 1-3 mm, there is an inherent error factor that is significantly larger than when the shell height is more than 15 mm, as in most groups reviewed in earlier parts of this series. Second, the degree of shell lip expansion is clearly dimorphic within a population. Narrowly expanded lips are characteristic of what I am terming 'new adults', while broadly expanded lips indicate 'old adults', that is, survivors of at least three wet seasons. The wider lip affects standard measurements by: a) increasing the shell diameter; b) increasing the shell height; c) decreasing the effective umbilical width; and d) thus altering both the H/D and D/U ratios. In dead collected specimens, the lip frequently is chipped or fractured, thus yielding reduced size measurements.

The generally small numbers of live collected individuals from a given station made it impractical to separate out lip classes for separate measurements, and thus material has been lumped. Where several populations of a species could be sampled, *Setobaudinia interrex, S. calvitia, S. hirsuta,* and *S. doongana* (**Tables 78, 79, 81**), major size variation was found among populations, adding yet another complication to between species comparisons. Summed size and shape variation is presented, but these data must be used only as rough guidelines to species characteristics. Far more emphasis should be placed on differences in shell structures.

Size and shape of shell – The total range in adult shell size, 4.45 mm (5.35-9.8 mm), is both proportionately and quantitatively less than the ranges shown by species of *Amplirhagada* (Solem, 1981a: 151) and *Westraltrachia* (Solem, 1984: 436). Both of the latter have 14.1 mm ranges that are, respectively, 1.22 and 1.37 times the minimum adult shell diameter, compared with the 0.83 proportion for *Setobaudinia.* This probably partly reflects the fact that *Setobaudinia* is near the minimum size for a camaenid and has a much lower whorl count (median 4-1/4 in *Setobaudinia* compared with 6 in *Amplirhagada*). In general, both within and among species, higher whorl count correlates with increased diameter.

Basic features of the shell are only slightly variable, and *Setobaudinia* has a very characteristic appearance. Spire elevation is slight to moderate. One species, *S. victoriana,* shows lateral compression of the body whorl, and some have weak angulation. Umbilical width is increased only in *S. pagoana* and *S. anatispretia,* narrowed in *S. victoriana.* Last whorl decoiling is regular in most taxa, but sharply increased in the Northern Territory and two undescribed taxa. Body whorl descent behind the aperture is marked only in *S. victoriana* and the undescribed Mitchell Plateau species.

Structure of shell lip – Much variation is found in the lip and this is summarised in **Table 77**. All references here are to the fully adult examples, with age variation ignored. Reflection of the shell lip involves deposition of multiple layers, which can be seen at relatively low magnifications (**Plate 69c**). Slightly higher magnification shows the characteristic crystals (**Plate 69d**) found in all land snail taxa with constricted apertures. The degree of lip expansion is dependent upon the number of layers deposited and how far out each new layer is extended.

Normally there are two nodes on the lip, which vary among species in size. One or the other node may be reduced to absent. The basal lip has a

Table 76: Range of Variation in *Setobaudinia, Baudinella,* and *Retroterra*

Taxon	Number of Adults Measured	Mean and Range of: Shell Height	Shell Diameter	H/D Ratio
SETOBAUDINIA				
collingii (Smith, 1893)	16	4.76 (4.3–5.25)	9.00 (8.15–9.8)	0.529 (0.497–0.559)
interrex	73	3.88 (2.8–5.2)	7.20 (5.35–8.95)	0.538 (0.470–0.627)
calvitia	377	3.67 (2.8–5.6)	6.90 (5.5–9.4)	0.531 (0.423–0.648)
hirsuta	137	4.13 (2.9–5.75)	7.72 (5.85–9.5)	0.533 (0.431–0.680)
pagoana	35	3.46 (3.0–3.9)	6.76 (6.0–7.5)	0.512 (0.455–0.560)
doongana	139	3.53 (2.7–4.5)	6.70 (5.45–8.5)	0.529 (0.430–0.630)
anatispretia	127	3.30 (2.7–4.3)	7.04 (5.8–7.85)	0.469 (0.386–0.565)
victoriana	28	2.83 (2.55–3.2)	5.92 (5.2–6.8)	0.477 (0.414–0.508)
sp. 1	5	4.51 (4.31–4.90)	8.65 (8.24–8.95)	0.519 (0.482–0.547)
sp. 2	2	3.08 (2.9–3.25)	5.53 (5.5–5.55)	0.557 (0.523–0.591)
BAUDINELLA				
baudinensis (Smith, 1893)	50	2.80 (2.5–3.2)	5.88 (5.25–6.25)	0.477 (0.419–0.534)
regia	154	4.24 (3.15–5.3)	7.40 (5.2–8.7)	0.574 (0.500–0.670)
RETROTERRA				
parva	21	4.56 (3.85–5.3)	10.49 (9.2–12.6)	0.436 (0.363–0.489)
costa	42	6.50 (5.3–9.2)	15.28 (13.4–19.4)	0.426 (0.347–0.502)
solituda	21	13.05 (10.5–14.45)	22.89 (20.8–24.6)	0.571 (0.505–0.634)

Table 76: Range of Variation in *Setobaudinia*, *Baudinella*, and *Retroterra* (continued)

Taxon	Number of Adults Measured	Mean and Range of:		
		Whorls	Umbilical Width	D/U Ratio
SETOBAUDINIA				
collingii (Smith, 1893)	16	4⅜+	2.26	4.01
		(4⅛–4⅝)	(1.9–2.9)	(3.19–4.40)
interrex	73	4¼	1.93	3.77
		(3⅞–4⅝)	(1.15–2.6)	(2.83–5.22)
calvitia	377	4¼	1.98	3.51
		(3⅝–4¾)	(1.3–2.6)	(2.63–5.67)
hirsuta	137	4¼+	2.01	3.93
		(3⅞–4¾)	(1.1–2.9)	(2.44–7.54)
pagoana	35	4¼	2.28	2.97
		(3⅞–4½+)	(1.9–2.7)	(2.60–3.55)
doongana	139	4+	1.70	3.96
		(3⅝–4¾–)	(1.1–2.5)	(2.78–6.32)
anatispretia	127	4+	2.13	3.33
		(3¾– –4¼+)	(1.6–2.6)	(2.63–4.41)
victoriana	28	4⅛+	1.10	5.51
		(3⅞+–4⅜–)	(0.85–1.7)	(3.79–7.09)
sp. 1	5	4⅜+	1.91	4.56
		(4⅛–4¾)	(1.76–2.03)	(4.26–4.93)
sp. 2	2	3⅞+	1.48	3.75
		(3¾+–4+)	(1.45–1.50)	(3.70–3.79)
BAUDINELLA				
baudinensis (Smith, 1893)	50	3¾+	1.78	3.33
		(3⅝– –4⅛)	(1.4–2.1)	(2.86–4.13)
regia	154	4¼–	1.95	3.82
		(3⅝–4½)	(1.3–2.55)	(2.88–4.90)
RETROTERRA				
parva	21	4½–	3.37	3.11
		(4⅛– –4¾+)	(2.7–3.95)	(2.68–3.56)
costa	42	4½–	4.61	3.33
		(4+–5)	(3.8–5.7)	(2.83–4.08)
solituda	21	5½+	5.09	4.51
		(5⅛–5⅞)	(4.2–5.7)	(4.12–5.14)

more elongated ridge-like node, which is initiated by a slight indentation of the whorl profile, followed by build-up within the aperture. The degree to which basal lip node size is caused by the external indentation or internal thickening varies with age and among individuals. The palatal node is mainly dependent upon development of a crease or gutter on the outer surface of the body whorl, which deflects the lip edge into the aperture. Frequently there is only minor internal thickening, except in the species *S. anatispretia*,

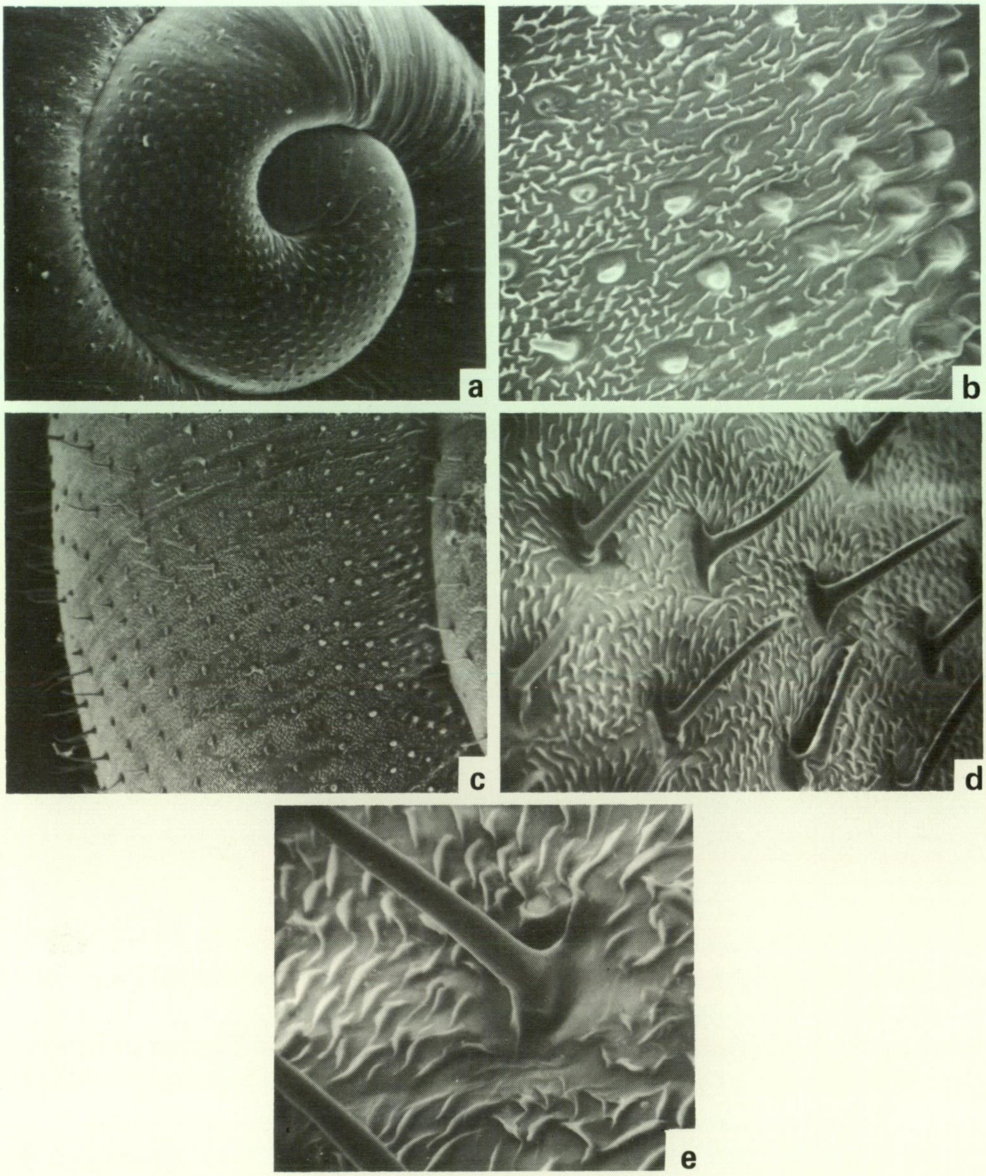

Plate 64: Shell sculpture in *Setobaudinia collingii* (Smith, 1893): Parry Island, Admiralty Gulf, Northwestern Australia. BM(NH) 92.1.29.167-178. Paratopotype. (a) shell apex and early spire at 36.4X; (b) suture area on body whorl with broken setae at 149X; (c) general view of suture and body whorl at 35.0X; (d) setae on body whorl at 145X; (e) base of seta on body whorl at 350X.

where this node is very large (**Figs 190b-c, f-g**). Allowing for age differences in shells, there seems to be quite minor intrapopulational variation.

Relationship between the parietal wall and where the basal and palatal lips attach to it shows several modifications. Normally there is a simple blending of the outer lips into a thin parietal callus. In two species with grossly expanded lips, *S. anatispretia* (**Figs 190b-c**) and *S. hirsuta* (**Figs 184f-g**), the expanded lip portion does not merge with the callus, but stops short of it, leaving a deep indentation at the margin. In two other species, *S. victoriana* (**Fig. 192b**) and the undescribed Mitchell Plateau species, the parietal callus is raised or greatly thickened, respectively. Both basal and palatal lips curve into the raised callus. In *S. victoriana* this results in a parietal lip that is partly detached from the parietal wall and forms a continuous shell lip.

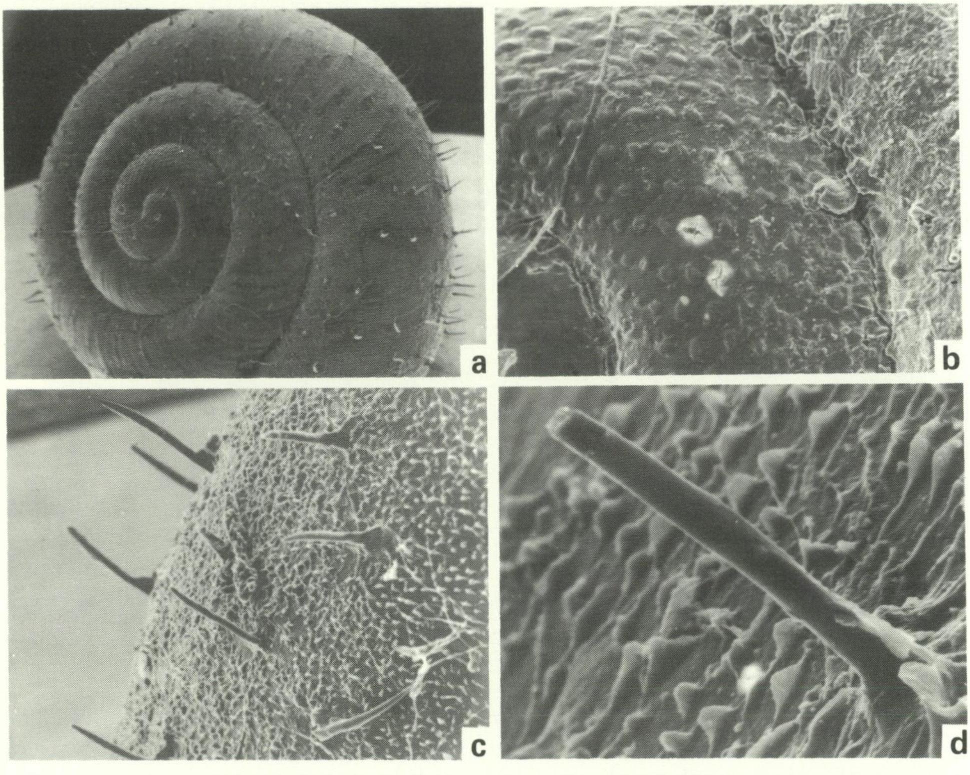

Plate 65: Shell sculpture of *Setobaudinia interrex:* Sta. E5 (9), Prince Regent River Reserve, Kimberley, WAM 376.75. (a) juvenile shell at 14.5X; (b) apex with mucus coagulated in suture at 73.2X; (c) setae on body whorl at 69.6X; (d) single seta on body whorl at 380X.

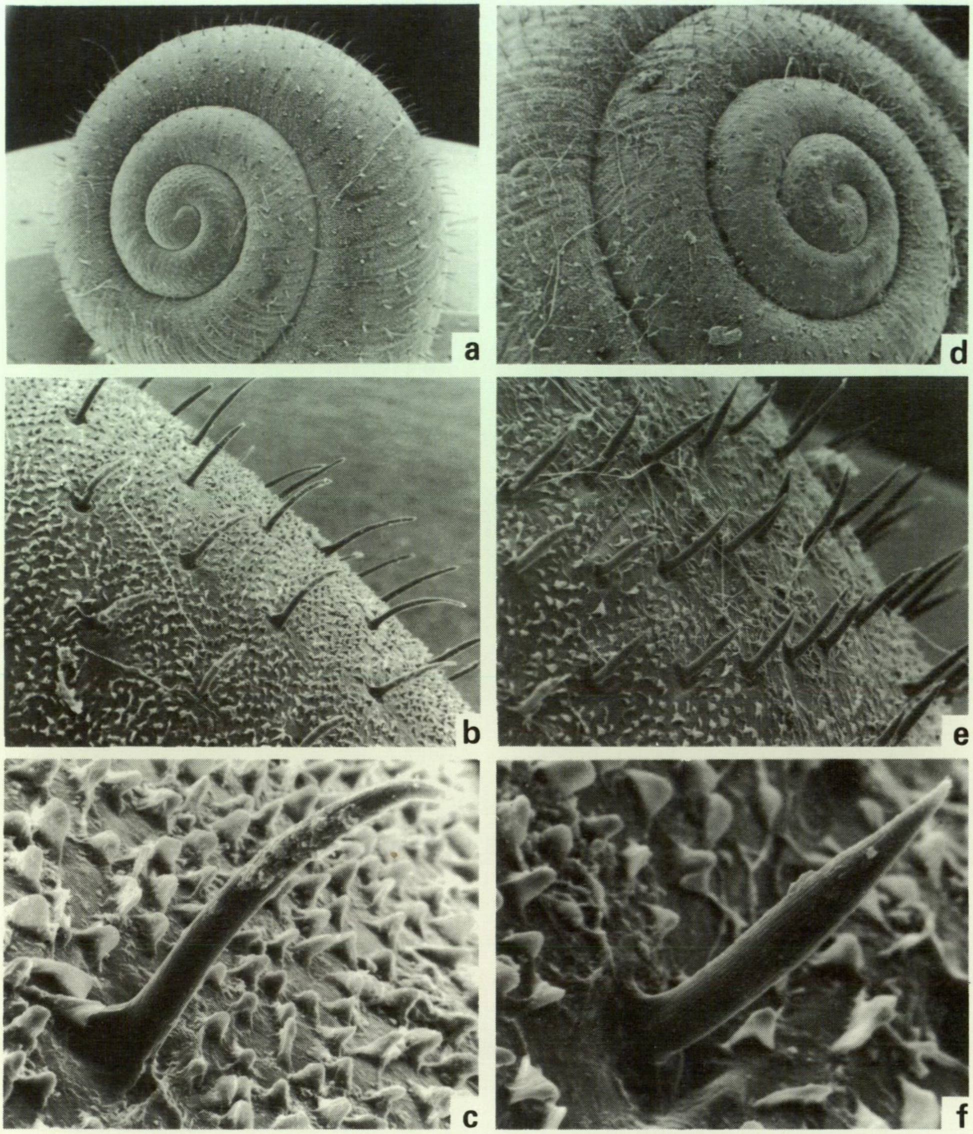

Plate 66: Shell sculpture in *Setobaudinia calvitia* and *S. hirsuta:* (a-c) *S. calvitia,* Sta. WA-207, Walsh Point, Mitchell Plateau, Kimberley, FMNH 200339, (a) juvenile shell at 14.8X; (b) setae on body whorl at 65.0X; (c) single seta on body whorl at 331X; (d-f) *S. hirsuta,* Sta. WA-390, Mitchell Plateau, Kimberley, FMNH 199973, (d) apex and spire of adult shell at 16.0X; (e) setae on body whorl at 73.2X; (f) single seta on body whorl at 371X.

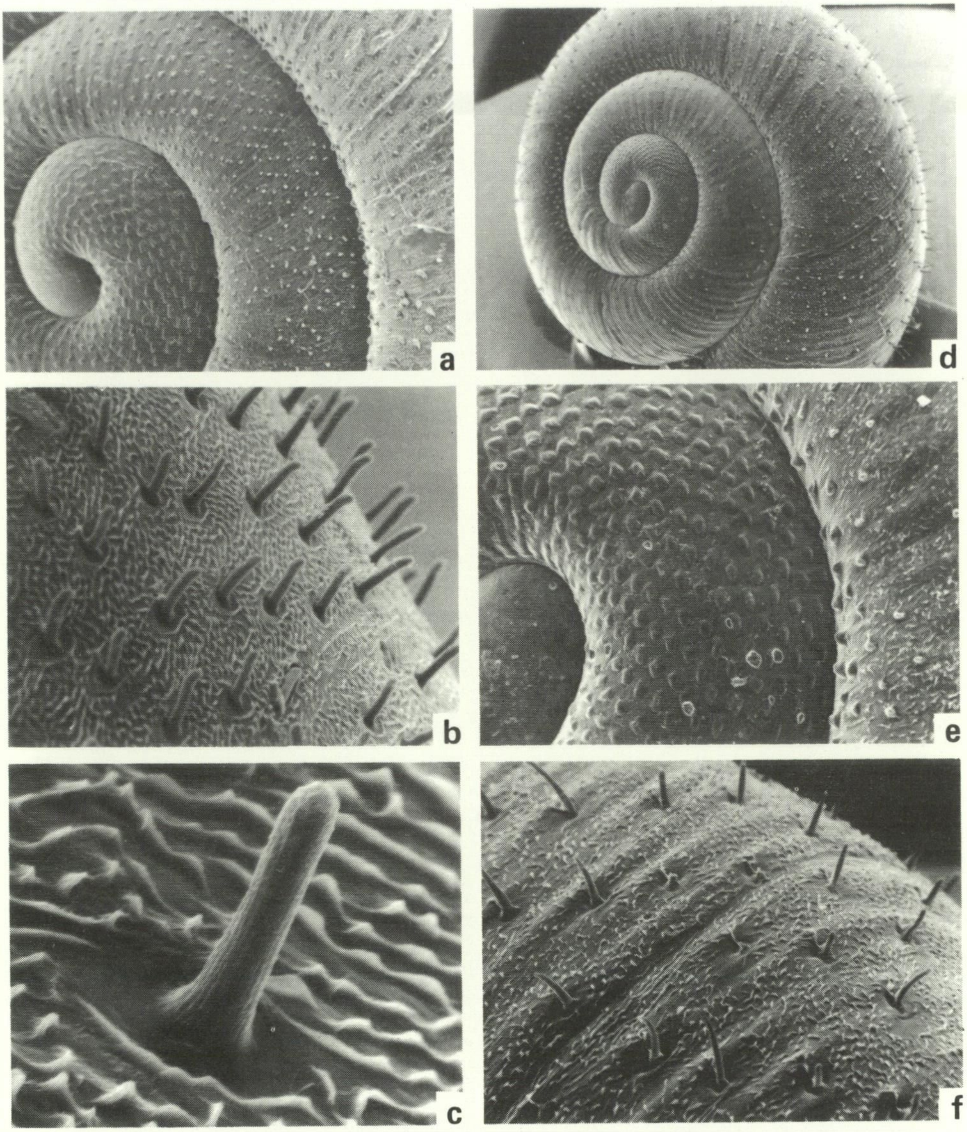

Plate 67: Shell sculpture in *Setobaudinia pagoana* and *S. doongana:* (a-c) *S. pagoana,* Sta. WA-217, Kalumburu-Pago Road, Kimberley, FMNH 200448, (a) apex and early spire at 39.1X; (b) setae on body whorl at 154X; (c) single seta on body whorl at 720X; (d-f) *S. doongana,* near Old Doongan Homestead, Drysdale River, Kimberley, WAM 186.76, (d) juvenile shell at 14.8X; (e) detail of apex and early spire at 71.5X; (f) setae on body whorl at 72.6X.

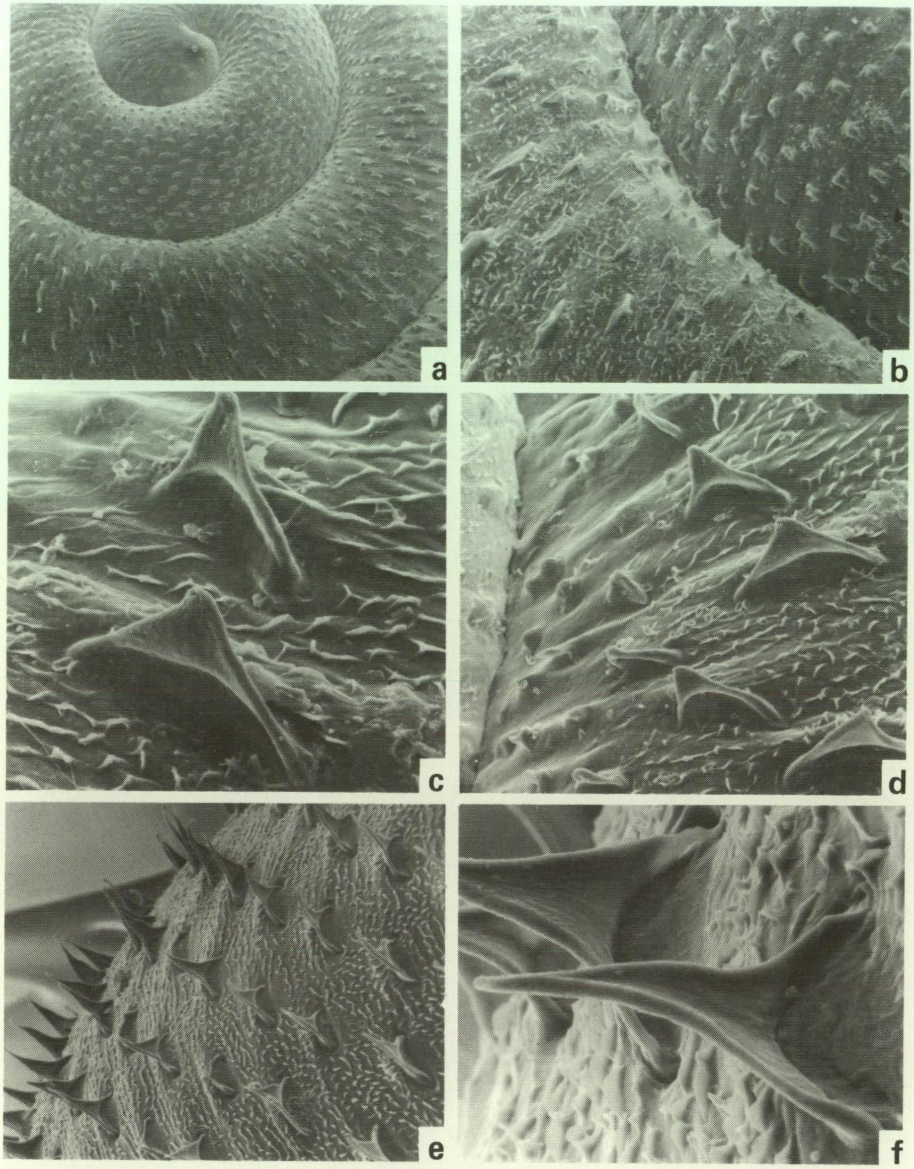

Plate 68: Shell sculpture of *Setobaudinia anatispretia:* Sta. WA-680, Victoria Highway, 24.4 km east of Timber Creek Police Station, Northern Territory, FMNH 205153, (a) apex and early spire of juvenile at 36.2X; (b) detail of apex and early spire at 86.5X; (c) periostracal protrusions near suture of body whorl at 265X; (d) body whorl near suture at 147X; (e) periostracal protrusions on body whorl at 71.5X; (f) detail of body whorl protrusions at 355X.

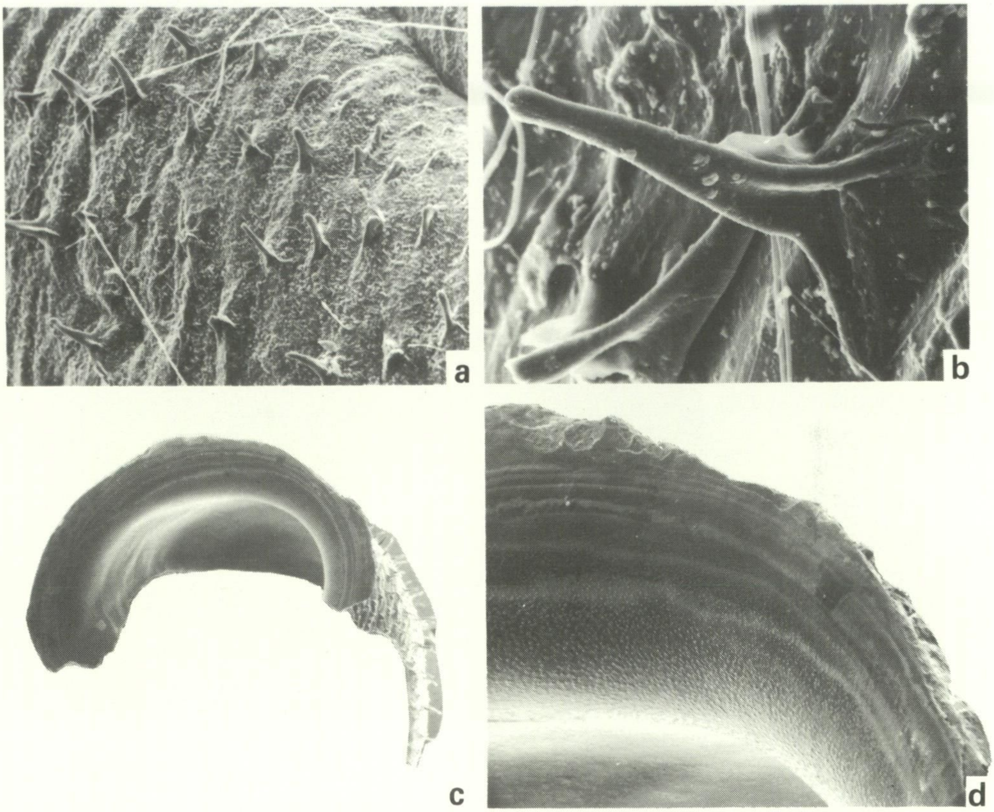

Plate 69: Shell sculpture of *Setobaudinia victoriana:* Sta. WA-681, Victoria Highway, 86 km south-west of Katherine, Northern Territory, FMNH 205163, (a) setae on body whorl at 77.3X; (b) single seta on body whorl at 365X; (c) lip of shell at 14.8X; (d) detail of shell lip at 73.2X.

Structure of periostracal setae – The setal projections in species of *Setobaudinia* are microscopic in comparison with the huge spines of *Damochlora spina* (**Fig. 240a-c**), and often hidden under debris or eroded from the surface in dead material. There are obvious differences in setal length and density. These can be examined visually in **Plates 64-69** and are ranked in **Table 77.** Most species have long, pointed setae with simple bases, that is, direct attachment without buttresses. The major changes occur in the two Northern Territory species. *S. victoriana* (**Plate 69a-b**) has two or three lateral buttresses extending from the setal base for a considerable distance. *S. anatispretia* (**Plate 68c-f**) has two huge buttresses, often forming a 'V', then gradually narrowing apically to an elongated shaft. Near the sutures, these setae are diminished in height and often have a triangular shape.

Table 77: Structural Variation in Species of *Setobaudinia*

Character	Species				
	Kimbolton	*interrex*	*calvitia*	*collingii*	*hirsuta*
SHELL LIP					
Merging	Simple	S	S	S	Indented
Expansion	Medium	Large	Medium	M	Gross
Basal node	Weak	Medium	W	M	M
Palatal node	Weak	Large	W	L	L
BODY WHORL SETAE					
Spacing	Sparse	S	S	Dense	D
Length	Long	L	L	L	Short
Tip	Pointed	P	P	P	P
Base	Simple	S	S	S	S
GENITALIA					
Free oviduct	?	Short	S	?	S
Vagina	?	Long	L	?	Short
Epiphallic lobe	?	Medium	Long	?	M
Epiphallic caecum	?	Long	L	?	L
Penis/vagina	?	L=	L=	?	M=
Verge type	?	None	Conical	?	Ridged
Penis wall	?	Ridges	Pustules	?	Ridges

Character	Species				
	Lawley	*doongana*	*pagoana*	*anatispretia*	*victoriana*
SHELL LIP					
Merging	Cont.	Simple	S	Indented	Cont.
Expansion	Large	Medium	M	Gross	G
Basal node	Tiny	Weak	Medium	W	W
Palatal node	Large	None	L	Huge	N
BODY WHORL SETAE					
Spacing	?	Sparse	Dense	D	S
Length	Medium	Long	Short	L	M
Tip	Pointed	P	Rounded	P	P
Base	Simple	S	S	Wide	W

Table 77: Structural Variation in Species of *Setobaudinia* (continued)

Character	Species				
	Lawley	*doongana*	*pagoana*	*anatispretia*	*victoriana*
GENITALIA					
Free oviduct	?	Short	S	Medium	M
Vagina	?	Long	Short	Very S	Very S
Epiphallic lobe	?	Medium	Short	Long	None
Epiphallic caecum	?	Long	Very L	V L	V Short
Penis/vagina	?	L=	S ½	S 3	M 3
Verge type	?	Long	Short	None	Spatulate
Penis wall	?	Circular Ridges	Longitudinal R	Pustules	Short R

Age changes in shell structure

Most available material of *Setobaudinia* was collected during the mid to late dry season (August to November), except for the early dry season collections of *S. anatispretia* and *S. victoriana* (June) and the late wet season (March) sampling on the Mitchell Plateau for *S. calvitia* and *S. hirsuta.* All of these samples show a consistent pattern of three growth stages: juveniles in which there has been no reflection of the lip; specimens with a thickened lip that is only partly reflected and slightly expanded, with small lip nodes; and specimens with the lip fully expanded and the lip nodes at maximum size. Where sufficient material was available, illustrations of both adult shell phases have been presented. *S. interrex* (**Figs 182c-d**), *S. hirsuta* (**Figs 184g-h**), *S. pagoana* (**Figs 187c-d**), and *S. anatispretia* (**Figs 190c-d**) are typical of taxa in which there is major internal thickening of the lip nodes as full expansion of the lip is reached. The contrast of the small nodes and thin lip, and the change in lips-parietal merging (**Figs 184g-h, 190c-d**) is especially dramatic. Differences are more subtile when the lip is less expanded when fully adult, as in *S. doongana* (**Figs 187g-h**) and *S. calvitia* (**Figs 184c-d**).

Live collected specimens of both growth phases in the Mitchell Plateau species had fully adult genitalia. Thus genital maturation and full shell maturation is not reached simultaneously. In many Kimberley camaenids, maturity of both the shell and male genitalia occurs late in the snail's second wet season; female genital maturity is postponed until the third wet season (Solem and Christensen 1984). *Setobaudinia* seems to have a different cycle: at least male genital maturity is reached before shell lip expansion is completed. There are two phases of lip expansion within populations of all species for which more than a handful of specimens were available. A logical hypothesis, on the basis of the late wet season samples compared with the mid to late dry season samples, is that snails end their first wet season as juveniles, partly expand the shell lip and reach some stage of genital maturity in their second wet season, and then complete lip expansion of the shell in their third wet season. Not enough material is available to try and estimate if full lip expansion is reached in the third or subsequent wet seasons. The multi-layered nature of the full lip is evident **(Plate 69c-d)**, but the timing of these accretions is unknown.

This pattern of adult dimorphic lip condition has not been observed in any other genus of Australian camaenids. It easily can cause confusion in attempting identifications. If only 'young adults' are available in a small sample, use of the key to species will be impossible.

Pattern of anatomical variation

Unfortunately much of the preserved material available to me had been fixed and stored in formalin. Degenerative tissue changes in the pallial and apical sectors had progressed to the point that structures could not be studied at all, or observed only in outline form. Alcohol fixed and preserved materials from the Mitchell Plateau, near Kalumburu, and from the Northern Territory stations yielded much more data, but is inadequate by itself to present other than a very tentative hypothesis as to maturation patterns and seasonal changes.

Changes in basic morphology are discussed first.

Radula and jaw – Specimens were mounted for SEM viewing after tissue maceration in cold potassium hydroxide for three hours and washing in a sonic cleaner. Tears were deliberately introduced into the radular ribbon in order to study row to row tooth interlock and observe the patterns of transition from lateral to marginal teeth. Rubber cement was used as a mounting medium. A sputter coater gave about 125 angstrom units of gold plating. Jaws were mounted on the same stub as the radula from that individual, and observations made with a Cambridge S4-10 stereoscan.

Jaws of typical *Setobaudinia* and *Baudinella* are shown on **Plate 70.** Usually the combined attachment membrane and lining of the buccal cavity roof disintegrates in the KOH or is shaken off in the sonic cleaning, but this is well preserved in the examples of both *S. hirsuta* **(Plate 70b)** and *B. baudinensis* **(Plate 70f)**. The jaws are typically camaenid. Differences in vertical rib numbers and widths are great in both individual jaws **(Plate 70d-e)** and within populations. The reason for this variation can be seen in **Plate 70c,** where an injury to the jaw has resulted in subsequent growth showing changed rib widths. Horizontal striation, which is most obvious in **Plate 70d,** also varies individually. The absence of such striation on the rib surfaces **(Plate 70a)** is the result of abrasion. There does seem to be a general tendency in both genera for the outer margins of the jaws to have reduced vertical

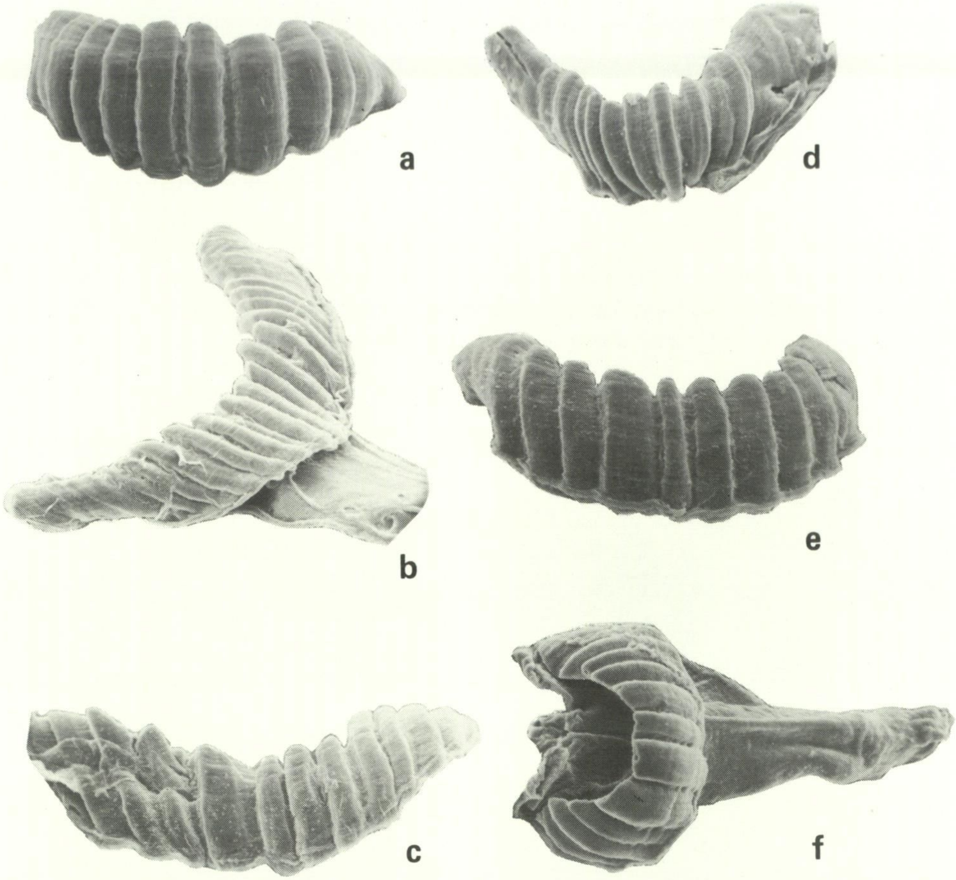

Plate 70: Jaws of *Setobaudinia* and *Baudinella:* (a) *Setobaudinia interrex,* Sta. E5 (1), Prince Regent River Reserve, Kimberley, WAM 472.75, 14 August 1974, Dissection A, at 120X; (b) *S. hirsuta,* Sta. WA-206, Mitchell Plateau, Kimberley, FMNH 200438, 18 October 1976, Dissection A, at 89X; (c) *S. pagoana,* Sta. WA-217, Kalumburu-Pago Road, Kimberley, FMNH 200448, 27 October 1976, Dissection A, at 144X; (d) *S. victoriana,* Sta. WA-681, Victoria Highway, 86 km south-west of Katherine, Northern Territory, FMNH 205163, Dissection A, at 134X; (e) *B. regia,* Sta. E5 (4), Prince Regent River Reserve, Kimberley, WAM 478.75, 15 August 1974, Dissection A, at 130X; (f) *B. baudinensis* (Smith, 1893, Baudin Island, Admiralty Gulf, Kimberley, WAM 379.80, 15 August 1976, membrane still attached, at 131X.

ribbing. This contrasts with the situation in typical *Westraltrachia* (Solem, 1984: Plate 31). No consistent differences among the species of *Setobaudinia* and *Baudinella* could be detected in the material available.

Radular teeth of *Setobaudinia* species (**Plates 71-75**) have few unusual features. Both central and lateral teeth have minute side cusps, with the ectocone becoming larger as the lateromarginal transition is approached (**Plates 71c, 72a, d, e, 73a, c, d, 74a-c, 75a-d**). Variation within a population as to side cusp size is very large, and I could detect no species differences in this feature. The mesocone of the laterals is short, with a curved tip, rounded point, and elevated at a rather high angle (**Plates 71a, 72b, e, 73a, d, 74a, b, 75a**). The basal support system, observable in the illustrations cited above, has no unusual features: laterals have a single support ridge on the ectoconal

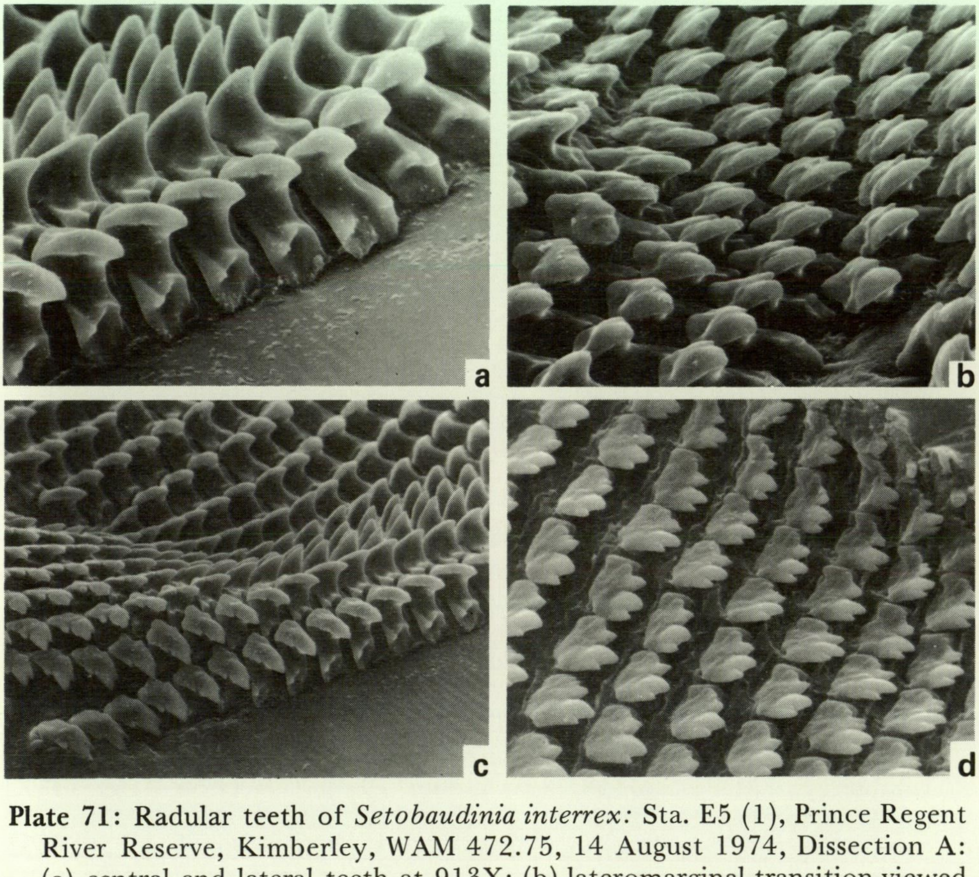

Plate 71: Radular teeth of *Setobaudinia interrex:* Sta. E5 (1), Prince Regent River Reserve, Kimberley, WAM 472.75, 14 August 1974, Dissection A: (a) central and lateral teeth at 913X; (b) lateromarginal transition viewed from centre of radula at 725X; (c) lateromarginal transition viewed from near edge of radula at 765X; (d) outer marginal teeth viewed from above at 745X.

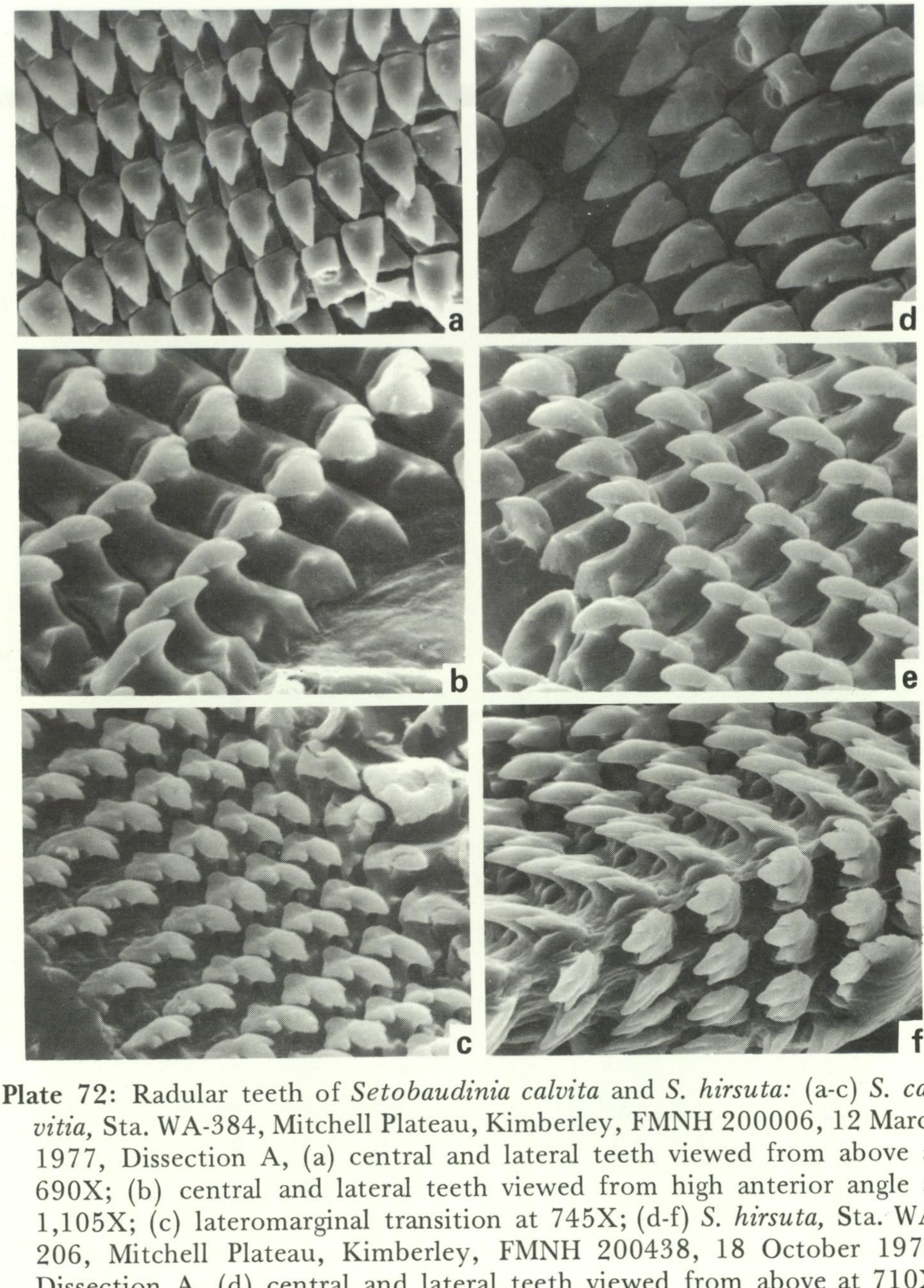

Plate 72: Radular teeth of *Setobaudinia calvita* and *S. hirsuta:* (a-c) *S. calvitia,* Sta. WA-384, Mitchell Plateau, Kimberley, FMNH 200006, 12 March 1977, Dissection A, (a) central and lateral teeth viewed from above at 690X; (b) central and lateral teeth viewed from high anterior angle at 1,105X; (c) lateromarginal transition at 745X; (d-f) *S. hirsuta,* Sta. WA-206, Mitchell Plateau, Kimberley, FMNH 200438, 18 October 1976, Dissection A, (d) central and lateral teeth viewed from above at 710X; (e) central and lateral teeth viewed from high anterior angle at 710X; (f) lateromarginal transition viewed on an artificial fold in radular membrane at 720X.

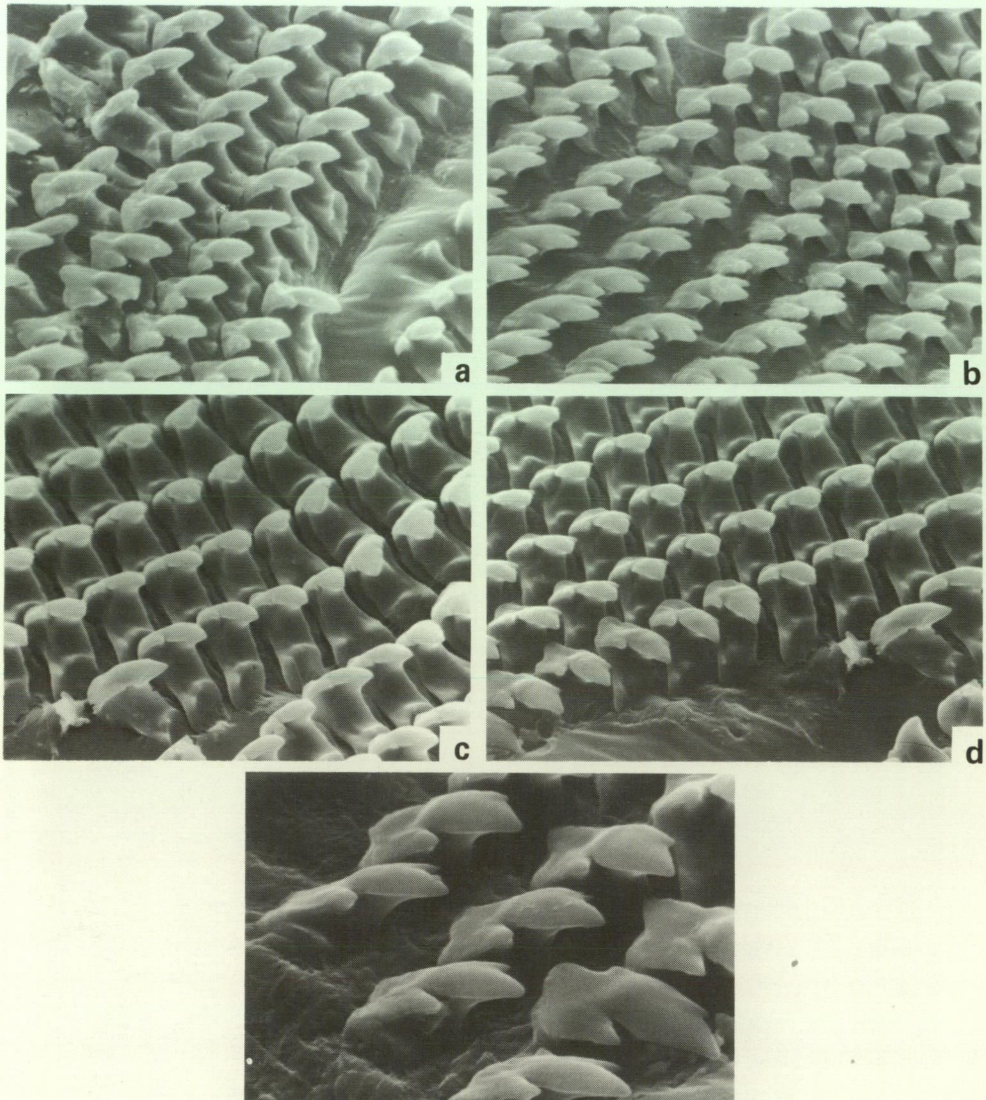

Plate 73: Radular teeth of *Setobaudinia pagoana* and *S. doongana:* (a-b) *S. pagoana,* Sta. WA-217, Kalumburu-Pago Road, Kimberley, FMNH 200448, 27 October 1976, Dissection A, (a) central and laterals at 655X; (b) lateromarginal transition at 715X; (c-e) *S. doongana,* Old Doongan Homestead, Drysdale River area, Kimberley, WAM 380.80, 22 August 1975, Dissection A, (c) central and lateral teeth at 718X; (d) lateromarginal transition at 740X; (e) early marginal teeth at 1,400X.

side of the base; the central tooth is readily distinguished by its two support ridges (**Plate 71a**). Transition between laterals and marginals involves the usual loss of the basal support system, increase in size of the ectocone, lowering of the mesoconal angle and sharpening of its tip, loss of the anterior flare, and then size reduction. (**Plates 71c, 72c, 73d, e, 74b, d, 75b**) illustrate the gradual nature of the change and the difficulty (if not impossibility) of making a sharp separation into lateral and marginal teeth. The marginals themselves are quite variable, and gradually become reduced in size (**Plate 71d, 72f, 74d, 75c**), until the outermost are mere blobs. A good example of these gradual changes in each half row of teeth is given in **Plate 75a.**

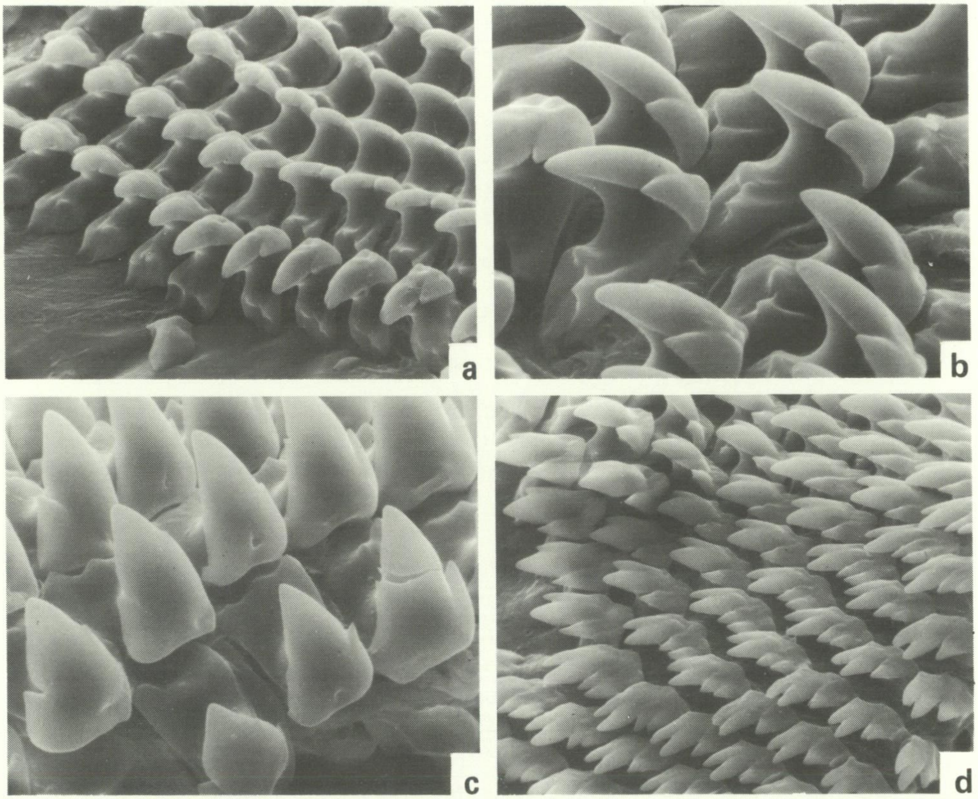

Plate 74: Radular teeth of *Setobaudinia anatispretia,* Sta. WA-680, Victoria Highway, 24.4 km east of Timber Creek Police Station, Northern Territory, FMNH 205153, 14 June 1980, Dissection A: (a) central and early lateral teeth at 672X; (b) late lateral teeth at 1,350X; (c) central and early lateral teeth viewed from above at 680X; (d) early marginals and late laterals at 680X.

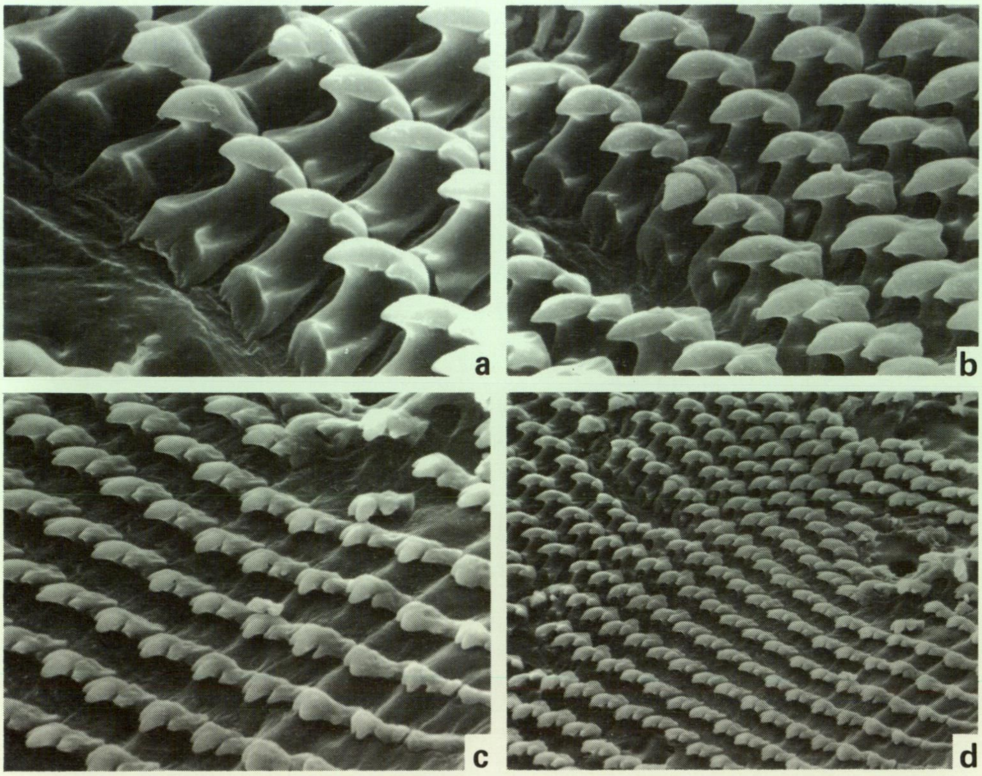

Plate 75: Radular teeth of *Setobaudinia victoriana:* Sta. WA-681, 86 km south-west of Katherine, Northern Territory, FMNH 205163, 2 June 1980, Dissection A: (a) central and early laterals at 1,190X; (b) latero-marginal transition at 1,015X; (c) detail of marginal teeth at 590X; (d) part row of teeth at 355X.

No significant radular differences among species could be detected. This is not surprising, since all *Setobaudinia* are at least micro-allopatric to each other, and they inhabit a region with a both predictable and heavy (750+ mm) wet season. Vegetation growth is lush, there are many days of potential activity following each rain, and thus no selective pressure for feeding specialisation exists. The general pattern of the lateral teeth mesocones in *Setobaudinia* does, however, differ from that of *Amplirhagada* (Solem, in press), and presentation of this data here will permit general discussions elsewhere.

Genitalia – Little data is available on the apical genitalia. All specimens of *Setobaudinia interrex* and *S. doongana* had been fixed and preserved in formalin, with the results that coagulated fluids had mostly destroyed the ovotestis, crystallisation of the albumen gland had obscured details of the carrefour-talon area, and most of the uterine tissue had crystallised and fused with adjacent organs. In a mid-dry season example of *S. doongana* (**Fig. 189c**), the ovotestis is proportionately smaller than in mid-October (very late dry season) *S. hirsuta* (**Fig. 186a**) from the Mitchell Plateau. The latter specimen shows indications of hermaphroditic duct (GD) kinking, whereas this had not started in mid-August examples of *S. interrex* (**Fig. 183a**) from the Prince Regent River. Early dry season (June) examples of *S. victoriana* (**Fig. 193b**) had the ovotestis so reduced that we were able to locate with certainty only one lobe, and the hermaphrodictic duct (**Fig. 193a**, GD) was a nearly straight tube. The pallial genitalia, spermatheca, prostate and uterus, are very slender in almost all dissected materials. Part of this may be due to formalin induced changes, but in the mid-October Mitchell Plateau specimens, there was enormous variation in size of the prostate-uterus. The prostate-uterus size difference between the illustrated *S. calvitia* (**Fig. 185a**) and *S. hirsuta* (**Fig. 186a**) is not a species difference – it reflects individual variation.

Variation in the terminal genitalia is better documented (**Table 77**) and relatively complex. The free oviduct generally is very short, being slightly elongated in both *S. anatispretia* and *S. victoriana* (**Figs 191a, 193a**). Vaginal length varies dramatically among species, the shortest being in the Northern Territory species (**Figs 191a, 193a**), becoming longer in *S. interrex* (**Figs 183a, c**), *S. calvitia* (**Fig. 185a**), and *S. doongana* (**Figs 189a, b**). Vaginal length is reduced in both *S. hirsuta* (**Fig. 186a**) and *S. pagoana* (**Fig. 188a**).

S. victoriana (**Fig. 193a**) is unusual in lacking an epiphallic lobe and in having the epiphallic caecum reduced to a nub. All other species have both structures, although with considerable variation in length. There is no clear geographic pattern to the size variations (**Table 77**). Internally, the caecum (**Figs 185b, 186b, 191b**) has longitudinal ridges, while the main body of the epiphallus and the epiphallic lobe tends towards dense pustules on the wall. There may be a complex, minute valvular entrance of the vas deferens into the epiphallus, but available material did not permit study of this aspect. The epiphallus itself receives the insertion of the vas deferens, reflects to enter the penis sheath (**Fig. 185b**) and then opens into the penis proper.

Penis length and vaginal length are not fully correlated, although there is a general pattern that a species with a long vagina will have a long penis that is about equal in length (**Table 77**). The penis sheath (PS) extends from the insertion of the penial retractor muscle (PR) to just above the atrium (Y). While the penis itself lacks external differentiating features, both the entrance of the epiphallus and the sculpture on the wall of the penis chamber differ significantly.

Setobaudinia anatispretia (**Fig. 191b**) and *S. interrex* (**Fig. 183b**) have large pilasters that flank a simple pore entrance into the penis chamber. *S. victoriana* (**Fig. 193c**) has these pilasters fused to provide a spatulate vergic structure (PV) that is partly free and partly attached. The remaining species have the pilasters formed into a conical verge-like structure. It clearly has evolved from the condition seen in *S. victoriana.* Pilasters have become free of the chamber wall and their edges touch, but do not fuse. Each verge has a groove extending from its base to near its tip **(Figs 189d-e)** and reaching well past the middle of the organ. The epiphallus opens directly into this deep groove. The verge may be elongately tubular **(Fig. 185b)**, almost as wide as it is long **(Fig. 188b)**, large and broad **(Fig. 189d)**, or flattened and with a prominent ridge on the side opposite the groove **(Fig. 186b)**. The latter species, *S. hirsuta,* is probably micro-sympatric with *S. calvitia,* the species with the long, cylindrical verge.

Penis wall chamber sculpture consists basically of either pustules or ridges: the latter may be circular, longitudinal, small, large or varied. Present data suggest that the patterns are species specific. Thus penial wall sculpture combined with vergic structure are the most obvious features involved in species recognition differences.

Inspection of **Table 77** shows that the changes in genital structures do not have geographic linearity. Absence of a verge occurs at the south-west extreme and near the north-east limits; incipient verge *(S. victoriana)* is at the western limit; and full verge is shared by species in the central and northern Kimberley.

Because of limited material, little can be said concerning seasonal variation in the genitalia, and no information on the maturation sequence is available. Only on the Mitchell Plateau are there samples available from both wet and dry seasons. The variation found in *S. calvitia* is summarised under that species, with the data on size variation in the terminal genitalia of both *S. calvitia* and *S. hirsuta* presented in **Table 80.** A hypothesis is presented that both seasonal and habitat correlated differences may be involved, and that there is an additional possibility of micro-geographic variability. Testing of these hypotheses will require considerable additional field work.

Relationships of *Setobaudinia*

Dissection of several Queensland taxa will be required before any synonymization can be attempted, but it will not be surprising if *Trachiopsis* Pilsbry, 1893 and *Setobaudinia* are eventually combined. The genotype of the former, *Trachiopsis tuckeri* (Pfeiffer, 1846) from Sir Charles Hardy's Island, Queensland (11°54′S, 143°26′E) has not been dissected. Two Queensland taxa, *T. strangulata* (Hombron and Jacquinot, 1841) from Torres Strait and *T. mucosa* (Cox, 1868) from the Clarence River, New South Wales, were dissected by Solem (1979: 113-116, figs 25a-d). They both lack the epiphallic lobe that is characteristic of the Western Australian *Setobaudinia* **(Figs 183a, 185a, 186a)**, but this is absent also in the Northern Territory *S. victoriana* **(Fig. 193a)**. Indeed, the genital similarities between *S. victoriana* and *T. strangulata* (Solem 1979: 114, figs 25b-d) are striking, with similar verges, remnant epiphallic caecum, same type of penial sheath, and epiphallic insertion of the penial retractor muscle. Differences are primarily conchological, with *Trachiopsis* having radial microridges and a less complex microsculpture (Solem 1979: 95, pl. 9d-h), the shell lip generally lacks protrusions, and there may be noticeable colour banding. The Western Australian *Setobaudinia* have elongated periostracal setae **(Plates 64-67)**, the shell lip in each species has prominent protrusions, and all shells are monochrome in colour. The Northern Territory *Setobaudinia* are partly transitional, in that *S. anatispretia* **(Plate 68c-f)** has variable setae with extremely broad bases, although the lip protrusions are large **(Figs 190b-d, f, g)**, and the shell colour is monochrome, while *S. victoriana* has intermediate basal buttressing of the setae **(Plate 69a-b)**, reduced lip protrusions **(Figs 192b, c)**, and monochrome colouration.

The typical *Setobaudinia* setae and microridges agree quite well with those found in *Austrochloritis* (Solem 1979: 96, pl. 10b-f). The other Western Australian genus with similar structures is *Damochlora* (Solem 1979: 101-113, figs 22-25, pl. 8a-f), which has the *Trachiopsis* type periostracal sculpture, but very different shell size, shape, umbilical contours, and lip expansion.

Until such time as the many small hirsute 'chloritids' from Queensland and New South Wales can be dissected and their structures evaluated, keeping *Setobaudinia* as a genus for the Western Australian and Northern Territory taxa is warranted. The Queensland *Trachiopsis tuckeri* (Pfeiffer, 1846) differs enough in shell features to make synonymization in the absence of anatomical data questionable. Little would be gained at this time in transferring either or both of the dissected Queensland taxa to *Setobaudinia*. Relationship is highly probable, but demonstration of this requires more material.

Systematic review

The sequence of species is roughly south-west to north-east, except that two undoubtedly new taxa represented by very few specimens are discussed last.

The following key is based upon fully mature adults in which the nature and spacing of the periostracal setae can be observed. It will not work for juveniles, 'new adults', or specimens with the periostracum worn off. Material of that nature should be treated geographically, with size and shape comparisons used to confirm or reject identification with the species recorded nearby. Minimal use has been made of anatomical differences, as most material will consist of dead shells.

Adult size differs dramatically among populations, with vine thickets having larger sized shells than collections from open forest areas. Thus adult size can be misleading in making any comparisons.

KEY TO THE SPECIES OF *SETOBAUDINIA*

1. Parietal wall of aperture with at most a thickened callus, never a raised lip 2

   Parietal wall with raised lip continuous with basal and palatal lips **(Figs 193b, c)** . . . . *Setobaudinia victoriana* sp. nov. (p. 771)

2. Palatal and basal lips strongly indented at junction with parietal wall **(Figs 184f, g, 190b, c)** 3

   Palatal and basal lips merge smoothly into parietal wall callus at junction **(Figs 182b-d)** 4

3. Periostracal setae densely packed and with simple bases **(Plate 66e, f)**; Mitchell Plateau, Kimberley . . . . *Setobaudinia hirsuta* sp. nov. (p. 755)

   Periostracal setae more widely spaced, longer, bases grossly expanded into buttresses **(Plate 68c-f)**; Northern Territory . . . . *Setobaudinia anatispretia* sp. nov. (p. 767)

4. Palatal lip with a prominent node when adult **(Figs 181b, 182b, c, 187b-d)** 5

   Palatal lip with at most a weak node when adult **(Figs 184b-d, 187f-h)** 7

5. Shell large, mean diameter about 9.0 mm, lip narrow; Parry Island, Admiralty Gulf . . . . *Setobaudinia collingii* (Smith, 1893)(p. 737)

   Shell smaller, mean diameter about 7 mm, lip widely expanded; Kimberley mainland 6

6. Umbilicus wider, mean D/U ratio about 3.00; near Kalumburu . . . . *Setobaudinia pagoana* sp. nov. (p. 758)

   Umbilicus narrower, mean D/U ratio about 3.75; Prince Regent River Reserve . . . . *Setobaudinia interrex* sp. nov. (p. 740)

7. Mitchell Plateau; penis chamber wall with pustules, verge elongated **(Fig. 185b)** . . . . *Setobaudinia calvitia* sp. nov. (p. 744)

   Drysdale River Reserve; penis chamber walls with circular ridges, verge very large **(Fig. 189d-e)** . . . . *Setobaudinia doongana* sp. nov. (p. 764)

SETOBAUDINIA COLLINGII (SMITH, 1893)

(Plate 64a-e; Figs 181a-c)

Helix (Gonostoma) collingii Smith, 1893, The Conchologist, **2** (5): 98, figs – Baudin Island, N. W. Australia. Here restricted to Parry Island, Admiralty Gulf (14°19′S, 125°46′E); Smith, 1894, Proc. Malac. Soc. London, **1**: 88.

Planispira (Trachiopsis) collingii (Smith), Pilsbry, 1893, Man. Conch., (2) **8**: 287-288, pl. 58, figs 10-11; Pilsbry, 1894, Man. Conch., (2) **9**: 114.

Planispira collingii (Smith), Hedley, 1916, Jour. Roy. Soc. Western Australia, **1**: 69.

Setobaudinia collingii (Smith), Iredale, 1933, Rec. Australian Museum, **19** (1): 55; Iredale, 1938, Australian Zool., **9** (2): 109 – listing in check list; Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 49-50 – copy of original description and remarks.

Comparative remarks

Setobaudinia collingii (Smith, 1893) is the largest known species, mean diameter 9.00 mm. Lip relatively slightly expanded, basal node weak, palatal node prominent **(Figs 181b-c)**, parietal insertion of both basal and palatal lips without indentation **(Figs 181b-c)**, umbilicus relatively narrow and regularly decoiling **(Fig. 181c)**. Periostracal setae crowded and long, with sharp points and simple bases **(Plate 64c-e)**. *S. hirsuta* from the Mitchell Plateau is noticeably smaller, mean diameter 7.72 mm, with grossly expanded lip that indents at both palatal and basal insertions **(Figs 184f-g)**, shell periphery laterally compressed, and much stronger basal and palatal lip nodes **(Figs 184f-g)**. *S. calvitia* from the Mitchell Plateau has longer, much more widely spaced periostracal hairs **(Plate 66b-c)**, a distinctly angled periphery **(Fig. 184b)**, more evenly decoiling umbilicus **(Fig. 184c)**, very weak lip nodes **(Figs 184b-c)**, and is much smaller **(Table 76)**. *Baudinella baudinensis* (Smith, 1893), from neighbouring Baudin Island, is much smaller, mean diameter 5.88 mm, has strong radial ribs **(Plate 76a-c)**, and very prominent lip nodes **(Plate 76b)**. The undescribed species from Kimbolton is very similar in shell form, although more narrowly umbilicated and with fewer periostracal hairs. *S. interrex* **(Figs 182b-c)** from the Prince Regent River Reserve, *S. pagoana* **(Figs 187b-c)** from near Kalumburu, and *S. anatispretia* **(Figs 190b-c)** from the Northern Territory are immediately differentiated by their very large palatal nodes. *S. victoriana* **(Fig. 192b)** from the Northern Territory has no palatal node and the parietal lip is elevated.

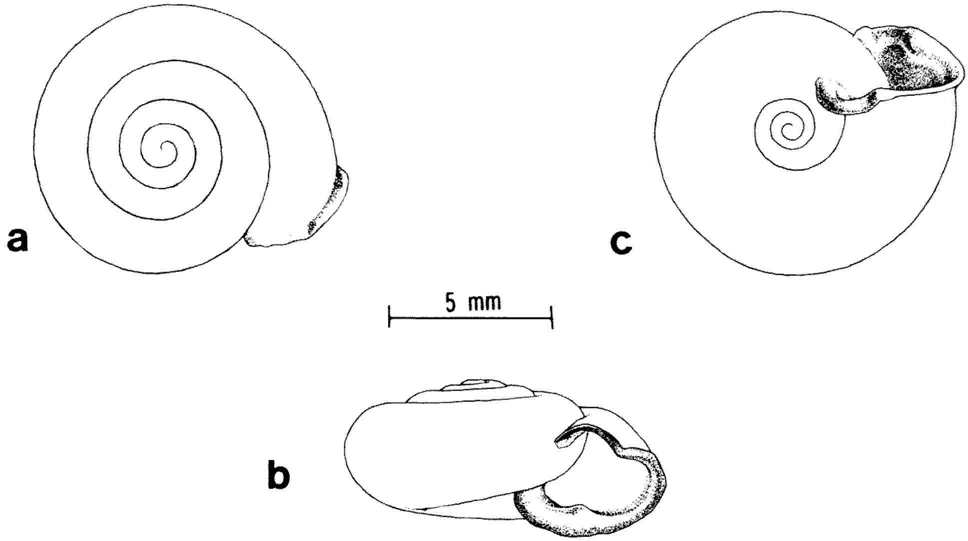

Fig. 181: Shell of *Setobaudinia collingii* (Smith, 1893): Parry Island, Admiralty Gulf, Kimberley, BM(NH) 1892.1.29.175, paratopotype of *Helix (Gonostoma) collingii* Smith, 1893. Scale line equals 5 mm. Drawings by Elizabeth Liebman.

Lectotype

BMNH 1892.1.29.175, Parry Island, Admiralty Gulf, Western Australia (1:100,000 'Admiralty Gulf' map sheet 4069 – grid reference 985:145, 14° 19'S, 125°46'E). Collected by J.J. Walker in 1890. Height of shell 4.9 mm, diameter 9.45 mm, H/D ratio 0.520, whorls 4¼, umbilical width 2.4 mm, D/U ratio 3.84.

Paralectotypes

BMNH 1892.1.29.167-178, 9 dead adults from the type locality.

Type lot or paratypes

Parry Island (6 dead adults, BMNH ex H. Fulton in 1895, SMF 27060/2 ex H. Fulton, FMNH 41696 ex W.F. Webb, G.K. Gude, E.A. Smith).

Diagnosis

Shell very large, diameter 8.15-9.8 mm (mean 9.00 mm), with $4^1/_8$ to $4^5/_8$ (mean $4^3/_8$+) normally coiled whorls. Apex and spire moderately and evenly elevated **(Fig. 181b)**, height of shell 4.3-5.25 mm (mean 4.76 mm), H/D ratio 0.497-0.559 (mean 0.529). Apical sculpture **(Plate 64a)** typical, postapical whorls with a dense cover of long, sharp pointed periostracal setae that have simple bases **(Plate 64c-e)**. Shell periphery rounded, body whorl not descending just before aperture. Lip moderately expanded (**Figs 181b-c**), merging simply into parietal wall. Basal lip with a weak to moderate node, palatal lip with a rather prominent node. Umbilicus (**Fig. 181c**) rather narrow, width 1.9-2.9 mm (mean 2.26 mm), regularly decoiling, D/U ratio 3.19-4.40 (mean 4.01). Colour of pre-1900 museum specimens light yellow horn, base nearly white, lip white. Based on 16 measured adults.

Anatomy unknown.

Remarks

All specimens seen of *Setobaudinia collingii* (Smith, 1893) probably are part of the original, and probably only, sample taken. They came to museums from private collections formed in the 1890s, made by individuals who are known to have traded extensively with E.A. Smith and Hugh Fulton. All have the locality 'Parry Island', rather than the 'Baudin Island' locality cited by Smith (1893). Since no *Setobaudinia* have been taken subsequently on Baudin Island by WAM staff, the label data is accepted over the published locality.

Table 78: Local Variation in *Setobaudinia collingii* (Smith, 1893), *S.* sp. and *S. interrex*

Taxon	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
S. collingii				
BMNH Types	10	4.85±0.085 (4.35–5.25)	9.17±0.147 (8.15–9.8)	0.530±0.006 (0.497–0.559)
Other Specimens	6	4.60±0.083 (4.3–4.85)	8.73±0.164 (8.25–9.25)	0.527±0.006 (0.500–0.542)
S. sp.				
WAM 650.77	5	4.51±0.101 (4.31–4.90)	8.65±0.132 (8.24–8.95)	0.519±0.011 (0.482–0.547)
S. interrex				
E5 (1), WAM 373.75	9D	4.81±0.110 (4.1–5.2)	8.48±0.112 (7.95–8.95)	0.574±0.009 (0.521–0.604)
E5 (7), WAM 473.75	6L	4.10±0.223 (3.3–4.6)	7.15±0.312 (6.05–7.85)	0.571±0.010 (0.550–0.592)
Sta. 1, WAM 610.80	11D	3.37±0.088 (2.9–3.7)	6.37±0.092 (5.9–6.95)	0.530±0.008 (0.481–0.611)
Sta. 1, WAM 338.80	4D	3.09±0.100 (2.8–3.25)	5.93±0.201 (5.35–6.3)	0.521±0.018 (0.471–0.581)
Sta. 2, WAM 360.80, WAM 361.80	13D	3.51±0.088 (2.8–3.9)	6.37±0.150 (5.4–7.15)	0.552±0.009 (0.489–0.592)

Table 78: Local Variation in *Setobaudinia collingii* (Smith, 1893), *S.* sp. and *S. interrex* (continued)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
S. collingii				
BMNH Types	10	4½ (4¼–4⅝)	2.28±0.074 (1.9–2.6)	4.05±0.067 (3.73–4.40)
Other Specimens	6	4⅜– (4⅛–4⅜+)	2.25±0.143 (2.0–2.9)	3.93±0.172 (3.19–4.39)
S. sp.				
WAM 650.77	5	4⅜+ (4⅛–4¾)	1.91±0.043 (1.76–2.03)	4.56±0.123 (4.26–4.93)
S. interrex				
E5 (1), WAM 373.75	9D	4½– (4¼–4½+)	2.14±0.088 (1.7–2.55)	4.00±0.142 (3.51–4.88)
E5 (7), WAM 473.75	6L	4¼– (4–4⅜)	1.83±0.058 (1.7–2.05)	3.91±0.159 (3.50–4.47)
Sta. 1, WAM 610.80	11D	4⅛+ (4– –4⅜)	1.80±0.052 (1.5–2.0)	3.57±0.100 (3.26–4.09)
Sta. 1, WAM 338.80	4D	4⅛– (4– –4⅛)	1.66±0.088 (1.5–1.85)	3.59±0.172 (3.31–4.07)
Sta. 2, WAM 360.80, WAM 361.80	13D	4⅛+ (4– –4¼+)	1.73±0.059 (1.4–2.1)	3.72±0.128 (2.83–4.50)

The measurements in **Table 78** suggest that, as was customary in earlier times, slightly smaller examples were 'traded' and slightly larger examples kept by the describer of a species. No test of statistical significance has been attempted in view of this historical fact.

The relatively narrow lip of *Setobaudinia collingii* **(Figs 181b-c)** and large size are its main distinguishing features.

SETOBAUDINIA INTERREX SP. NOV.
(Plates 65a-d, 70a, 71; Figs 182a-d, 183a-c)

Comparative remarks

Setobaudinia interrex is average in size, mean diameter 7.20 mm, with a regularly decoiling umbilicus **(Fig. 182c)**, rounded periphery **(Fig. 182b)**, prominent lip nodes **(Figs 182c-d)**, and broadly expanded palatal and basal lips that do not indent at the parietal wall **(Fig. 182c)**. Periostracal setae long, sharp tipped, and rather widely spaced **(Plate 65a, c, d)**. Both epiphallic lobe (EL) and caecum (EC) prominent (**Figs 183a, c**). Apex of the penis with complex pilasters that do not form a functioning verge, walls of penis chamber with low, indistinct ridged sculpture. *Baudinella regia*, which often is sympatric with *S. interrex*, has shorter and more widely spaced periostracal setae (**Plate 77c-d**), prominent radial ribs on the shell (**Figs 194d-f, Plate 77a**), very large lip nodes, a grossly expanded lip (**Figs 194e-f**), a somewhat higher spired shell (**Table 76**), and grossly different anatomy (**Fig. 196a**). Both Mitchell Plateau species, *S. calvitia* and *S. hirsuta*, differ in having conical verges (**Figs 185b, 186b**). *S. calvitia* has an angulated body whorl (**Fig. 184b**), much weaker palatal lip nodes (compare **Figs 182b-d** and **184b-d**) and less expanded lip. *S. hirsuta* has larger, much more densely packed setae (**Plate 66e-f**), more prominent lip nodes (**Figs 184f-g**), and there is gross indentation of both the palatal and basal lips at their junction with the parietal wall. The Kimbolton material has a much larger shell, diameter 8.65 mm, weaker lip nodes, and is narrowly umbilicated. *S. pagoana* and *S. doongana* have cylindrical verges, plus both lip and setal differences. Both *S. anatispretia* and *S. victoriana* have the bases of the setae broadened into buttresses (**Plates 68a-f, 69a-b**) and show significant anatomical differences – the former has greatly elongated epiphallic lobe (EL) and caecum (EC) plus a very short vagina (V) (**Fig. 191a**); the latter has a modified vergic papilla (**Fig. 193c**).

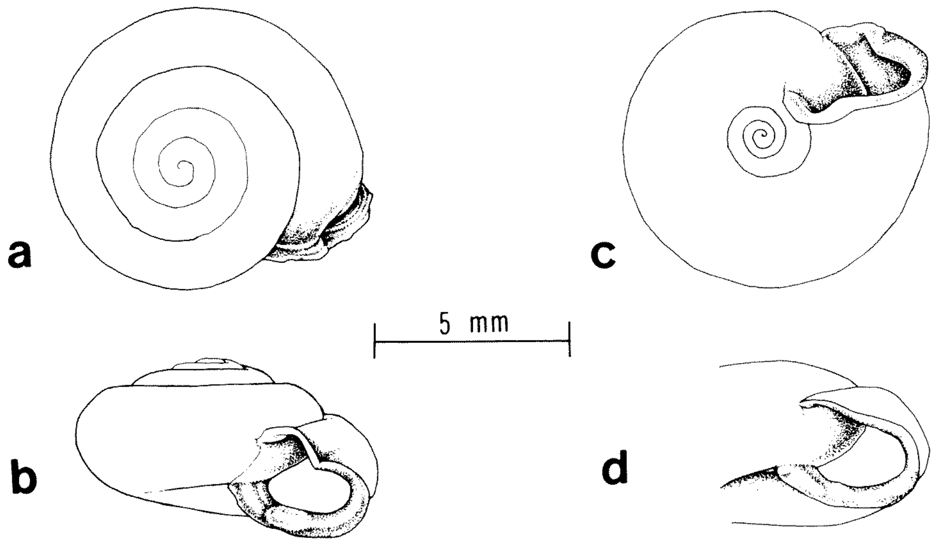

Fig. 182: Shell of *Setobaudinia interrex:* (a-c) Sta. E5 (1), Prince Regent River Reserve, Kimberley, WAM 616.80, holotype; (d) Sta. E5 (1), Prince Regent River Reserve, Kimberley, WAM 373.75, subadult paratopotype. Scale line equals 5 mm. Drawings by Linnea Lahlum.

Holotype

WAM 616.80, Sta. E5 (1), small gully at north-east corner of main gorge below Enid Falls, Rufous Creek, Roe River, Prince Regent River Reserve, Kimberley, Western Australia (1:250,000 'Prince Regent' map sheet SD 51-16 – grid reference 348:086). Collected by B.R. Wilson and Peter Smith 14 August 1974. Height of shell 4.65 mm, diameter 8.6 mm, H/D ratio 0.541, whorls 4½, umbilical width 2.0 mm, D/U ratio 4.30.

Paratopotypes

WAM 373.75, WAM 472.75, WAM 477.75, FMNH 209034, 7 live and 8 dead adults, 3 live juveniles from the type locality.

Paratypes

Prince Regent River Reserve (all specimens collected in August 1974): Sta. E1, upper Prince Regent River (15°49'S, 125°37'E) (1 dead juvenile, WAM 249.75, collected by K.T. Richards 22 August 1974); Sta. E5 (6), eastern end of deep gully about 2 km due west of Enid Falls ('Prince Regent' SD 51-16 – 344:085) (3 dead adults, 3 dead juveniles, WAM 369.75, collected 17 August 1974); Sta. E5 (7), below opening of deep gully about 3 km west of Enid Falls ('Prince Regent' SD 51-16 – 343:085) (3 dead adults, WAM 473.75, WAM 612.80 collected 17 August 1974); Sta. E5 (9), west slope of valley of northern tributary of Rufous Creek ('Prince Regent' SD 51-16 – 346:088) (4 dead adults, 34 dead juveniles, WAM 376.75, WAM 645.77, FMNH 209035 collected 18 August 1974); Sta. E5 (10), near spring feeding northern tributary of Rufous Creek ('Prince Regent' SD 51-16 – 346:089) (1 dead adult, 1 dead juvenile, WAM 251.75, WAM 367.76 collected 18 August 1974); Sta. W4 (1), scree slopes below eastern face of Mt. Trafalgar (15°17'S, 125°04'E), Saint George Basin, Prince Regent River estuary (6 dead adults, 3 dead juveniles, WAM 374.75 collected 26 August 1974); Sta. W4 (4), scree slopes of Mt. Trafalgar ('Prince Regent' SD 51-16 – 291:068) (1 live, 2 dead adults, 6 dead juveniles, WAM 350.75, WAM 375.75, WAM 471.75 collected 27 August 1974); Sta. W5, Python Cliffs (15°20'S, 124°56'E), Saint George Basin, Prince Regent River estuary (1 live, 1 dead adult, WAM 368.75, WAM 469.75).

Prince Regent River Reserve (all specimens collected in July 1977): Sta. 1, west bank Roe River (15°15'S, 125°33'E), Prince Regent River Reserve (11 dead adults, 3 dead juveniles, WAM 338.80, WAM 610.80, FMNH 209037); Sta. 2, island, north side mouth of Roe River estuary (15°06'S, 125°21'E), Prince Frederick Harbour (13 dead adults, 5 dead juveniles, WAM 360.80, WAM 361.80, FMNH 209036); north side mouth of Hunter River estuary (15°02'S, 125°21'E), Prince Frederick Harbour (2 dead adults, WAM 340.80); north of mouth of Hunter River estuary (15° 02'S, 125°23'E) (2 dead adults, 1 dead juvenile, WAM 354.80, WAM 355.80, WAM 364.80).

Beverley Springs Station: 270° from Forward Fuel Dump (see Miles and Burbidge 1975: 11-12) (3 dead adults, WAM 371.75 collected 12 August 1974); north of Beverley Springs Station (1 dead adult, WAM 370.75 collected 12 August 1974).

Diagnosis

Shell average in size, diameter 5.35-8.95 mm (mean 7.20 mm), with 3⅞ to 4⅝ (mean 4¼) normally coiled whorls. Apex and spire generally moderately and evenly elevated **(Fig. 182b)**, height of shell 2.8-5.2 mm (mean 3.88 mm), H/D ratio 0.470-0.627 (mean 0.538). Apical sculpture **(Plate 65a)** typical, postapical whorls **(Plate 65b-d)** with long, rather widely spaced, sharp pointed periostracal setae with simple bases. Shell periphery rounded, body whorl not descending significantly. Lip strongly expanded

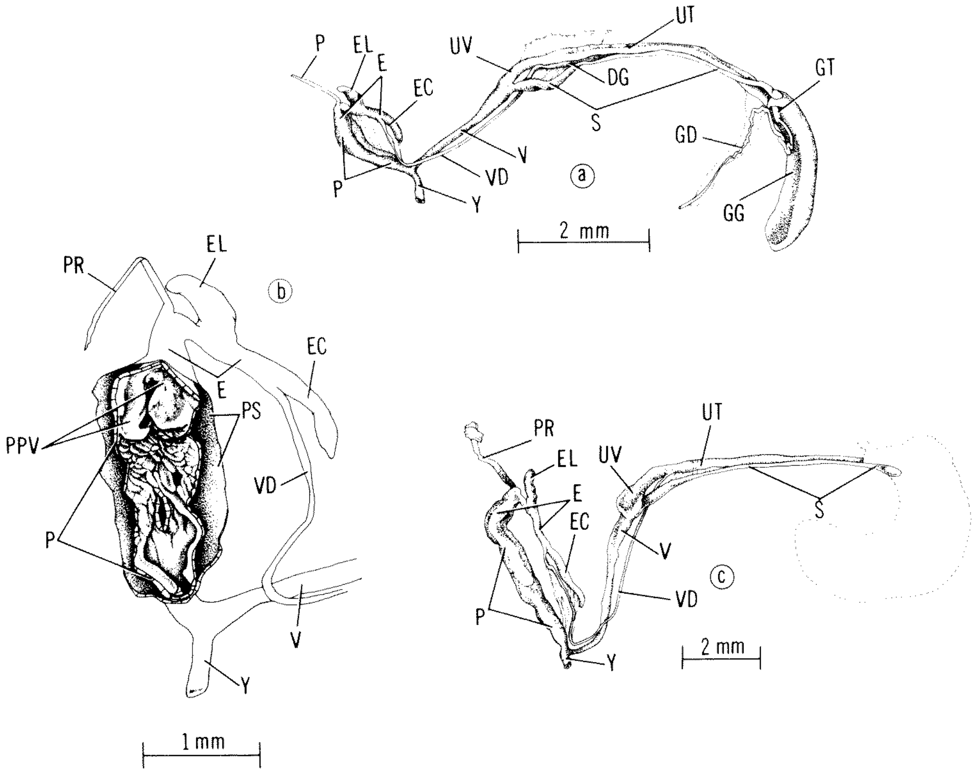

Fig. 183: Genitalia of *Setobaudinia interrex:* (a-b) Sta. E5 (1), Prince Regent River Reserve, Kimberley, WAM 472.75, 14 August 1974, Dissection A, (a) whole genitalia, (b) interior of penis; (c) Sta. W4 (4), Prince Regent River Reserve, WAM 471.75, 26 August 1974, Dissection A, whole genitalia. Scale lines as marked. Drawings by Linnea Lahlum.

(**Figs 182b-c**), merging smoothly into parietal wall. Basal lip with moderate node, palatal lip with a large node. Umbilicus (**Fig. 182c**) average, regularly decoiling, width 1.15-2.6 mm (mean 1.93 mm), D/U ratio 2.83-5.22 (mean 3.77). Periostracal colour dark yellow-brown, lighter on base, lip white. Based on 73 measured adults.

Genitalia (**Figs 183a-c**) typical, with long vagina (V) and penis complex. Epiphallic lobe (EL) shorter (**Figs 183a-b**) than in most species, apex of penis chamber (**Fig. 183b**) with large pilasters, but no verge. Walls of penis chamber with vague ridges. Based on five dissected adults.

Remarks

Setobaudinia interrex and *Baudinella regia* share the same basic distribution in the Prince Regent River Reserve. Hence recognising the rather smooth surfaced, although more hirsute, larged sized 'regent' *(interrex)* compared with the distinctly more ornamented, although smaller, 'prince' *(regia)*, seemed reasonably appropriate.

Size and shape variation of *Setobaudinia interrex* is extensive (**Table 78**), with the diameter increase resulting from a higher whorl count. It is not possible to indicate ecological differences that might correlate with this variation. Actual sympatry with *Baudinella regia* is fairly extensive, with examples of both species collected as Stas E5 (1), E5 (7), E5 (10), and W4 (4) of the 1974 WAM survey, and Stas 1 and 2 of Barry Wilson's 1977 trip. At only three stations are the specimens numbers large enough that the possibility of covariation can be addressed. The limited data is:

Station	*S. interrex*			*B. baudinensis*		
	No.	Mean Diameter	Mean Whorls	No.	Mean Diameter	Mean Whorls
E5 (1)	9	8.48	4 1/2–	35	7.53	4 1/4–
E5 (2)	6	7.15	4 1/4–	4	7.51	4 1/4+
Sta. 1	11	6.37	4 1/8+	10	6.92	4 3/8–

There is no pattern and it is quite probable that no covariation exists.

The two inland records for *Setobaudinia interrex* are not precisely localised as their label data was not sufficient to provide geographic coordinants.

SETOBAUDINIA CALVITIA SP. NOV.

(Plates 66a-c, 72a-c; Figs 184a-c, 185a-c)

Comparative remarks

Setobaudinia calvitia is average in size and shape, with an angulated periphery (**Fig. 184b**), normally decoiling umbilicus (**Fig. 184c**), rather

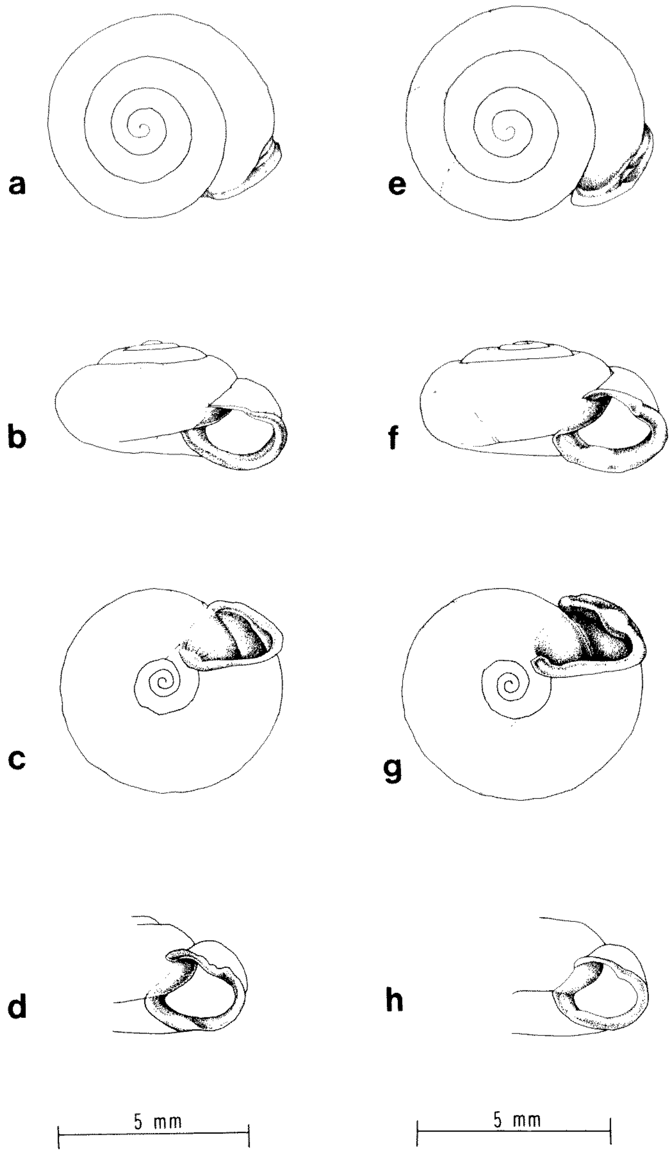

Fig. 184: Shells of *Setobaudinia calvitia* and *S. hirsuta:* (a-d) *S. calvitia,* (a-c) Sta. WA-384, Mitchell Plateau, Kimberley, WAM 623.80, holotype, (d) Sta. WA-203, Mitchell Plateau, WAM 626.80, subadult paratopotype; (e-h) *S. hirsuta,* Sta. WA-390, Mitchell Plateau, (e-g) WAM 624.80, holotype, (h) WAM 625.80, subadult paratype. Scale lines equal 5 mm. Drawings by Linnea Lahlum.

small lip nodes and lip expansion (**Figs 184b-d**), and fairly prominent descensions of last part of body whorl (**Fig. 184b**). Palatal and basal lips do not indent at their junction with parietal wall (**Fig. 184c**). Periostracal setae long and widely spaced, with sharp points and simple bases (**Plate 66b-c**). Epiphallic lobe (EL) and vagina (V) long (**Figs 185a-c**). Verge quite elongated and slender, walls of penis chamber with pustulose sculpture (**Fig. 185b**). The other Mitchell Plateau species, *S. hirsuta,* is larger, shell periphery rounded, lip grossly expanded with sharp indentations at parietal wall (**Fig. 184g**), and lip nodes very prominent (**Figs 184b-c**). Its periostracal setae are much shorter and densely packed (**Plate 66d-f**). Anatomically, *S. hirsuta* has epiphallic lobe (EL) and vagina (V) much shorter (**Fig. 186a**), verge (PV) short, broad, side opposite gutter with longitudinal ridge. Penis chamber wall with ridged, not pustulose, sculpture (**Fig. 186b**). *S. collingii* (Smith, 1893) from Parry Island, Admiralty Gulf, is much larger, mean diameter 9.00 mm, has a somewhat narrower umbilicus (**Fig. 181c**), less expanded lip with weaker nodes (**Fig. 181b**), and more densely packed periostracal setae (**Plate 64c-e**). *S. interrex* from the Prince Regent River Reserve is very similar in size and shape, but lacks the body whorl descension, has much more prominent lip nodes and expanded lip (**Figs 182c-d**). *S. interrex* differs most significantly in its lack of a verge and presence of ridged, rather than pustulose, penis chamber wall sculpture (**Fig. 183b**). *S. pagoana* differs in its very strong lip nodes (**Fig. 187b**), smaller size, and more widely open umbilicus, while *S. doongana* has reduced lip nodes (**Fig. 187f-h**) and very different penis structures (**Figs 189d-e**). *S. anatispretia* and *S. victoriana* differ most obviously in the buttressed bases of their periostracal setae.

Holotype

WAM 623.80, Sta. WA-384, vine thicket south-west of WA-213 stream, west of 'drop-off' camp area, Mitchell Plateau, Kimberley, Western Australia (1:100,000 'Warrender' map sheet 4068 – grid reference 006:812, ca 14°38'S, 125°48'E). Collected by L. Price and C. Christensen 12 March 1977. Height of shell 3.5 mm, diameter 6.0 mm, H/D ratio 0.525, whorls 4⅛, umbilical width 1.5 mm, D/U ratio 4.00.

Paratopotypes

WAM 640.80, WAM 641.80, FMNH 200002, FMNH 200006, 5 live, 4 dead adults, 5 live juveniles from the type locality.

Paratypes

Mitchell Plateau (WAM staff collections): vine thicket ca 1 km past AMAX Crusher on road to Mitchell River (15 live adults, 1 live juvenile, WAM 371.80, FMNH 209046 collected 4 November 1976); Sta. MP 1, open woodland ca 2.5 km west of AMAX Crusher (7 dead adults, 7 dead juveniles, WAM 408.77, collected 22 August 1975); Sta. MP 3b, 300 m from track, south-east ('Warrender' 4068 – 022:537) (3 dead adults, 19 dead juveniles, WAM 411.77, collected by Shirley Slack-Smith 23 August 1975); Sta. MP 1, under bauxite boulders, ca 1 km past AMAX Crusher on road to Mitchell River (16 live adults, 1 live juvenile, WAM 378.80, FMNH 209047, collected 22 August 1975); Sta. MP 5, top of hillside facing north-west, edge of vine thicket under boulders (5 dead adults, 1 dead juvenile, WAM 397.77, collected 23 August 1975); Sta. 1, basalt outcrop, near AMAX Crusher ('Warrender' 4068 – 018:535) (2 dead adults, 11 dead juveniles, WAM 400.77, collected 23 August 1975); Sta. 1, Warrender Road, 6 km north of Surveyor Pool turnoff, open eucalypt woodlands under lateritic boulders (23 live adults, WAM 372.80, FMNH 209048, collected 3 November 1976); Sta. 3, ca 250-300 meters south-east from road (38 live adults, WAM 377.80, collected 23 August 1975); Crystal Creek guaging station (1 dead adult, 1 dead juvenile, WAM 348.80, collected 30 October 1976); Sta. 3, Crystal Creek at base of baobab tree (3 dead adults, 1 dead juvenile, WAM 333.80, collected 2 November 1976); Port Warrender Bay (1 dead adult, WAM 319.80, collected 29 October 1976); Walsh Point (4 live adults, 2 live juveniles, WAM 373.80, collected 25 October 1976); south side Walsh Point (29 dead adults, 5 dead juveniles, WAM 346.80, FMNH 209049, collected 2 October 1976); Sta. 7, north side Walsh Point, 10 live adults, 13 dead juveniles, WAM 339.80, WAM 374.80, collected 30 October 1976); north side Walsh Point (3 dead adults, 1 dead juvenile, WAM 334.80, collected 28 October 1976); Walsh Point (10 dead adults, 5 dead juveniles, WAM 344.80, collected 28 October 1976).

Mitchell Plateau (FMNH surveys, WA-201-4, WA-207, WA-212, WA-221 collected by Alan Solem October 1976; WA-383, WA-394, WA-399, collected by L. Price and C. Christenson mid-March 1977): Sta. WA-201, 'drop-off' camp area, Port Warrender Road ('Warrender' 4068 – 011:813) (3 live, 75 dead adults, 3 dead juveniles, WAM 633.80, WAM 634.80, FMNH 199553, FMNH 199557, FMNH 199994, FMNH 200030, FMNH 200372-3); WA-202, 2nd line of boulders east of Port Warrender-AMAX Camp road ('Warrender' 4068 – 014:814) (2 live, 2 dead adults, 1 live juvenile, FMNH 200378-9); Sta. WA-203, fissures in creek-side boulders, east of Port Warrender-AMAX Camp road ('Warrender' 4068 – 016:811) (8 live, 3 dead adults, WAM 626.80, WAM 635.80, FMNH 200383, FMNH 200385); Sta. WA-204, vine thicket, 1.6 km along Crystal Creek Road ('Warrender' 4068 – 005:887) (6 live, 18 dead adults, WAM 636.80, WAM 637.80, FMNH 199563, FMNH 199811, FMNH 200387, FMNH 200397, FMNH 200407, FMNH 200417, FMNH 200422); Sta. WA-207, Walsh Point, Port Warrender ('Warrender' 4068 – 066:875) (3 live, 12 dead adults, 7 dead juveniles, WAM 638.80, FMNH 199520, FMNH 200339); Sta. WA-212, vine thicket at west end of WA-201 gully ('Warrender' 4068 – 007:813) (11 live, 49 dead adults, 4 live, 1 dead juvenile, WAM 639.80, FMNH 200073, FMNH 200075, FMNH 200451, FMNH 200459-60, FMNH 200463, FMNH

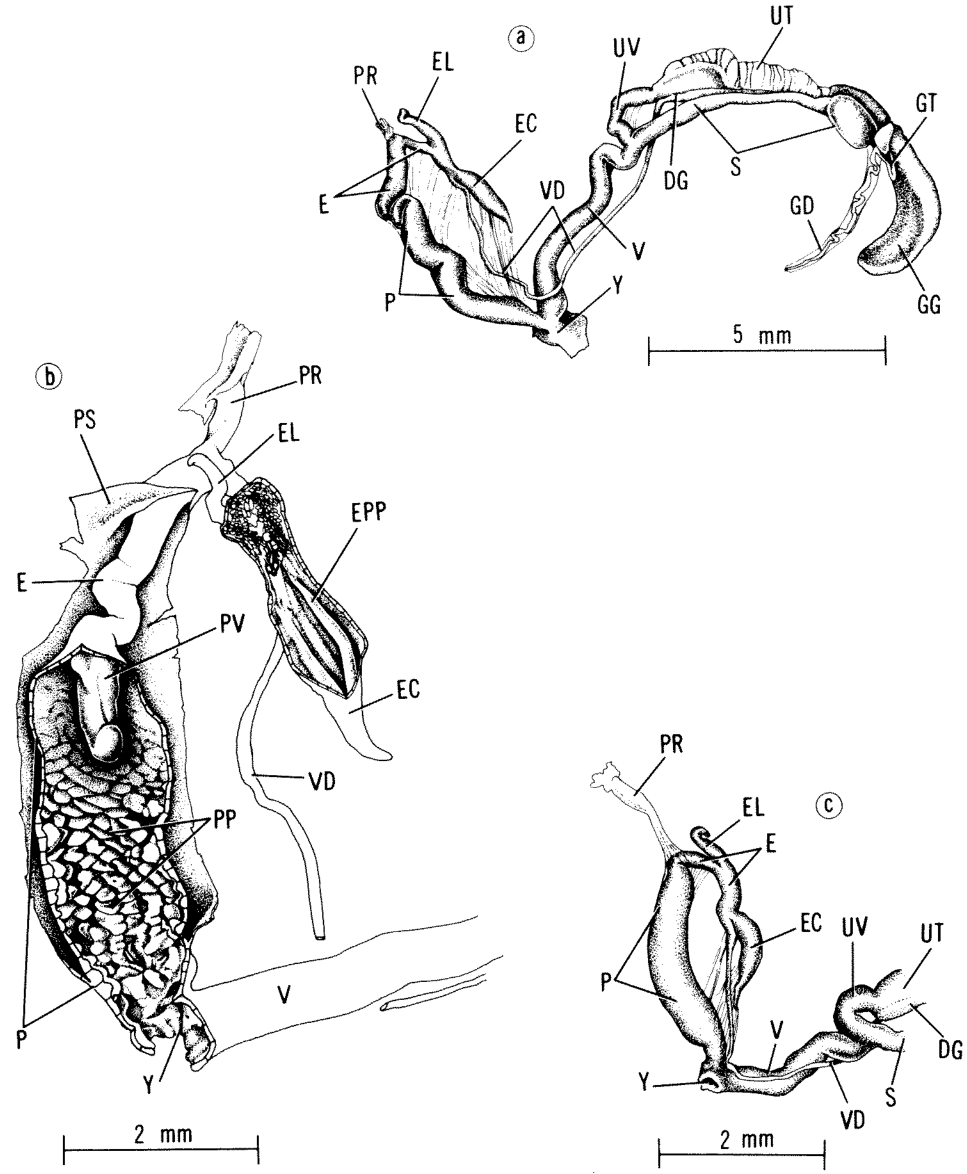

Fig. 185: Genitalia of *Setobaudinia calvitia:* (a-b) Sta. WA-384, Mitchell Plateau, Kimberley, FMNH 200006, 12 March 1977, (a) Dissection B, whole genitalia; (b) Dissection A, interior of penis and epiphallus; (c) Sta. WA-201A, Mitchell Plateau, FMNH 200373, 15-16 October 1976, Dissection A, terminal genitalia. Scale lines as marked. Drawings by Linnea Lahlum.

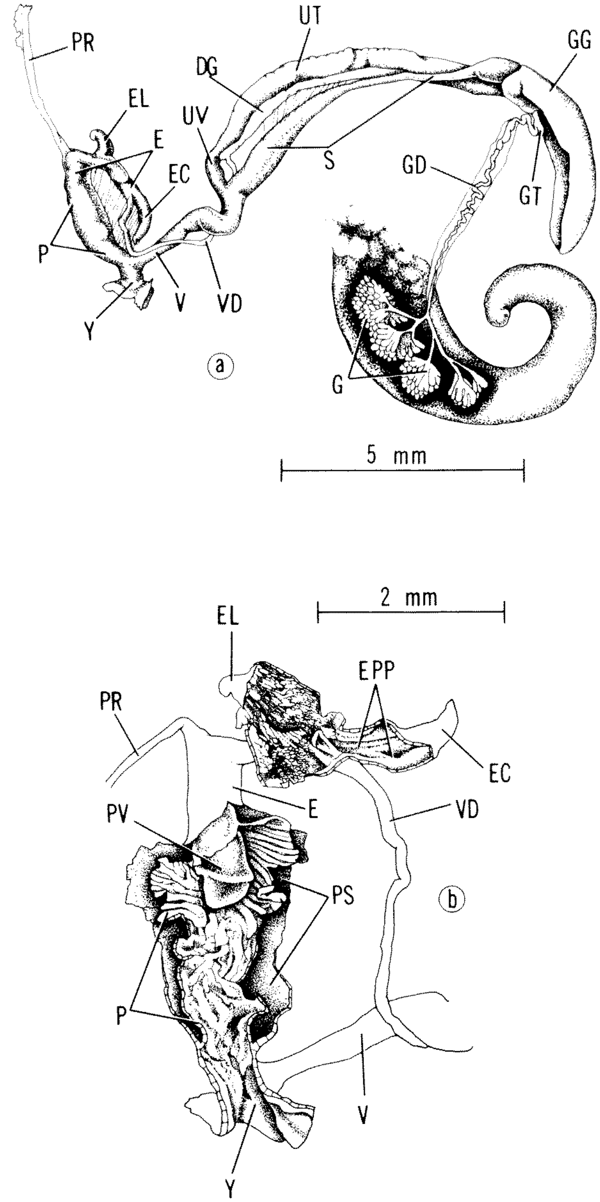

Fig. 186: Genitalia of *Setobaudinia hirsuta:* Sta. WA-206, Mitchell Plateau, Kimberley, FMNH 200438, 18 October 1976, Dissection A, (a) whole genitalia, (b) interior of penis and epiphallus. Scale lines as marked. Drawings by Linnea Lahlum.

200468, FMNH 200784); Sta. WA-221, single rock pile at WA-201 gully base, 'drop-off' camp area ('Warrender' 4068 – 007:813) (3 dead adults, FMNH 200567, FMNH 205375); Sta. WA-383, ca 10 m uphill from WA-212, drop-off area ('Warrender' 4068 – 007:813) (1 dead adult, FMNH 199975); Sta. WA-394, sandstone boulders, south-east side Crystal Creek, north-east of road, 8.2 km from Walsh Point Road ('Warrender' 4068 – 001:946) (2 live, 1 dead adult, FMNH 199353, FMNH 200012); Sta. WA-399, sandstone rocks and baobab tree above Crystal Creek guaging station ('Warrender' 4068 – 013:965) (3 live adults, FMNH 199819).

Other areas: Sta. 4, Gibb River-Kalumburu Road, 6 km north of Hair Creek ('Couchman' 4167 – 990:125) (3 dead adults, 4 dead juveniles, WAM 403.77, FMNH 209050, collected by Barry R. Wilson and Shirley Slack-Smith 22 August 1975).

Diagnosis

Shell of average size, diameter 5.5-9.4 mm (mean 6.90 mm), with 3⅝ to 4¾ (mean 4¼) normally coiled whorls. Apex and spire usually strongly elevated **(Fig. 184b)**, height of shell 2.8-5.6 mm (mean 3.67 mm), H/D ratio 0.423-0.648 (mean 0.531). Apical sculpture **(Plate 66a)** typical, postapical whorls **(Plate 66b-c)** with widely spaced, long, pointed periostracal setae with simple bases. Shell periphery weakly angulated, body whorl descending moderately behind aperture. Lip moderately expanded **(Figs 184a-d)**, merging simply into parietal wall. Basal lip with a weak or reduced node, palatal lip with a reduced node. Umbilicus **(Fig. 184c)** relatively open, regularly decoiling, width 1.3-2.6 mm (mean 1.98 mm), D/U ratio 2.63-5.67 (mean 3.51). Periostracal colour dark yellow-brown, base somewhat lighter, lip white. Based on 377 measured adults.

Genitalia **(Figs 185a-c)** typical of genus, unusual only in the narrow, elongated verge **(Fig. 185b)** and penis wall chamber sculpture of prominent pustules **(Fig. 185b)**. Based on dissection of 12 adults.

Remarks

Setobaudinia calvitia was the most commonly collected species on the Mitchell Plateau, with 377 measured adults compared with 137 for the somewhat larger sized *S. hirsuta*. The names for these species relate to their 'pelts', the densely packed but shorter setae of *S. hirsuta* **(Plate 66e)** contrasting with the almost bald appearing *S. calvitia* with its widely spaced, long, setae **(Plate 66b)**.

Variation in both shell and genitalia was extensive. **Table 79** summarizes part of the shell variation. The vine thicket collections from Stas WA-204, WA-212, WA-384 and Sta. 1 (WAM 371.80) include the larger individuals, with mean diameters, respectively, of 6.93, 7.08 and 7.22, 6.89, and 8.62 mm. The vine thickets at WA-204 and WA-384 were both very small in size, whereas the others were quite large. The smallest specimens, Sta. WA-203, came from fissured boulders by a stream, where small size would be an advantage. They averaged 6.45 mm in diameter, with 4¼− whorls, compared to the 8.62 mm and 4⅜+ whorls for the largest sized population (WAM 371.80). The diameter shift results from the change in whorl number, which is caused by a difference in growth cessation. The vine thickets remain moist longer than do the open woodlands, thus increased activity time and opportunity for growth is available to snails within the vine thickets.

Table 79: Local Variation in *Setobaudinia calvitia* and *S. hirsuta*

Taxon	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
S. calvitia				
WA-201, FMNH 199557	23D	3.47±0.060 (2.95–4.1)	6.62±0.048 (6.25–7.2)	0.523±0.005 (0.463–0.609)
WA-201, FMNH 200030	9L	3.31±0.072 (3.0–3.75)	6.85±0.103 (6.3–7.25)	0.483±0.008 (0.465–0.517)
WA-201, FMNH 199553	50D	3.58±0.042 (2.95–4.2)	6.83±0.046 (6.15–7.7)	0.524±0.005 (0.451–0.609)
WA-203, FMNH 200383	8L	3.27±0.062 (3.0–3.5)	6.45±0.108 (6.0–6.9)	0.507±0.010 (0.469–0.543)
WA-204, FMNH 199563	17D	3.96±0.055 (3.7–4.5)	6.93±0.086 (6.2–7.45)	0.573±0.011 (0.497–0.643)
WA-207, FMNH 200339	15L	3.67±0.079 (3.25–4.2)	6.85±0.131 (6.3–8.1)	0.536±0.010 (0.463–0.609)
WA-212, FMNH 200460	11L	3.85±0.089 (3.4–4.25)	7.22±0.138 (6.5–7.9)	0.534±0.008 (0.487–0.592)
WA-212, FMNH 200463	37L	4.02±0.045 (3.5–4.6)	7.08±0.056 (6.5–7.8)	0.568±0.005 (0.529–0.648)
WA-384, FMNH 200006	11L	3.61±0.096 (3.25–4.1)	6.89±0.147 (6.2–7.65)	0.524±0.010 (0.465–0.591)
MP–1, WAM 378.80	16L	3.44±0.054 (3.0–3.7)	7.09±0.093 (6.55–7.7)	0.486±0.007 (0.453–0.545)
Sta. 3, WAM 377.80	38L	3.25±0.042 (2.8–4.0)	6.43±0.090 (5.7–8.0)	0.507±0.005 (0.438–0.580)
Sta. 7, WAM 374.80	10L	3.47±0.092 (3.05–4.0)	6.44±0.066 (6.1–6.8)	0.538±0.013 (0.484–0.602)
Sta. 7, WAM 371.80	15L	4.99±0.091 (4.35–5.6)	8.62±0.119 (7.85–9.4)	0.580±0.008 (0.521–0.634)
Walsh Point, WAM 344.80	10D	3.58±0.092 (3.1–4.1)	6.73±0.092 (6.1–7.15)	0.533±0.012 (0.456–0.586)
Walsh Point, WAM 346.80	29D	3.49±0.059 (3.05–4.15)	6.59±0.073 (5.65–7.5)	0.529±0.006 (0.484–0.615)
Warrender Road, WAM 372.80	23L	3.53±0.068 (3.0–4.05)	6.90±0.092 (6.2–7.8)	0.511±0.005 (0.470–0.555)

Table 79: Local Variation in *Setobaudinia calvitia* and *S. hirsuta* (continued)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
S. hirsuta				
WA-206, FMNH 200438	5L	4.99±0.134 (4.55–5.35)	8.64±0.144 (8.4–9.2)	0.577±0.010 (0.541–0.606)
WA-206, FMNH 200437	10D	5.07±0.109 (4.75–5.75)	8.50±0.173 (7.75–9.35)	0.597±0.012 (0.542–0.680)
WA-210, FMNH 200445	22D	3.69±0.060 (3.0–4.1)	7.07±0.083 (6.15–7.8)	0.522±0.007 (0.441–0.594)
WA-390, FMNH 199973	12L	3.52±0.098 (3.15–4.15)	7.08±0.095 (6.6–7.7)	0.497±0.012 (0.441–0.572)
WA-391, FMNH 199804	15L	3.66±0.099 (2.9–4.6)	7.39±0.146 (5.85–8.1)	0.495±0.009 (0.439–0.568)
WA-397 FMNH 199834	6L	4.06±0.105 (3.7–4.4)	8.28±0.133 (7.7–8.5)	0.490±0.007 (0.470–0.518)
Sta. 3, Crystal Creek, WAM 376.80	13L	3.69±0.102 (3.0–4.15)	7.36±0.112 (6.35–8.0)	0.501±0.011 (0.432–0.585)
near Crusher, WAM 406.77	8D	4.70±0.263 (4.35–5.1)	7.83±0.139 (7.3–8.4)	0.600±0.008 (0.567–0.637)
Sta. 4, WAM 399.77	25D	4.84±0.078 (4.1–5.7)	8.28±0.090 (7.6–9.4)	0.585±0.007 (0.513–0.663)
Lawley River, WAM 349.80	6D	4.32±0.180 (3.7–4.85)	8.81±0.218 (8.15–9.4)	0.490±0.014 (0.447–0.527)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
S. calvitia				
WA-201, FMNH 199557	23D	4⅛+ (4– –4½–)	2.03±0.043 (1.75–2.5)	3.28±0.059 (2.76–3.67)
WA-201, FMNH 200030	9L	4¼ (4–4½+)	2.04±0.058 (1.75–2.3)	3.37±0.064 (3.08–3.60)
WA-201, FMNH 199553	50D	4¼ (4–4½+)	2.03±0.026 (1.6–2.45)	3.38±0.034 (2.85–4.13)
WA-203, FMNH 200383	8L	4¼– (4–4⅜–)	1.99±0.055 (1.8–2.25)	3.25±0.066 (2.89–3.45)
WA-204, FMNH 199563	17D	4¼+ (4⅛– –4½)	1.94±0.054 (1.6–2.4)	3.60±0.083 (2.83–4.15)
WA-207, FMNH 200339	15L	4¼+ (4⅛–4½)	2.06±0.039 (1.8–2.3)	3.34±0.081 (2.93–4.05)
WA-212, FMNH 200460	11L	4⅜– (4⅛– –4½)	2.08±0.065 (1.7–2.5)	3.50±0.092 (3.00–4.18)

Table 79: Local Variation in *Setobaudinia calvitia* and *S. hirsuta* (continued)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
WA-212, FMNH 200463	37L	4¼ (4–4½)	1.94±0.028 (1.6–2.3)	3.67±0.045 (3.13–4.25)
WA-384, FMNH 200006	11L	4¼– (4–4½)	1.99±0.084 (1.6–2.4)	3.50±0.104 (2.83–4.03)
MP–1, WAM 378.80	16L	4½ (4⅛––4⅝–)	2.03±0.044 (1.8–2.5)	3.50±0.076 (2.88–4.16)
Sta. 3, WAM 377.80	38L	4⅛+ (3⅝–4½+)	1.99±0.036 (1.3–2.5)	3.25±0.052 (2.9–4.62)
Sta. 7, WAM 374.80	10L	4¼ (4⅛–4½)	1.91±0.039 (1.7–2.15)	3.38±0.056 (3.16–3.71)
Sta. 7, WAM 371.80	15L	4⅜+ (4¼–4¾)	1.73±0.037 (1.5–2.0)	5.00±0.098 (4.37–5.67)
Walsh Point, WAM 344.80	10D	4¼ (4+ –4½+)	2.14±0.086 (1.8–2.6)	3.18±0.097 (2.63–3.63)
Walsh Point, WAM 346.80	29D	4¼– (4–4½)	1.94±0.033 (1.7–2.35)	3.41±0.046 (2.87–4.06)
Warrender Road, WAM 372.80	23L	4¼+ (4– –4¾)	2.00±0.040 (1.7–2.4)	3.47±0.041 (3.08–3.94)
S. hirsuta				
WA-206, FMNH 200438	5L	4½– (4¼–4⅝)	1.81±0.084 (1.5–2.0)	4.81±0.230 (4.30–5.67)
WA-206, FMNH 200437	10D	4⅜ (4¼–4⅝–)	1.85±0.052 (1.6–2.1)	4.63±0.104 (4.21–5.19)
WA-210, FMNH 200445	22D	4¼– (3⅞+–4½+)	2.00±0.068 (1.6–3.2)	3.60±0.089 (2.43–4.35)
WA-390, FMNH 199973	12L	4¼+ (4+ –4½)	1.94±0.060 (1.65–2.2)	3.68±0.010 (3.24–4.18)
WA-391, FMNH 199804	15L	4⅜– (3⅞–4⅝)	2.12±0.077 (1.5–2.55)	3.53±0.094 (3.00–4.05)
WA-397 FMNH 199834	6L	4⅜ (4¼– –4⅝–)	2.43±0.067 (2.25–2.65)	3.42±0.124 (2.91–3.73)
Sta. 3, Crystal Creek, WAM 376.80	13L	4¼+ (4⅛––4⅝–)	2.26±0.037 (2.0–2.5)	3.26±0.044 (2.96–3.48)
near Crusher, WAM 406.77	8D	4¼ (4+–4½)	1.71±0.053 (1.55–1.95)	4.60±0.144 (3.86–5.07)
Sta. 4, WAM 399.77	25D	4¼+ (4–4½+)	1.71±0.041 (1.1–2.2)	4.89±0.126 (4.02–7.55)
Lawley River, WAM 349.80	6D	4⅜– (4⅛–4½)	2.58±0.109 (2.2–2.9)	3.45±0.169 (2.91–4.16)

Genital variation is puzzling, involving the possibility of multiple variational bases. Too little data is available to present other than tentative hypotheses, but they do point out several intriguing problems. **Table 80** presents the evidence for both *S. calvitia* and *S. hirsuta.* These data are taken from individuals whose bodies were extended from the shell at the time of preservation. Several other dissections, based on partly to completely retracted individuals, were not utilized, as it was impossible to make these measurements accurately because of distorsions in form and coiling of the tubes. Examples of *S. calvitia* show extraordinary variation in length of the terminal genitalia; the variation is much smaller in *S. hirsuta.*

Table 80: Size Variation in Terminal Genitalia of *Setobaudinia calvitia* and *S. hirsuta*

Station	Date collected	Forest type	Length of male complex in mm	Length of penis in mm	Length of vagina in mm	Lip
			Setobaudinia calvitia			
201	15–16.X	open	2.1	1.2	1.25	B
203	17.X	open	3.1	1.1	3.3	B
204	17.III	vine	6.1	2.1	2.1	B
207	20.X	open	3.0	1.7	2.0	B
212	21.X	vine	4.2	2.8	5.3	B
399	18–19.III	open	3.9	1.8	1.3	B
384	12.III	vine	6.3	3.0	4.9	N
384	12.III	vine	5.4	2.7	4.9	N
			Setobaudinia hirsuta			
206	18.X	vine	3.0	1.8	3.2	
206	18.X	vine	2.4	----	3.3	
390	14.III	open	3.2	1.6	1.5	
391	14.III	open	2.4	1.3	2.5	
396	16.III	open	3.2	1.2	1.45	
397	17.III	open	2.6	1.2	2.0	

Lip is either (B)road (older adult) or (N)arrow (new adult)

It is possible that the variation has both a seasonal and a habitat component in *S. calvitia.* It is quite possible that microgeographic differences also are involved. Dry season samples from open forest **(Table 80)** have short penes. Wet season samples from vine thickets have enormous penes and very long vaginae. A wet season specimen from open forest has the penis much longer than those taken in the dry season, but still much shorter than the wet season vine thicket specimens. The only dry season vine thicket specimen has the penis shorter than its wet season analogs, but the vagina very long.

Unfortunately, although two live adults were taken in the dry season at Sta. WA-204, both of them are so deeply retracted into the shell that it would be impossible to make comparable measurements on them if they were dissected.

It is plausible to hypothesize that the genitalia grows larger in the vine thicket specimens than it does in the open forest dwellers. An overall impression from dissection of all *Setobaudinia* in this study is that early to mid dry season examples of all species (except *anatispretia,* **Fig. 191a**, 14 June) have the genitalia very slender (**Figs 183a, c 189a, b, 193a**). Late dry season specimens (**Figs 185a, c, 186a, 188a**) have the tubes of the genitalia with greater diameter. It is thus possible that the genitalia becomes reduced in size during the dry season and enlarges to functional size late in the dry season. The general pattern in Kimberley camaenids of late dry season enlargement for at least apical parts of the genitalia has been documented by Solem and Christensen (1984). *Setobaudinia* would differ from this pattern if the actual volume of the terminal genitalia changed seasonally. In the other genera, major size changes are restricted to the prostate-uterus and apical organs, with the terminalia remaining essentially constant in size.

A combined pattern of variation could thus account for the observed Mitchell Plateau genital variations: 1) seasonal size change – small in dry to larger in wet; and 2) habitat size change – smaller in open forest and larger in vine thickets. Testing of this would require sampling the same stations in early, mid, and late dry seasons, plus early, mid and late wet seasons from both open forest and vine thickets. More than one station in each habitat would be required in order to test whether some of the, for example, vaginal length variation is caused by micro-geographic variation. There is the precedent in Mitchell Plateau camaenids for vine thicket taxa to vary locally in anatomy and shell features, i.e. *Amplirhagada castra* Solem (1981a: 291) and *A. varia* (*Ibid.,* 293-302).

Field studies on *Setobaudinia calvitia* thus could yield information of considerable biological interest.

SETOBAUDINIA HIRSUTA SP. NOV.
(Plates 66d-f, 70b, 72d-f; Figs 184e-h, 186a-b)

Comparative remarks

Setobaudinia hirsuta is relatively large, mean diameter 7.72 mm, exceeded in size only by *S. collingii* (Smith, 1893) and the undescribed species from Kimbolton. *S. hirsuta* is most readily recognised by its densely packed, short periostracal setae with sharp points (**Plate 66d-f**), grossly expanded lip that sharply indents at the parietal margins (**Figs 184f-g**), large lip nodes (**Figs 184f-h**), and rounded body whorl periphery. The longitudinally ridged, short verge and penis chamber wall sculpture of circular ridges (**Fig. 186b**) are diagnostic. Differences from the other described Mitchell Plateau species, *S. calvitia,* have been given above in the diagnosis of that species. *S. collingii* (Smith, 1893) differs in its reduced lip nodes, absence of any lip indentation at the parietal wall (**Fig. 181b**), and larger size, mean diameter 9.00 mm. *S. interrex* has much more widely spaced periostracal setae (**Plate 65a, c, d**), a less expanded lip that does not indent at the corners (**Figs 182b-d**), smaller size, and the penis lacks a verge (**Fig. 183b**). *S. pagoana* has a large palatal node, less expanded lip (**Figs 187b-d**), and much more widely open umbilicus, in addition to being much smaller, mean diameter 6.76 mm. Its densely packed setae are significantly shorter and with rounded points (**Plate 67b-c**). *S. doongana* has greatly reduced lip nodes and lip expansion (**Figs 187f-h**), plus much more widely spaced periostracal setae (**Plate 67d, f**). Both *S. anatispretia* and *S. victoriana* differ in the wide, buttressed bases of their periostracal setae (**Plates 68c, e, 69a, b**).

Holotype

WAM 624.80, Sta. WA-390, under boulders by stream, 1.9 km southeast of AMAX Camp, off main road, Mitchell Plateau, Kimberley, Western Australia (1:100,000 'Warrender' map sheet 4068 – grid reference 072: 587, ca 14°50'S, 125°51'E). Collected by L. Price and C. Christensen 14 March 1977. Height of shell 3.6 mm, diameter 6.7 mm, H/D ratio 0.537, umbilical width 1.7 mm, D/U ratio 3.94.

Paratopotypes

WAM 625.80, FMNH 199972-3, 7 live, 2 dead adults, 1 dead juvenile from the type locality.

Paratypes

Mitchell Plateau (WAM staff collections): Sta. MP 4, vine thicket near AMAX Crusher ('Warrender' 4068 – 018:535) (8 dead adults, 2 dead juveniles, WAM 406.77, collected 23 August 1975); Sta. MP 3, along road from AMAX Crusher to Mitchell River ('Warrender' 4068 – 022:523) (4 dead adults, 4 dead juveniles, WAM 401.77, collected 23 August 1975); Sta. MP 3b, along AMAX Crusher road ('Warrender' 4068 – 022:537) (3 dead adults, 1 dead juvenile, WAM 398.77, collected by Barry R. Wilson and Shirley Slack-Smith 23 August 1975); Sta. MP 4, vine thicket near AMAX Crusher ('Warrender' 4068 – 022:538) (25 dead adults, 9 dead juveniles, WAM 399.77, collected 23 August 1975); Sta. 3, Crystal Creek at base of baobab tree (13 live adults, WAM 376.80, FMNH 209052, collected 2 November 1976); Crystal Creek Pool (1 dead adult, WAM 468.77, collected 30 October 1976).

Mitchell Plateau (FMNH surveys, WA-205, WA-206, WA-210 collected by A. Solem October 1976; WA-391, WA-395-7 collected by L. Price and C. Christensen mid-March 1977): Sta. WA-205, gully above Camp Creek on trail to big vine thicket ('Warrender' 4068 – 039:520) (3 dead adults, FMNH 200338); Sta. WA-206, big vine thicket above Camp Creek ('Warrender' 4068 – 039:520) (5 live, 10 dead adults, 2 dead juveniles, WAM 642.80, FMNH 200437-8); Sta. WA-210, 5.0 km from AMAX turnoff towards Camp Creek Crusher ('Warrender' 4068 – 049:563) (23 dead adults, WAM 643.80, FMNH 199614, FMNH 200445); Sta. WA-391, under boulders along main road, 0.8 km south-east of AMAX mining camp ('Warrender' 4068 – 067:596) (3 live, 2 dead adults, 1 dead juvenile, WAM 644.80, FMNH 199285, FMNH 199804); Sta. WA-395, vine thicket on south-west slope, ca 1.3 km south-east of AMAX Crusher ('Warrender' 4068 – 056:541) (1 dead adult, FMNH 199298); Sta. WA-396, under basalt boulders, 1 km east-south-east of AMAX Crusher, ca 0.3 km north-west of WA-395 ('Warrender' 4068 – 053:543) (2 live adults, FMNH 199979); Sta. WA-397, under boulders in open forest 10.2 km south-east of AMAX mining camp, on main road ('Warrender' 4068 – 137:542) (6 live adults, WAM 645:80, FMNH 199834).

Lawley River: head of east arm, Lawley River estuary, east bank (6 dead adults, WAM 349.80, collected by Barry R. Wilson 19 July 1977).

Admiralty Gulf: vine thicket at base of cliffs, south-west Osborne Island (1 dead adult, 5 dead juveniles, WAM 324.80, collected by W.K. Youngson 28 June 1973).

Diagnosis

Shell large, diameter 5.85-9.5 (mean 7.72 mm), with 3⅞ to 4¾ (mean 4¼+) normally coiled whorls. Apex and spire slightly to moderately and evenly elevated **(Fig. 184f)**, height of shell 2.9-5.75 mm (mean 4.13 mm), H/D ratio 0.431-0.680 (mean 0.533). Apical sculpture **(Plate 66d)** typical, postapical whorls **(Plate 66e-f)** with dense cover of rather short periostracal setae with sharp points and simple bases. Shell periphery rounded to slightly laterally compressed, body whorl descending slightly behind aperture. Lip grossly expanded when fully adult **(Fig. 184g)**, both palatal and basal sections strongly indented at points of merging with parietal wall. Basal lip with a moderate node, palatal lip with a very large node. Umbilicus **(Fig. 184g)** typical, regularly decoiling, width 1.1-2.9 mm (mean 2.01 mm), D/U ratio 2.44-7.54 (mean 3.93). Periostracal colour dark yellow-brown, shell base lighter, lip white. Based on 137 measured adults.

Genitalia **(Figs 186a-b)** with penis complex and vagina (V) distinctly shorter than in *S. calvitia* **(Fig. 185a)**, penis very short and broad with a longitudinal ridge **(Fig. 186b)**, walls of penis chamber with vague circular pilasters in upper section **(Fig. 186b)**, pilasters tending towards longitudinal orientation near atrium (Y). Based on 6 dissected adults.

Remarks

It has not been proven that *S. calvitia* and *S. hirsuta* are actually microsympatric on the Mitchell Plateau, but their distributions so completely interdigitate that at times there must be contact between individuals from adjacent populations of the two species. The shortened penis complex and vagina of *S. hirsuta* **(Figs 186a-b)**, in comparison with the length of the same organs in *S. calvitia* **(Fig. 185a)**, represent a common type of 'species recognition' change in Kimberley camaenids (Solem 1984: 694, table 73). The differences in verge and penis wall chamber sculpture – long tubular verge and pustulose wall sculpture in *S. calvitia* **(Fig. 185b)**, contrasted with a short, ridged verge and circular to longitudinal ridged wall and sculpture in *hirsuta* **(Fig. 186b)** – also are comparable to the 'species recognition' changes seen in species of *Amplirhagada* (Solem 1981a).

The only congruence in station number for the two species is WAM station MP 3b of 23 August 1975. There were two separate vials, one marked as 'A81' and the other 'A82', with the second indicated as 300 meters from the track. Thus actually two different populations were sampled.

The specimens from Osborne Island (WAM 324.80) are worn, but come closest to this species. If correctly identified, then the range of *S. hirsuta* extends beyond that of the undescribed species from the Lawley River reported on below (p. 774-5).

Size and shape variation among populations of *S. hirsuta* is summarised in **Table 79**. Diameter and whorl count increment is correlated as usual, and the vine thicket populations, Sta. WA-206, and Lawley River, have the largest shells. There is a 1.74 mm range in mean diameter among populations, compared with a 2.19 mm range for the smaller *S. calvitia* **(Table 79)**.

Anatomical variation appears to be much less than in *S. calvitia* **(Table 80)**, but the fact that only wet season open forest and dry season vine thicket examples have been dissected may be misleading, since the open forest size would be maximal in the wet season, and the vine thicket size would be minimal in the dry season. The Sta. WA-206 specimens have significantly longer vaginae, and their short penes might be seasonal variation.

SETOBAUDINIA PAGOANA SP. NOV.
(Plates 67a-c, 70c, 73a-b; Figs 187a-d, 188a-b)

Comparative remarks

Setobaudinia pagoana is characterised by its widely open umbilicus **(Fig. 187c)**, very prominent palatal node **(Figs 187b-d)**, dense periostracal setae with rounded tips **(Plate 67a-c)**, and rounded periphery **(Fig. 187b)**. Epiphallic lobe (EL) very short, epiphallic caecum (EC) quite long **(Fig. 188a)**. Conical verge short and broad **(Fig. 188b)**. Walls of penis chamber with only

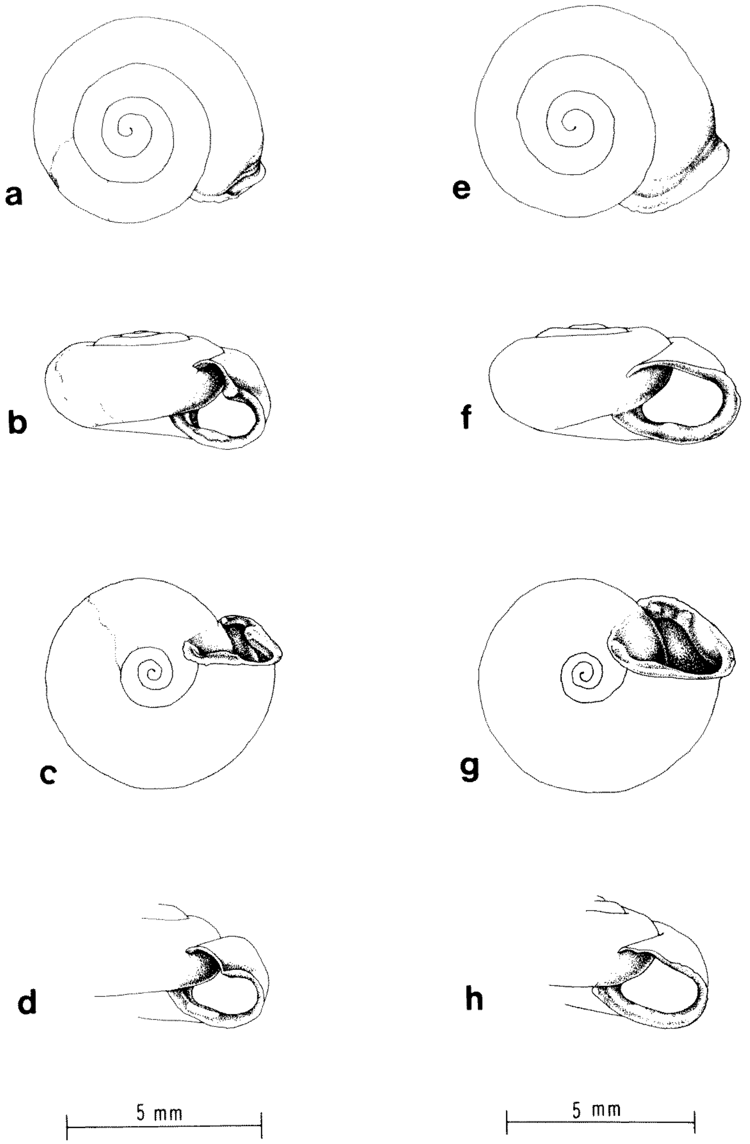

Fig. 187: Shells of *Setobaudinia pagoana* and *S. doongana:* (a-d) *S. pagoana,* Sta. WA-217, Pago-Kalumburu Road, Kimberley, (a-c) WAM 631.80, holotype, (d) WAM 632.80, subadult paratopotype; (e-h) *S. doongana,* Old Doongan Homestead, Drysdale River area, Kimberley, (e-g) WAM 627.80, holotype, (h) WAM 628.80, subadult paratopotype. Scale lines equal 5 mm. Drawings by Linnea Lahlum.

a very few longitudinal ridges **(Fig. 188b)**. The Drysdale area *S. doongana* differs in its narrower umbilicus **(Fig. 187g)**, greatly reduced palatal node **(Figs 187f-g)**, angulated periphery **(Fig. 187f)**, widely spaced and comparatively few setae **(Plate 67d-f)**, elongated verge **(Figs 189d-e)** and circular ridges on the penis chamber wall **(Fig. 189d)**. *S. hirsuta* **(Fig. 184b)** from the Mitchell Plateau, differs most obviously in the sharp indentation of both palatal and basal lips where they join the parietal wall, and much greater lip expansion **(Figs 184f-h)**. *S. anatispretia* **(Plate 68a-f)** and *S. victoriana* **(Plate 69a-b)** from the Northern Territory have bases of the setae broadened into buttresses and show several anatomical changes.

Holotype

WAM 631.80, Sta. WA-217, sandstone outcrops east of Pago-Kalumburu Road, 15.5 km south of Pago Mission ruins, near Kalumburu, Kimberley, Western Australia (1:100,000 'Drysdale' map sheet 4269 – grid reference 447:258, ca 14°14′S, 126°38′E). Collected by Alan Solem 27 October 1976. Height of shell 3.0 mm, diameter 6.2 mm, H/D ratio 0.484, whorls 4, umbilical width 2.0 mm, D/U ratio 3.10.

Paratopotypes

WAM 632.80, WAM 646.80, WAM 647.80, FMNH 200447-8, 20 live, 14 dead adults, 3 live juveniles from the type locality.

Paratypes

Sta. WA-218, under stones under large baobab tree near banana patch, Kalumburu Mission ('Drysdale' 4269 – 457:180, ca 14°18′S, 126°39′ E) (3 live, 3 dead juveniles, FMNH 199495, FMNH 200535, FMNH 200539).

Diagnosis

Shell of average size, diameter 6.0-7.5 mm (mean 6.76 mm), with 3⅞ to 4½+ normally coiled whorls. Apex and spire generally slightly and evenly elevated **(Fig. 187b)**, height of shell 3.0-3.9 mm (mean 3.46 mm), H/D ratio 0.455-0.560 (mean 0.512). Apical sculpture **(Plate 67a)** typical, post-apical whorls **(Plate 67b-c)** with a dense cover of short periostracal setae with rounded tips and simple bases. Shell periphery rounded, body whorl not descending behind lip **(Fig. 187b)**. Lip moderately to strongly expanded **(Figs 187b-d)**, merging smoothly into parietal wall. Basal lip with a moderately prominent node, palatal node very prominent. Umbilicus **(Fig. 187c)** widely open, last whorl decoiling more rapidly, width 1.9-2.7 mm (mean 2.28 mm), D/U ratio 2.60-3.55 (mean 2.97). Periostracal colour dark yellow-brown, base lighter, lip white. Based on 35 measured adults.

Genitalia **(Figs 188a-b)** with shortened penis complex and vagina (V), very long epiphallic caecum (EC) and shortened epiphallic lobe (EL) **(Fig. 188a)**. Penis with elongated verge (PV), walls of penis chamber with sharply outlined longitudinal pilasters. Based on three dissected adults.

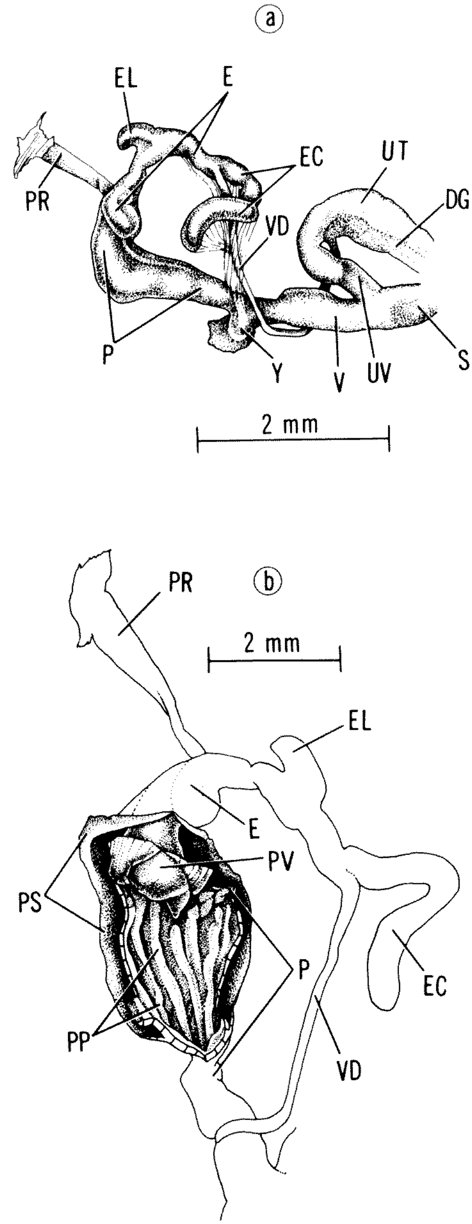

Fig. 188: Genitalia of *Setobaudinia pagoana:* Sta. WA-217, Pago-Kalumburu Road, Kimberley, FMNH 200448, 27 October 1976, Dissection A, (a) post-pallial genitalia, (b) interior of penis. Scale lines as marked. Drawings by Linnea Lahlum.

Remarks

The name *pagoana* is taken from the ruins of Pago Mission, north of Kalumburu, since previously I have described *Amplirhagada kalumburuana* Solem, 1981 from the same general area. All known examples were taken under rocks or in litter among huge boulders. No specimens were found in the vine thicket (Sta. WA-220) a few km south of Kalumburu, the type

Table 81: Local Variation in *Setobaudinia pagoana, S. doongana, S. anatispretia* and *S. victoriana*

Taxon	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
S. pagoana				
WA-217, FMNH 200448	21L	3.48±0.043 (3.05–3.9)	6.78±0.072 (6.1–7.5)	0.513±0.006 (0.455–0.551)
WA-217, FMNH 200447	14D	3.43±0.052 (3.0–3.7)	6.72±0.094 (6.1–7.5)	0.511±0.006 (0.481–0.560)
S. doongana				
B1-5, WAM 193.76	9L	3.96±0.118 (3.3–4.45)	7.61±0.014 (7.0–8.4)	0.522±0.010 (0.472–0.561)
C1-2, WAM 194.76	13D	3.59±0.078 (3.25–4.1)	6.56±0.092 (6.0–7.1)	0.549±0.006 (0.511–0.602)
C1-6, WAM 196.76	7D	3.13±0.122 (2.7–3.3)	5.98±0.091 (5.7–6.4)	0.521±0.018 (0.460–0.632)
C1-7, WAM 197.76	34D	3.47±0.059 (3.0–4.35)	6.27±0.082 (5.45–7.60)	0.552±0.008 (0.490–0.628)
21 km from Doongan, WAM 187.76	11D	3.46±0.079 (2.95–3.95)	6.93±0.081 (6.4–7.45)	0.502±0.009 (0.431–0.530)
Old Doongan, WAM 186.76	16L	3.27±0.029 (3.1–3.6)	6.65±0.079 (6.2–7.35)	0.491±0.005 (0.471–0.509)
S. anatispretia				
WA-680, 1-VI-80, FMNH 205143	20L	3.15±0.057 (2.8–3.9)	6.88±0.068 (6.2–7.7)	0.458±0.008 (0.406–0.565)
WA-680, 1-VI-80, FMNH 205142	16D	3.36±0.059 (3.0–3.8)	7.17±0.069 (6.7–7.75)	0.469±0.007 (0.417–0.514)
WA-680, 14-VI-80, FMNH 205153	22L	3.38±0.056 (2.8–4.0)	7.00±0.060 (6.5–7.5)	0.483±0.008 (0.427–0.555)
WA-680, 14-VI-80, FMNH 205152	69D	3.31±0.039 (2.7–4.3)	7.06±0.042 (5.8–7.85)	0.468±0.004 (0.386–0.562)
S. victoriana				
WA-681, FMNH 205163	5L	3.08±0.051 (2.95–3.2)	6.17±0.099 (5.9–6.45)	0.499±0.004 (0.484–0.508)
WA-681, FMNH 205162	23D	2.77±0.028 (2.52–2.99)	5.87±0.087 (5.22–6.81)	0.472±0.004 (0.414–0.496)

Table 81: Local Variation in *Setobaudinia pagoana, S. doongana, S. anatispretia* and *S. victoriana* (continued)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
S. pagoana				
WA-217, FMNH 200448	21L	4¼ (3⅞–4½+)	2.24±0.047 (1.9–2.7)	3.04±0.057 (2.64–3.55)
WA-217, FMNH 200447	14D	4¼ (3⅞–4½)	2.34±0.041 (2.1–2.65)	2.88±0.046 (2.60–3.23)
S. doongana				
B1-5, WAM 193.76	9L	4⅛– (4–4¼+)	2.06±0.059 (1.7–2.25)	3.72±0.121 (3.32–4.31)
C1-2, WAM 194.76	13D	4¼– (3⅞–4⅜+)	1.81±0.049 (1.3–2.0)	3.66±0.140 (3.20–5.23)
C1-6, WAM 196.76	7D	4– (3¾– –4⅛+)	1.57±0.031 (1.35–1.70)	3.82±0.100 (3.63–4.37)
C1-7, WAM 197.76	34D	4⅛– (3¾–4¾)	1.58±0.029 (1.3–1.95)	4.00±0.071 (3.16–4.69)
21 km from Doongan, WAM 187.76	11D	4– (3⅞–4½–)	1.66±0.048 (1.4–1.9)	4.19±0.010 (3.61–4.93)
Old Doongan, WAM 186.76	16L	4– (3¾–4⅛)	1.69±0.048 (1.2–1.95)	3.98±0.129 (3.25–4.69)
S. anatispretia				
WA-680, 1-VI-80, FMNH 205143	20L	4 (3¾–4¼)	2.09±0.050 (1.75–2.5)	3.33±0.070 (2.76–3.89)
WA-680, 1-VI-80, FMNH 205142	16D	4 (3¾–4¼)	2.12±0.059 (1.6–2.45)	3.42±0.094 (2.92–4.41)
WA-680, 14-VI-80, FMNH 205153	22L	4⅛– (3⅞–4¼)	2.04±0.040 (1.6–2.35)	3.46±0.068 (2.79–4.28)
WA-680, 14-VI-80, FMNH 205152	69D	4⅛– (3¾– –4¼+)	2.18±0.022 (1.8–2.6)	3.26±0.034 (2.63–4.19)
S. victoriana				
WA-681, FMNH 205163	5L	4 (4– –4+)	1.51±0.058 (1.35–1.7)	4.10±0.092 (3.79–4.37)
WA-681, FMNH 205162	23D	4⅛+ (3⅞+–4⅜–)	1.02±0.018 (0.85–1.16)	5.82±0.114 (4.75–7.09)

locality for *A. kalumburuana.* Specimens of *Damochlora rectilabrum* (Smith, 1894) were taken both there and at WA-218 with *S. pagoana.*

Only the one population yielded adult specimens, and there is no significant size difference between live and dead specimens **(Table 81).**

SETOBAUDINIA DOONGANA SP. NOV.
(Plates 67d-f, 73c-e; Figs 187e-h, 189a-e)

Comparative remarks

Setobaudinia doongana is average in size and shape **(Table 76)** except for the somewhat narrow umbilicus **(Fig. 187g)**. A slightly angulated periphery **(Fig. 187f)**, relatively narrow lip expansion **(Figs 187f, g)**, near absence of a palatal node **(Fig. 187f)**, and near lack of any body whorl descension **(Figs 187f, h)** combine with the widely spaced, rather sparse setae **(Plate 67d, f)** to characterise it. Anatomically, the long epiphallic lobe (EL) **(Figs 189a, b)**, very large verge **(Figs 189d-e)**, and circular ridges on the penis chamber wall **(Fig. 189d)** are diagnostic features. *S. pagoana* from Kalumburu has a much wider umbilicus **(Fig. 187c)**, rounded shell periphery **(Fig. 187b)** massive palatal node and greater lip expansion **(Figs 187b-d)**, dense and stubby setae with rounded tips **(Plate 67a-c)**, a very short epiphallic lobe (EL) **(Fig. 188a)**, short verge **(Fig. 188b)**, and only a few longitudinal ridges on the penis chamber walls. *S. calvitia* and *S. collingii* (Smith, 1893) come closest in shell lip features and shape. The former differs anatomically in its long epiphallic lobe (EL) **(Fig. 185a)**, smaller verge **(Fig. 185b)**, and pustulose sculpture on the penis wall chamber **(Fig. 185b)**. *S. collingii* differs in its very large size, mean diameter 9.00 mm, rounded periphery **(Fig. 181b)**, larger nodes and more expanded lip **(Figs 181b-c)**. *S. hirsuta, S. interrex* and *S. anatispretia* all have very prominent palatal nodes and widely expanded lips, plus differences in penial anatomy. *S. victoriana* **(Figs 192a-c)** has the parietal lip elevated and lip nodes reduced, the umbilicus is small and decoils very rapidly. It lacks the epiphallic lobe (EL) **(Fig. 193a)**, and the verge is a modified papilla **(Fig. 193c)**.

Holotype

WAM 627.80, under rocks around Old Doongan Homestead, open eucalypt woodland, near Carson River, North Kimberley, Western Australia (1: 100,000 'Ashton' map sheet 4267 – grid reference BJ358045, ca 15°9′27″S, 126°32′21″E). Collected by Barry R. Wilson and Shirley Slack-Smith 13 August 1975. Height of shell 3.3 mm, diameter 6.8 mm, H/D ratio 0.485, whorls 3⅞ –, umbilical width 1.8 mm, D/U ratio 3.78.

Paratopotypes

WAM 185.76, WAM 186.76, WAM 628.80, FMNH 209038, FMNH 209043, 15 live, 4 dead adults, 20 live, 18 dead juveniles from the type locality.

Paratypes

Drysdale River National Park (all specimens collected August 1975): Sta. B1-3, entrance to Glider Gorge (1:100,000 'Carson' 4268 – 655:602) (1 dead adult, 3 dead juveniles, WAM 188.76); Sta. B1-4, scree slope, south side Glider Gorge entrance ('Carson' 4268 – 657:599) (2 dead adults, WAM 189.76); Sta. B1-5, ca 0.5 km up Glider Gorge ('Carson' 4268 – 662:600) (3 live, 10 dead adults, 7 live, 7 dead juveniles, WAM 190.76-192.76, FMNH 209040, FMNH 209045); Sta. B1-8, on Carson Escarpment about 1 km north of Glider Gorge ('Carson' 4268 – 659:611) (9 live adults, 3 live juveniles, WAM 193.76); Sta. C1-2, western side Worriga Gorge, Palmoondoora Creek, ca 0.5 km downstream from Morgan Falls ('Ashton' 4267 – 491:376) (13 dead adults, 10 dead juveniles, WAM 194.76, FMNH 209044); Sta. C1-5, Elasmias Creek, 0.5 km upstream from Palmoondoora Creek ('Ashton' 4267 – 493:366) (5 live, 2 dead adults, 4 dead juveniles, WAM 195.76); Sta. C1-6, Worriga Gorge on Palmoondoora Creek, west bank below Morgan Falls ('Ashton' 4267 – 489:369) (7 dead adults, 22 dead juveniles, WAM 196.76, FMNH 209041); Sta. C1-7, east side Colochasia Creek Valley, north-east Worriga Gorge ('Ashton' 4267 – 490:394) (34 dead adults, 22 dead juveniles, WAM 197.76, FMNH 209042); Sta. C1-8, east bank Palmoondoora Creek in Worriga Gorge ('Ashton' 4267 – 492:388) (2 dead adults, 1 dead juvenile, WAM 198.76); Sta. C2-1, west of Carson River, north of Woorakin Creek junction ('Ashton' 4267 – 585:347) (7 dead adults, 29 dead juveniles, WAM 199.76, WAM 200.76, WAM 206.76); Sta. C2-2, east of Carson River just south of Woorakin Creek ('Ashton' 4267 – 585: 340) (2 dead adults, 3 dead juveniles, WAM 201.76, WAM 202.76, WAM 204.76); Sta. C2-3a, below waterfall on creek flowing into Carson River north of Woorakin Creek ('Ashton' 4267 – 590:345) (3 dead juveniles, WAM 203.76); Sta. C2-8, east of Carson River about 0.5 km south of Woorakin Creek junction ('Ashton' 4267 – 583:337) (2 dead adults, 15 dead juveniles, WAM 205.76); Sta. C4, Carlia Creek running into Carson Escarpment, 1-2 km east of Carson River (15°01′S, 126°49′E) (5 dead adults, 4 dead juveniles, WAM 207.76); Sta. C5-2, Forest Creek about 0.4 km upstream from Dysphania Gorge ('Carson' 4268 – 768:789) (1 dead juvenile, WAM 209.76); Sta. C5-4, Forest Creek about 0.75 km upstream from Dysphania Gorge ('Carson' 4268 – 786:785) (3 dead adults, 6 dead juveniles, WAM 211.76); Sta. C5-5, Forest Creek about 0.75 km upstream from Dysphania Gorge ('Carson' 4268 – 786:785) (3 dead juveniles, WAM 212.76); Sta. C5-6, Forest Creek about 1 km upstream from Dysphania Gorge ('Carson' 4268 – 792:778) (1 dead adult, 1 dead juvenile, WAM 213.76).

24 km from Old Doongan Homestead on Doongan-Old Doongan Road (6 dead adults, 13 dead juveniles, WAM 405.77, WAM 409.77); 21 km from Old Doongan Homestead on Doongan-Old Doongan Road (10 live, 11 dead adults, 4 live, 3 dead juveniles, WAM 187.76, WAM 380.80, FMNH 209039).

Diagnosis

Shell of average size, diameter 5.45-8.5 mm (mean 6.70 mm), with 3⅝ to 4¾– (mean 4+) normally coiled whorls. Apex and spire slightly elevated

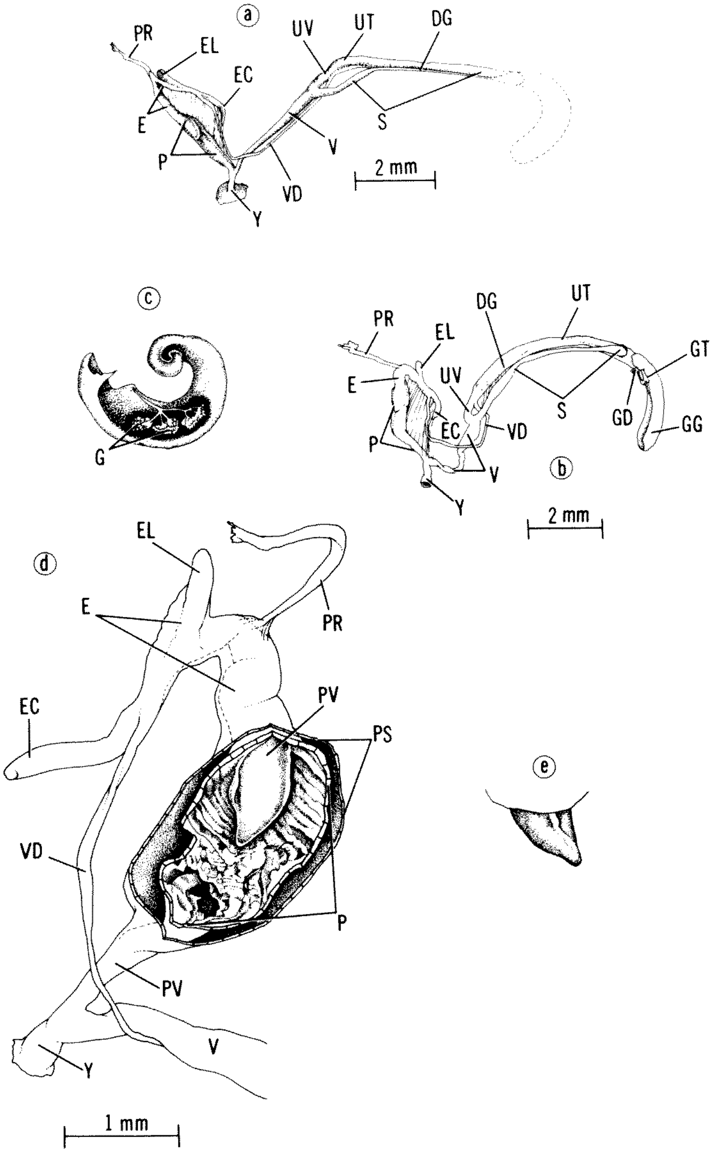

Fig. 189: Genitalia of *Setobaudinia doongana:* (a) Old Doongan Homestead, Drysdale area, Kimberley, WAM 186.76, 13 August 1975, Dissection A, subapical genitalia; (b-e) ca 2 km on road from Old Doongan to Doongan Homestead, Drysdale River area, Kimberley, WAM 380.80, (b) whole genitalia, Dissection A, (c) ovotestis, Dissection A, (d) interior of penis, Dissection B, (e) detail of verge, Dissection B. Scale lines as marked. Drawings by Linnea Lahlum.

(**Fig. 187f**), height of shell 2.7-4.5 mm (mean 3.53 mm), H/D ratio 0.430-0.630 (mean 0.529). Apical sculpture (**Plate 67d**) typical, postapical whorls (**Plate 67e-f**) with long, widely spaced periostracal setae with pointed tips and simple bases. Shell periphery rounded to slightly angulated, body whorl descending slightly to moderately behind aperture. Lip moderately expanded (**Figs 187b-d**), merging smoothly into parietal wall. Basal lip with only a trace of a node, palatal node greatly reduced to absent. Umbilicus (**Fig. 187g**) typical, regularly decoiling, width 1.1-2.5 mm (mean 1.70 mm), D/U ratio 2.78-6.32 (mean 3.96). Periostracal colour dark yellow-brown, base of shell lighter, lip white. Based on 139 measured adults.

Genitalia (**Figs 189a-e**) typical of genus, except for slight shortening of epiphallic lobe (EL). Penis with a large, slender verge (PV, **Figs 189d-e**), wall of penis chamber with vague circular ridges. Based on three dissected adults.

Remarks

Setobaudinia doongana is named after Doongan Station in recognition of the contributions its owners have made in hosting scientific work in the Drysdale River area over the past decades.

Size and shape variation in the larger samples is summarised in **Table 81**. The size range in mean shell diameter is 1.63 mm, with the largest shells from Glider Gorge (Sta. B1-5) and the smallest from Worriga Gorge (Sta. C1-6). No available information on the two habitats suggests the reasons for this difference in size.

Additional examples were collected in a creek gorge east of the Kalumburu-Gibb River Road, 12.7 km S of the Carson River (Sta. WA-1054, 'Carson' 4268 – 402:922, 126°35'E, 14°32'S) (5 live 35 dead adults FMNH 211973-4) in June 1984. This is a significant range extension and suggests that *S. pagoana* is restricted to areas north of Kalumburu Mission.

SETOBAUDINIA ANATISPRETIA SP. NOV.
(Plates 68a-f, 74a-d; Figs 190a-g, 191a-b)

Comparative remarks

Setobaudinia anatispretia is of average size, somewhat depressed shape (**Fig. 190b**), mean H/D ratio 0.469, with a very rapidly decoiling umbilicus (**Figs 190c, g**), dense periostracal setae with greatly broadened bases (**Plate 68a-f**), very broadened lip that is indented at its insertions onto the parietal wall (**Figs 190b-c**), and huge palatal node (**Figs 190b-c**). Anatomically, the absence of a verge (**Fig. 191b**), very short vaginal region (**Figs 191a-b**), very long epiphallic lobe (EL) (**Figs 191a-b**), and short penis (**Fig. 191a**) combine to distinguish it from other *Setobaudinia*. The Prince Regent River *S. interrex* also lacks a verge (**Fig. 183b**), but obviously differs in its narrower,

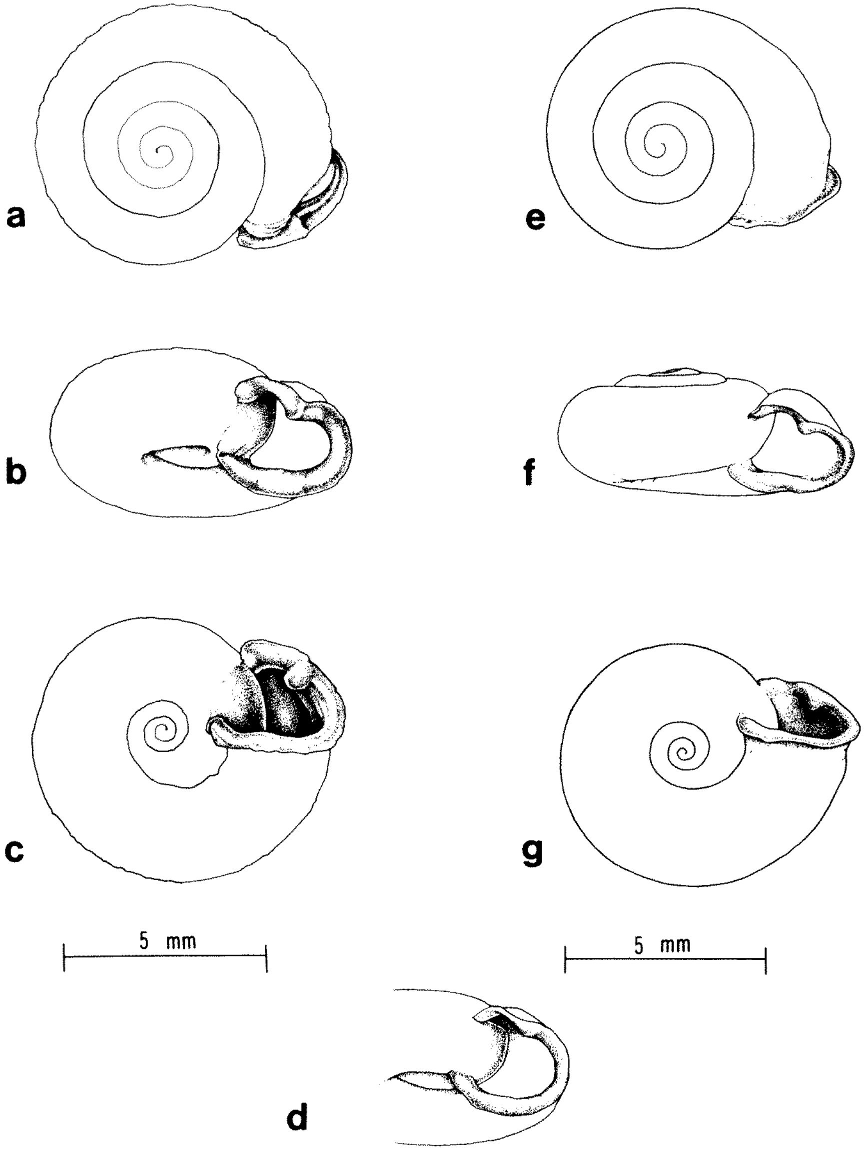

Fig. 190: Shells of *Setobaudinia anatispretia:* (a-d) Sta. WA-680, 24.4 km east of Timber Creek Police Station, Victoria Highway, Northern Territory, (a-c) WAM 629.80, holotype, (d) WAM 630.80, subadult paratopotype; (e-g) Victoria River, Northern Territory, BM(NH) 1978105. Scale lines equal 5 mm. Drawings by Linnea Lahlum (a-d) and Elizabeth Liebman (e-g).

regularly decoiling umbilicus (**Fig. 182c**), more elevated spire (**Fig. 182b**), smaller lip nodes (**Figs 182b-d**), and widely spaced periostracal setae that lack broadened bases (**Plate 65a, c, d**). It also has a very long vagina and the epiphallic lobe (EL) is much shorter (**Figs 183a, c**). All other *Setobaudinia* have a functional verge and show combinations of shell feature differences. Only *S. victoriana* shares the broadened setal bases (**Plate 69a-b**), although they are not as prominent, but its elevated parietal lip, very small umbilicus, and greatly reduced lip nodes (**Figs 192b-c**) easily separate the two species.

Holotype

WAM 629.80, Sta. WA-680, limestone outcrops on both sides of Victoria Highway, 24.4 km east of Timber Creek Police Station, 44.1 km west of Fitzroy Station turnoff, Northern Territory (1:100,000 'Stokes' map sheet 5066 – grid reference ca 722:583, ca 15°45′S, 130°36′E). Collected by Alan Solem, L. Price and Barbara Duckworth 14 June 1980. Height of shell 3.9 mm, diameter 7.8 mm, H/D ratio 0.500, whorls 4½, umbilical width 2.3 mm, D/U ratio 3.39.

Paratopotypes

WAM 632.80, WAM 648.80-651.80, FMNH 205142-3, FMNH 205152-3, 42 live, 84 dead adults, 1 live, 6 dead juveniles from the type locality.

Other material

Northern Territory: Victoria River (1 dead adult, BMNH 1978105).

Diagnosis

Shell of average size, diameter 5.8-7.85 mm (mean 7.04 mm), with 3¾– to 4¼+ (mean 4+) normally coiled whorls. Apex and spire flat to slightly elevated (**Figs 190b, f**), height of shell 2.7-4.3 mm (mean 3.30 mm), H/D ratio 0.386-0.565 (mean 0.469). Apical sculpture (**Plate 68a-b**) typical, postapical sculpture highly modified. Periostracal setae densely packed (**Plate 68e**), with very wide lateral buttresses, almost triangular near the suture (**Plate 68b-c**), with extended sharp points on main portion of whorls (**Plate 68e-f**). Shell periphery rounded, body whorl descending moderately just before aperture. Lip grossly expanded (**Figs 190b-d**), strongly indented where both palatal and basal sections meet parietal wall. Basal node reduced to a trace, palatal node extremely large and thickened internally. Umbilicus rather wide, last whorl decoiling more rapidly, width 1.6-2.6 mm (mean 2.13 mm), D/U ratio 2.63-4.41 (mean 3.33). Periostracal colour dark yellow-brown, base of shell lighter, lip white. Based on 127 measured adults.

Genitalia (**Figs 191a-b**) unusual in extreme shortening of both penis complex and vagina (V), very long epiphallic lobe (EL) and epiphallic caecum (EC). Apex of penis (**Fig. 191b**) with complex pilasters, but no verge, lower walls of penis chamber with sharply defined pustules (PPR). Based on three dissected adults.

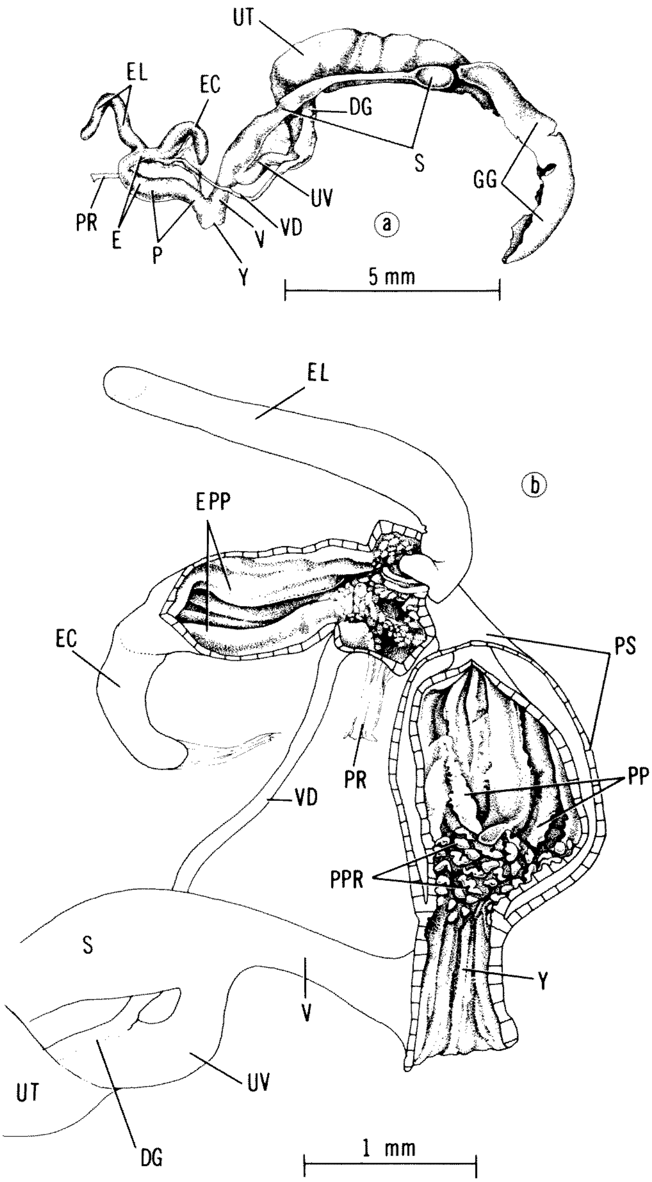

Fig. 191: Genitalia of *Setobaudinia anatispretia:* Sta. WA-680, 24.4 km east of Timber Creek Police Station, Victoria Highway, Northern Territory, FMNH 205153, 14 June 1980, (a) whole genitalia, Dissection B, (b) interior of penis and epiphallus, Dissection A. Scale lines as marked. Drawings by Linnea Lahlum.

Remarks

Setobaudinia anatispretia celebrates the invaluable assistance that Barbara Duckworth of the Australian Museum, Sydney has given over the years to malacologists and entomologists from all parts of the world, and recognises her participation in the collection of the type series of this species. This was her initial exposure to Western Australian semi-arid area collecting, and her infectious enthusiasm then and on subsequent hot and dusty days on the long road from Katherine to Perth gave a needed boost to the spirits of the other passengers, who had been in the field a much longer time.

Two other camaenids were found at this station, *Prototrachia sedula* Solem, 1984 and *Mesodontrachia fitzroyana*. The former aestivated under single boulders away from the cliff base, while *Setobaudinia anatispretia* was common in rubble at the cliff base and in fissure litter on the cliff itself. *Mesodontrachia fitzroyana* was found mainly in fissures and around large boulders of the cliff itself.

Variation among the samples taken on 1 and 14 June 1980 is minor **(Table 81)**. The only other known specimen (BMNH 1978105) bears a pre-1900 hand written label stating 'Victoria River, Australia'. Although without trace of periostracum, it agrees quite well **(Figs 190e-g)** with the type set. The type locality lies within the Victoria River drainage, but whether this specimen was derived from that colony or indicates that other colonies exist, is unknown.

SETOBAUDINIA VICTORIANA SP. NOV.
(Plates 69a-d, 70d, 75a-d; Figs 192a-c, 193a-b)

Comparative remarks

Setobaudinia victoriana is the smallest described species, mean diameter 5.92 mm, and is easily recognised by its raised parietal lip **(Fig. 192c)**, laterally compressed periphery **(Fig. 192b)**, absence of a palatal node **(Fig. 192c)**, and small umbilicus whose last whorl decoils very rapidly **(Fig. 192c)**. It is unusual in that the bases of the periostracal setae are buttressed **(Plate 69a, b)**, although not as dramatically as in *S. anatispretia* **(Plate 68a-f)**. All other *Setobaudinia* have the bases of the setae quite simple in structure. Anatomically, the absence of the epiphallic lobe **(Fig. 193a)**, spatulate verge **(Fig. 192c)** and very short vagina (V) **(Fig. 193a)** separate it from all other species. Only *S. doongana* might be confused on the basis of lip structure, since it also has a reduced palatal node **(Figs 187b-c)**. All other species have a prominent palatal node. The presence of an epiphallic lobe in the other taxa, and a conical verge in most other species, are distinguishing features.

Holotype

WAM 653.80, Sta. WA-681, limestone sink ca 90 m north of Victoria Highway, ca 86 km south-west of Katherine, Northern Territory (1:100,000

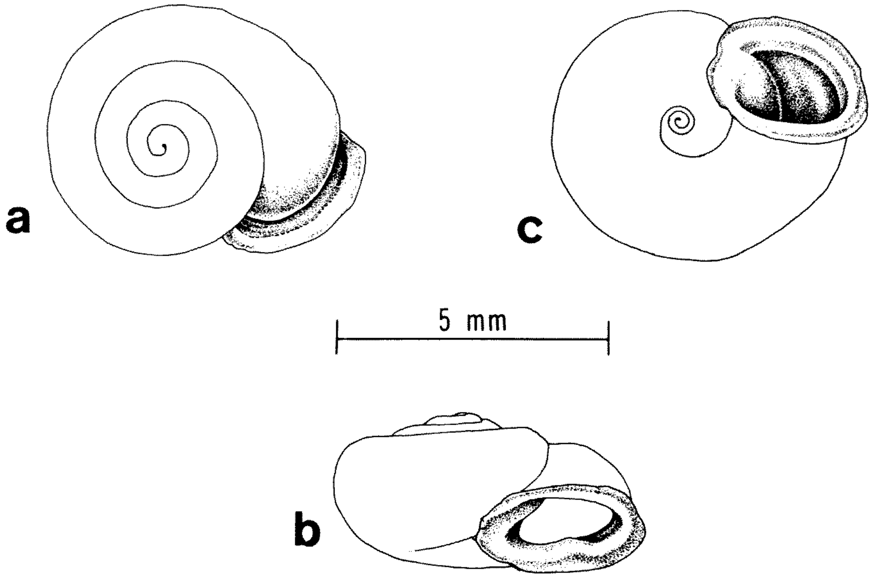

Fig. 192: Shell of *Setobaudinia victoriana:* Sta. WA-681, 86 km southwest of Katherine, Victoria Highway, Northern Territory, WAM 629.80, holotype. Scale line equals 5 mm. Drawings by Linnea Lahlum.

'Willeroo' map sheet 5264 – grid reference 979:351, ca 15°02′S, 131°46′E). Collected by A. Solem, L. Price, F. and J. Aslin 2 June 1980. Height of shell 3.15 mm, diameter 6.0 mm, H/D ratio 0.525, whorls 4⅛, umbilical width 1.5 mm, D/U ratio 4.00.

Paratopotypes

WAM 652.80, WAM 655.80, FMNH 205162-3, 4 live, 23 dead adults, 11 dead juveniles from the type locality.

Diagnosis

Shell small, diameter 5.2-6.8 mm (mean 5.92 mm), with 3⅞+ to 4⅜– (mean 4⅛+) normally coiled whorls. Apex and spire slightly and evenly elevated **(Fig. 192b)**, height of shell 2.52-3.2 mm (mean 2.83 mm), H/D ratio 0.414-0.508 (mean 0.477). Apical sculpture typical, postapical whorls **(Plate 69a-b)** with rather widely spaced, median length periostracal setae with sharp points and widely buttressed base. Shell periphery laterally compressed, body whorl descending sharply behind aperture. Lip strongly expanded **(Plate 69c-d, Figs 192a-c)**, basal and palatal segments merging into raised parietal lip to form a continuous lip. Basal node weak, palatal lip without node **(Fig. 192c)**. Umbilicus **(Fig. 192c)** narrow, last whorl decoiling very rapidly, width 0.85-1.7 mm (mean 1.10 mm), D/U ratio 3.79-

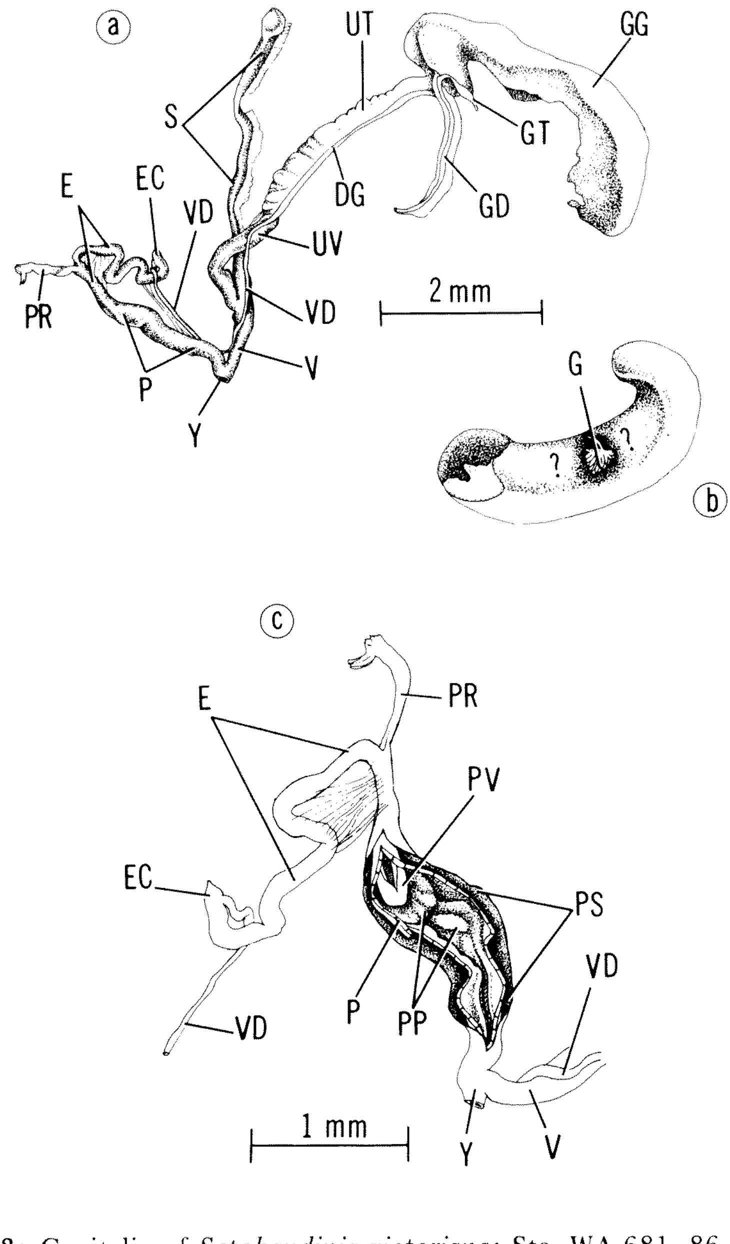

Fig. 193: Genitalia of *Setobaudinia victoriana:* Sta. WA-681, 86 km southwest of Katherine, Victoria Highway, Northern Territory, FMNH 205163, 2 June 1980, Dissection A: (a) whole genitalia, (b) interior of penis. Scale lines as marked. Drawings by Linnea Lahlum.

7.09 (mean 5.51). Periostracal colour dark yellow-brown, lip white. Based on 28 measured adults.

Genitalia (**Figs 193a-c**) modified in several aspects from typical *Setobaudinia* pattern. Vagina (V) short, but free oviduct elongated (**Fig. 193a**). Epiphallic lobe absent, epiphallic caecum short, penis complex rather long, fibers binding vas deferens and epiphallus to penis reduced (**Fig. 193a**). Walls of penis chamber with short ridges, verge spatulate (**Fig. 193c**) rather than tubular, very short. Based on one dissected adult.

Remarks

Setobaudinia victoriana is named from the Victoria Highway, which runs within a few metres of the limestone sink that is the type locality. About four person hour efforts resulted in only the five live and 23 dead adult specimens listed above. They were in litter at the base of large limestone boulders in a marshy sink, the only one that we found between Kununurra and Katherine. Undoubtedly there are other such limestone outcropings hidden among the hill systems of this region, but it will require considerable local knowledge to discover where they are and to sample any snail fauna therein.

As commented on above, *Setobaudinia victoriana* is partly transitional to such eastern genera as *Trachiopsis* Pilsbry, 1893. Almost no land snail collecting has been done in the vast area between Kununurra, Arnhem Land, and Torres Strait. Until this gap is filled by collecting activity, it is premature to attempt east-west synonymies.

Only one specimen was dissected in view of its very distinctive structures and the limited material available. **Table 81** summarises size variation.

SETOBAUDINIA SP.

Material

Stewart River, Kimbolton, north of Derby (16°36′S, 123°31′E) (5 adults, WAM 650.77, FMNH 209058, collected by W.A. Butler 18 September 1975).

North side of west arm of Lawley River estuary, east edge of Mitchell Plateau ('Warrender' 4068 – 110:777, ca 14°39′S, 125°53′E) (2 adults, WAM 331.80, WAM 352.80, collected by Barry R. Wilson 18 August 1977).

Remarks

Two additional species are represented by very limited material. They are not formally described, although obviously representing new species on the basis of observable character states.

The Kimbolton specimens were mostly collected alive, then immersed in formalin for an unknown period of time. The shells are extensively damaged as a result, and would fragment during the considerable handling needed for description. Much of the periostracum has flaked off. This population represents the southernmost record yet known for *Setobaudinia*. On the basis of the narrow, rapidly decoiling umbilicus, large size and higher whorl count (sp. 1 in **Table 76**), only slight spire elevation, absence of body whorl descension, sparse periostracal setal covering, and limited lip expansion with weak lip nodes **(Table 77)**, this population cannot be placed in either *S. interrex* from the Prince Regent River (its nearest geographical relative), or *S. collingii* (Smith, 1893) from the Admiralty Gulf, the species with the most similar shell features.

The Lawley River specimens were collected alive, but aestivating, and then dried out. The shell surface is so covered with debris that the pattern of setal spacing could not be observed. On the basis of their very small size, low whorl count, elevated spire and high H/D ratio for a *Setobaudinia* (sp. 2 in **Table 76**), they clearly differ from the other two Mitchell Plateau species, *S. calvitia* and *S. hirsuta*. The sharp descension of the body whorl, huge palatal lip node, great expansion of the outer lip, and very weak basal lip node are other contrasting features. The most unusual shell feature is the heavy parietal wall thickening into which the basal and palatal lips merge. The parietal lip itself is not quite elevated, and thus differs from the pattern seen in *S. victoriana* **(Figs 192b-c)**, in which the parietal lip is elevated and thus continuous with the basal and palatal lips. The lip of the Lawley River specimens is intermediate between the typical *Setobaudinia* pattern and that found in *S. victoriana*, thus indicating how the latter could have evolved. On the basis of variations found in other *Setobaudinia*, they clearly represent yet another species. In the absence of any anatomical data, and with only two adult specimens available, description is withheld. Since *S. hirsuta* (see p. 757) has been collected from the east arm of the Lawley River estuary and south-west Osborne Island, there clearly is range overlap between at least these two species, if not also with *S. calvitia*.

GENUS *BAUDINELLA* THIELE, 1931

Baudinella Thiele, 1931, Handbuch syst. Weichtierkunde, **1**: 685 – type species *Helix (Gonostoma) baudinensis* Smith, 1893 by original designation; Iredale, 1938, Australian Zool., **9** (2): 109 – listing in a check list; Iredale 1939, Jour. Roy. Soc. Western Australia, **25**: 49, pl. 3, fig. 9; Zilch 1960, Handbuch der Paläozoologie, Gastropoda, Teil 2, Euthyneura, Lief. **4**: 619, figs 2170.

Gonobaudinia Iredale, 1933, Rec. Australian Mus., **19**: 55 – type species *Helix (Gonostoma) baudinensis* Smith, 1893 by original designation.

Diagnosis

Shell small, adult diameter 5.2-8.7 mm, whorl number reduced to $3\frac{5}{8}$ to $4\frac{1}{2}$. Spire moderately **(Fig. 194b)** to strongly **(Fig. 194e)** elevated, not

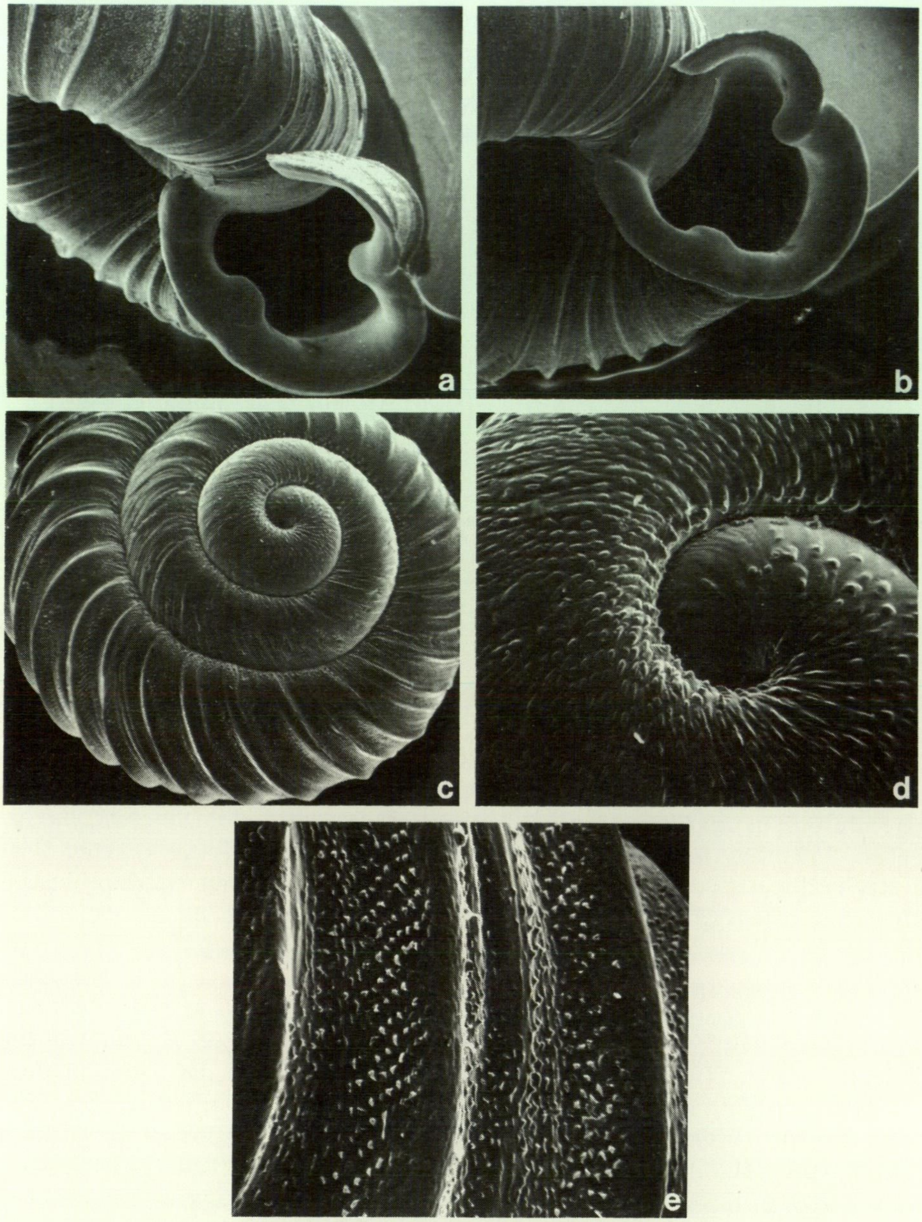

Plate 76: Shell of *Baudinella baudinensis* (Smith, 1893): Baudin Island, Admiralty Gulf, Kimberley, BM(NH) 90.12.30.121-7, paratype: (a) aperture from side view at 18.2X; (b) aperture tilted to show lip nodes at 15.8X; (c) general view of shell sculpture at 16.3X; (d) detail of apex at 62.5X; (e) body whorl sculpture at 82.5X.

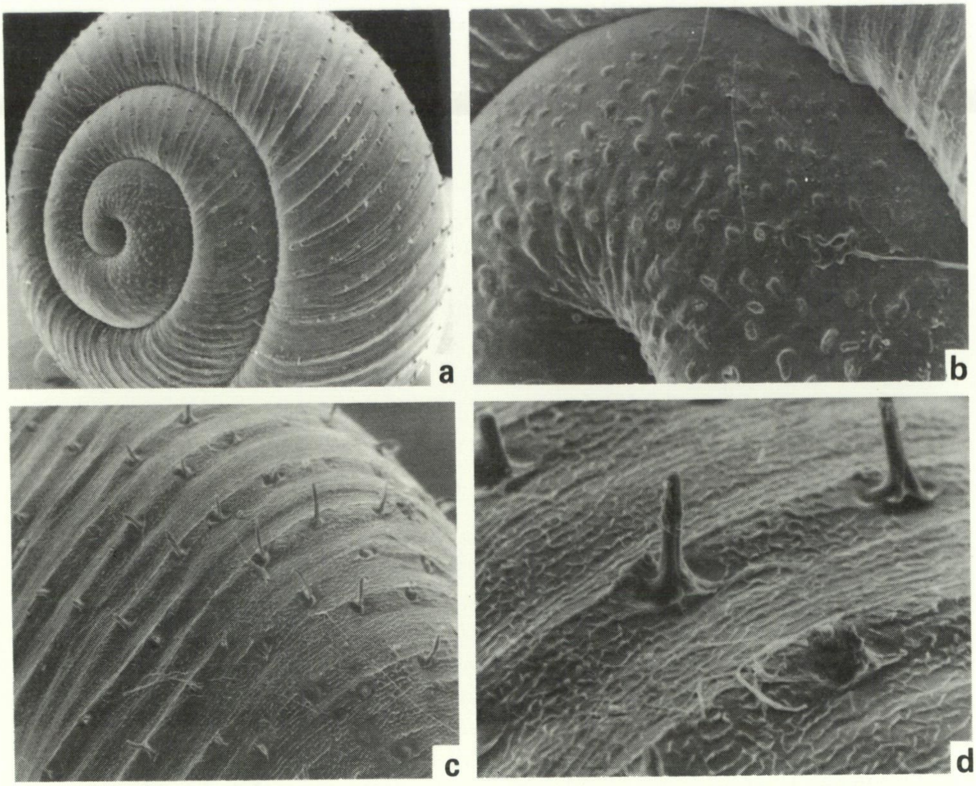

Plate 77: Shell of *Baudinella regia,* Sta. E5 (4), Prince Regent River, Kimberley, WAM 478.75: (a) juvenile shell at 15.6X; (b) shell apex at 75.5X; (c) hairs and radial ribbing on body whorl at 41.5X; (d) single hairs on body whorl at 168X.

rounded above. Umbilicus moderately to widely open **(Figs 194c, f)**, decoiling normal to somewhat more rapidly. Apical whorls **(Plates 76a, d, 77a-b)** 1¼ to 1½, sculpture of prominent, irregularly spaced tubercles. Postapical whorls developing closely **(Plate 77a)** to moderately spaced **(Plate 76c)** radial ribs that are most prominent on last half of body whorl. Microsculpture of tiny projections **(Plate 76e)** or anastomosing ridgelets plus widely spaced, short periostracal setae **(Plate 77a, c-d)**. Setae with sharp points and only slightly widened bases. Body whorl slightly **(Fig. 194e)** to moderately **(Fig. 194b)** descending behind aperture. Parietal wall with thin callus **(Plate 76a-b)**. Lip strongly expanded, basal and palatal edges curving into parietal wall **(Plate 76a-b)**. Basal node very prominent, composed primarily of internal additions. Palatal node thickened internally, but initial prominence resulting from crease in lip **(Plate 76a)**. Shell periphery rounded. Periostracal colour yellow brown, lip white. Genitalia with short free oviduct (UV), spermatheca (S) hooked **(Fig. 195a)** or tightly coiled **(Fig. 196a)**, bound by fibres to base of prostate-uterus. Vagina (V) variable in length. Vas deferens (VD) entering very long epiphallus (E) with longitudinal pilasters. No epiphallic lobe or caecum. Penial retractor muscle attaching on epiphallus which then reflexes anteriorly. Transition to penis (P) not marked externally, interior with shift in pilasters **(Fig. 195b)**. No penis sheath. Demarcation between epiphallus and penis not clearly defined, penis chamber walls with one **(Fig. 195b)** or two **(Fig. 196b)** types of pilasters. Jaw **(Plate 70e-f)** without unusual features. Central and lateral radular teeth **(Plate 78a, c-e)** with high elevation, curved, rather blunt mesocones. Lateromarginal transition **(Plate 78d-e)** rather gradual, lateral teeth few in number.

Type species: *Helix (Gonostoma) baudinensis* Smith, 1893 by original designation.

Comparative remarks

The shells of *Setobaudinia* and *Baudinella* are very similar, differing primarily in the absence of prominent radial ribs in the former **(Plate 66)** and presence in the latter **(Plate 76a, c, Figs 194a-f)**. In addition, the lip nodes in *Baudinella* are much more prominent. Anatomically, *Baudinella* lacks a penis sheath, any trace of a verge, has no epiphallic lobe or caecum, the spermatheca is hooked or tightly coiled against the base of the prostate-uterus, and the epiphallus is very long and coiled. *Setobaudinia,* in contrast, has a long penis sheath, there is either a large verge or large apical pilasters in the penis, the epiphallus has a caecum and normally a lobe, the spermatheca has a simple shaft and reaches the albumen gland, and the epiphallus is proportionately shorter. *Retroterra* differs in its much larger size **(Table 76)**, sculpture of closely spaced radial ribs **(Figs 197, 200)**, the near absence of lip nodes and very slightly reflected lip, much wider umbilicus **(Table 76)**, and more loosely coiled whorls. Anatomically, *Retroterra* **(Figs 198, 199, 201)** shares with *Baudinella* the unusual spermatheca (S), very long epiphallus and lack of a penis sheath, but differs in the presence of an epiphallic caecum and a penial stimulator or verge. The Napier Range *Kendrickia ignivenatus* **(Figs 202a-c)** is larger **(Table 83)**, more widely umbilicated, with spiral colour bands, and has very crowded, unusual radial ribbing without any trace of microsculpture on the shell. Anatomically, *Kendrickia* **(Figs 203a-d)** has a very short spermatheca, huge epiphallic caecum, very short penis with large verge and lacks a penis sheath.

Previous studies and nomenclature

Baudinella baudinensis (Smith, 1893) was described in the same paper as *Setobaudinia collingii* (Smith, 1893), and subsequent literature citations exactly parallel the history of that species recited under *Setobaudinia* (p. 713). A few examples of *Baudinella baudinensis* were deposited by J.J.

Walker in the Australian Museum (AM C.65035), which enabled Iredale (1939) to comment on the calcified epiphragm and refigure this species.

Distribution and basic ecology

The only records of *Baudinella* are from Baudin Island, Admiralty Gulf and the Prince Regent River Reserve. Collections have been made from litter and under stones. Both species are 'free sealers' in that a heavily calcified epiphragm is secreted across the aperture of aestivating specimens. No other information is available about their ecology.

Since all live collected material of *Baudinella* was taken in August, no data is available on seasonal variation of the genitalia or the maturation patterns.

Patterns of structure

Differences in shell shape and ribbing **(Figs 194a-f)** are minor, and the few anatomical differences between *Baudinella baudinensis* and *B. regia* are discussed under the comparative remarks of each species.

In shell features, *Baudinella* and *Setobaudinia* have the same general appearance, especially in regard to apertural features, but there are major differences in anatomy.

Relationships of *Baudinella*

Conchologically, *Baudinella* is very similar to *Setobaudinia,* but in anatomy it is much closer to *Retroterra.* The later genus probably is derived from *Baudinella.* Both *Kendrickia* and *Mouldingia* Solem, 1984 from the Napier Range have shell aspects that recall *Baudinella,* but show major differences in anatomy that indicate very different evolutionary histories.

Systematic review

The following key will separate the two known species.

KEY TO THE SPECIES OF *BAUDINELLA*

1. Spire strongly elevated; radial ribs closely spaced **(Fig. 194e)**; Prince Regent River Reserve . . . . *Baudinella regia* sp. nov. (p. 782)

   Spire weakly elevated; radial ribs more widely spaced **(Fig. 194b)**; Baudin Island, Admiralty Gulf . . . . *Baudinella baudinensis* (Smith, 1893)

BAUDINELLA BAUDINENSIS (Smith, 1893)
(Plates 70f, 76a-e, 78a-b; Figs 194a-c, 195a-b)

Helix (Gonostoma) baudinensis Smith, 1893, The Conchologist, 2 (5): 97-98, figs – Baudin Island, N.W. Australia. Here restricted to Baudin

Island, Admiralty Gulf (14°08'S, 125°36'E); Smith, 1894, Proc. Malac. Soc. London, **1**: 88.

Planispira (Trachiopsis) baudinensis (Smith), Pilsbry, 1893, Man. Conch., (2) **8**: 286-287, pl. 58, figs 8-9; Pilsbry, 1894, Man. Conch., (2) **9**: 114.

Planispira baudinensis (Smith), Hedley, 1916, Jour. Roy. Soc. Western Australia, **1**: 69.

Angasella (Baudinella) baudinensis (Smith), Thiele, 1931, Handbuch der Systematischen Weichtierkunde, **1**: 685.

Gonobaudinia baudinensis (Smith), Iredale, 1933, Rec. Australian Museum, **19** (1): 55.

Baudinella baudinensis (Smith), Iredale, 1938, Australian Zool., **9** (2): 109 – listing in check list; Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 49, pl. 3, fig. 9.

Comparative remarks

Baudinella baudinensis (Smith, 1893) is easily separated from *B. regia* by its smaller size **(Table 76)**, less elevated spire **(Figs 194b, e)**, and more widely spaced, larger radial ribs **(Figs 194a-f)**. The several *Setobaudinia* species found in the same general region, *S. collingii* (Smith, 1893), *S. calvitia,* and *S. hirsuta,* all differ in the total absence of radial ribs on the shell **(Figs 181, 184)**, their much more prominent periostracal setae **(Plates 64, 66, 76, 77)**, and their much smaller basal lip nodes. *Retroterra parva* from the Prince Regent River area is almost twice as large **(Table 76)**, has a much wider umbilicus **(Fig. 197b)**, much finer and more crowded radial ribs **(Figs 197a-c)**, and reduced lip nodes **(Figs 197b-c)**. Anatomically, the shorter spermatheca (S), vagina (V) and single type of ridging within the penis **(Figs 195a-b)** of *Baudinella baudinensis* contrast with the very long, coiled spermatheca, longer vagina, and two types of penis ridging **(Figs 196a-b)** found in *B. regia.*

Lectotype

BMNH 1890.12.30.121, Baudin Island, Admiralty Gulf, Kimberley, Western Australia (1:100,000 'Admiralty Gulf' map sheet 4069 – grid reference 810:365, ca 14°08'S, 125°36'E). Collected by J.J. Walker in 1890. Height of lectotype 2.7 mm, diameter 6.2 mm, H/D ratio 0.435, whorls 3¾+, umbilical width 1.85 mm, D/U ratio 3.95.

Paralectotypes

BMNH 1890.12.30.122-7, 6 dead adults from the type locality.

Type lot material or paratypes

Baudin Island (9 dead adults, AMS C.35065 ex J.J. Walker, SMF 27059/2 ex Moellendorff, FMNH 41659 ex W.F. Webb, G.K. Gude, Beddome, FMNH 41658 ex G.K. Gude).

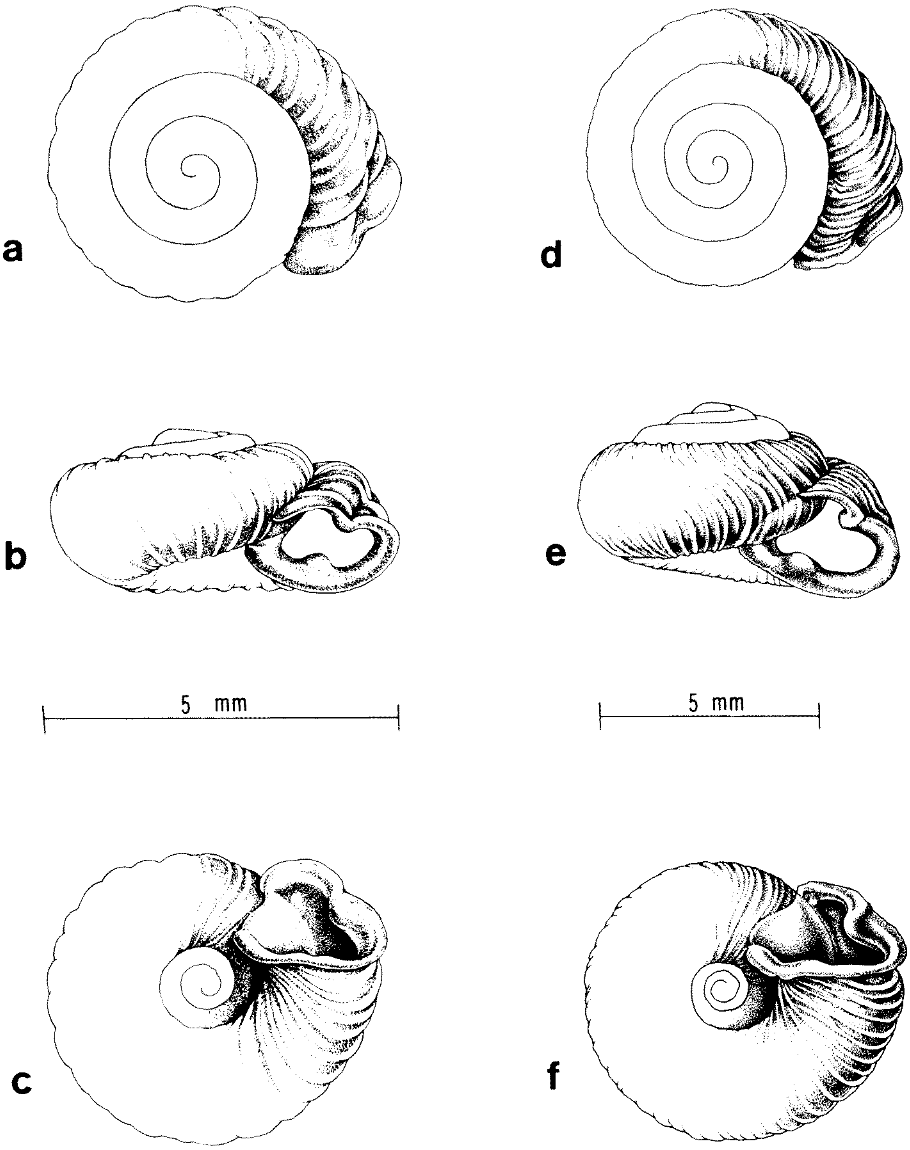

Fig. 194: Shells of *Baudinella baudinensis* (Smith, 1893) and *B. regia:* (a-c) *B. baudinensis,* Baudin Island, Admiralty Gulf, Kimberley, BM (NH) 1890.12.30.127, paratopotype of *Helix (Gonostoma) baudinensis* Smith, 1893; (d-f) *B. regia,* Sta. E5 (4), Prince Regent River Reserve, Kimberley, WAM 613.80, holotype. Scale lines equal 5 mm. Drawings by Elizabeth Liebman (a-c) and Linnea Lahlum (d-f).

Other material

Baudin Island (1 live, 33 dead adults, WAM 327.80, WAM 362.80, WAM 379.80, FMNH 209059).

Diagnosis

Shell very small, diameter 5.25-6.25 mm (mean 5.88 mm), with $3\frac{5}{8}$ – to $4\frac{1}{8}$ (mean $3\frac{3}{4}$+) rather tightly coiled whorls. Apex and spire slightly elevated **(Fig. 194b)**, height of shell 2.5-3.2 mm (mean 2.80 mm), H/D ratio 0.419-0.534 (mean 0.477). Apical sculpture **(Plate 76c-d)** of sharp, elongated pustules, vaguely oriented in radial rows, postapical whorls with prominent, rather widely spaced radial ribs **(Plate 76a, c, e)** on body whorl and part of penultimate whorl **(Figs 194a-c)**. Microsculpture **(Plate 76e)** of irregularly spaced projections that normally are worn off of rib edges. Shell periphery rounded, body whorl descending slightly just before aperture. Lip strongly expanded **(Figs 194b-c, Plate 76a-b)**, corners indented when merging into parietal wall. Basal and palatal lips with very prominent nodes **(Figs 194b-c, Plate 76a-b)**, formed by a combination of lip creasing and internal thickening. Umbilicus **(Fig. 194b)** widely open, regularly decoiling, width 1.4-2.1 mm (mean 1.78 mm), D/U ratio 2.86-4.13 (mean 3.33). Colour dark yellow-brown, lip white. Based on 50 measured adults.

Genitalia **(Figs 195a-b)** with rather short vagina (V) and spermatheca (S), epiphallus (E) long, penis (P) slender. Interior of penis with small pilasters, epiphallus with large, somewhat poorly defined longitudinal pilasters. Radular teeth **(Plate 78a-b)** and jaw **(Plate 70f)** typical. Based on one dissected adult.

Remarks

The single live specimen, WAM 379.80, was collected by Fred E. Wells on 15 August 1976 in leaf litter. Barry R. Wilson took a number of dead examples (WAM 327.80, WAM 362.80) 22 August 1977 from soil in rock crevices, but found no live material. Despite the relatively extensive collecting on the Mitchell Plateau by WAM and FMNH staff, no trace of any *Baudinella* has been found on the mainland. Quite possibly, this, or another species, will be found on other offshore islands as most of them have not yet been sampled for land snails.

BAUDINELLA REGIA SP. NOV.

(Plates 70e, 77a-d, 78c-e; Figs 194d-f, 196a-b)

Comparative remarks

Baudinella regia differs from the genotype, *B. baudinensis* (Smith, 1893) in its larger size **(Table 76)**, more elevated spire **(Fig. 194e)**, finer and more crowded radial ribbing **(Figs 194d-f)**, and slightly narrower umbilicus **(Figs**

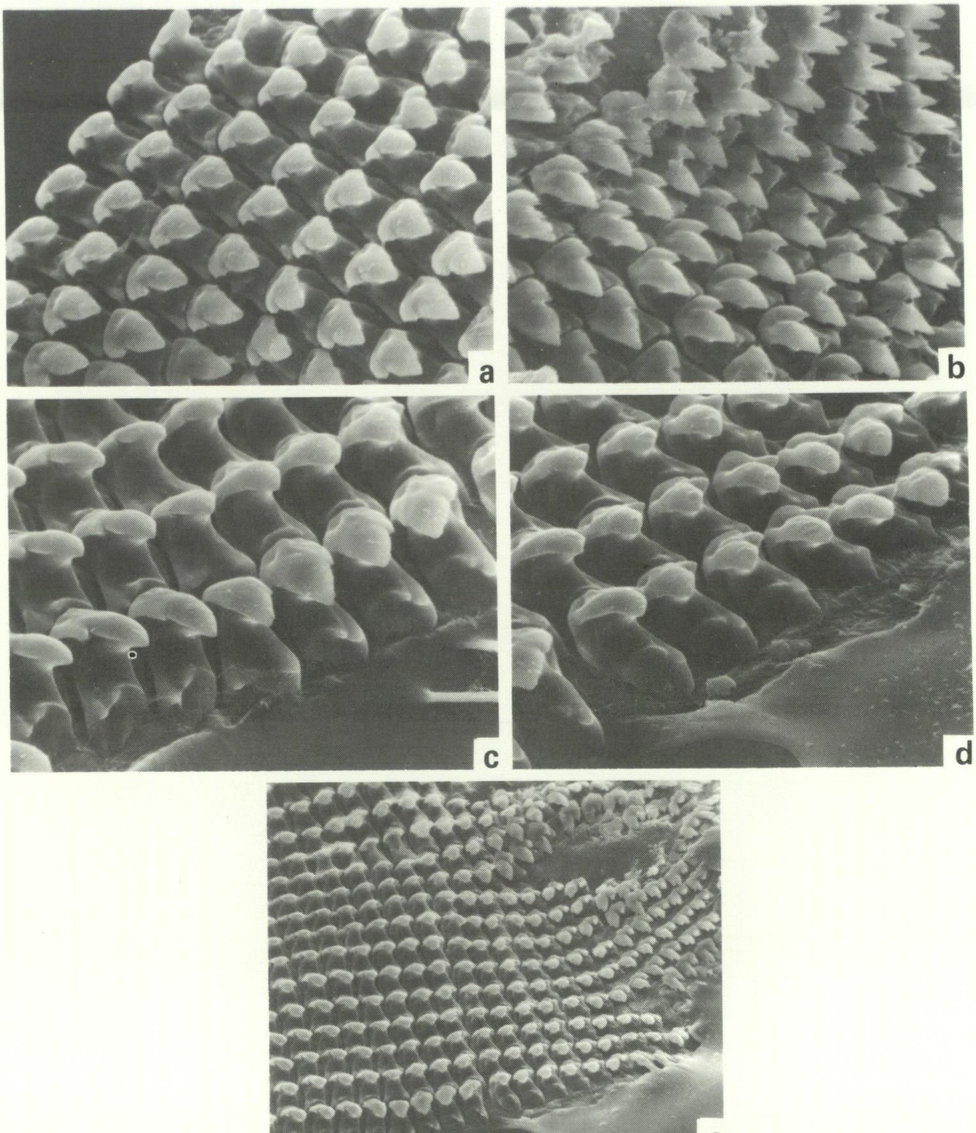

Plate 78: Radular teeth of *Baudinella:* (a-b) *B. baudinensis* (Smith, 1893), Baudin Island, Admiralty Gulf, Kimberley, WAM 379.80, Dissection A, (a) central and lateral teeth at 660X; (b) lateromarginal transition at 680X; (c-e) *B. regia,* Sta. E5 (4), Prince Regent River Reserve, Kimberley, WAM 478.75, 15 August 1974, Dissection A, (c) central and early laterals at 1,135X; (d) low angle view of lateromarginal transition at 1,100X; (e) part row of teeth at 575X.

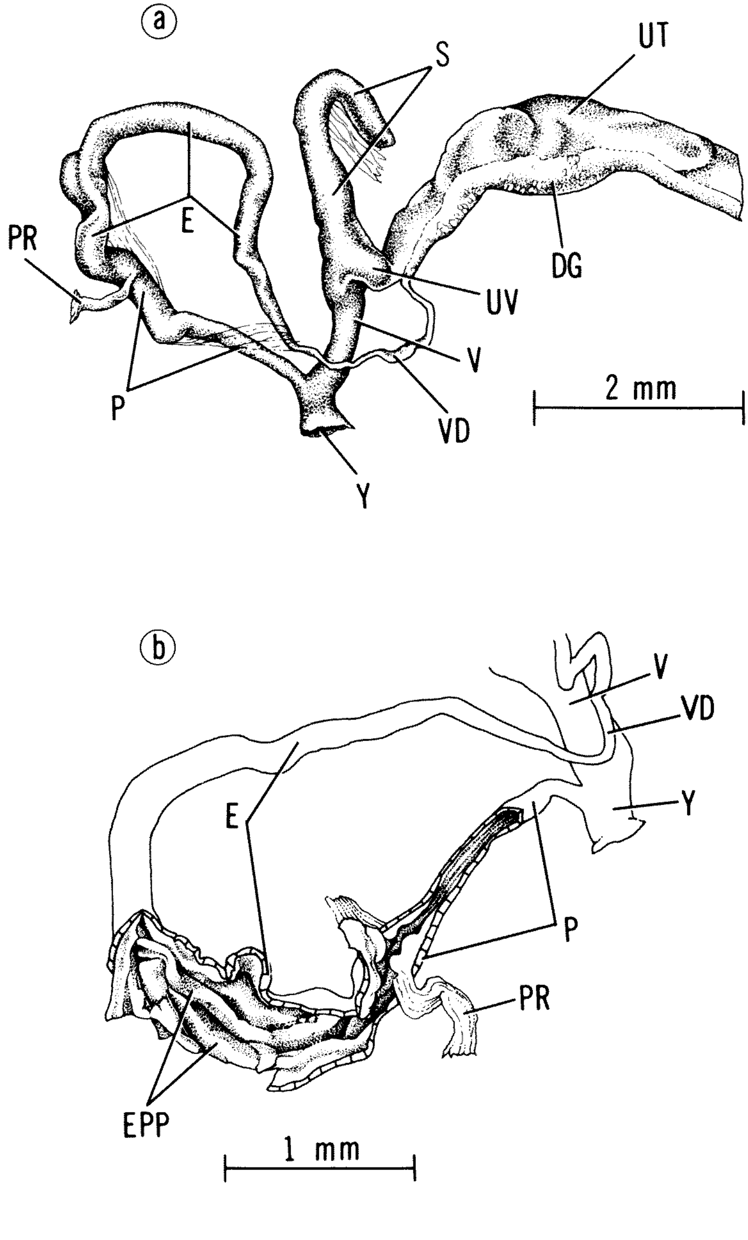

Fig. 195: Genitalia of *Baudinella baudinensis* (Smith, 1893): Baudin Island, Admiralty Gulf, Kimberley, WAM 379.80, 15 August 1976, Dissection A, (a) postapical genitalia, (b) interior of penis. Scale lines as marked. Drawings by Linnea Lahlum.

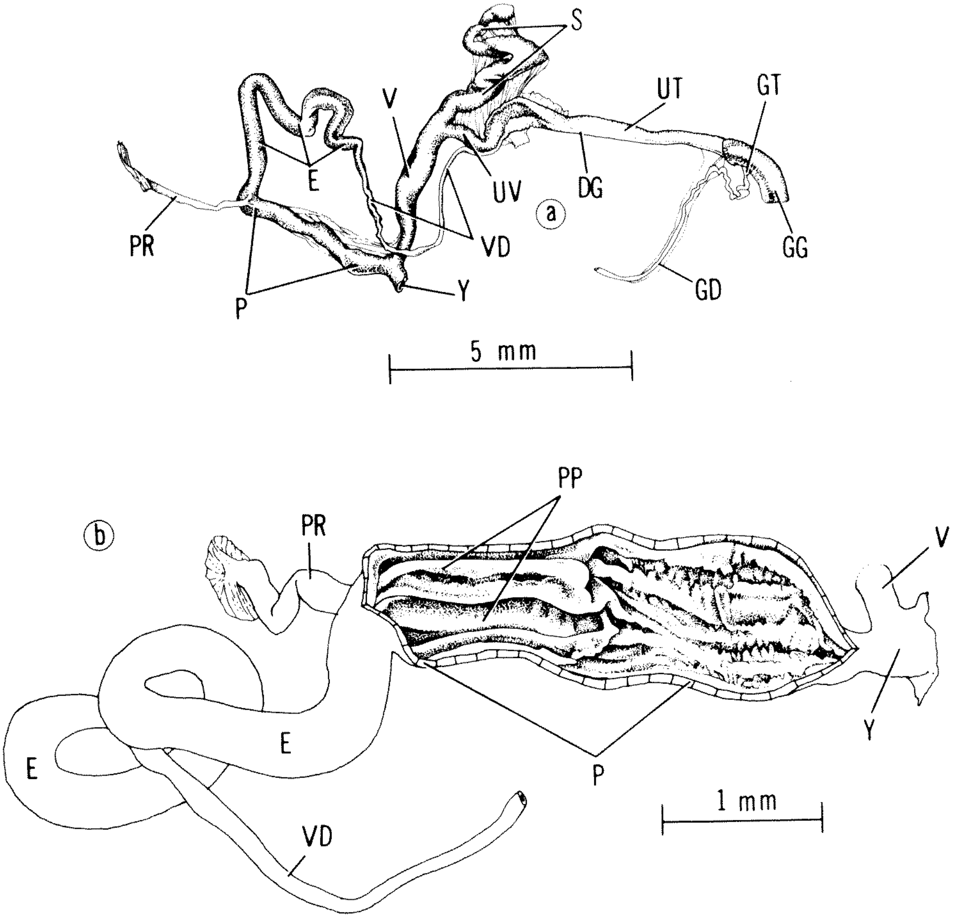

Fig. 196: Genitalia of *Baudinella regia:* Sta. E5 (4), Prince Regent River Reserve, Kimberley, WAM 478.75, 15 August 1974, (a) whole genitalia, Dissection A, (b) interior of penis, Dissection B. Scale lines as marked. Drawings by Linnea Lahlum.

194c, f). The often sympatric *Setobaudinia interrex* **(Figs 182a-c)** lacks radial ribbing and has a microsculpture of long periostracal setae and micro-projections **(Plate 65c-d)** that is very different from more widely spaced setae and low micro-ridges of *B. regia* **(Plate 73a, c-d).** Species of *Retroterra* are much larger in size **(Table 76),** lack major lip nodes **(Figs 197b, c),** and have closely spaced, rather fine radial ribs at least above the periphery. Anatomically, *B. regia* **(Figs 196a-b)** has a very long, coiled spermatheca (S), long vagina (V) and the penis has two types of longitudinal ridging, whereas *B. baudinensis* has a shorter spermatheca and vagina, and only one type of pilaster in the penis (see **Figs 195a-b**). Species of *Retroterra* differ most obviously in having a short to medium length epiphallic caecum (EC) and a vergic papilla (**Figs 198a, 199, 201a, c, f**).

Holotype

WAM 613.80, Sta. E5 (4), west slope of main gorge below Enid Falls, Rufous Creek, Roe River, Prince Regent River Reserve, Kimberley, Western Australia (1:250,000 'Prince Regent' map sheet SD 51-16 – grid reference 348:086, ca 15°07'S, 125°33'E). Collected by Barry R. Wilson and Peter Smith 15 August 1974. Height of shell 4.6 mm, diameter 7.5 mm, H/D ratio 0.613, whorls 4½–, umbilical width 1.9 mm, D/U ratio 3.95.

Paratopotypes

WAM 346.75, WAM 352.75, WAM 478.75, FMNH 209053, FMNH 209054, 17 live, 16 dead adults, 7 live, 1 dead juvenile from the type locality.

Paratypes

Prince Regent River Reserve (all specimens collected August 1974): Sta. E5 (1), small gully entering north-east corner of main gorge below Enid Falls ('Prince Regent' SD 51-16 – 348:086) (9 live, 42 dead adults, 11 dead juveniles, WAM 343.75, WAM 344.75, WAM 348.75, WAM 349. 75, WAM 614.80, WAM 615.80); Sta. E5 (7), below opening of deep gully about 3 km west of Enid Falls campsite ('Prince Regent' SD 51-16 – 344: 085) (6 live, 5 dead adults, 2 live juveniles, WAM 354.75, WAM 355.75, WAM 473.75); Sta. E5 (8), steep scree below western rampart of deep gully, 2-3 km west of Enid Falls campsite ('Prince Regent' SD 51-16 – 343:084) (3 dead adults, WAM 353.75); Sta. E5 (10), vine thicket near spring, northern Rufous Creek tributary, about 1.5 km north of Enid Falls campsite ('Prince Regent' SD 51-16 – 346:089) (2 dead adults, 2 dead juveniles, WAM 351.75, WAM 372.75); Pitta Creek, Upper Prince Regent River ('Prince Regent' SD 51-16 – 353:992) (25 dead adults, 10 dead juveniles, WAM 347.75, FMNH 209056); Sta. W4 (4), scree slopes of Mt Trafalgar, edge of vine thicket, Saint George Basin ('Prince Regent' SD 51-16 – 291:068) (4 dead juveniles, WAM 350:75); Sta. W6, Youwangela Creek (15°34'S, 125°25'E), tributary of Prince Regent River (3 live, 11 dead adults, 2 dead juveniles, WAM 345.75, WAM 468.75).

Prince Regent River Reserve (all specimens collected July 1977): Sta. 1, west bank of Roe River (15°15'S, 125°33'E) (25 dead adults, 2 dead juveniles, WAM 318.80, WAM 365.80, WAM 611.80, FMNH 209057); Sta. 3, north bank, mouth of Roe River estuary, Prince Frederick Harbour (15°08'S, 125°33'E) (1 dead adult, 1 dead juvenile, WAM 341.80).

Diagnosis

Shell small, diameter 5.2-8.7 mm (mean 7.40 mm), with 3⅝ to 4½ tightly coiled whorls. Apex and spire strongly elevated (**Fig. 194e**), height of shell 3.15-5.3 mm (mean 4.24 mm), H/D ratio 0.500-0.670 (mean 0.531). Apical sculpture (**Plate 77a-b**) of rather widely and irregularly spaced pustules, postapical whorls (**Plate 77a, c-d**) with prominent radial ribs and a microsculpture of short, quite widely spaced periostracal setae with simple bases. Anastomosing microridges cover the periostracal surface between the setae (**Plate 77d**). Shell periphery rounded, body whorl descending slightly behind aperture. Lip strongly expanded, with very prominent palatal and basal lip nodes (**Figs 194e-f**). Basal and palatal lips strongly curved into parietal wall. Umbilicus (**Fig. 194f**) rather narrow, last whorl decoiling more rapidly, width 1.3-2.55 mm (mean 1.95 mm), D/U ratio 2.88-4.90 (mean 3.82). Periostracal colour dark yellow-brown, lip white. Based on 154 measured adults.

Genitalia (**Figs 196a-b**) with spermatheca (S) long and coiled, vagina (V) relatively long, upper portion of penis with simple pilasters, lower portion with corrugated pilasters. Jaw (**Plate 70e**) and radular teeth (**Plate 78c-e**) typical. Based upon 3 dissected individuals.

Remarks

Baudinella regia is sympatric with *Setobaudinia interrex* at several localities in the Prince Regent River area. Most lots of specimens were mixed. Dirt encrusted individuals are very easy to confuse as the two species are very similar in size and overall appearance. Size variation in *B. regia* (**Table 82**) is less than in *S. interrex* (**Table 78**).

GENUS *RETROTERRA* NEW GENUS

Diagnosis

Shell medium to large, adult diameter 9.2-24.6 mm, whorl count normal in *parva* and *costa*, increased in *solituda*. Spire ranging from almost flat *(parva, costa)* (**Figs 197c, 200b**) to strongly elevated and rounded above *(solituda,* **Fig. 200d**). Umbilicus moderately *(solituda,* **Fig. 200d**) to widely *(parva,* **Fig. 197b**) open, regularly decoiling. Apical sculpture unknown because of eroded surfaces, probably of weak elongated pustules. Postapical whorls with fine *(solituda)* to very prominent radial ribs *(parva, costa)* which sometimes anastomose (**Fig. 197a**). Ribbing prominent above periphery in all species, continuing unchanged onto base and into umbilicus *(costa),* somewhat reduced below periphery *(parva),* or absent below periphery *(solituda).* No significant microsculpture observed. Body whorl rounded, not *(solituda)* to moderately *(parva,* **Fig. 197c**) descending behind aperture. Lip moderately *(parva,* **Figs 197b-c**) to barely *(solituda,* **Figs 200e-f**) expanded,

Table 82: Local Variation in *Baudinella baudinensis*, *B. regia*, *Retroterra parva*, *R. costa* and *R. solituda*

Taxon	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
B. baudinensis (Smith, 1893)				
Types, BMNH 90.12.30.121-7	7D	2.74±0.038 (2.6–2.9)	5.86±0.090 (5.5–6.2)	0.469±0.011 (0.435–0.509)
WAM 362.80	15D	2.80±0.052 (2.5–3.2)	5.90±0.042 (5.65–6.2)	0.474±0.008 (0.419–0.529)
WAM 327.80	18D	2.81±0.038 (2.5–3.15)	5.92±0.049 (5.45–6.25)	0.475±0.007 (0.435–0.532)
B. regia				
E5 (1), WAM 344.75	6D	4.31±0.159 (3.8–4.9)	7.39±0.142 (6.95–7.8)	0.581±0.018 (0.540–0.639)
E5 (1), WAM 343.75	35D	4.27±0.041 (3.6–4.6)	7.53±0.051 (6.7–8.15)	0.568±0.004 (0.500–0.631)
Sta. 1, WAM 318.80	10D	3.96±0.059 (3.65–4.3)	6.92±0.089 (6.3–7.3)	0.569±0.008 (0.529–0.591)
E5 (4), WAM 478.75	17L	4.19±0.051 (3.7–4.5)	7.41±0.058 (6.95–7.8)	0.570±0.009 (0.510–0.602)
W6, WAM 345.75	11D	4.10±0.121 (3.35–4.45)	7.37±0.149 (6.35–8.25)	0.559±0.008 (0.500–0.639)
W6, WAM 347.75	25D	4.28±0.059 (3.5–4.85)	7.53±0.088 (6.4–8.6)	0.571±0.009 (0.518–0.628)
R. parva				
W6 (1), WAM 250.75, 253.75	12D	4.54±0.140 (3.85–5.3)	10.73±0.303 (9.2–12.6)	0.424±0.007 (0.362–0.460)
R. costa				
E5 (6), WAM 241.75	9D	6.27±0.107 (5.8–6.7)	15.69±0.185 (14.9–16.7)	0.400±0.009 (0.347–0.436)
Sta. 3, WAM 329.80	11D	6.59±0.185 (5.4–7.5)	14.49±0.220 (13.4–15.4)	0.454±0.010 (0.400–0.498)
R. solituda				
W6 (1), WAM 433.75, 498.75	5L, D	14.06±0.237 (13.3–14.5)	23.55±0.351 (22.7–24.6)	0.597±0.011 (0.570–0.634)
W6 (5), several sets	10L, D	12.41±0.269 (10.5–13.35)	22.54±0.295 (20.8–23.4)	0.550±0.007 (0.505–0.578)

Table 82: Local Variation in *Baudinella baudinensis, B. regia, Retroterra parva, R. costa* and *R. solituda* (continued)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
B. baudinensis (Smith, 1893)				
Types, BMNH 90.12.30.121-7	7D	3¾ (3⅝– –3⅞)	1.67±0.062 (1.4–1.85)	3.53±0.146 (3.28–3.67)
WAM 362.80	15D	3¾+ (3⅝–3⅞+)	1.78±0.040 (1.5–2.0)	3.35±0.083 (2.90–4.13)
WAM 327.80	18D	3¾+ (3⅝– –4)	1.84±0.032 (1.6–2.1)	3.23±0.048 (2.86–3.57)
B. regia				
E5 (1), WAM 344.75	6D	4¼– (4–4⅜+)	1.94±0.068 (1.65–2.1)	3.85±0.201 (3.31–4.65)
E5 (1), WAM 343.75	35D	4¼– (3⅞+–4⅜+)	2.01±0.031 (1.55–2.25)	3.77±0.058 (3.30–4.90)
Sta. 1, WAM 318.80	10D	4⅜– (4¼–4½)	1.71±0.048 (1.4–1.95)	4.07±0.110 (3.67–4.89)
E5 (4), WAM 478.75	17L	4¼ (4+–4⅜+)	1.96±0.031 (1.7–2.2)	3.79±0.068 (3.31–4.41)
W6, WAM 345.75	11D	4+ (3⅝–4¼)	2.11±0.071 (1.8–2.4)	3.52±0.088 (3.13–4.14)
W6, WAM 347.75	25D	4⅛+ (4–4¼+)	1.93±0.038 (1.5–2.45)	3.93±0.079 (3.05–4.50)
R. parva				
W6 (1), WAM 250.75, 253.75	12D	4⅜ (4⅛– –4¾+)	3.58±0.065 (3.1–3.95)	3.00±0.069 (2.68–3.44)
R. costa				
E5 (6), WAM 241.75	9D	4⅜ (4+–4½+)	4.99±0.123 (4.5–5.7)	3.15±0.053 (2.83–3.37)
Sta. 3, WAM 329.80	11D	4½ (4¼– –4¾–)	4.25±0.069 (3.8–4.65)	3.41±0.047 (3.10–3.64)
R. solituda				
W6 (1), WAM 433.75, 498.75	5L, D	5⅝+ (5⅜+–5⅞)	4.99±0.075 (4.8–5.25)	4.72±0.099 (4.38–4.92)
W6 (5), several sets	10L, D	5½– (5⅛–5⅞)	5.01±0.117 (4.2–5.6)	4.51±0.087 (4.18–5.14)

only *parva* with a significant basal lip node. Periostracal colour dark yellow-brown, sometimes with reddish suffusions, base may be much lighter, lip white. Genitalia with short free oviduct (UV) and medium to long vagina (V). Spermatheca (S) unusual in being long and either sinuated *(costa,* **Fig. 201f)** or complexly kinked *(parva,* **Fig. 198a,** *solituda,* **Fig. 201a**), bound tightly to lower part of prostate-uterus. Vas deferens (VD) simple, entering epiphallus (E) laterally at base of prominent epiphallic caecum (EC). Interior of epiphallus (**Figs 198a, 201e**) with simple to corrugated longitudinal pilasters. Penial retractor muscle (PR) inserts onto epiphallus. Length of epiphallic portion above insertion of penial retractor muscle is species variable, much longer than combined epiphallus-penis below muscle insertion, extremely long in *solituda* (**Fig. 201a**). Junction of penis and epiphallus marked by a stimulatory papilla in *solituda,* spatulate verge in *costa,* and an almost tubular verge in *parva* (**Figs 199a-b**). Walls of penis interior smooth *(costa)* or longitudinally ridged *(parva, solituda).* No penis sheath. Jaw typical camaenid. Radula variable, with *parva* and *costa* (**Plate 79a-b**) having the lateral teeth mesocones blunt tipped and curved, while in *solituda* (**Plate 79e-f**) they are sharp tipped and not curved.

Type species: *Retroterra costa,* sp. nov.

Comparative remarks

Retroterra differs from *Baudinella* in ribbing and microsculpture, reduction or loss of lip expansion and basal nodes, and much larger size. The broad, rather widely spaced radial ribs and huge lip nodes of *Baudinella* (**Figs 194a-f**) contrast with the same structures in *Retroterra* (**Figs 197a-c, 200a-f**). The lack of either a verge or an epiphallic caecum in *Baudinella* are the main anatomical differences between the two closely related genera.

Setobaudinia has no radial ribbing, a complex microsculpture of periostracal setae, generally prominent lip nodes and expanded lip, a well developed penis sheath, simple spermatheca, and a much shorter epiphallus with normally both a caecum and a lobe (see **Figs 186a-b**). Basically the two genera have the same type of verge.

Kendrickia ignivenatus from the Napier Range is similar to *Retroterra parva* in shell features (**Figs 202a-c**), although differing in having a colour pattern, narrower umbilicus (**Table 83**) and more strongly descending body whorl. Anatomically, its very short spermatheca, massive epiphallic caecum, huge verge, and short penis (**Figs 203a-d**) immediately separate it from *Retroterra.*

Distribution and basic ecology

All known examples of *Retroterra* come from the Prince Regent, Roe, and Hunter River drainages in the Prince Regent River Reserve area. No

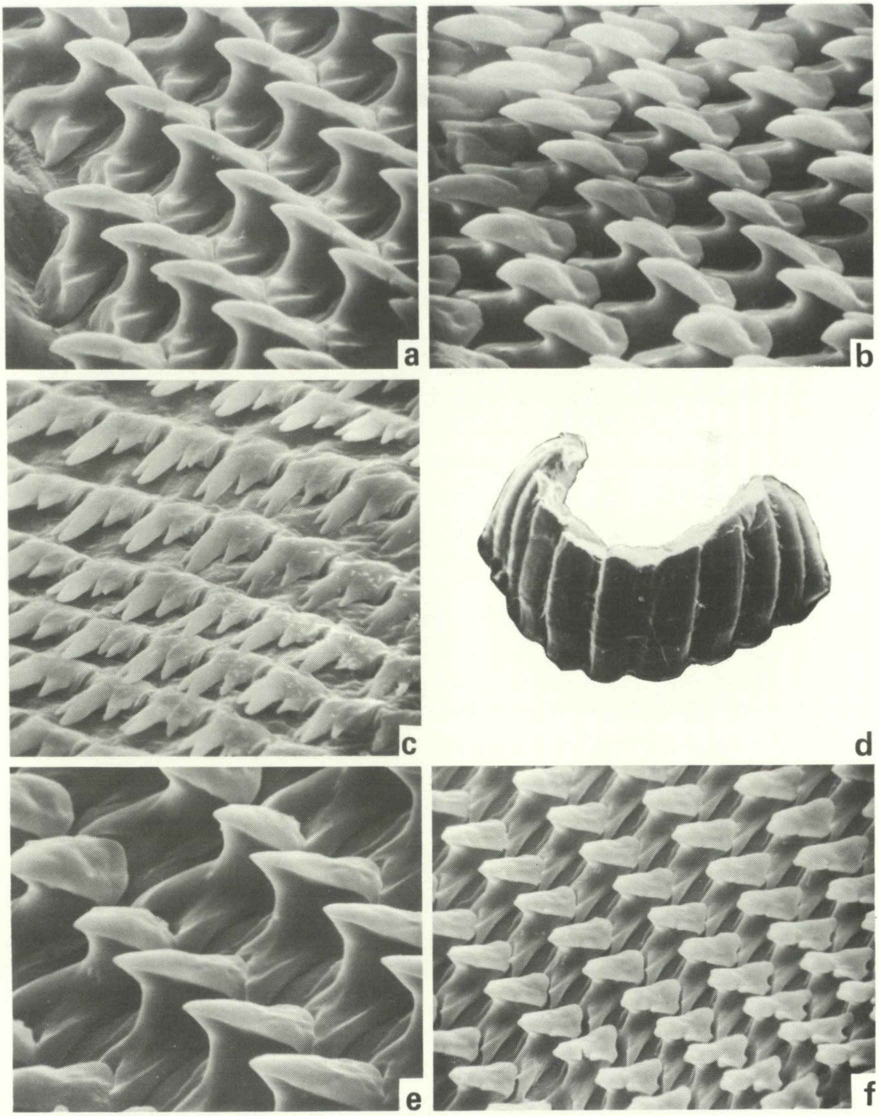

Plate 79: Radula and jaw of *Retroterra costa* and *R. solituda:* (a-d) *R. costa,* Sta. E5 (4), Enid Falls, Roe River, Prince Regent River Nature Reserve, 15 August 1974, WAM 476.75, Dissection A, (a) mid angle view of central and early laterals at 700X; (b) mid angle side view of early (bottom) to mid (top) laterals at 705X; (c) high angle view of outer marginals at 725X; (d) jaw at 70X; (e-f) *R. solituda,* Sta. W6 (1), Youwanjela Creek, Upper Prince Regent River, August 1974, WAM 493.75, Dissection A, (e) high angle side view of central and early laterals at 750X; (f) lateral teeth at 375X.

land snail collecting has been done in the Upper Mitchell River or in the inland areas between the Mitchell and Lawley Rivers. Near coastal and coastal areas of the Mitchell Plateau and a few islands in the Admiralty Gulf have been sampled for land snails with good results: the absence of *Retroterra* from this area seems real. South of the Prince Regent River, beginning with the Glenelg drainage and continuing through the Charnley drainage and Walcott Inlet, past the King Leopold Ranges, and into the peninsula and archipelagoes flanked by Collier Bay and King Sound, there are only scattered records of *Torresitrachia, Setobaudinia, Amplirhagada, Kimboraga* and *Xanthomelon.* These are based upon specimens that were collected incidental to field work by non-malacologists. This area cannot be considered to be well collected, and discovery of *Retroterra* some distance south of the Prince Regent River would not be surprising.

Field notes of the collectors indicate that live specimens were taken in litter or under rocks. All collections were made in the mid-dry season, July and August, so that live material was aestivating. Many dead specimens have a calcified epiphragm a short distance behind the aperture. Sometimes there is a second epiphragm about 1/8 th whorl back, rarely a third epiphragm that is even more deeply recessed.

Sympatry among the three *Retroterra, Setobaudinia interrex* and *Baudinella regia* was fairly extensive. All three *Retroterra* were collected at Sta. W6 (2); four of the five species (except *R. solituda*) at Sta. E5 (1); three species at Stas E5 (10) and the Roe River estuary collections of 1977. Generally the three *Retroterra* were allopatric, with sympatry of two species at Stas E5 (1) and W6 (1); all three species were taken only at W6 (2). In each case the specimen numbers are so low that any ideas as to species dominance are only wild guesses.

Since all collections are from the mid-dry season, there is no data available on genital maturation or seasonal variations. The ovotestis (G), hermaphroditic duct (GD), prostate (DG) and uterus (UT) are in dry season reduced size state in all species **(Figs 198a-b, 201a-b, f).** The terminal genitalia and albumen gland (GG) appear to be of fully functional size, when compared with the material studied earlier – *Torresitrachia* and *Xanthomelon* (Solem, 1979), *Amplirhagada* (Solem, 1981a), and the *Westraltrachia* group (Solem, 1984). *Retroterra* probably conforms to the model of seasonal variation and maturation proposed by Solem and Christensen (1984).

Patterns of structure

The trend for increased size, from the small *Retroterra parva* to the medium sized *R. costa* and very large *R. solituda* has some correlation with changes in lip expansion and nodes, rib reduction, and shape changes. Anatomical differences are discussed under the individual species and probably relate mainly to species recognition factors in view of the occasional sympatry among the species.

Relationships of *Retroterra*

Relationship between *Retroterra* and *Baudinella* is indicated in both shell and soft anatomy. They share the very unusual kinked or coiled spermatheca, elongated epiphallus, lack of a penis sheath (**Figs 196a, 198a, 201a**), and general pattern of penis pilaster sculpture (**Figs 196b, 199a, 201b-c**). *Baudinella* lacks a verge and has no epiphallic caecum, while *Retroterra* has a prominent caecum (**Figs 196a, 198a, 201a, d, f**) and either a verge or a stimulatory papilla (**Figs 196b, 199a-b, 201c**). The heavy and wide ribbing and periostracal setal sculpture of *Baudinella* (**Plates 76-77, Figs 194a-f**) are very different from that of *Retroterra* (**Figs 197a-c, 200a-d**) with its fine, sometimes anastomosing radial ribs and absence of microsculpture. The very strongly reflected shell lip and large lip nodes in *Baudinella* (**Plate 76a-b, Figs 194b-c, e-f**) contrast with the slight lip reflection and absence of lip nodes in *Retroterra costa* and *R. solituda* (**Figs 200b-c, d-f**), but *R. parva* (**Figs 197a-c**) is partly intermediate in that the lip is broadly expanded, a basal lip node persists, and some specimens show a trace of the upper lip crease that forms much of the palatal lip node in both *Baudinella* and *Setobaudinia*.

Systematic review

The name *Retroterra* is a rough approximation of 'outback'. It is intended to honour not only this vast and marvellous part of Australia, but also the people, past and present inhabitants alike, of the Outback. Many of them have contributed greatly to the success of these studies, and this is a token of thanks. Because this genus seems restricted to the small Prince Regent area, which is so difficult of access, it is an appropriate receptor for the name.

The following key will enable identification of adult specimens, but juveniles of *R. costa* and *R. parva* can be easily confused. Firm identification would require comparison with adult specimens.

KEY TO THE SPECIES OF *RETROTERRA*

1. Base of shell with prominent radial sculpture 2

   Base of shell smooth or with weak growth lines at most ....
   Retroterra solituda sp. nov. (p. 802)

2. Lip strongly expanded, with distinct basal lip node (**Figs 197b-c**); ribbing slightly reduced in prominence on shell base; diameter 9-13 mm
   Retroterra parva sp. nov. (p. 794)

   Lip weakly expanded, no basal lip node (**Figs 200a-c**); ribbing not reduced in prominence on shell base; diameter 13-20 mm ....
   Retroterra costa sp. nov. (p. 798)

RETROTERRA PARVA SP. NOV.
(Figs 197a-c, 198a-b, 199a-b)

Comparative remarks

Retroterra parva is the smallest of the three species, averaging only 10.49 mm in diameter with 4½– whorls, has the radial sculpture reduced on the shell base, and retains a noticeable basal node on the moderately expanded lip (**Figs 197a-c**). *R. costa,* at the same whorl count, is 15.28 mm in mean diameter, has the radial sculpture continue onto the shell base at full strength, and the very weakly expanded lip has no trace of a basal node (**Figs 200a-c**). The very large *R. solituda* averages 22.89 mm in diameter with 5½+ whorls, has no radial sculpture on the shell base, and the lip is very weakly expanded and without trace of nodes. The sympatric *Baudinella regia* (**Figs 194d-f**) is less than 9 mm in diameter, has a narrower umbilicus, much more prominent radial ribs, and huge lip nodes. *Setobaudinia interrex* (**Figs 182a-c, Plate 65**) has no radial ribbing, a microsculpture of periostracal setae, very large lip nodes, and is less than 9 mm in size. *Kendrickia ignivenatus* from the Napier Range (**Figs 202a-c**) has a similar appearing shell with prominent basal lip node, heavier and irregular sculpture, spiral colour bands, and much

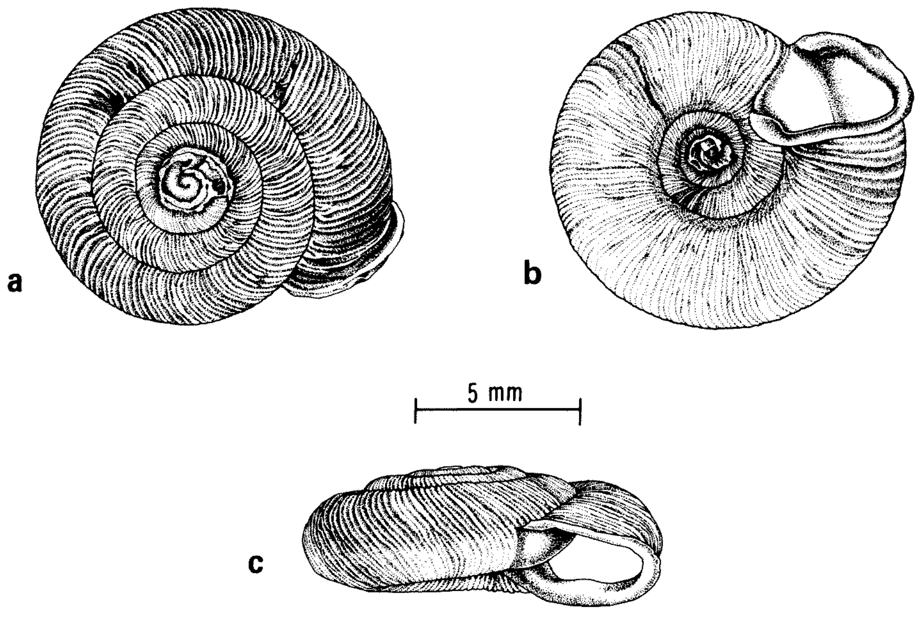

Fig. 197: Shell of *Retroterra parva:* Sta. 2, north side, mouth of Prince Regent River estuary, Kimberley, WAM 601.80, holotype. Scale line equals 5 mm. Drawings by Linnea Lahlum.

more expanded lip. It also (**Table 83**) is much more narrowly umbilicated. Anatomically, the coiled spermatheca, very long epiphallus, long epiphallic caecum (**Fig. 198a**), and absence of a penis sheath (**Fig. 199a**) separate *R. parva* from *Setobaudinia interrex,* while *Baudinella baudinensis* (Smith, 1893) lacks both an epiphallic caecum and a verge (**Figs 196a-b**). *Retroterra costa* and *R. solituda* (**Figs 201a-f**) have a stimulatory papilla in the penis rather than a verge, and differ also in proportionate size of the terminal genitalia. *Kendrickia ignivenatus* (**Figs 203a-d**) differs most obviously in its short spermatheca, very short penis with huge verge, and very long epiphallic caecum.

Holotype

WAM 601.80, Sta. 2, in sand and litter under stones, open eucalypt woodland, north side, mouth of Prince Regent River estuary, Kimberley, Western Australia (15°26'S, 125°04'E). Collected by Barry R. Wilson 26 July 1977. Height of shell 4.65 mm, diameter 11.35 mm, H/D ratio 0.410, whorls 4¾, umbilical width 3.5 mm, D/U ratio 3.24.

Paralectotypes

WAM 353.80, 2 dead adults from the type locality.

Paratypes

Prince Regent River Reserve (all specimens collected August 1974): Sta. E5 (1), small gully entering north-east corner, main gorge below Enid Falls, Rufous Creek, Roe River (1:250,000 'Prince Regent' map sheet SD 51-16 – 348:086) (1 dead adult, WAM 252.75); Sta. W6 (1), valley slope on north side Youwanjela Creek, Upper Prince Regent River ('Prince Regent' SD 51-16 – 332:032, ca 15°34'S, 125°25'E) (12 dead adults, 2 dead juveniles, WAM 250.75, WAM 253.75); Sta. W6 (2), about 300 m east of main campsite, Youwanjela Creek, Upper Prince Regent River ('Prince Regent' SD 51-16 – 332:033) (2 live adults, 1 live juvenile, WAM 470.75).

Prince Regent River Reserve (all specimens collected July 1977): west side Purulba Creek (15°30'S, 125°09.5'E) (5 dead adults, 5 dead juveniles, WAM 330.80, WAM 356.80).

Diagnosis

Shell relatively small, diameter 9.2-12.6 mm (mean 10.49 mm), with 4⅛– to 4¾+ (mean 4½–) normally coiled whorls. Apex and spire slightly elevated (**Fig. 197c**), height of shell 3.85-5.3 mm (mean 4.56 mm), H/D ratio 0.363-0.489 (mean 0.436). Apical sculpture generally eroded. Postapical whorls with prominent, rather crowded radial ribs that occasionally anastomose, becoming somewhat reduced in prominence below periphery and on shell base (**Figs 197a-c**). No significant microsculpture observed. Shell periphery rounded, body whorl descending gradually behind aperture

(**Fig. 197c**). Lip moderately expanded and thickened, with a noticeable basal node (**Fig. 197c**) and occasional slight trace of the palatal node groove (**Fig. 197b**) characteristic of *Baudinella* and *Setobaudinia.* Umbilicus widely open, almost regularly decoiling, width 2.7-3.95 mm (mean 3.37 mm), D/U ratio 2.68-3.56 (mean 3.11). Colour reddish yellow brown, somewhat lighter on shell base, lip white. Based on 21 measured adults.

Genitalia (**Figs 198-199**) with very long and complexly kinked spermatheca (S) that is bound by fibres to lower fifth of prostate-uterus, free oviduct (UV) short, vagina (V) long. Epiphallus (E) long, with prominent caecum (EC). Vas deferens (VD) not coiled about epiphallus or penis. Epiphallus very long and slender, internally with simple longitudinal pilasters (EPP)

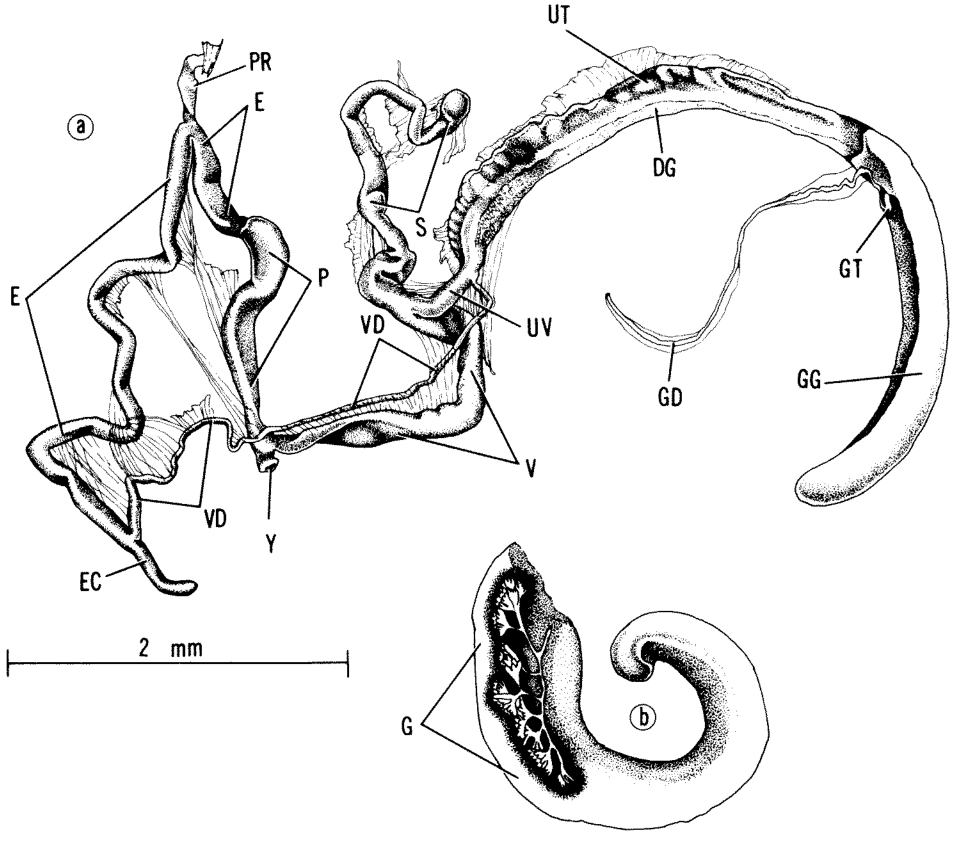

Fig. 198: Whole genitalia of *Retroterra parva.* Sta. W6 (2), Youwanjela Creek, Prince Regent River Reserve, 20 August 1974, WAM 470.75, Dissection A, (a) whole genitalia, (b) ovotestis. Scale line equals 2 mm. Drawings by Linnea Lahlum.

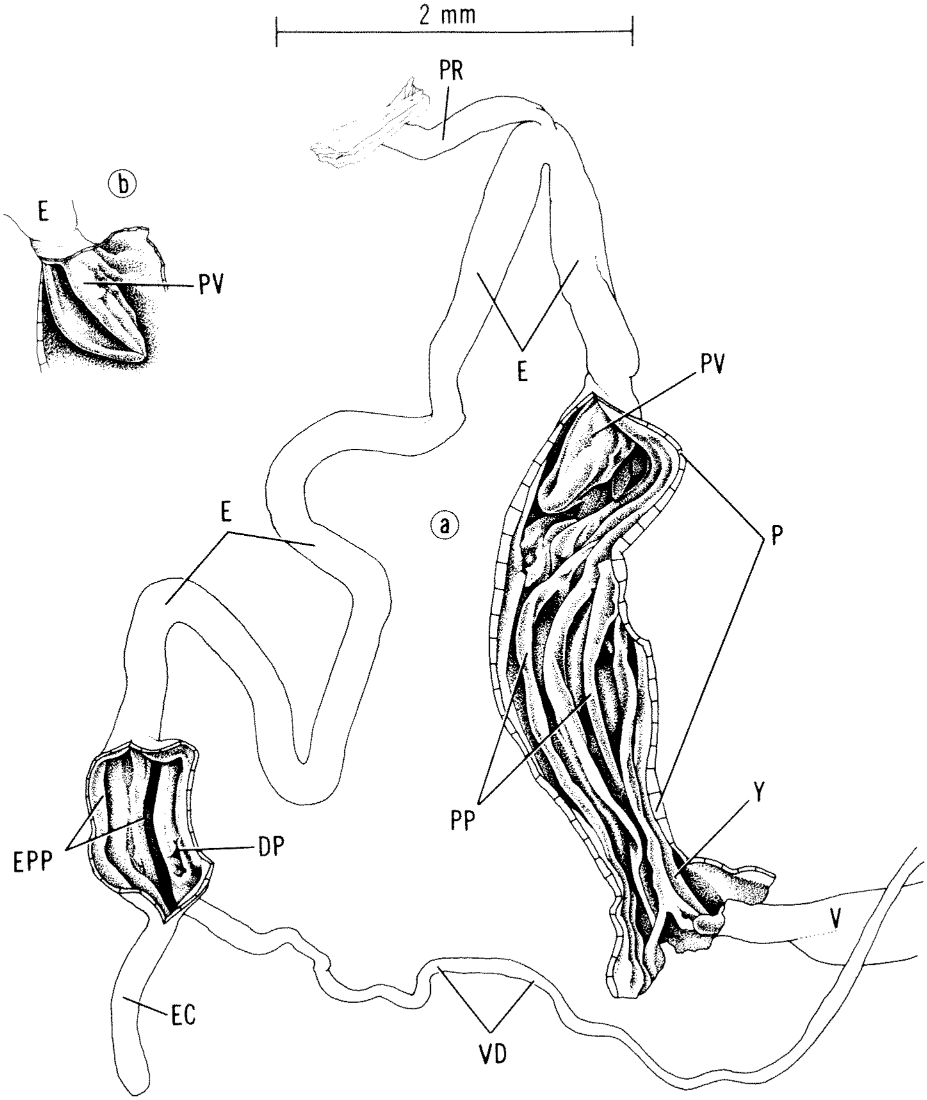

Fig. 199: Interior of penis complex of *Retroterra parva.* Sta. W6 (2), Youwanjela Creek, Prince Regent River Reserve, 20 August 1974, WAM 470.75, Dissection A, (a) interior of penis complex, (b) detail of vergic papilla. Scale line equals 2 mm. Drawings by Linnea Lahlum.

and vas entering through a pilaster with a simple pore (DP). Walls of penis with prominent longitudinal pilasters and apical verge (PV, **Figs 199a-b**) that is midway between spatulate and deeply grooved (**Fig. 199b**). Radula and jaw as in *R. costa* (**Plate 79a-d**). Based on two dissected individuals.

Remarks

Retroterra parva is named for its small size in comparison with the other two species. In lip characteristics it is intermediate between *Baudinella* and *Retroterra,* but the anatomical features clearly place it within the latter genus.

Only one set (**Table 82**) was large enough to present data on variation. Although recorded from both the Prince Regent and the Roe River drainages, records are few and material of this species is very limited.

RETROTERRA COSTA SP. NOV.
(Plate 79a-d; Figs 200a-c, 201f)

Comparative remarks

Retroterra costa differs from both of its congeners in having the radial ribbing continue into the umbilicus without any decrease in prominence, its simple lip (**Figs 200b-c**), and intermediate size (**Table 76**). *R. parva* (**Figs 197b-c**) differs in having the sculpture decrease in prominence below the periphery, retains a distinct basal node on a broadly expanded lip, and is much smaller (**Table 76**). *R. solituda* (**Figs 200d-f**) has fine radial sculpture on the spire, but the shell is smooth below the periphery, there is only very slight lip expansion, and it is very large with an increased whorl count (**Table 76**). *Kendrickia ignivenatus* (**Figs 202a-c**) from the Napier Range is smaller (**Table 83**), has a much broader lip with prominent basal node, spiral colour bands and much more prominent sculpture. Species of *Torresitrachia* (Solem, 1979: 50-56, plates 2-6) are much more narrowly umbilicated and have complex microsculpture; *T. regula,* which is sympatric with *R. costa,* averages 15.6 mm in diameter with $5^{1}/_{8}-$ whorls, but has an umbilical width of only 1.3-2.8 mm, with a D/U ratio of 6.50-10.6, and is thus easily separated on umbilical size and shape. Anatomically, *R. costa* (**Fig. 201f**) has a shorter epiphallus (E) and spermatheca (S) than *R. solituda* (**Fig. 201a**), no longitudinal pilasters on the wall of the penis, and a verge exactly equivalent to that seen in *R. parva* (**Fig. 199**). *R. parva* (**Figs 198-199**) differs in having prominent longitudinal pilasters inside the penis (**Fig. 199**), a longer epiphallus (E) and epiphallic caecum (EC, **Fig. 198**). Differences from other genera were covered above under *R. parva,* except for *Torresitrachia,* which differs in its long spermatheca (S), absence of a verge, usually pustulose wall sculpture in the penis chamber (Solem 1979: figs 12-18), (**Figs 237c, 239b**), and often a very short vagina (V).

Holotype

WAM 1360.75, Sta. E5 (10), vine thicket by spring feeding the northern tributary of Rufous Creek, about 1.5 km north of Enid Falls campsite, Roe River, Prince Regent River Reserve, Kimberley, Western Australia

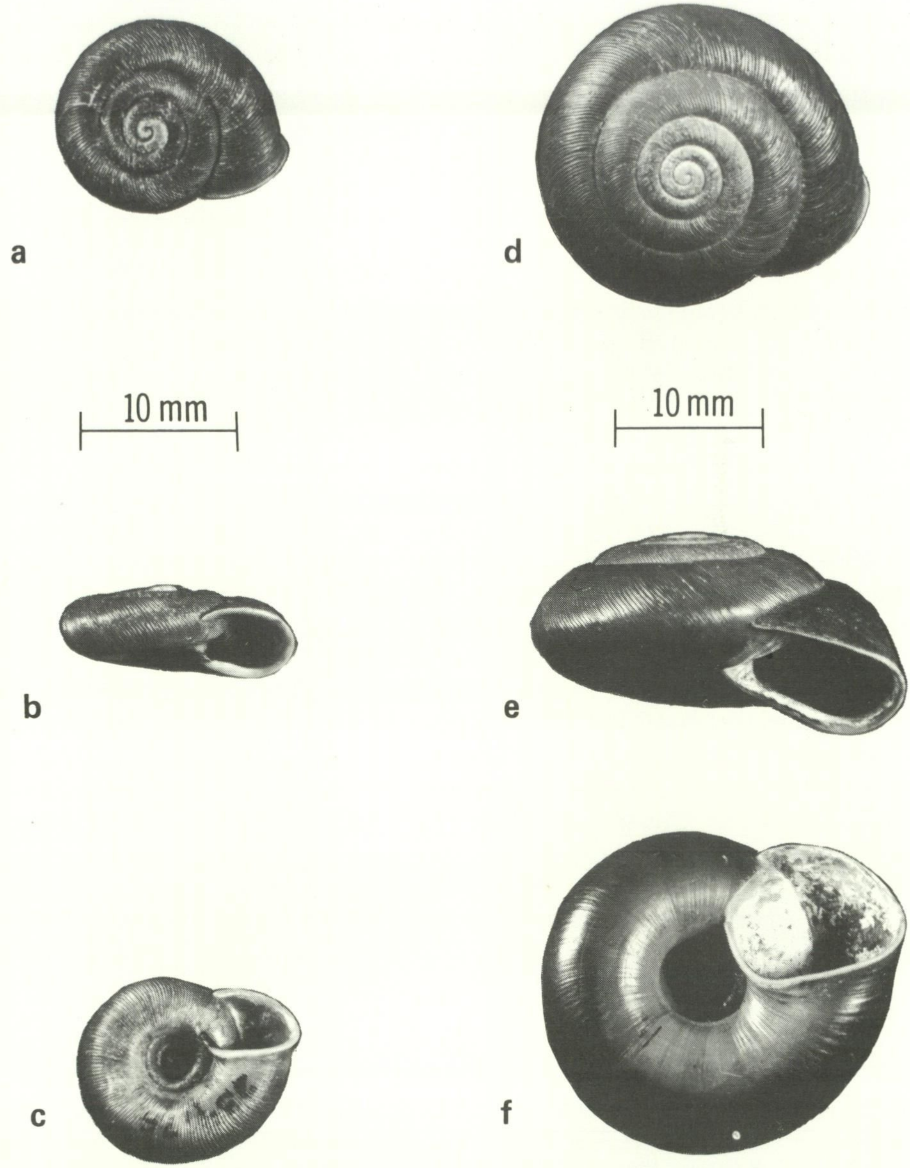

Fig. 200: Shells of *Retroterra costa* and *R. solituda:* (a-c) *R. costa,* Sta. E5 (10), Rufous Creek, Roe River, Prince Regent River Reserve, WAM 1360.75, holotype; (d-f) *R. solituda,* Sta. W6 (5), Youwanjela Creek, Upper Prince Regent River, WAM 1359.75, holotype. Scale lines equal 10 mm. Photographs by C. Bryce.

(1:250,000 'Prince Regent' map sheet SD 51-16 – grid reference 346: 089). Collected by Barry R. Wilson and Peter Smith 18 August 1974. Height of shell 6.5 mm, diameter 15.15 mm, H/D ratio 0.432, umbilical width 4.4 mm, D/U ratio 3.42 mm.

Paratopotypes

WAM 239.75, 2 dead adults, 3 dead juveniles from the type locality.

Paratypes

Prince Regent River Reserve (all specimens collected in August 1974): Sta. El, Upper Prince Regent River near Gundarara Creek (15°49'S, 125° 37'S) (1 dead adult, WAM 237.75); Sta. E4, Wyulda Creek at upper Roe River (15°26'S, 125°36'E) (1 dead adult, WAM 246.75); Sta. E5 (1), small gully at north-east corner of main gorge below Enid Falls, Rufous Creek, Upper Roe River ('Prince Regent' SD 51-16 – 348:086) (1 live adult, WAM 474.75); Sta. E5 (3), campsite on top of Enid Falls, Rufous Creek, Upper Roe River (15°07'S, 125°33'E) (2 dead adults, WAM 243.75); Sta. E5 (4), west slope of main gorge below Enid Falls, Rufous Creek, Upper Roe River ('Prince Regent' SD 51-16 – 348:086) (2 live, 4 dead adults, 3 live, 4 dead juveniles, WAM 240.75, WAM 247.75, WAM 476.75, FMNH 200812); Sta. E5 (6), east side deep gully about 2 km west of Enid Falls campsite, Rufous Creek, Upper Roe River ('Prince Regent' SD 51-16 – 344:085) (9 dead adults, 3 dead juveniles, WAM 241.75); Sta. E5 (8), deep gully 2-3 km west of Enid Falls campsite, Rufous Creek, Upper Roe River ('Prince Regent' SD 51-16 – 343:084) (1 dead adult, WAM 245.75); Sta. E6, Garimbu Creek, tributary of Upper Roe River (15°28'S, 125°29'E) (2 dead adults, 3 dead juveniles, WAM 244.75); Sta. W6 (2), about 300 m east of main campsite, Youwanjela Creek, Upper Prince Regent River ('Prince Regent' SD 51-16 – 332:033) (5 dead juveniles, WAM 238.75, WAM 242.75).

Prince Regent River Reserve (all specimens collected in July 1977): Sta. 1, west bank Roe River estuary (15°15'S, 125°33'E) (1 dead adult, 6 dead juveniles, WAM 337.80); Sta. 2, island, north side mouth of Roe River estuary, Prince Frederick Harbour (15°06'S, 125°21'E) (4 dead adults, WAM 326.80); Sta. 3, north bank, mouth of Roe River estuary, Prince Frederick Harbour (15°08'S, 125°23'E) (12 dead adults, 5 dead juveniles, WAM 329.80, WAM 357.80, FMNH 209061); King Cascade, Upper Prince Regent River (15°37'S, 125°18'E) (1 dead juvenile, WAM 363.80).

Diagnosis

Shell medium in size, diameter 13.4-19.4 mm (mean 15.28 mm), with 4+ to 5 (mean 4½–) rather loosely coiled whorls. Apex and spire very slightly elevated **(Fig. 200b)**, height of shell 5.3-9.2 mm (mean 6.50 mm), H/D ratio 0.347-0.502 (mean 0.426). Apical sculpture usually eroded,

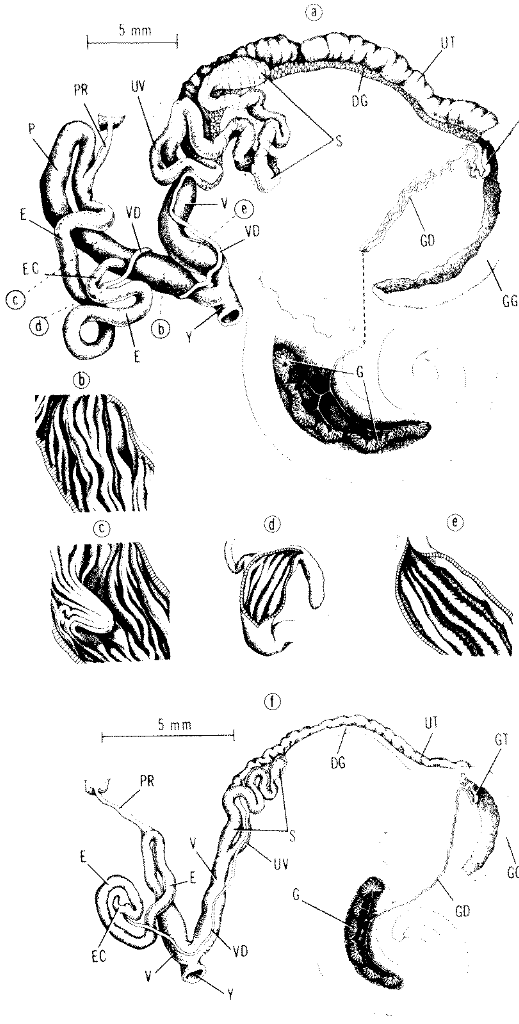

Fig. 201: Genitalia of *Retroterra solituda* and *R. costa:* (a-e) *R. solituda,* a, Sta. W6 (5), Youwanjela Creek, Prince Regent River, 21 August 1974, WAM 501.75, Dissection B, whole genitalia, b-e, Sta. W6 (1), Youwanjela Creek, Prince Regent River Reserve, 19 August 1974, WAM 498.75, Dissection A, b is penis chamber wall sculpture near atrium, c is penial stimulator near mid-penis, d is entrance of vas deferens into epiphallus and wall sculpture of epiphallic caecum, e is wall sculpture of mid-epiphallus; (f) *R. costa,* whole genitalia, Sta. E5 (1), Enid Falls, Rufous Creek, Roe River, Prince Regent River Reserve, 14 August 1974, WAM 474.75, Dissection B. Scale lines as marked. Drawings by Elizabeth A. Liebman.

traces of regularly spaced radial ribs often visible, postapical sculpture of prominent, regularly spaced, sometimes anatomosing radial ribs that continue across the periphery and into the umbilicus **(Figs 200a-c)** without change in prominence. No significant microsculpture. Shell periphery rounded, body whorl descending very slightly just before aperture **(Fig. 200b)**. Lip weakly expanded, no trace of lip nodes. Junction of palatal and basal lips with parietal callus simple. Umbilicus **(Fig. 200c)** widely open, regularly decoiling, width 3.8-5.7 mm (mean 5.09 mm), D/U ratio 4.12-5.14 (mean 4.51). Colour dark yellow brown, some specimens with a reddish suffusion, base of shell lighter in tone, lip white. Based on 42 measured adults.

Genitalia **(Fig. 201f)** with moderately long, sinuated spermatheca (S) that is bound to lower quarter of prostate-uterus, long vagina (V), and long epiphallus (E) with prominent caecum (EC). Penial retractor muscle (PR) attaching to epiphallus. Interior of penis with smooth walls. A spatulate verge of the same type seen in *R. parva* **(Fig. 199b)** occupies the penis apex. Its location is approximately where the epiphallus crosses the penis in **Fig. 201f.** Jaw **(Plate 79d)** typical. Radular teeth **(Plate 79a-d)** having mesocone of central and lateral teeth with blunt, rounded tip that curves slightly downward. Based on two dissected adults.

Remarks

Retroterra costa is named for its relatively strong radial ribs that do not change in prominence on the shell base or in the umbilicus, which contrasts with the partial reduction of these ribs in *R. parva* **(Figs 197a-c)** and loss on the shell base in *R. solituda* **(Figs 200a-c)**.

Undoubtedly extensive local size variation exists, but only two sets were large enough to warrant listing **(Table 82)**. They differ noticeably in size and shape.

RETROTERRA SOLITUDA SP. NOV.
(Plate 79e-f; Figs 200d-f, 201a-e)

Comparative remarks

Retroterra solituda is distinguished by its large size, mean diameter 22.89 mm, high whorl count, mean 5½+, fine radial sculpture above and smooth shell below the periphery **(Figs 200d-f)**, thin lip, and absence of any lip nodes. *R. costa* is smaller, mean diameter 15.28 mm, with only 4½– whorls, stronger radial ribs that continue into the umbilicus without size reduction, and more expanded lip, *R. parva* **(Figs 197a-c)** is only about 10.5 mm in diameter with 4½ whorls, has strong radial sculpture, and a markedly expanded lip with a prominent basal node. Its wide umbilicus and depressed shape **(Table 76)** easily separate it from the two Prince Regent River Reserve *Amplirhagada, A. wilsoni* and *A. elevata* (Solem 1981a: 254, figs 55e-f), which are strongly elevated and with closed or at most very slightly open umbilici. Juveniles could be confused, but the shell sculpture is very different in the two genera. Anatomically, the extremely long spermatheca (S) and epiphallus (E) of *Retroterra solituda* **(Fig. 201a)** distinguish it from *R. costa* **(Fig. 201f)**, and its small penial stimulator **(Fig. 201c)** contrasts with the verges **(Figs 199a-b)** found in *R. parva* and *R. costa.*

Holotype

WAM 1359.75, Sta. W6 (5), valley slopes on south side of Youwanjela Creek, Upper Prince Regent River, Kimberley, Western Australia (1:250, 000 'Prince Regent' map sheet SD 51-16 – grid reference 332:032). Collected by Peter Smith 23 August 1974. Height of shell 13.1 mm, diameter 23.2 mm, H/D ratio 0.565, whorls $5\frac{3}{8}$–, umbilical width 4.95 mm, D/U ratio 4.69.

Paratopotypes

WAM 432.75, WAM 434.75, WAM 436.75, WAM 437.75, WAM 443.75, WAM 486.75, WAM 497.75, WAM 501.75, FMNH 200816-7, 3 live, 7 dead adults, 8 live, 3 dead juveniles from the type locality.

Paratypes

Prince Regent River Reserve (all specimens collected August 1974): Sta. W6 (1), valley slope on north side of Youwanjela Creek ('Prince Regent' SD 51-16 – 332:032) (3 live, 2 dead adults, 1 live, 4 dead juveniles, WAM 433.75, WAM 439.75, WAM 442.75, WAM 498.75); Sta. W6 (2), gully about 300 m east of main campsite, Youwanjela Creek ('Prince Regent' SD 51-16 – 332:032) (1 dead adult, 2 dead juveniles, WAM 435.75); Sta. W6 (3), eastern bank of northern tributary of Youwanjela Creek, 1.5 km west of main campsite, Upper Prince Regent River ('Prince Regent' SD 51-16 – 331:034) (1 live, 2 dead adults, 1 live juvenile, WAM 440.75, WAM 500.75); Sta. W6 (4), northern tributary, 1 km upstream from Youwanjela Creek junction, Upper Prince Regent River ('Prince Regent' SD 51-16 – 331:034) (1 live, 1 dead adult, 2 live juveniles, WAM 438.75, WAM 499.75); Sta. W6 (6), west of main campsite, Youwanjela Creek, Upper Prince Regent River ('Prince Regent' SD 51-16 – 331:033) (1 dead juvenile, WAM 441.75).

Prince Regent River Reserve (all specimens collected 27 July 1977): Sta. 2, west side Purulba Creek, Prince Regent River (15°30'S, 125°09.5'E) (1 dead juvenile, WAM 358.80).

Diagnosis

Shell very large, diameter 20.8-24.6 mm (mean 22.89 mm), with $5\frac{1}{8}$ to $5\frac{7}{8}$ (mean $5\frac{1}{2}$+) normally coiled whorls. Apex and spire moderately and evenly elevated, rounded above **(Fig. 200e)**, height of shell 10.5-14.45

mm (mean 13.05 mm), H/D ratio 0.505-0.634 (mean 0.571). Apical sculpture of very fine radial ribs, postapical sculpture of very fine and crowded radials that fade out at periphery, base of shell (**Fig. 200f**) nearly smooth. No significant microsculpture. Shell periphery rounded, body whorl descending slightly behind aperture. Lip very slightly expanded and thickened (**Fig. 200e**), without nodes. Umbilicus open, regularly decoiling, umbilical width 4.2-5.7 mm (mean 5.09 mm), D/U ratio 4.12-5.14 (mean 4.51). Colour dark reddish green above periphery and partway below periphery, abruptly becoming light greenish-yellow horn on base and in umbilicus, lip white. Based on 21 measured adults.

Genitalia (**Figs 201a-e**) with very long spermatheca (S) that is tightly coiled and bound by fibres to base of prostate-uterus, free oviduct (UV) and vagina (V) rather short, latter thick. Vas deferens (VD) partly wound around penis, entering (**Fig. 201d**) laterally onto epiphallus-epiphallic caecum (EC) junction through simple pore. Epiphallic caecum prominent, internally with simple pilasters. Epiphallus (P) very large, coiled, internally (**Fig. 201e**) with corrugated pilasters. Penial retractor muscle inserting on epiphallus. Penis (P) short, internally (**Figs 201b-c**) with anastomosing longitudinal pilasters and a small penial stimulator that extends as a rather high pilaster for about 2 mm apicad, but does not function as a verge. Radular teeth (**Plate 79e-f**) with sharp pointed central and laterals that are not curved at tip. Jaw typical. Based on two dissected adults.

Remarks

Retroterra solituda is known only from tributaries of the Prince Regent River, and its name refers to this restricted range. Several dead specimens had the lip chipped back or a hole in the shell, suggesting rodent predation. Variation in lumped material from two stations is summarised in **Table 82**. Specimens from Sta. W6 (1) are larger and distinctly higher spired than the types from Sta. W6 (5).

The abrupt change in subperipheral sculpture, lighter coloured base, and fine supraperipheral sculpture are reminiscent of the Rhytididae from New Zealand and eastern Australia, but the anatomy clearly places this as a camaenid.

GENUS *KENDRICKIA* NEW GENUS

Shell smaller than average, apex and spire usually slightly and almost evenly elevated, rarely flat or rounded above (**Fig. 202c**), body whorl moderately to abruptly descending before aperture. Umbilicus (**Fig. 202b**) widely open, last whorl decoiling much more rapidly, partly closed by variable, but usually quite pronounced reflexion of the columellar lip. Apical whorls 1¼, smooth (**Plate 80a**). Postapical sculpture (**Plate 80b**) of rather prominent radial ribs. Some are continuous from suture into umbilicus, some

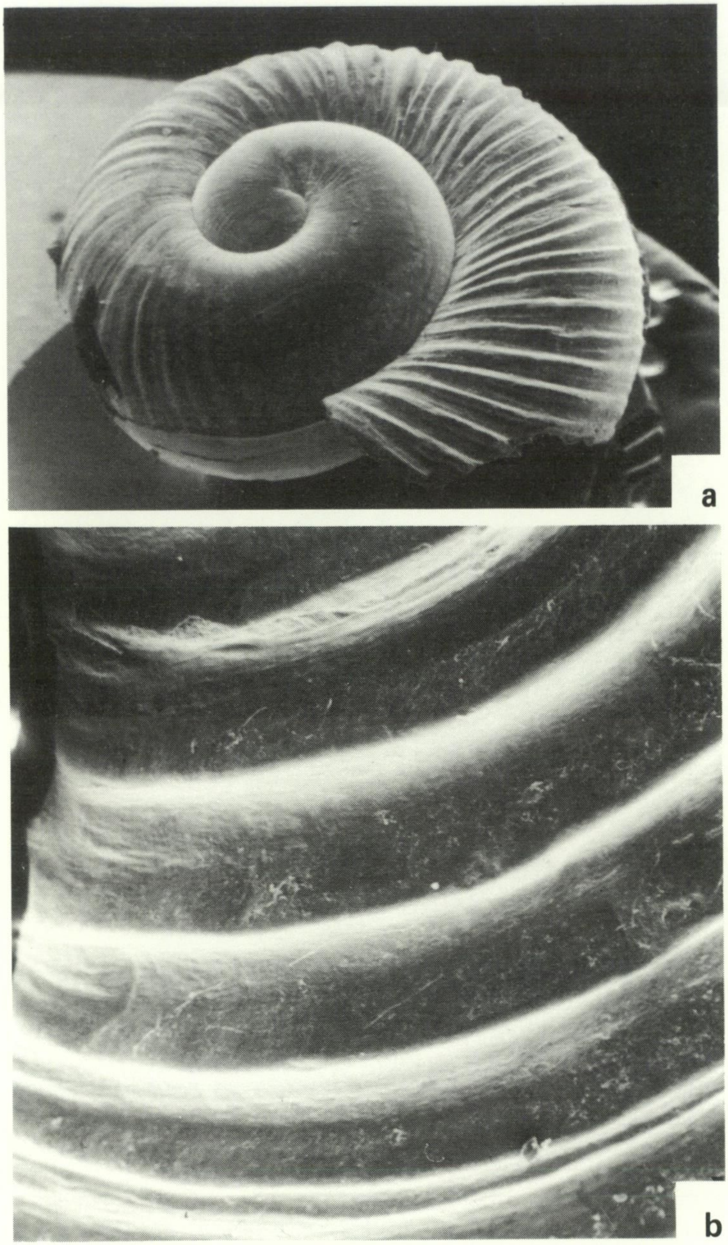

Plate 80: Shell sculpture of *Kendrickia ignivenatus:* Sta. WA-300, near northwest end of Napier Range, South Kimberley, 6 December 1976, FMNH 199944, Dissection A, a is apex and early spire at 29X, b is body whorl sculpture near suture at 73X.

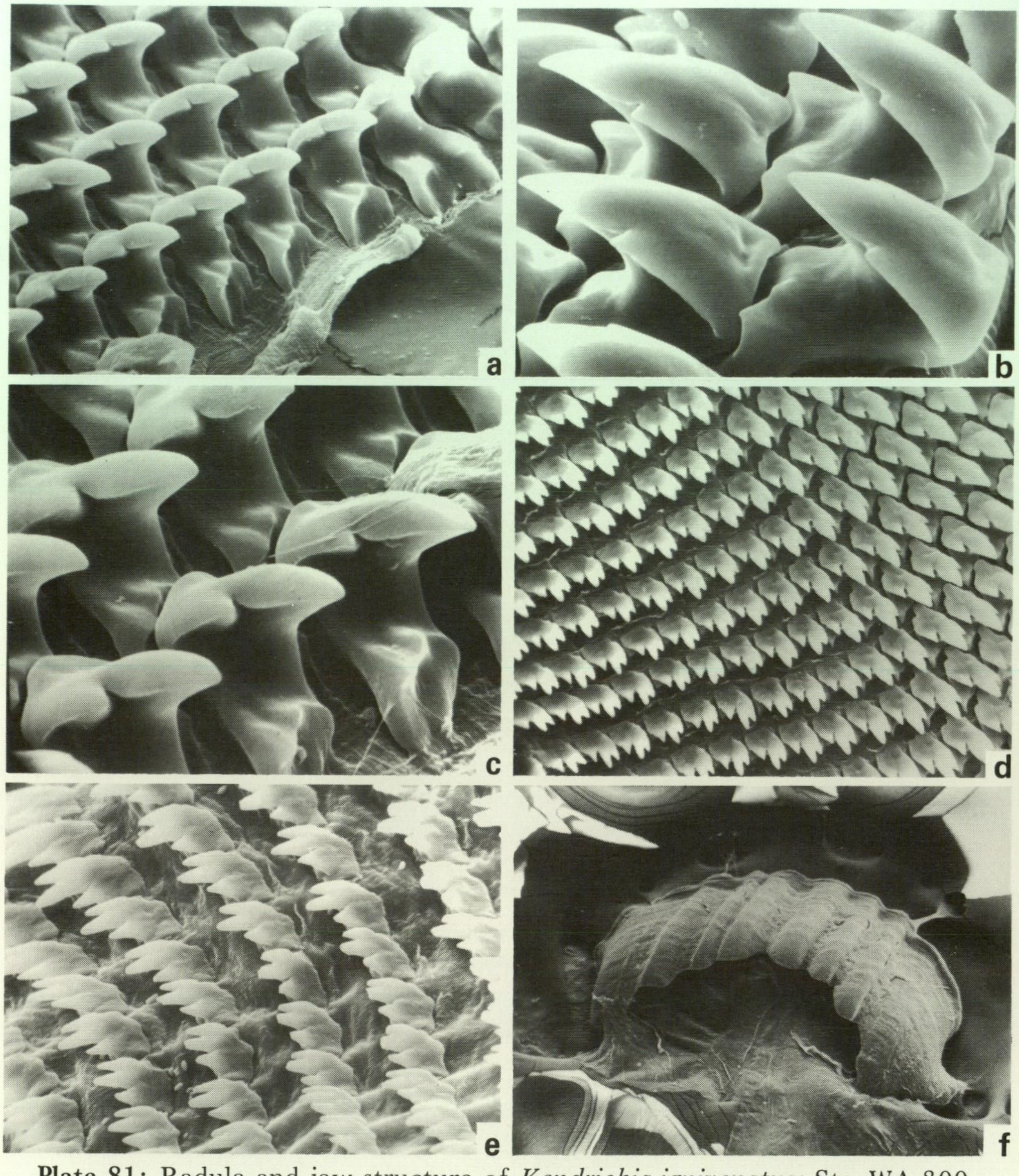

Plate 81: Radula and jaw structure of *Kendrickia ignivenatus:* Sta. WA-300, near north-west end of Napier Range, South Kimberley, 6 December 1976, FMNH 199944, (a) medium angle rear lateral view of central and laterals at 635X, Dissection B; (b) low angle view of central and first lateral at 1,275X, Dissection A; (c) beginning of lateromarginal transition at 1,250X, Dissection B; (d) lateromarginal transition at 200X, Dissection B; (e) outer marginals at 630X, Dissection A; (f) jaw at 61X, Dissection A.

extend only part of a whorl, rarely do they anastomose. No microsculpture visible at 75x. Sculpture on shell base and in umbilicus not reduced in prominence. Lip very strongly expanded after sharp reflexion (**Figs 202a-c**), normally with a prominent basal node, columellar lip projecting over umbilicus to variable extent, parietal wall with a thick callus over previous whorl sculpture. Shell periphery laterally compressed, strongly rounded above and on basal margin (**Fig. 202c**). Shell colour variable, apex and spire normally a translucent yellow-brown, on last whorl a reddish spiral, slightly supraperipheral band often present, bordered above and below by white zones. Below periphery white zones variable in presence and numbers, base lighter, umbilicus with same tone as spire. Genitalia (**Figs 203a-c**) with hermaphroditic duct (GD) reflexing to enter head of talon (GT). Other apical genital organs without unusual features. Free oviduct (UV) very short, merging at a 45° angle with shaft of spermatheca (S) to form rather long and thick vagina (V). Head of spermatheca moderately expanded, reaching point about one-third of way from base of prostate (DG) and uterus (UT) to base of albumen gland (GG), lightly anchored to prostate-uterus by fibres. Atrium (Y) very short. Terminal male genitalia without a sheath. Vas deferens (VD) slender for entire length, normally wrapped around epiphallus (E), entering at junction of epiphallic caecum (EC) and epiphallus proper through a pilaster (**Fig. 203d**). Epiphallic caecum long, with coiled tip, diameter at base equal to that of epiphallus. Latter a thick-walled tube extending to point of insertion for penial retractor muscle (PR), where a large vergic pilaster marks transition to penis (P). Penial retractor muscle arising from diaphragm, inserting directly onto penis-epiphallic junction. Entire tract from vas entrance to penis base thick-walled, with low, vague ridges. Vergic papilla (PV) cone shaped, with a deep lateral groove extending nearly to tip, almost equal in length to penis chamber. Jaw (**Plate 81f**) typically camaenid, prominent vertical ribs in central portion, outer margins with reduced ribs or ribless. Radula with typical camaenid teeth. Central and laterals (**Plate 81a-c**) retain ectocones, endocone becoming increasingly prominent on laterals as lateromarginal transition approached (**Plate 81d**). Mesoconal cusp at high angle, blunted and curved (**Plate 81a-c**) in mid and outer laterals. Marginal teeth (**Plate 81e**) without unusual features, cusps becoming subequal.

Type species: *Kendrickia ignivenatus* sp. nov.

Comparative remarks

In general appearance, *Kendrickia* can be confused with members of the following Kimberley genera – *Setobaudinia* Iredale, 1933, *Baudinella* Thiele, 1931, and *Mouldingia* Solem, 1984. The relatively flat shell, greatly expanded lip with a basal node, and presence of distinct radial ribs or dense periostracal hairs give all of these taxa a similar conchological look. *Kendrickia* differs from the neighbouring *Mouldingia occidentalis* (Solem

1984: figs 163a-c, plate 52) in its lack of sulci **(Fig. 202c)**, total lack of any apical or postapical microsculpture **(Plate 80b)**, larger size **(Table 83)** and higher whorl count. The other genera are much smaller in size and have very complex microsculpture **(Plates 64-69, 76-77)**.

Two extra-limital genera can be confused with *Kendrickia*. Both *Pleuroxia* Ancey, 1887 and *Semotrachia* Iredale, 1933 have species that appear similar in shell form and colour, but differ greatly in shell sculpture and anatomy. *Semotrachia,* from the Red Centre of Australia, does seem to be fairly closely related, but comparisons must be deferred until that genus is revised. *Pleuroxia, s. l.,* whose distribution ranges from Alice Springs, Northern Territory and the Flinders Ranges of South Australia to near Norseman, Western Australia, and then reappears on the west coast from

Table 83: Range of Variation in *Kendrickia, Kimboraga, Quistrachia, Carinotrachia,* and *Mesodontrachia*

Taxon	Number of Adults Measured	Mean and Range of: Shell Height	Shell Diameter	H/D Ratio
KENDRICKIA				
ignivenatus	560	5.02 (3.6–6.4)	10.81 (9.05–12.4)	0.464 (0.370–0.602)
KIMBORAGA				
yampiensis	21	18.25 (15.6–21.2)	21.97 (19.8–24.7)	0.830 (0.717–0.923)
exanimus	12	16.97 (16.2–17.7)	19.11 (18.0–19.9)	0.889 (0.828–0.923)
mccorryi	42	11.59 (9.55–13.35)	18.06 (15.35–20.1)	0.641 (0.570–0.723)
yammerana	40	13.33 (11.95–16.35)	19.9 (18.4–22.5)	0.671 (0.618–0.729)
micromphala (Gude, 1907)	108	17.85 (15.2–20.6)	21.0 (18.15–23.35)	0.849 (0.758–0.968)
QUISTRACHIA				
monogramma (Ancey, 1898)	662	10.21 (7.75–12.8)	17.03 (14.1–20.65)	0.599 (0.509–0.753)
CARINOTRACHIA				
carsoniana	21	10.53 (9.1–11.75)	16.61 (11.9–18.6)	0.638 (0.549–0.874)
MESODONTRACHIA				
desmonda	27	12.74 (10.9–15.45)	19.06 (17.3–21.7)	0.668 (0.610–0.716)
fitzroyana	359	12.07 (10.3–14.25)	20.07 (17.3–23.1)	0.601 (0.522–0.682)

Table 83: Range of Variation in *Kendrickia, Kimboraga, Quistrachia, Carinotrachia,* and *Mesodontrachia* (continued)

Taxon	Number of Adults Measured	Mean and Range of: Whorls	Umbilical Width	D/U Ratio
KENDRICKIA				
ignivenatus	560	4⅜+ (4⅛– –5⅛)	2.56 (1.4–3.7)	4.38 (2.68–7.64)
KIMBORAGA				
yampiensis	21	4¾– (4¼–5¼+)	lateral crack	---
exanimus	12	4⅜– (4–4¾–)	lateral crack	---
mccorryi	42	4⅛+ (3⅞–4⅜)	2.61 (1.9–3.8)	7.13 (4.47–10.1)
yammerana	40	4¼+ (4+–4⅝)	2.07 (1.5–2.95)	9.78 (7.09–13.6)
micromphala (Gude, 1907)	108	4⅜– (3⅞+–4¾)	lateral crack to minute	---
QUISTRACHIA				
monogramma (Ancey, 1898)	662	4⅜ (3⅞– –4⅞–)	2.68 (1.65–3.9)	6.45 (4.39–10.4)
CARINOTRACHIA				
carsoniana	21	5⅛– (4¾–5¼)	2.25 (1.6–2.95)	7.60 (5.17–10.9)
MESODONTRACHIA				
desmonda	27	4⅞– (4¾+–5)	1.61 (0.85–2.1)	12.2 (8.95–22.1)
fitzroyana	359	5⅜+ (5 –5⅞–)	1.23 (0.4–2.5)	18.0 (7.96–50)

Geraldton to the North West Cape, belongs to a different subfamily (Solem, in preparation). Its similarity is convergent in nature.

The absence of a penis sheath, presence of a prominent epiphallic caecum, large vergic papilla in the penis chamber, and insertion of the penial retractor muscle at the penis-epiphallic junction, are the main diagnostic features of *Kendrickia. Xanthomelon* von Martens, 1860 (Solem 1979: 26-27, figs 7-8), *Amplirhagada* Iredale, 1933 (Solem 1981a: 204, figs 44a-c), *Westraltrachia* Iredale, 1933 (Solem 1984: figs 112-113), *Mouldingia* Solem (1984: 497-498, figs 164-165), and *Kimboraga* Iredale, 1939 **(Figs 208-211)** all have a penis sheath and no epiphallic caeca. The penial retractor muscle inserts apically at the vas deferens-epiphallic junction, except in *Kimboraga* that lacks a differentiated epiphallus. All of these genera, except *Amplirhagada,* lack a verge. *Damochlora* Iredale, 1938 (Solem 1979: 102, figs 22a-c) has a penis sheath, a verge, and both an epiphallic caecum and epiphallic flagellum. The penial retractor muscle inserts near the apex of the epiphallus. *Torresitrachia* Iredale, 1939 (Solem 1979: 68-69, figs 13-14) lacks a penis sheath, has no verge or vergic papilla, possesses a small to large epiphallic caecum, has very different wall sculpture in the penis chamber, and has epiphallic insertion of the penial retractor muscle.

The most similar genera in anatomy are *Rhagada* Albers, 1860 and *Setobaudinia* Iredale, 1933. The latter **(Figs 185-186, 188-189, 191, 193)** has a huge epiphallic flagellum and very different penis chamber morphology. The former **(Figs 227-235)** differs in its much longer spermatheca, higher insertion of the penial retractor muscle, and very different shell features.

Distribution and basic ecology

The only known species of *Kendrickia* is found in the north-west part of the Napier Range. It has a discontinuous distribution from the east margin of the Chedda Cliffs, ca 9 km west of Barker Gorge, to the north-west tip of the Range near Hawkstone Creek (Solem 1984: 631, fig. 159), an air distance of about 22 km, but a 'cliff face distance' of ca 33 km. About half of the collecting stations in this area were negative for this species. The presence of a calcified epiphragm across the aperture indicates that this is a 'free sealer'.

Remarks

Great pleasure is taken in naming this genus after George W. Kendrick of the Western Australian Museum. His deep interest in the non-marine molluscs of Australia, and extraordinary efforts in collecting materials during the course of mainly paleontological activities, have been instrumental in facilitating these reviews. My initial field efforts in Western Australia were based largely on his advice and experience. It was his collections of land molluscs made in the South Kimberley in the mid-1960s that indicated this would be a worthwhile project. In addition, his broad knowledge of ecology, biogeography, and geology has been shared unstintingly, greatly improving these contributions. *Kendrickia* is thus a small token of thanks for many years of help and friendship.

KENDRICKIA IGNIVENATUS SP. NOV.
(Plates 80-81; Figs 202a-c, 203a-d)

Comparative remarks

Kendrickia ignivenatus differs from most Kimberley taxa in its widely open umbilicus **(Fig. 202b)**, laterally compressed whorls, flared lip with a basal node **(Fig. 202c)**, prominent radial ribs, and relatively flat shape.

The heavily ribbed *Mouldingia occidentalis* and *M. orientalis* (Solem 1984: 640, figs 163a-f, 639, 645, Plates 52-53) differ in their very strong sulci and very complex microsculpture. The much smaller species of *Setobaudinia* **(Figs 181, 184, 187)** lack radial ribs, have a complex microsculpture **(Plates 64-69)**, and much greater development of lip nodes. Anatomically, the lack of a penis sheath, very large verge, presence of a prominent epiphallic caecum, and insertion of the penial retractor muscle at the penis-epiphallic junction are the diagnostic features separating *Kendrickia ignivenatus* from other Napier Range and Kimberley taxa. Additional comparative remarks have been given under the generic commentary.

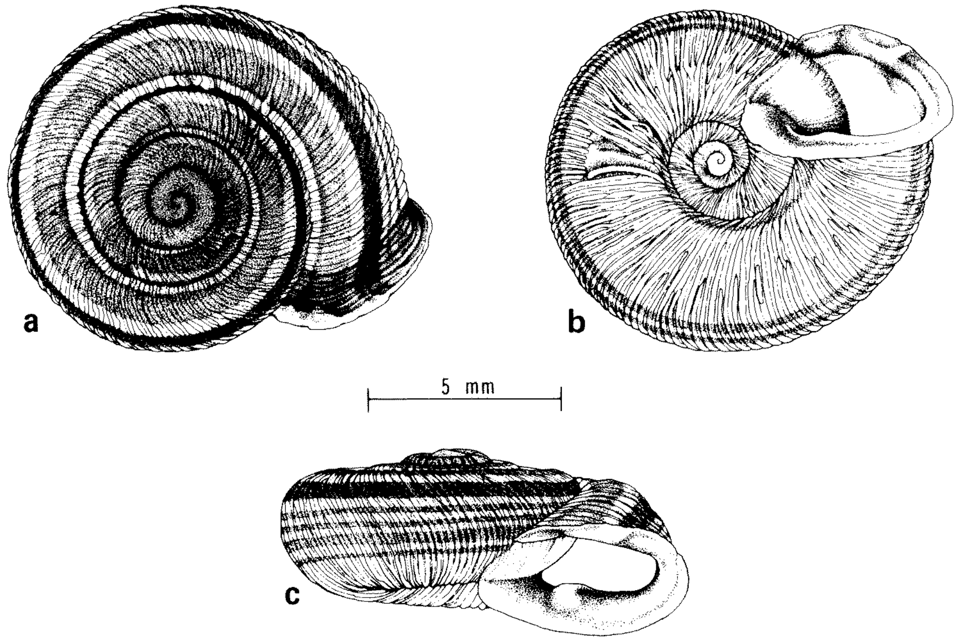

Fig. 202: Shell of *Kendrickia ignivenatus*. Sta. WA-300, near north-west end of Napier Range, South Kimberley, WAM 591.80, holotype. Scale line equals 5 mm. Drawings by Linnea Lahlum.

Holotype

WAM 591.80, Sta. WA-300, cliffs at north-west end Napier Range, west of Van Emmerick (= Patterson) Range, ca 18.3 bush track km from Red Bull Bore, south-west Kimberley, Western Australia (1:100,000 'Lennard' map sheet 3863 – ca 660:110). Collected by Laurie Price and Carl Christensen 6 December 1976. Height of shell 4.95 mm, diameter 11.0 mm, H/D ratio 0.450, whorls 4½–, umbilical width 2.20 mm, D/U ratio 5.00.

Paratopotypes

WAM 592.80-595.80, FMNH 199211, FMNH 199253, FMNH 199944, FMNH 200260, 115 live, 159 dead adults, 2 live juveniles from the type locality.

Paratypes

Sta. NRII-6, north-west end of Napier Range bearing 115° to north side Van Emmerick Range (1:250,000 'Lennard River' map sheet SE 51-8 – 234:855) (49 live, 59 dead adults, WAM 248.80, WAM 281.80, WAM 283.80, WAM 286.80, WAM 288.80); Sta. WA-717, 2.1 km south of Hawkstone Creek crossing, 1 km east of track, north end Napier Range ('Lennard' 3863 – 674:147) (17 live, 10 dead adults, WAM 589.80-590.80, FMNH 205354-5); Sta. WA-715, 7.6 bush track km north of Original Napier Downs Homestead ('Lennard' 3863 – 707:064) (9 live, 3 dead adults, WAM 596.80, FMNH 205341-2); Sta. NR III-1, 5 km north of Original Napier Downs Homestead (1 live, 13 dead adults, 1 live juvenile, WAM 280.80, WAM 287.80); Sta. WA-714, south side Wagon Pass, 2.1 km from west entrance ('Lennard' 3863 – 730:001) (13 live, 26 dead adults, WAM 597.80-598.80, FMNH 205329-30, FMNH 205338); Sta. NRII-18, ca 3 km south-east of west entrance to Wagon Pass (1 live, 13 dead adults, WAM 282.80, WAM 285.80); Sta. WA-322, 0.6 km east of track, 3 km south-east Original Napier Downs Homestead ('Lennard' 3863 – 719:985) (16 live, 16 dead adults, WAM 599.80-600.80, FMNH 199330, FMNH 200143); 1 mile north of Old Napier Downs Cave in gulley ('Lennard' 3863 – ca 745:945) (1 live, 38 dead adults, WAM 279.80, WAM 414.77, collected by G.W. Kendrick and A.M. Douglas 10 July 1966).

Distribution limits in Napier Range

Kendrickia ignivenatus has been collected from the north-west tip of Napier Range limestone south-east to the east margin of the Chedda Cliffs, about 9 km west of Barker Gorge. Its distribution is not continuous, as no specimens were found in large samples from 12 stations within its known range. The exact eastern limit is unknown, but no material was taken in samples from Stations WA-192, WA-324, WA-320, WA-312, WA-313, WA-354, and WA-355, which are scattered through the 9 km between the Chedda Cliffs and Barker Gorge. Thus a maximum range extension of perhaps one km, the distance between Old Napier Downs Cave and WA-192, is possible. The total range is about 22 km, not allowing for the sinuations in the cliff faces.

Diagnosis

Shell relatively small, 9.05-12.4 mm (mean 10.81 mm) in diameter, with $4^1/_8-$ to $5^1/_8$ (mean $4^3/_8+$) rather tightly coiled whorls. Apex and spire slightly and usually evenly elevated, sometimes almost flat, body whorl descending moderately to abruptly over last one-sixteenth whorl before aperture (**Fig. 202c**), height of shell 3.6-6.4 mm (mean 5.02 mm), H/D ratio 0.370-0.602 (mean 0.464). Apex smooth (**Plate 80a**). Postapical sculpture (**Plate 80a-b**) of fine, crowded radial ribs whose interstices are two to three times their width, and which may be continuous from suture into umbilicus or extend for only part of whorl, rarely anastomosing with other radial ribs. No diminution in sculptural prominence on shell base or in umbilicus. No microsculpture visible between major ribs. Shell periphery (**Fig. 202c**) laterally compressed, body whorl strongly rounded above and on basal margin. Lip sharply reflexed and strongly expanded, not continuous across parietal wall, columellar portion often more strongly expanded and variably extending part way across umbilicus. Basal lip with a prominent, rather long node (**Fig. 202c**). Parietal wall with relatively thick callus over ribbing on penultimate whorl, never with a free lip edge. Umbilicus normally widely open, last whorl decoiling more rapidly, degree of closure affected by both extent of columellar lip expansion and degree of body whorl descent, umbilical width 1.4-3.7 mm (mean 2.56 mm), D/U ratio 2.68-7.64 (mean 4.38). Colour variable, with spire a translucent yellow-brown, same tone in umbilicus with base lighter. Periphery of body whorl with a narrow to wide reddish spiral band, bordered above and below by narrower white zones. Lower palatal wall of shell often with several narrow, spiral white zones. Based on 560 measured adults.

Genitalia (**Figs 203a-d**) with hermaphroditic duct (GD) reflexing to enter directly onto head of talon (GT). Ovotestis (G) of several distinct clumps. Albumen gland size age dependent, illustrated example (**Fig. 203a**, GG) a third wet season adult and thus with very small albumen gland. Prostate (DG) and uterus (UT) without unusual features. Free oviduct (UV) very short, joining shaft of spermatheca at about 45° angle to form vagina (V). Spermatheca (S) much longer than free oviduct, but head reaching less than one-third of way up prostate-uterus. Vagina (V) thick-walled, relatively long. Atrium (Y) very short. Vas deferens (VD) slender for entire length, not bound to peni-oviducal angle by fibres, circling epiphallus at insertion point of penial retractor muscle, entering epiphallus through a pilaster (**Fig. 203d**). Epiphallic caecum (EC) large, tip coiled, chamber and pilasters continuous with epiphallic chamber, whose wall have low, irregular pilasters. Penial retractor muscle (PR) arising from diaphragm, inserting at right angles onto wall of epiphallus (E). Latter thick-walled, passage into penis proper (P) marked by presence of huge vergic papilla (PV) that reaches to atrium. Papilla grooved along most of one side. Wall of penis thick and glandular, with vague low pilasters. Illustrated specimen with a spermatophore (SP) *in situ*.

Jaw (**Plate 81f**) with prominent vertical ribs in centre, reduced on margins. Radula with typical marginal teeth and lateromarginal transition (**Plate 81d-e**). Central and lateral teeth (**Plate 81a-c**) with mesocone that is curved at tip, small to prominent side cusps, and prominent anterior flare.

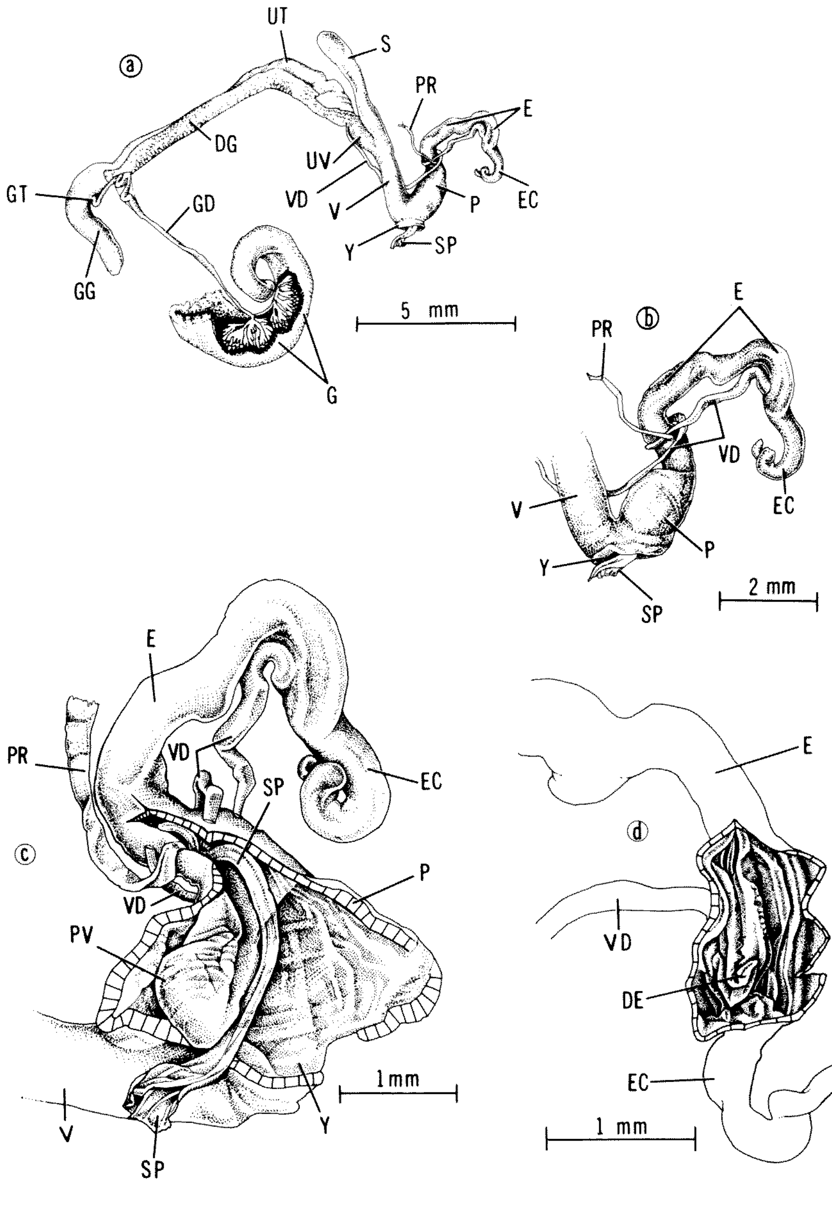

Fig. 203: Genitalia of *Kendrickia ignivenatus:* Sta. WA-300, near northwest end of Napier Range, South Kimberley, 6 December 1976, FMNH 199944, Dissection A, (a) whole genitalia, (b) detail of terminal genitalia, (c) interior of penis with partly extruded spermatophore, (d) entrance of vas deferens into epiphallus. Scale lines as marked. Drawings by Linnea Lahlum.

Remarks

Kendrickia ignivenatus is patchy in distribution. It is talus associated and locally may be quite abundant. In contrast, specimens of *Amplirhagada napierana* Solem, 1981, *A. percita* (Iredale, 1939), and *Westraltrachia woodwardi* (Fulton, 1902) are generally distributed throughout the northwest Napier Range, although often in low numbers locally, while *Kendrickia ignivenatus* may be concentrated in one small part of a gulley or cliff area. The concordance between positive localities by FMNH staff (WA-717, WA-300, WA-715, WA-714, WA-322) for both *Kendrickia* and *Westraltrachia* reflects our effectiveness in finding 'good pockets of specimens' to exploit. Only at WA-716 and WA-321 were specimens of *W. woodwardi* taken without finding colonies of *Kendrickia.* In contrast, WAM staff were collecting in a somewhat different manner. They collected *Westraltrachia* and *Kendrickia* sympatrically at NRII-6, NRIII-1, and NRII-18, but found only *Westraltrachia* at Stations NR VII, NR VIII, NR IX, NR VI, NR V, NR IV, and NRII 14-17. We do not have enough information about the ecology of *Kendrickia* to indicate possible differences from *Amplirhagada* and *Westraltrachia.*

Local variation in size and shape is summarised in **Table 84.** The populations with larger shell diameter have higher whorl counts. Umbilical size depends more on the degree of whorl descension and columellar lip expansion than on diameter changes. These variations are not analysed further. Patterns of variations between sympatric *Westraltrachia woodwardi* and *Kendrickia ignivenatus* are variable. At the northern end of the Napier Range, Stations NRII-6, WA-717, and WA-300, large size in one means smaller size in the other. At the stations to the south-east, WA-715, WA-714, NRII-18, WA-322, and near Old Napier Downs Cave, *W. woodwardi* shows moderate variation, but *Kendrickia* almost none. The reasons for these differences are unknown.

The specimen whose anatomy is illustrated **(Figs 203a-d)** was taken near the end of a heavy thunderstorm and then drowned overnight prior to fixation and preservation in ethanol. The finding of a spermatophore essentially *in situ* **(Fig. 203c,** SP), is a fortunate accident. The form of the spermatophore obviously differs greatly from that of the sympatric *Amplirhagada* (Solem 1981a: 241, fig. 52e). Its external walls seem to be a 'chitinized' material, but no chemical or structural analysis was attempted. The date of collection, 6 December 1976, was at the very start of the delayed 1976-7 Napier Range wet season. Whether this was the first rain, or a second rain at that site is unknown. The presence of a presumably fully formed spermatophore in this specimen at that time is highly significant. First, the specimen is a 'third wet season' snail whose shell had reached maturity late in the previous dry season. While I have hypothesised that such specimens are 'male active' at the beginning of the third wet season (Solem 1984: 482), this specimen provides direct evidence of such activity. Second, this indicates that *Kendrickia,* as do previously revised genera of Kimberley camaenids (Solem 1979, 1981a, 1981b, 1984), becomes male active *before* being activated by rains.

The changes are not as noticeable as in *Amplirhagada* (Solem 1981a: 241, figs 52a, d-f) or *Westraltrachia* (Solem 1984: figs 114b-c). The late dry season examples of *Kendrickia* **(Figs 203a-d)** show major enlargement of the hermaphroditic duct (GD), although the degree of coiling is much less than in *Amplirhagada* or *Westraltrachia.* Dissection of individuals collected on 30 December 1976 from the same population (Sta. WA-300, FMNH

Table 84: Local Variation in *Kendrickia ignivenatus*

Station	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
NR II-6, WAM 281.80	47L	5.24±0.055 (4.55–6.4)	10.72±0.076 (9.95–11.7)	0.489±0.005 (0.414–0.564)
NR II-6, WAM 288.80	56D	5.27±0.050 (4.5–6.3)	10.79±0.078 (9.8–12.3)	0.489±0.005 (0.430–0.600)
WA-717, FMNH 205354	17L	4.38±0.077 (3.81–4.87)	9.91±0.068 (9.5–10.4)	0.443±0.008 (0.377–0.496)
WA-717, FMNH 205355	10D	4.14±0.077 (3.56–4.49)	10.17±0.162 (9.45–11.0)	0.407±0.007 (0.370–0.445)
WA-300, FMNH 199944	102L	5.07±0.035 (4.25–5.85)	11.37±0.038 (10.2–12.4)	0.446±0.003 (0.372–0.533)
WA-300, FMNH 199253	141D	5.04±0.026 (4.35–5.85)	11.04±0.042 (9.6–12.3)	0.457±0.003 (0.394–0.602)
WA-715 FMNH 205341	9L	4.70±0.118 (4.0–5.15)	10.23±0.084 (9.9–10.6)	0.459±0.011 (0.401–0.511)
NR III-1, WAM 287.80	13D	4.84±0.080 (4.5–5.4)	10.68±0.167 (9.8–11.65)	0.453±0.007 (0.417–0.500)
WA-714, FMNH 205329	13L	4.74±0.083 (4.3–5.4)	10.14±0.123 (9.05–10.6)	0.469±0.013 (0.420–0.597)
WA-714, FMNH 205330	24D	4.69±0.067 (4.0–5.25)	10.40±0.082 (9.6–11.25)	0.451±0.005 (0.406–0.507)
NR II-18, WAM 285.80	13D	4.90±0.071 (4.6–5.65)	10.23±0.102 (9.8–11.15)	0.480±0.010 (0.430–0.568)
WA-322, FMNH 200143	16L	4.79±0.062 (4.45–5.2)	10.05±0.104 (9.25–10.85)	0.477±0.007 (0.442–0.524)
WA-322, FMNH 199330	16D	4.67±0.074 (4.1–5.05)	10.34±0.078 (9.75–11.1)	0.452±0.006 (0.408–0.492)
Old Napier Downs Cave, WAM 414.77	38D	5.33±0.054 (4.5–6.0)	10.50±0.091 (9.4–11.8)	0.507±0.006 (0.441–0.601)

Table 84: Local Variation in *Kendrickia ignivenatus*

Station	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
NR II-6, WAM 281.80	47L	4½– (4⅛–5)	2.37±0.050 (1.7–2.8)	4.61±0.092 (3.33–6.12)
NR II-6, WAM 288.80	56D	4½ (4¼–5⅛)	2.71±0.363 (1.7–3.55)	4.69±0.093 (3.11–6.48)
WA-717, FMNH 205354	17L	4¼+ (4⅛+–4½–)	2.58±0.057 (2.1–3.0)	3.86±0.074 (3.41–4.47)
WA-717, FMNH 205355	10D	4¼– (4⅛–4¼+)	3.05±0.089 (2.55–3.5)	3.35±0.090 (2.95–3.75)
WA-300, FMNH 199944	102L	4½ (4⅛+–4⅞)	2.46±0.032 (1.65–3.28)	4.70±0.059 (3.50–6.75)
WA-300, FMNH 199253	141D	4½– (4⅛– –4¾)	2.67±0.029 (1.85–3.6)	4.20±0.043 (3.12–5.50)
WA-715 FMNH 205341	9L	4⅜– (4⅛– –4⅜+)	2.46±0.055 (2.15–2.7)	4.16±0.084 (3.88–4.69)
NR III-1, WAM 287.80	13D	4⅜– (4⅛–4⅝)	2.33±0.132 (1.8–3.4)	4.72±0.545 (3.35–5.92)
WA-714, FMNH 205329	13L	4⅜– (4¼– –4⅝+)	2.27±0.087 (1.55–2.8)	4.54±0.151 (3.69–5.87)
WA-714, FMNH 205330	24D	4⅜– (4⅛+–4⅝)	2.41±0.045 (1.95–2.95)	4.36±0.087 (3.59–5.43)
NR II-18, WAM 285.80	13D	4⅜ (4¼– –4⅝)	2.61±0.076 (2.15–3.1)	3.96±0.127 (3.16–4.86)
WA-322, FMNH 200143	16L	4⅜– (4⅛+–4½)	2.56±0.082 (1.95–3.15)	3.97±0.112 (3.43–4.91)
WA-322, FMNH 199330	16D	4⅜– (4¼– –4⅝–)	2.72±0.078 (2.2–3.3)	3.85±0.105 (3.32–4.59)
Old Napier Downs Cave, WAM 414.77	38D	4⅜ (4¼– –4⅝)	2.34±0.051 (1.4–2.9)	4.59±0.123 (3.71–7.64)

200260) and early dry season specimens collected 21 June 1980 from Sta. WA-717 (FMNH 205354) enabled the following comments.

An unusual feature of *Kendrickia* is that the first two whorls of the shell are empty space. The digestive gland apex normally lies about 2 to 2¼ whorls above the aperture, with the apical portion containing mucus in preserved examples. Mid-dry season examples have the ovotestis grossly reduced in volume, with individual lobes less than 10% of late dry or early wet season volume; the hermaphroditic duct has shrunk to a tiny duct, whereas in the others it is a thick coiled tube near the talon, tapering apically to a straight tube as it nears the ovotestis; the albumen gland is highly variable in size, but not enough samples are available to permit statistical analysis of the variation in size; and both the prostate and uterus are very slender. The change from late dry to early wet season specimen involves gross changes only in the lower uterus. This becomes swollen to the point that the spermathecal head is enveloped by the uterine tissue and visible only if the latter is dissected away.

The name *ignivenatus* honours circumstances surrounding the initial collection of this species in 1966. George W. Kendrick and Athol Douglas were exploring a gulley running north from old Napier Downs Cave. Douglas had gone up the gulley in search of lizards, while Kendrick began to move rocks in a talus pile. Just as he was reaching an area of the talus rich in specimens, he became aware that Douglas had fired some brush to evict lizards. The fire, now out of local control, was racing down the gulley. It threatened incineration. A quick last grab for specimens and George Kendrick ran down the gulley ahead of the flames, and into eventual recognition of his dedicated efforts.

GENUS *KIMBORAGA* IREDALE, 1939

Kimboraga Iredale, 1933, Rec. Australian Mus., **19** (1): 50 – *nomen nudum;* Iredale, 1938, Australian Zool., **9** (2): 99 – mention in a check list; Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 47 – type species *Chloritis micromphala* Gude, 1907 by original designation.

Nomenclature

Salisbury (1934: 83) and Zilch (1960: 727) both listed *Kimboraga* Iredale (1933: 50) as 'non descr.' His vague sentence 'Examination does not reveal any hairs, however, and to my surprise I found that Gude noted their absence, so that it cannot be classed as *"Chloritis"* at all, and is therefore named *Kimboraga* nov. gen.' is not an adequate description by any standard. Iredale (1939: 47) did give a reasonable description, and *Kimboraga* must date from that publication.

Diagnosis

Shell large, adult diameter 15.35-24.7 mm, mean whorl counts $4^1/_8$+ to 4¾–, largest in *yampiensis.* Spire strongly elevated in all species (**Figs 205, 206, 207a-c, 212**), not rounded above. Umbilicus variable, narrowly open in *mccorryi* (**Fig. 206c**) and *yammerana* (**Fig. 204c**), a lateral crack in *koolanensis* (**Fig. 212c**), to closed in *yampiensis* (**Fig. 204f**). Apices generally worn smooth, without any noticeable sculpture. Postapical whorls with prominent, quite narrow radial ribs that continue onto the shell base in *exanimus* and *yampiensis,* present on spire but absent from base in *mccorryi,* absent in *yammerana* and *micromphala,* which show fine spiral lines. Body whorl rounded, inflated, descending moderately behind aperture. Parietal wall with a thin to moderately heavy callus. Lip moderately expanded, but only slightly thickened. Combination of body whorl descension and inflation inclines the aperture noticeably from the shell axis. Colour light yellow horn in Napier Range species, reddish-purple suffusion present in Prince Regent River *(exanimus)* and Yampi Sound *(yampiensis)* taxa, lip white. No colour banding. Genitalia **(Figs 208-211)** with very short spermatheca (S), head bulbous at least in wet season, bound to base of prostate-uterus **(Fig. 211a)**. Vagina (V) very short **(Figs 209a, 210b, 211c)** to short **(Figs 208a, b)**. Apical and pallial genitalia without unusual features. Vas deferens (VD) very slender for entire length, coiled or kinked near peni-oviducal angle, entering penis sheath (PS) near apex of penis, although sometimes bound to outer wall of penis sheath **(Figs 209a-b)** for a considerable distance. Inside penis sheath, vas deferens long, except in *micromphala* **(Fig. 211b)**, coiled apically to insertion of penial retractor muscle (PR) then reflexing anteriorly and coiled until expansion just before entering penis (P). Penis sheath extending from just above atrium (Y) to slightly above insertion of penial retractor muscle, walls thin **(Figs 208c, 211c)**, medium **(Fig. 209b)**, or thick **(Fig. 210b)**. Penis itself varying from short *(yampiensis,* **Figs 208a, c)** to much longer than sheath *(mccorryi,* **Fig. 209b)**, wall thickness partly dependent upon relative size of wall pustules. Vas opening into penis (DP) simple, located above a simple vergic papilla (PPV) in *yampiensis* **(Fig. 208c)**, a vergic papilla that in some specimens forms a near tube *(micromphala,* **Fig. 211b)**, or just above a short *(mccorryi,* **Fig. 209b**; *micromphala,* **Fig. 211b)** to very long *(yammerana,* **Fig. 210b)** principal pilaster (PT). In *yampiensis* **(Fig. 208c)**, principal pilaster located lateral to the vas opening. Surfaces of principal pilasters with enlarged pustules. Wall of penis chamber with very large **(Fig. 209b)** to very small **(Fig. 210b)** pustules, orientation variable. Lower part of penis chamber with simple longitudinal pilasters. Jaw **(Plate 83f)** typically camaenid, with prominent vertical ribs. Radular teeth **(Plates 82a-f, 83a-e)** without unusual features, laterals with blunt, somewhat curved mesocones.

Type species: *Chloritis micromphala* Gude, 1907.

Comparative remarks

Shell form in *Kimboraga* is markedly similar to that of *Parglogenia pelodes* (Pfeiffer, 1846), found near Darwin **(Figs 207d-f)**, but the latter has setal microsculpture (Solem 1979: 132, pl. 11, figs a-b), which is totally absent from all *Kimboraga.* The elevated spire with rounded whorls, relatively steep inclination of the aperture, reduced mean number of whorls (less than 5), inflation of the body whorl, and lack of colour bands on the shell contrast with the situation in *Amplirhagada* Iredale, 1933. In this genus, the spire is rounded above, if elevated, the spire whorls are flatter (Solem 1984: 503, pl. 51), mean whorl counts are 5⅜ to 7¼, the body whorl is not

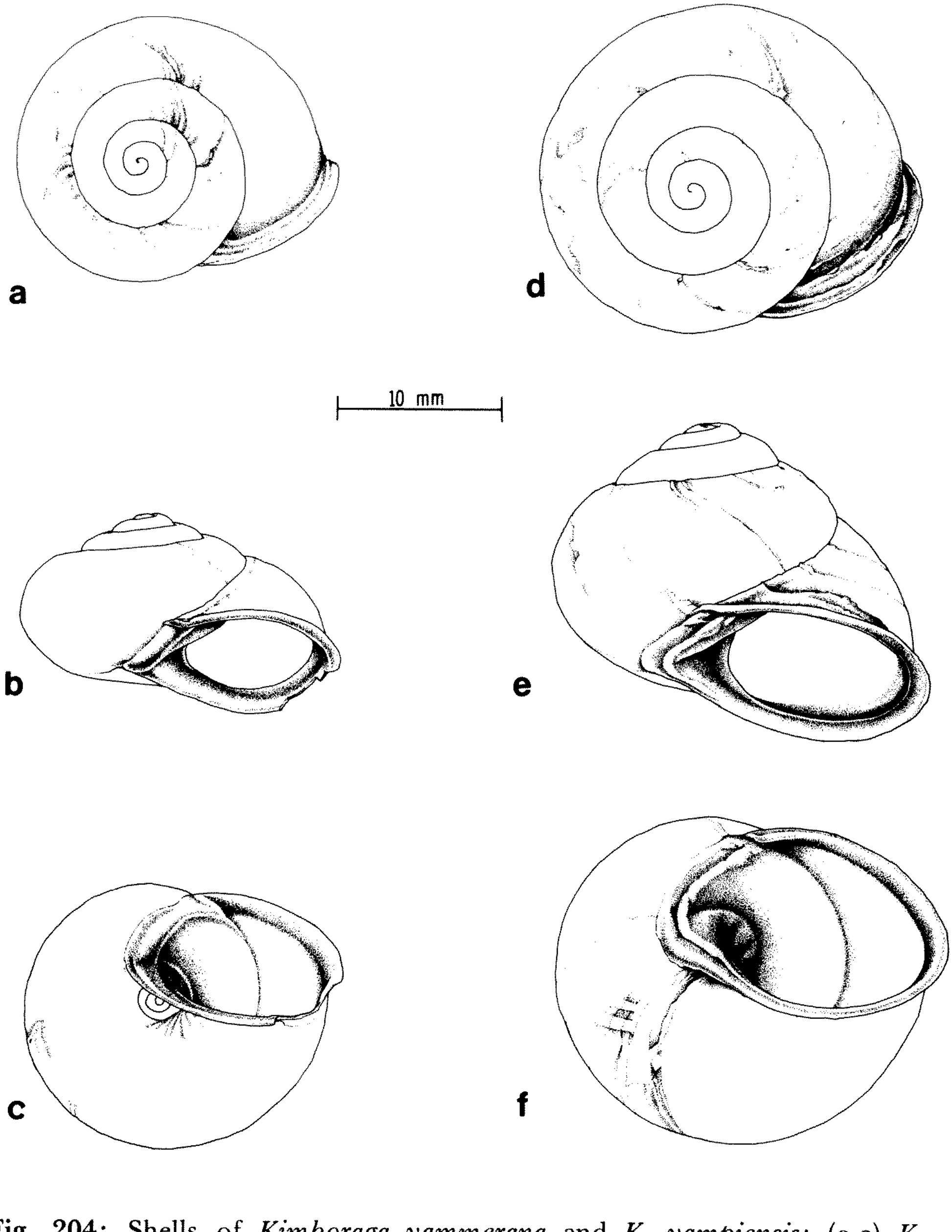

Fig. 204: Shells of *Kimboraga yammerana* and *K. yampiensis:* (a-c) *K. yammerana,* Sta. WA-337, 6.4 km east of Yammera Gap, Napier Range, WAM 603.80, holotype; (d-f) *K. yampiensis,* home garden, Koolan Island, Yampi Sound, WAM 604.80, holotype. Scale line equals 10 mm. Drawings by Linnea Lahlum.

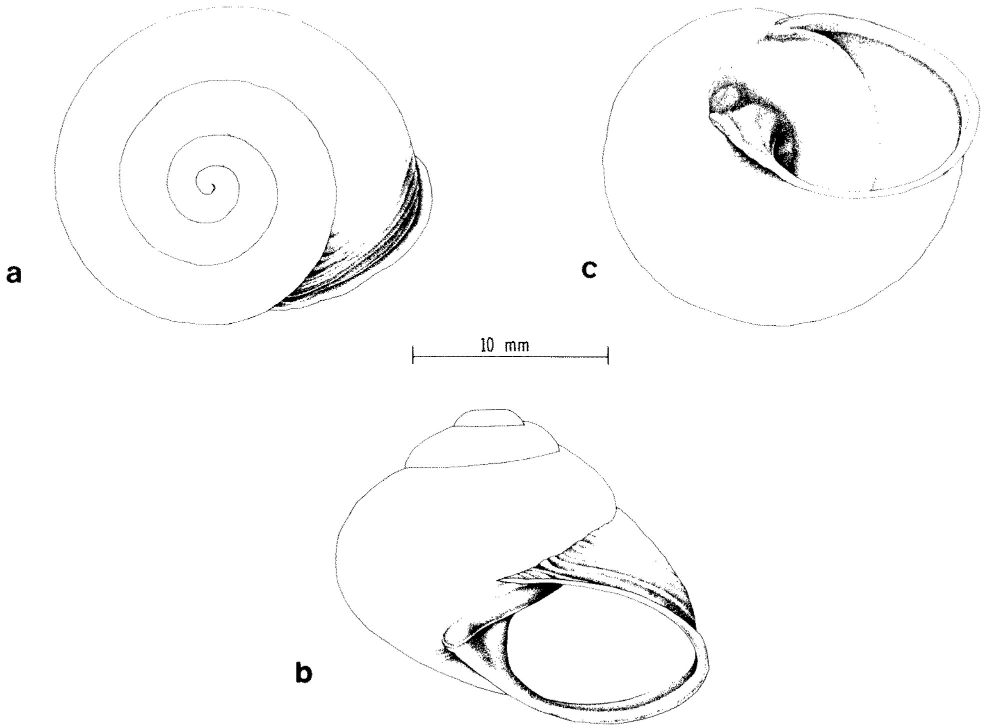

Fig. 205: Shells of *Kimboraga exanimus,* Sta. W4 (1), Mt Trafalgar, Prince Regent River Reserve, WAM 605.80, holotype. Scale line equals 10 mm. Drawings by Linnea Lahlum.

inflated, and there are frequently colour bands and/or suffusions. The two *Amplirhagada* present in the Napier Range west of Yammera Gap, *A. percita* (Iredale, 1939) and *A. napierana* Solem, 1981, come close in shell colour, but differ in form and whorl characteristics. Two species of *Xanthomelon* von Martens, 1860 are sympatric with *Kimboraga* in the Prince Regent River area, *X. ruberpumilio* Solem, 1979 and *X. prudhoensis* (Smith, 1894). They differ in having prominent shell sculpture (Solem 1979: 14, pl. 1), globose shape (Solem 1979: 12-13, figs 1-2, 21, Table 1), and very thick shells. No other genus that is sympatric anywhere with *Kimboraga* can be confused with it.

Anatomically, the lack of a tubular verge in *Kimboraga* immediately separates it from *Amplirhagada.*

Distribution and basic ecology

There are three species of *Kimboraga* known from the Napier Ranges, one in the Prince Regent River Reserve, and one (possibly two) in the Yampi

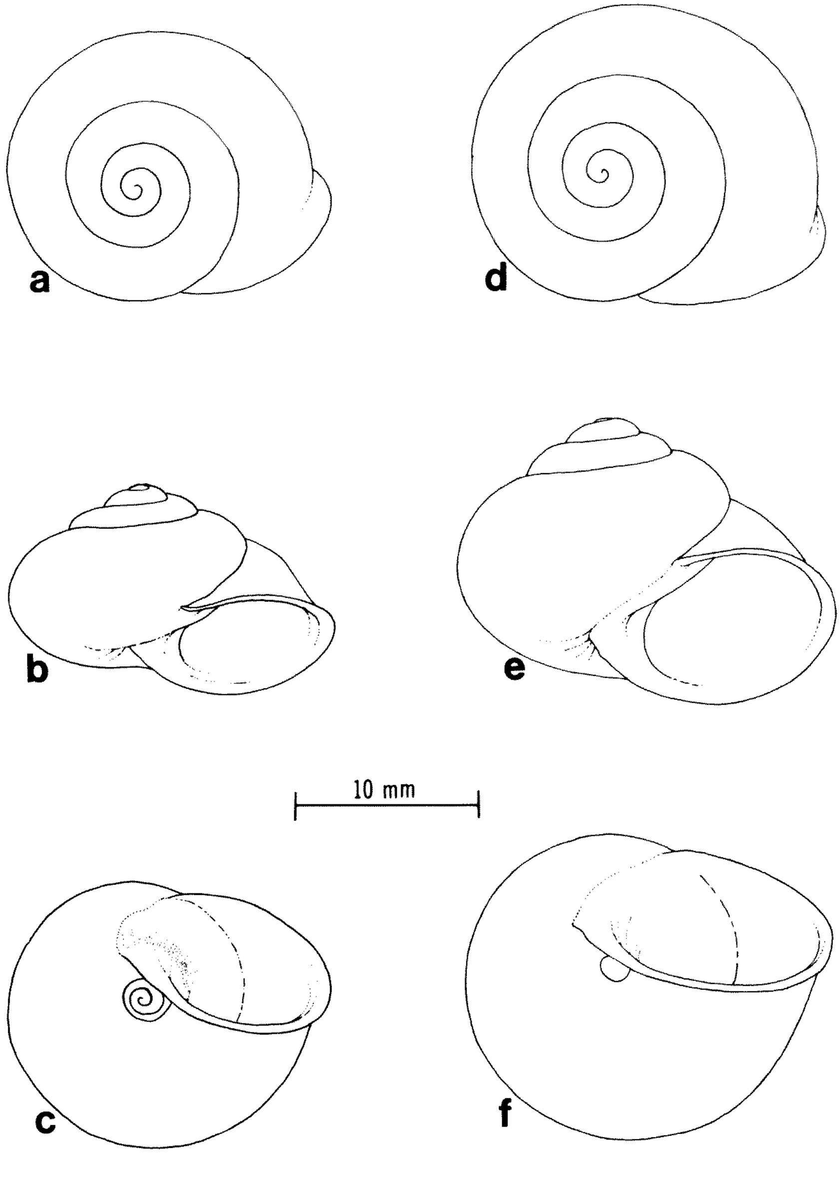

Fig. 206: Shells of *Kimboraga mccorryi* and *K. micromphala* (Gude, 1907): (a-c) *K. mccorryi,* Sta. WA-322, 3 km south-east Original Napier Downs Homestead ruins, Napier Range, WAM 602.80, holotype; (d-f) *K. micromphala* (Gude, 1907), Barrier Range (= Napier Range), north-west Australia, AM C.101132, holotype. Scale line equals 10 mm. Drawings by Elizabeth A. Liebman.

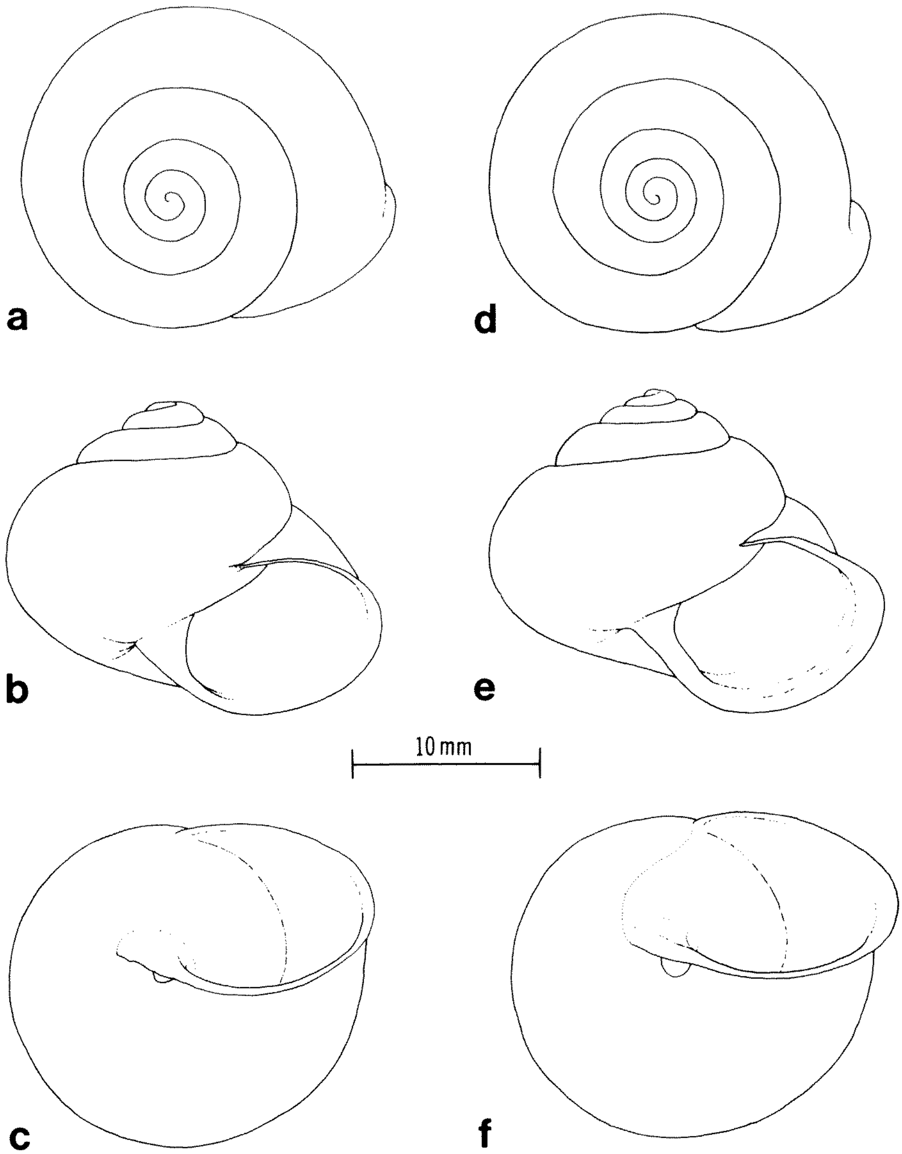

Fig. 207: Shells of *Kimboraga micromphala* (Gude, 1907) and *Parglogenia pelodes* (Pfeiffer, 1846): (a-c) *K. micromphala* (Gude, 1907), Sta. WA-194, Windjana Gorge, Napier Range, FMNH 200053; (d-f) *Parglogenia pelodes* (Pfeiffer, 1846), Sta. WA-107, Darwin, Northern Territory, FMNH 182337. Scale line equals 10 mm. Drawings by Elizabeth A. Liebman.

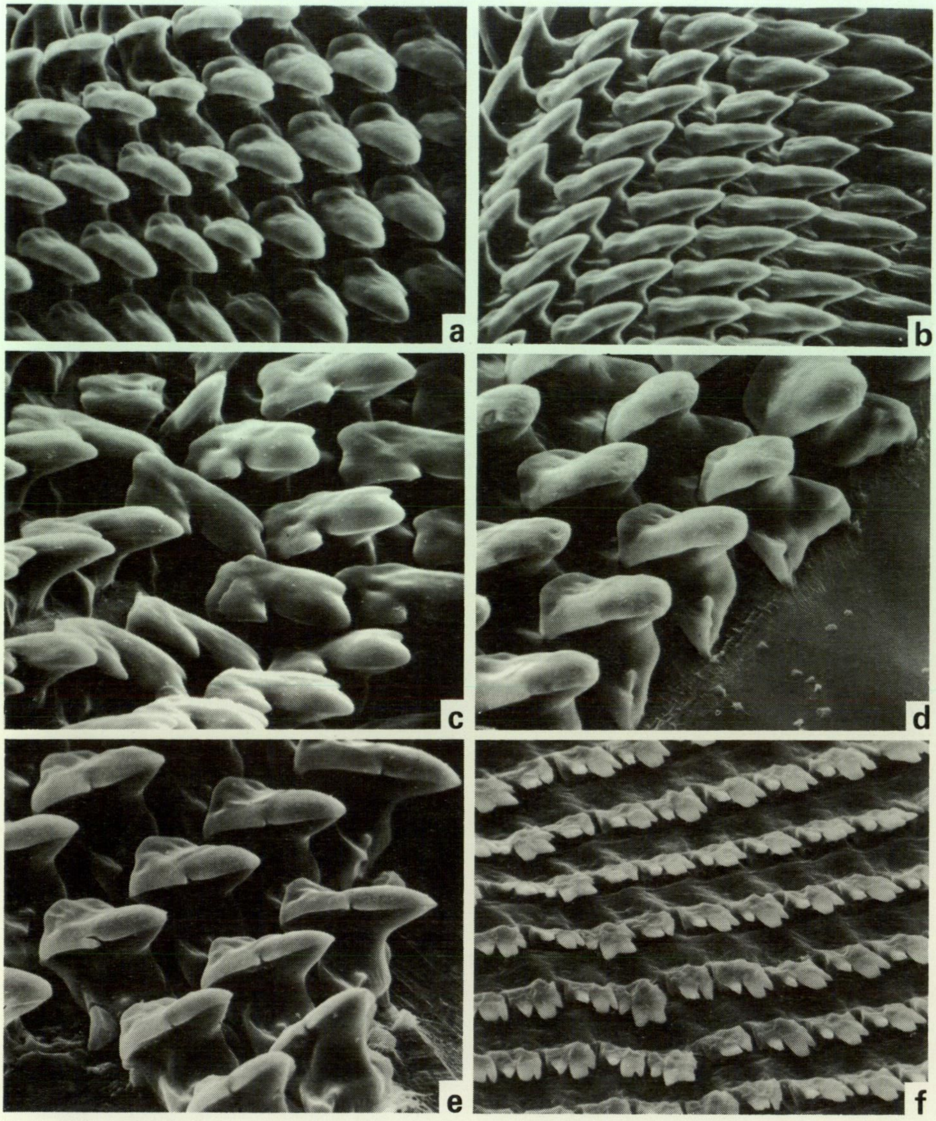

Plate 82: Radulae of *Kimboraga mccorryi* and *K. yammerana:* (a-c) *K. mccorryi,* Sta. WA-322, 3 km south-east Original Napier Downs Homestead ruins, Napier Range, 17 December 1976, FMNH 199327, Dissection B, (a) high angle posterior view of central and early laterals at 335X; (b) high side angle view of central and early laterals at 320X; (c) lateromarginal transition at 635X; (d-f) *K. yammerana,* Sta. WA-337, 6.4 km east-south-east Yammera Gap, Napier Range, 1 March 1977, FMNH 199816, (d) high angle view of central and early laterals at 560X; (e) lateral teeth at 595X; (f) marginal teeth at 350X.

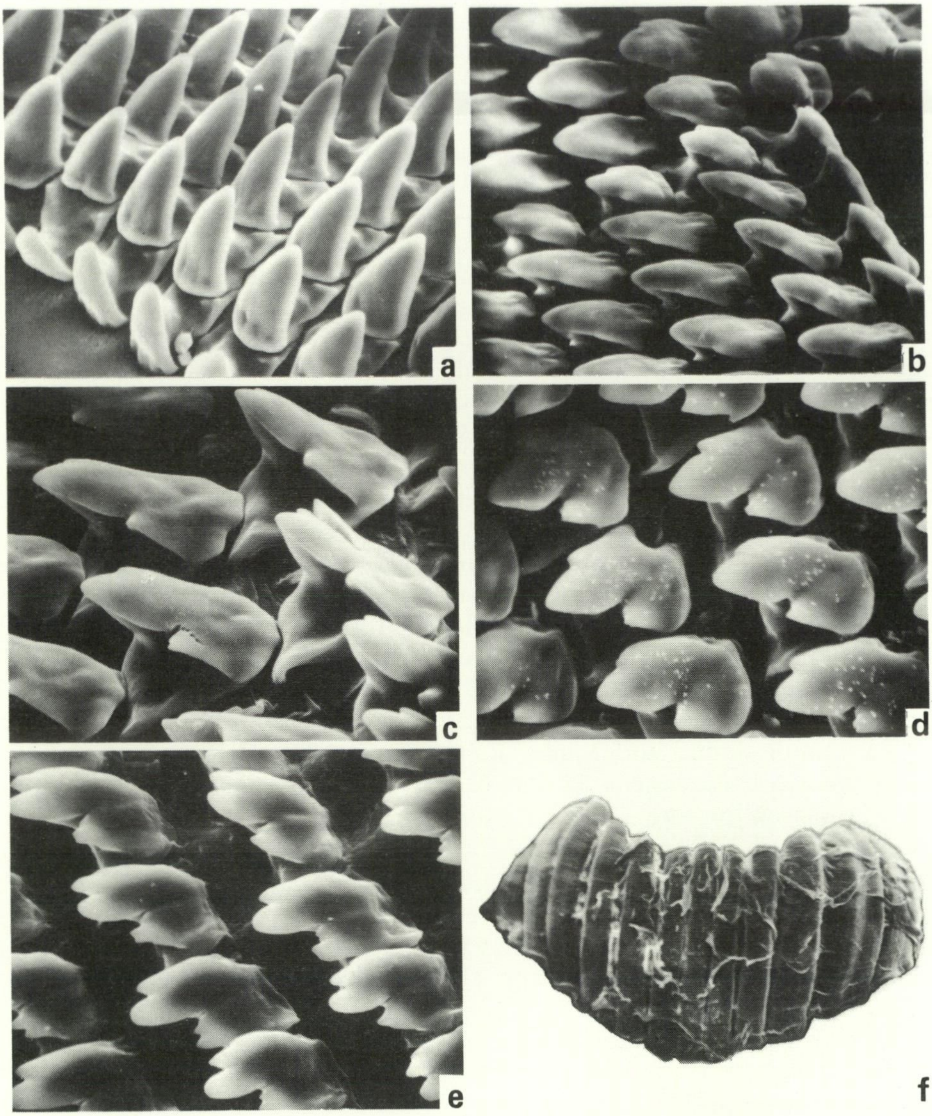

Plate 83: Radula of *Kimboraga micromphala* (Gude, 1907) and jaw of *K. mccorryi:* (a-e) *K. micromphala,* Sta. WA-194, south-east corner Windjana Gorge, Napier Range, 4 January 1977, FMNH 200053, (a) high anterior view of central and early laterals at 375X; (b) lateral view of central and early laterals at 380X; (c) outer laterals at 765X; (d) early marginals at 730X; (e) mid marginals at 730X; (f) jaw of *K. mccorryi,* Sta. WA-322, 3 km south-east of Original Napier Downs Homestead ruins, Napier Range, 17 December 1976, FMNH 199327, Dissection B, at 37.0X.

Sound area. Quite probably others exist. The Napier Range taxa have restricted distributions: *K. micromphala* (Gude, 1907) has been found at the south entrance of Windjana Gorge, then up to a few hundred metres west and about 1.2 km east. It has not been collected on the north side of Windjana Gorge or the Napier Range; *K. yammerana* has been taken at a single station, WA-337, located 6.4 km east of Yammera Gap; and *K. mccorryi* has been found in very limited numbers at six stations located from 3.2 km west of Barker River Gorge to about 15 km north-west of Barker River Gorge, a total range of less than 12 km. So few specimens are known of the Prince Regent River *K. exanimus* (**Table 83**) that the actual species range is unknown. *K. yampiensis* has been collected on both Koolan and Cockatoo Islands, plus adjacent mainland records. No inland land snail collecting has been done in this region, so that its actual range is unknown. A sixth species, *Kimboraga koolanensis* (Iredale, 1939), known only from very worn and bleached specimens, is grouped here in desperation. Its affinities cannot be determined without live specimens. It at least looks vaguely like a *Kimboraga,* but may well belong to a different genus.

A single dead juvenile (NMV) from near the Robinson River, 8.8 km east of Stuart River-Oobagooma Road, about 74 km north-north-east of Derby, collected by A.C. Beauglehole 14 June 1976, although bleached and worn, has the shape and sculpture of *Kimboraga exanimus* and *K. yampiensis.* It is too worn for identification, but indicates that the genus does occur inland in this region.

The Yampi Sound and Napier Range species are, at least in part, cave associated. Live specimens of the Napier Range taxa were taken during the wet season on the roofs of caves, either actually crawling about or resting in small hollows in the roof. No live adults have been taken in the dry season. Some of the Yampi Sound specimens came from caves, but the live specimens were taken from a garden, undoubtedly well watered.

The cave roof habitat is a distinct shift compared with the other Napier Range taxa, which are talus, litter, or crevice shelterers. Presumably they aestivate, sealed to a rock surface, deep within rock fissures radiating from the caves in which they have been found.

Patterns of structure

Shell shape and umbilical state are correlated, with the relatively low spired *K. mccorryi* (**Figs 206b-c**) and *K. yammerana* (**Figs 204b-c**) having narrowly open umbilici, while the higher spired *K. micromphala* (**Figs 206e-f, 207a-c**), *K. exanimus* (**Figs 205b-c**), and *K. yampiensis* (**Figs 204 e-f**) have basically closed umbilici. All of the above species agree in the protruding spire with sharply rounded whorls, inflated body whorl, and steeply inclined aperture.

Radial ribbing is prominent and continues onto the shell base in the two western species, *K. yampiensis* and *K. exanimus;* present above the periphery but absent from the shell base in the westernmost Napier Range species, *K. mccorryi;* and absent in the eastern species, *K. yammerana* and *K. micromphala.* The latter two species, in fresh material, show the same incised spiral lines found in *Amplirhagada percita* (Iredale, 1939)(Solem 1981a: 160, pl. 14f).

Genital variation involves the proportions of the terminalia, size and orientation of the penis chamber sculpture, presence and characteristics of the principal pilaster, presence and nature of a vergic papilla, length of the vas deferens after it enters the penis sheath, and relative thickness of the walls for the penis and penis sheath. Details are presented under the individual species and summarised above in the genus diagnosis. With two exceptions, all live adult material of *Kimboraga* was collected early in the wet season. The specimens of *K. yampiensis* from a house garden were collected in July, mid-dry season, and one set of *K. micromphala* (Gude, 1907) was taken 21 March, late in the wet season. Except for the last set, all specimens were in full readiness for mating, with enlarged ovotestis, hermaphroditic duct, and prostate-uterus. The March collected material showed the typical late wet season condition of shrunken ovotestis and hermaphroditic duct, reduced size of prostate-uterus as outlined by Solem and Christensen (1984). These changes allow increased food storage space to enhance survival chances over the forthcoming dry season. The apparently anomalous situation of the July collected Koolan Island specimens being in mating readiness during the mid-dry season is easily explained by their being collected in a home garden. Watering of lawn and flowers would provide a near permanent wet season microenvironment and may have altered the cycle in this population.

Relationships of *Kimboraga*

Kimboraga differs from *Amplirhagada* in lacking a tubular verge and in having the principal pilaster less differentiated; in its cave roof habitat; and in the elevated spire, reduced whorl count, inflated body whorl, and more strongly inclined aperture of the shell. The conchological and habitat changes are specialisations within the context of the Australian Camaenidae. Current evidence is not adequate to state categorically whether the less specialised pilaster of *Kimboraga* is primitive or derived. In general, a vergic stimulator would be considered to be less specialised than a tubular verge, but the vergic papillae of *Kimboraga* appear to be raised portions of the penis wall, rather than equivalent to the large pilasters or spatulate verges of *Setobaudinia.* An additional feature in which the two genera agree is in having the same type of spermatophore mass (see Solem 1981a: 241, fig. 52e). Up to four such masses were found inside the spermathecal head of mid-wet season *Kimboraga.* The contrast with the horny spermatophore of *Kendrickia* (**Fig. 203c**) is great.

In most features, *Kimboraga* and *Amplirhagada* agree in structure, and a very close relationship is hypothesised. *Kimboraga* occupies a fringing distributional pattern to that of *Amplirhagada*. The question of evolutionary direction is deferred until data on other genera is available for reference.

Systematic review

The following key will separate adult shells in good condition, but is inadequate for very worn specimens.

KEY TO THE SPECIES OF *KIMBORAGA*

1. Fine to moderately prominent radial ribs on at least the spire 2
   Spire with at most radial growth striae or smooth 4
2. Radial ribs continuing onto shell base 3
   Radial ribs absent from shell base; Napier Range . . . .
   Kimboraga mccorryi sp. nov. (p. 836)
3. Ribs fine, rounded, crowded; reddish suffusion; Yampi Sound . . . .
   Kimboraga yampiensis sp. nov. (p. 828)
   Ribs larger, sharp edged; more widely spaced; colour yellow horn; Prince Regent River Reserve . . . .
   Kimboraga exanimus sp. nov. (p. 835)
4. Umbilicus closed or a narrow crack **(Figs 206f, 207c)** 5
   Umbilicus distinctly open **(Fig. 204c)** . . . .
   Kimboraga yammerana sp. nov. (p. 841)
5. Lip slightly reflected and expanded **(Fig. 206e)**; Windjana Gorge area; Napier Range . . . .
   Kimboraga micromphala (Gude, 1907)(p. 843)
   Lip strongly reflected **(Fig. 212c)**; Koolan Island, Yampi Sound . . . .
   Kimboraga koolanensis (Iredale, 1939)(p. 845)

KIMBORAGA YAMPIENSIS SP. NOV.
(Figs 204d-f, 208a-c)

Comparative remarks

Kimboraga yampiensis is larger and with a less elevated spire **(Table 83)** than *K. exanimus* from the Prince Regent River area. It also tends to have a deeper colour suffusion and the sculpture is less prominent. In both species the ribbing continues onto the base without loss in prominence, whereas in the other ribbed species, *K. mccorryi* from the western Napier Ranges, the radial sculpture stops at the shell base and the umbilicus **(Fig. 206c)** is distinctly open. None of the other species have radial ribbing.

Anatomically, the longer vagina (V), short and fat penis (**Figs 208a, c**) with vergic papilla (PPV) and broad principal pilaster (PT) of *K. yampiensis* are distinctive. *K. micromphala* (**Figs 211a-b**) has a shorter vagina, longer penis, the wall sculpture of the penis is much larger, the principal pilaster is reduced, and the vergic papilla is modified. *K. yammerana* (**Figs 210a-f**) has a very prominent principal pilaster and very tiny wall pustules, while *K. mccorryi* (**Figs 209a-b**) has a very long penis with huge wall pustules and a greatly reduced principal pilaster.

Holotype

WAM 604.80, house garden, Koolan Island, Yampi Sound, Kimberley, Western Australia (1:250,000 'Yampi' map sheet SE 51-3 – ca 135:963). Collected by John Milton and John Bannister July 1967. Height of shell 20.7 mm, diameter 24.0 mm, H/D ratio 0.863, whorls 4¾–, umbilicus a narrow lateral crack.

Paratopotypes

WAM 256.74, WAM 332.74, FMNH 209065, 3 live, 1 dead adults from the type locality.

Paratypes

Cockatoo Island, Yampi Sound (3 dead adults, WAM 419.77, collected by G. Shaw August 1968).

Silver Gull Creek, opposite Koolan Island ('Yampi' SE 51-3 – ca 132:956) (3 dead adults, WAM 249.74, FMNH 209064, collected by R.W. George 30 October 1961); Wotjulum, near Cockatoo Island (10 dead adults, 4 dead juveniles, WAM 595.77, WAM 596.77, FMNH 209066, collected by A.M. Douglas 1955).

Other material

Dugong Bay, cave floor in valley at south-east end of Bay, west-southwest of Collier Bay ('Yampi' SE 51-3 – ca 152:930) (2 dead juveniles, WAM 474.77, collected by J. Clarke).

Diagnosis

Shell relatively large, diameter 19.8-24.7 mm (mean 21.97 mm), with 4¼ to 5¼+ normally coiled whorls. Apex and spire moderately and evenly elevated (**Fig. 204e**), not rounded above, height of shell 15.6-21.2 mm (mean 18.25 mm), H/D ratio 0.717-0.923 (mean 0.830). Apical sculpture not observed. Postapical whorls with crowded, narrow, generally rounded radial ribs that continue onto the shell base without loss in prominence. Shell periphery rounded, body whorl inflated, descending gradually for a considerable distance behind aperture, which is strongly inclined from shell axis. Lip moderately expanded and thickened, parietal wall often with a

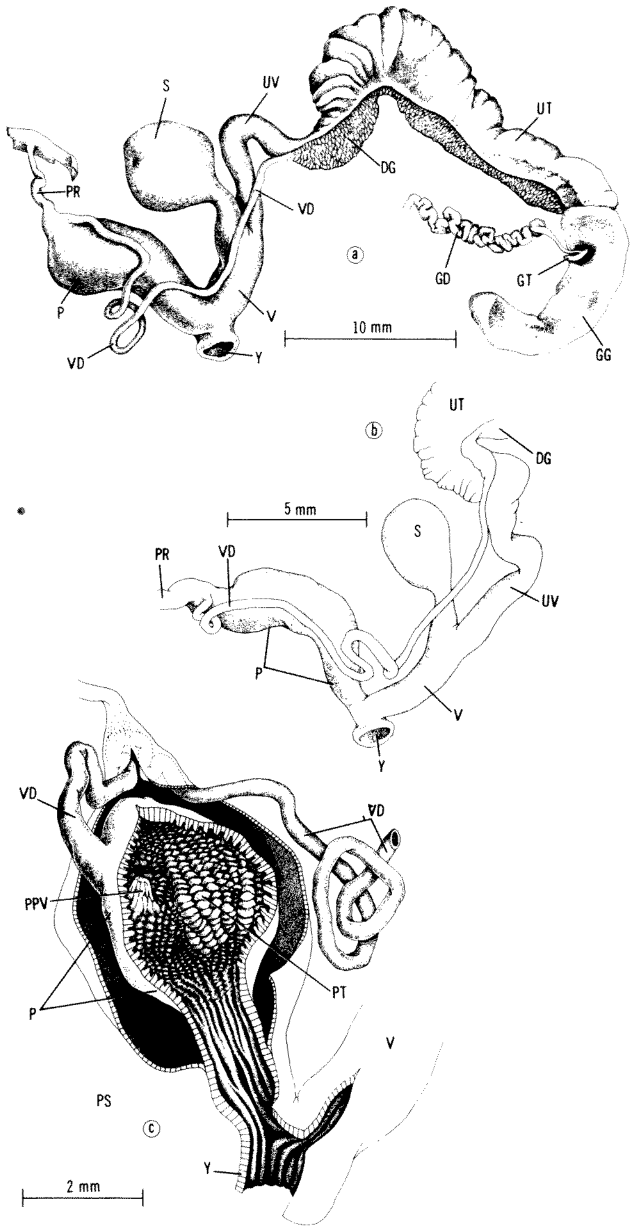

Fig. 208: Genitalia of *Kimboraga yampiensis:* (a, c) Koolan Island, Yampi Sound, July 1967, WAM 604.80, holotype, a is whole genitalia, c is penis interior; (b) Koolan Island, Yampi Sound, July 1967, WAM 332.74, paratype, outline of terminal genitalia. Scale lines as marked. Drawings by Elizabeth A. Liebman.

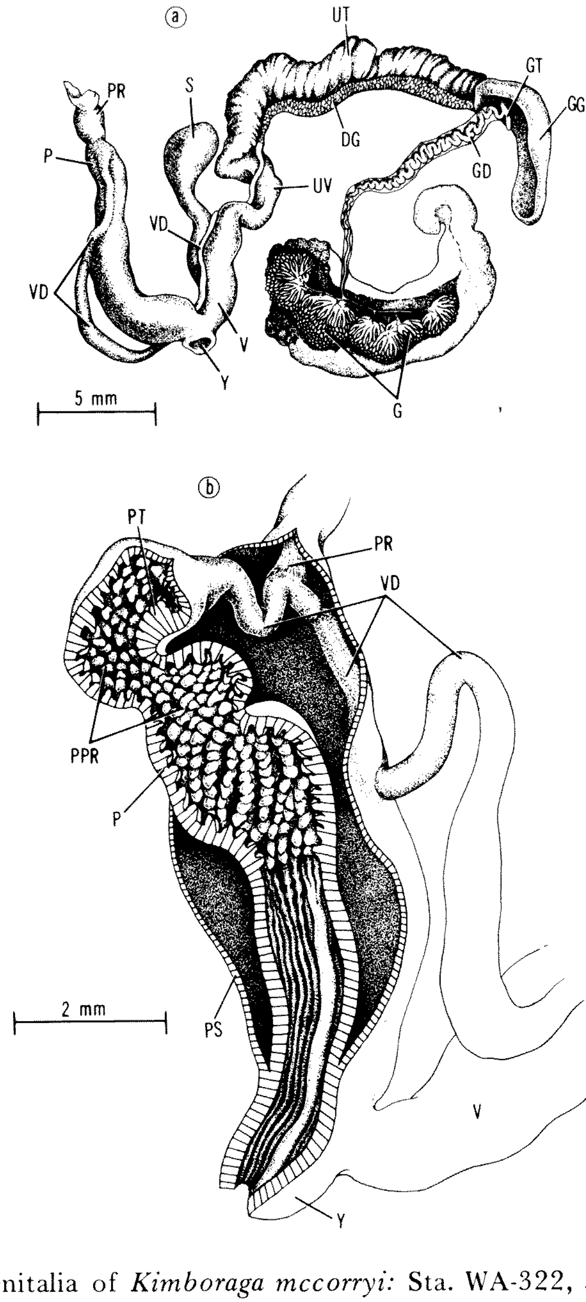

Fig. 209: Genitalia of *Kimboraga mccorryi:* Sta. WA-322, 3 km south-east Original Napier Downs Homestead ruins, Napier Range, 17 December 1976, FMNH 199327, Dissection B, paratopotype, (a) whole genitalia, (b) penis interior. Scale lines as marked. Drawings by Elizabeth A. Liebman.

heavy callus (**Figs 204e-f**). Umbilicus at most a narrow lateral slit, sometimes closed. Periostracal colour greenish yellow, often with variable reddish suffusion, lip white. Based on 21 measured adults.

Genitalia (**Figs 208a-c**) with free oviduct (UV) and vagina (V) relatively long. Vas deferens (VD) entering penis sheath near apex, coiled or kinked to penial retractor insertion, then coiled or kinked down to penis proper. Penis (P) short and fat, sheath with thin walls. Penis chamber with large pustules above, lower portion with simple longitudinal pilasters extending into atrium (Y). Principal pilaster (PT) wide, with enlarged pustules. A small vergic papilla (PPV) located just below opening of vas deferens. Jaw and radular teeth typical. Based on 2 dissected adults.

Remarks

The name *yampiensis* refers to its distribution along the fringes of Yampi Sound. Specimens from the mainland and Cockatoo Island are slightly smaller and mostly (except Silver Gull Creek sample) more depressed than the material collected from a 'house garden' on Koolan Island (**Table 85**).

Table 85: Local Variation in *Kimboraga yampiensis, K. exanimus, K. mccorryi, K. yammerana* and *K. micromphala*

Taxon	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
K. yampiensis				
Koolan Island WAM 322.74 WAM 604.80	4L	20.78±0.217 (20.2–21.2)	23.65±0.296 (22.8–24.1)	0.879±0.005 (0.863–0.886)
Wotjulum, WAM 595.77	3D	17.83±0.426 (17.0–18.4)	22.65±0.589 (21.5–23.45)	0.788±0.002 (0.785–0.791)
Wotjulum, WAM 596.77	7D	17.06±0.512 (15.7–19.9)	20.69±0.346 (19.83–22.66)	0.824±0.015 (0.767–0.878)
Cockatoo Id., WAM 419.77	3D	16.25±0.542 (15.6–17.3)	21.14±0.303 (20.8–21.7)	0.769±0.034 (0.717–0.833)
Silver Gull Creek WAM 249.74	3D	19.18±0.395 (18.7–20.0)	21.85±0.699 (20.5–22.8)	0.879±0.025 (0.838–0.923)
K. exanimus				
W4 (1), WAM 313.75	7D	16.94±0.142 (16.6–17.45)	19.00±0.084 (18.65–19.3)	0.892±0.008 (0.860–0.923)
W4 (4), WAM 314.75	5D	17.01±0.301 (16.2–17.7)	19.26±0.340 (18.0–19.9)	0.884±0.014 (0.828–0.908)
K. mccorryi				
WA-322, FMNH 199327, FMNH 200146	8L, D	12.76±0.148 (12.1–13.35)	18.29±0.239 (17.3–19.15)	0.698±0.008 (0.644–0.723)

Table 85: Local Variation in *Kimboraga yampiensis, K. exanimus, K. mccorryi, K. yammerana* and *K. micromphala* (continued)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
WA-321, FMNH 199310	12D	12.35±0.127 (11.75–13.25)	19.03±0.140 (18.35–20.1)	0.649±0.005 (0.627–0.683)
WA-324, FMNH 199084, FMNH 200769	6L, D	11.28±0.272 (10.65–11.8)	18.49±0.253 (17.8–19.4)	0.611±0.123 (0.580–0.657)
WA-312, FMNH 199337	8D	10.20±0.138 (9.55–10.8)	16.93±0.256 (15.35–17.75)	0.603±0.007 (0.570–0.623)
K. yammerana				
WA-337, FMNH 199270	17D	13.32±0.249 (11.95–16.35)	20.05±0.214 (18.8–22.5)	0.664±0.008 (0.618–0.729)
WA-337, FMNH 200118	21L	13.36±0.112 (12.65–14.55)	19.75±0.139 (18.4–20.95)	0.678±0.006 (0.630–0.728)
K. micromphala (Gude, 1907)				
Types, type lot	11D	16.88±0.181 (16.2–17.8)	20.43±0.217 (19.15–21.8)	0.821±0.010 (0.758–0.888)
WA-193, SW corner Windjana	3D	16.48±0.782 (15.2–17.9)	20.57±0.892 (18.9–21.95)	0.801±0.009 (0.784–0.815)
WA-194, SE corner Windjana, FMNH 199182	45D	18.18±0.147 (16.0–20.6)	21.27±0.145 (18.8–23.35)	0.855±0.005 (0.808–0.968)
WA-194, FMNH 199851	18L	18.24±0.175 (16.75–19.2)	21.24±0.218 (19.85–22.85)	0.859±0.005 (0.816–0.912)
1 km SE Windjana, WAM 840.76	9D	16.48±0.801 (15.5–18.1)	19.65±0.835 (18.15–21.0)	0.839±0.021 (0.794–0.865)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
K. yampiensis				
Koolan Island, WAM 322.74, WAM 604.80	4L	4⅝– (4⅜–4¾)	crack	---
Wotjulum, WAM 595.77	3D	4½– (4¼–4¾)	crack	---
Wotjulum, WAM 596.77	7D	4¾+ (4⅝+–5¼+)	crack	---

Table 85: Local Variation in *Kimboraga yampiensis, K. exanimus, K. mccorryi, K. yammerana* and *K. micromphala* (continued)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
Cockatoo Id., WAM 419.77	3D	4¾+ (4¾– –4¾+)	crack	---
Silver Gull Creek WAM 249.74	3D	4¾+ (4¾+–4⅞–)	crack	---
K. exanimus				
W4 (1), WAM 313.75	7D	4⅛+ (4–4¼)	crack	---
W4 (4), WAM 314.75	5D	4½+ (4½– –4¾–)	crack	---
K. mccorryi				
WA-322, FMNH 199327, FMNH 200146	8L, D	4¼ (4⅛–4⅜)	2.23±0.077 (1.9–2.5)	8.28±0.356 (6.92–10.1)
WA-321, FMNH 199310	12D	4⅛ (4–4⅜)	2.55±0.069 (2.2–2.9)	7.52±0.205 (6.50–8.82)
WA-324, FMNH 199084, FMNH 200769	6L, D	4¼ (4¼– –4¼+)	2.90±0.272 (2.0–3.6)	6.57±0.521 (5.03–8.90)
WA-312, FMNH 199337	8D	4+ (3⅞–4⅛)	2.93±0.154 (2.4–3.8)	5.90±0.322 (4.47–7.40)
K. yammerana				
WA-337, FMNH 199270	17D	4⅜– (4⅛–4⅝)	2.06±0.073 (1.5–2.6)	9.97±0.428 (7.58–13.6)
WA-337, FMNH 200118	21L	4¼+ (4+–4⅝)	2.05±0.484 (1.7–2.95)	9.79±0.275 (7.09–11.5)
K. micromphala (Gude, 1907)				
Types, type lot	11D	4⅛ (3⅞+–4¼+)	crack	---
WA-193, SW corner Windjana	3D	4+ (4+–4⅛–)	crack	---
WA-194, SE corner Windjana	45D	4⅜ (4–4⅝)	crack	---
WA-194, FMNH 199851	18L	4⅜+ (4¼–4½)	crack	---
1 km SE Windjana, WAM 840.76	9D	4¼+ (4⅛+–4½)	crack	---

The latter specimens lived in an artificially wet situation, and had maximum opportunity to reach their maximum size potential. This is discussed in further detail below under *K. exanimus*.

Both dissected specimens agreed in genital structures. Although collected in July, the middle of the dry season, the prostate (DG), uterus (UT), and hermaphroditic duct (GD) are in 'wet season' status. This contrasts with the typical reduced size seen in mid-dry season *Amplirhagada* from the Prince Regent River (Solem 1981a: 259, figs. 57a-b) or *Torresitrachia* (Solem 1979: 68, figs 13a-b, 88, figs 17a-f) from the Prince Regent and Kimbolton areas. This apparent departure from the model presented by Solem and Christensen (1984) concerning seasonal variation, is readily explainable by the specimens of *K. yampiensis* coming from a house garden, with water continuously available throughout the year.

KIMBORAGA EXANIMUS SP. NOV.
(Figs 205a-c)

Comparative remarks

Kimboraga exanimus is probably closely related to *K. yampiensis* **(Figs 204d-f)** from the Yampi Sound area, but the latter is larger, generally less elevated, has the radial ribs more crowded, and a strong colour suffusion that is lacking in *K. exanimus*. Both species have the radial ribbing continuing onto the shell base, while *K. mccorryi* from the Western Napier Range has the sculpture restricted to above the periphery. The other species lack any radial ribbing. Both *K. mccorryi* and *K. yammerana* differ obviously in having their umbilici narrowly open **(Figs 204c, 206c)**.

Holotype

WAM 656.80, Sta. W4 (1), in vine thickets on scree slopes below eastern face of Mt Trafalgar near main campsite, Prince Regent River Reserve, Kimberley, Western Australia (1:250,000 'Prince Regent' map sheet SD 51-16 – grid reference 291:068, ca 15°17'S, 125°04'E). Collected by Barry R. Wilson and Peter Smith 30 August 1974. Height of shell 17.0 mm, diameter 19.0 mm, H/D ratio 0.895, whorls 4¼–, umbilicus a very narrow lateral crack.

Paratopotypes

WAM 310.75, WAM 311.75, WAM 313.75, FMNH 209063, 6 dead adults, 5 dead juveniles from the type locality.

Paratypes

Prince Regent River Reserve (all specimens collected in August 1974): Sta. E5 (1), north-east corner of main gorge below Enid Falls, Rufous Creek, Roe River ('Prince Regent' SD 51-16 – 348:086) (1 dead juvenile, WAM

312.75); Sta. W4 (4), around large sandstone boulders at juncture of open woodland and vine thickets, scree slopes of Mt Trafalgar ('Prince Regent' SD 51-16 – 291:068) (7 dead adults, 4 dead juveniles, WAM 314.75, FMNH 209062).

Diagnosis

Shell a little smaller than average, diameter 18.0-19.9 mm (mean 19.11 mm), with 4 to 4¾– (mean 4⅜ –) normally coiled whorls. Apex and spire strongly and evenly elevated (**Fig. 205b**), whorls of spire strongly rounded, height of shell 16.2-17.7 mm (mean 16.97 mm), H/D ratio 0.828-0.923 (mean 0.889). Apical sculpture not observed. Postapical whorls with narrow, sharp, sometimes anastomosing, somewhat crowded radial ribs that continue onto shell base without change in prominence. Shell periphery rounded, body whorl inflated, descending moderately behind aperture, which is markedly inclined from the shell axis. Lip slightly expanded and thickened, parietal wall with a noticeable callus. Umbilicus (**Fig. 205c**) varying from an extremely narrow, lateral crack to closed. Periostracal colour dark greenish or brownish yellow, lip white. Based on 12 measured adults.

Anatomy unknown.

Remarks

The name *exanimus* comes from the Latin for lifeless or dead, referring to the fact that no live material of this species has been collected. Except for a possibly misidentified juvenile from Rufous Creek, Upper Roe River (WAM 312.75), all specimens were taken from a vine thicket or its fringes on the slopes of Mt Trafalgar, Prince Regent River Reserve. No information is thus available as to its aestivation strategy.

Only one specimen had an H/D ratio of less than 0.860, whereas only three 'wild collected' examples of *K. yampiensis* exceeded 0.860 in H/D ratio. The overlap between the species is caused by the material of *K. yampiensis* that were collected from a well watered house garden on Koolan Island (**Table 85**), which have an increased whorl count, greater diameter, and thus increased H/D ratio. The watered garden environment would permit routine growth to maximum size.

KIMBORAGA MCCORRYI SP. NOV.

(Plates 82a-c, 83f; Figs 206a-c, 209a-b)

Comparative remarks

Kimboraga mccorryi is readily distinguishable by its combination of a relatively open umbilicus (**Fig. 206c**) and having radial ribs that end at the shell periphery. In both *K. exanimus* and *K. yampiensis* the umbilicus is nearly closed and the radial ribs extend onto the shell base without diminution in size. None of the other *Kimboraga* have any radial ribbing. The sympatric *Amplirhagada napierana* Solem, 1981 and *A. percita* (Iredale, 1939) both lack radial ribbing on any part of the shell and are much more narrowly umbilicated. Anatomically, *K. mccorryi* has a very long, thick-walled penis with very large wall pustules and reduced principal pilaster **(Fig. 209b)**, plus the vas deferens (VD) is attached to the outer wall of the sheath for a considerable distance. The vergic papillae (PPV) of *K. yampiensis* **(Fig. 208c)** and *K. micromphala* (Gude, 1907) **(Fig. 211b)** and the very large main pilaster of *K. yammerana* **(Fig. 210b-e)** easily separate those species.

Holotype

WAM 602.80, Sta. WA-322, 0.6 km east of road along south side Napier Range, 3.0 km south-east of Original Napier Downs Homestead, east of Derby, Kimberley, Western Australia (1:100,000 'Lennard' 3863 map sheet – grid reference 719:985). Collected by Laurie Price and Carl Christensen 17 December 1976. Height of shell 13.35 mm, diameter 18.9 mm, H/D ratio 0.706, whorls 4¼, umbilical width 2.1 mm, D/U ratio 9.00.

Paratopotypes

WAM 668.80, FMNH 199327, FMNH 200146, 2 live, 5 dead adults from the type locality.

Paratypes

Napier Range (all specimens collected October 1976 through February 1977): Sta. WA-321, 12.7 km west of Barker Gorge, south side of range ('Lennard' 3863 – 719:955) (12 dead adults, 2 dead juveniles, WAM 665.80, FMNH 199310); Sta. WA-192, near Chedda Cliffs, 9.1 km from Barker River Gorge, south side of range ('Lennard' 3863 – 757:945) (3 dead adults, 1 live juvenile, WAM 666.80, FMNH 199418, FMNH 200367); Sta. WA-324, 7.1 km west of Barker Gorge, south side of range ('Lennard' 3863 – 765: 935) (2 live, 4 dead adults, 1 live juvenile, WAM 667.80, FMNH 199084, FMNH 200769); Sta. WA-320, 4.7 km west of Barker River Gorge, south side of range ('Lennard' 3863 – 788:921) (1 dead adult, FMNH 199342); Sta. WA-312, crevices in rock walls, under rocks, 3.2 km west of Barker River Gorge, south side of range ('Lennard' 3863 – 808:914) (2 live, 8 dead adults, WAM 664.80, FMNH 199337, FMNH 200193).

Diagnosis

Shell small for genus, diameter 15.35-20.1 mm (mean 18.06 mm), with $3\frac{7}{8}$ to $4\frac{3}{8}$ (mean $4\frac{1}{8}$+) normally coiled whorls. Apex and spire strongly and evenly elevated **(Fig. 206b)**, whorls strongly rounded, height of shell 9.55-13.55 mm (mean 11.59 mm), H/D ratio 0.570-0.723 (mean 0.671).

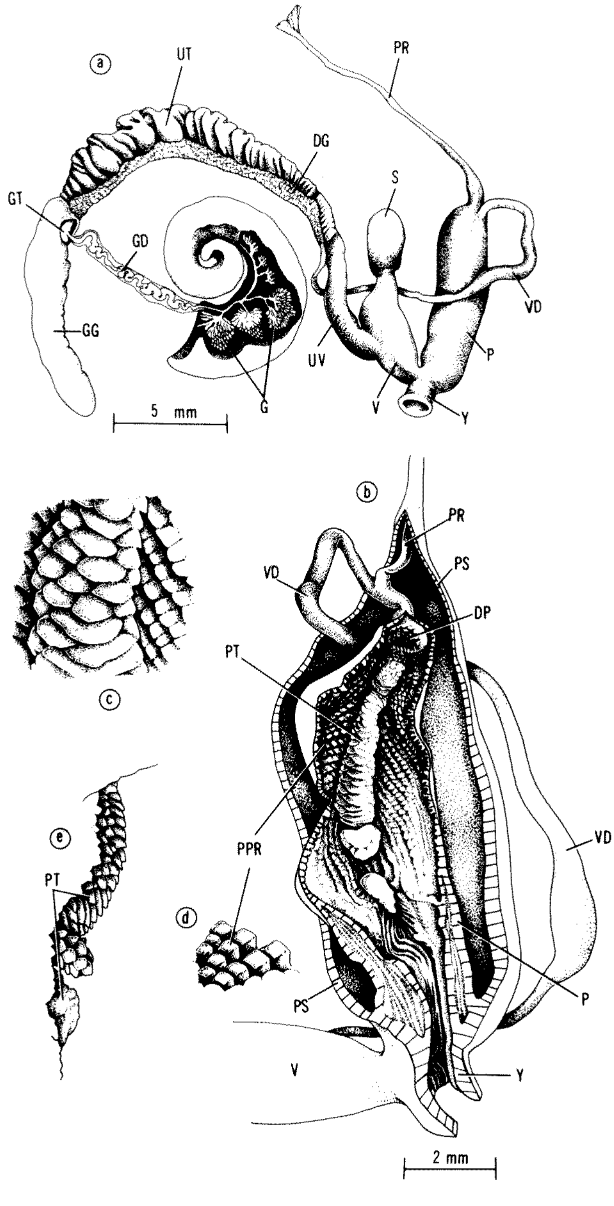

Fig. 210. Genitalia of *Kimboraga yammerana:* Sta. WA-337, 6.4 km east-south-east Yammera Gap, south side Napier Range, 1 March 1977, FMNH 199816, (a) whole genitalia, Dissection B, (b) interior of penis, Dissection A, (c) detail of main pilaster, Dissection A, (d) detail of penis chamber wall pustulations, Dissection A, (e) lateral view of main pilaster, Dissection A. Scale lines as marked. Drawings by Marjorie M. Connors.

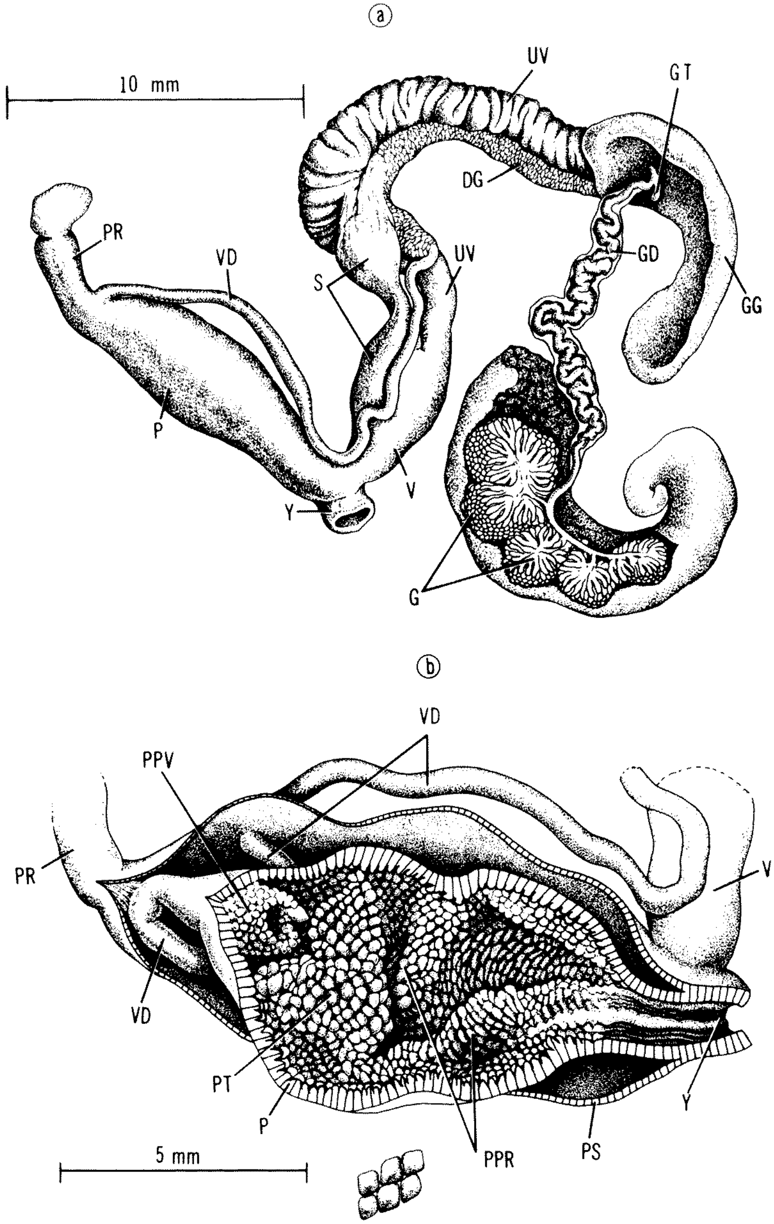

Fig. 211: Genitalia of *Kimboraga micromphala* (Gude, 1907): Sta. WA-194, Windjana Gorge, Napier Range, 4 January 1977, FMNH 200053, Dissection C, (a) whole genitalia, (b) interior of penis. Scale lines as marked. Drawings by Elizabeth A. Liebman.

Apical whorls smooth in fresh material. Postapical sculpture of narrow, crowded, sometimes anatomosing radial ribs that do not extend below the periphery. Shell periphery rounded, body whorl descending markedly behind aperture, body whorl somewhat inflated, aperture inclined significantly from shell axis. Lip moderately expanded, slightly thickened. Parietal wall with a thin callus. Umbilicus **(Fig. 206c)** open, regularly decoiling, partly covered by reflexion of columellar lip, width of umbilicus 1.9-3.8 mm (mean 2.61 mm), D/U ratio 4.47-10.1 (mean 7.13). Periostracal colour light yellow-horn, lip white. Based on 42 measured adults.

Genitalia **(Figs 209a-b)** with short vagina (V) and long penis (P). Vas deferens (VD) attached to outside of penis sheath by fibres for some distance, entering subapically to almost immediate insertion of penial retractor muscle (PR), reflexed portion to penis longer. Penis (P) slender, noticeably longer than penis sheath (PS), walls thick, sculptured internally with very large pustules in upper two-thirds, lower portion with simple longitudinal ridges. Principal pilaster (PT) short, located at penis apex, accidentally cut in dissection used for **Fig. 209b.** No vergic papilla. Jaw **(Plate 83f)** typical, radular teeth **(Plate 82a-c)** without unusual features. Based on two dissected adults.

Remarks

This species is named after Mr Bob McCorry, former manager of Napier Downs Station and now at Louisa Downs. His many kindnesses to WAM staff in the mid-1970s facilitated the extensive collecting done by Barry R. Wilson and Shirley Slack-Smith. By permitting several FMNH staff, L. Price, C. Christensen, R. Buick, and L. Keller, to utilise the stockman's hut at Napier Downs throughout the 1976-7 wet season, the material on which hypotheses as to maturation and seasonal genital variation were based (Solem and Christensen 1984) could be obtained. This is thus a small token of appreciation for his help.

Kimboraga mccorryi has been collected in limited numbers at every station from a point 3.0 km south of Original Napier Downs Homestead ruins (WA-322) to 3.2 km west of Barker Gorge, a total range of about 13 km (Solem 1984: fig. 159). Only six live adults were obtained, compared with 124 live adult *Amplirhagada* and 92 *Westraltrachia woodwardi* (Fulton, 1902) from the same stations **(Table 86)**. All of these collections were made in December 1976, before the Barker River flooded and made this region inaccessible. It was also before probable major activation of *K. mccorryi* and before the cave roof habitat preference of other *Kimboraga* had been noted. Thus these different numbers may reflect simple differences of aestivation site, with the *Kimboraga* remaining out of the reach of collectors, but the other two genera occuring in talus rubble or in accessible crevices.

Table 86: Adult specimens of camaenids from stations in the range of *Kimboraga mccorryi*

Station	*Kimboraga mccorryi*	*Amplirhagada percita*	*Amplirhagada napierana*	*Westraltrachia woodwardi*
WA-322	2L, 6D	11L, 92D		3L, 40D
WA-321	12D		18L, 34D	4L, 24D
WA-192	3D		32L, 157D	72L, 102D
WA-324	2L, 4D		20L, 23D	5L, 18D
WA-320	1D		12L, 35D	14L, 35D
WA-213	2L, 8D		31L, 47D	44L, 38D

L = collected alive; D = collected dead

The specimens from Sta. WA-312 are smaller in diameter because of lowered whorl count (**Table 85**). This may reflect local moisture conditions rather than any genetic difference. Specimens from the north-western localities are higher spired and more narrowly umbilicated, but too little material is available to permit establishing that this is clinal variation. Because of the limited live collected material available, only two adult specimens were dissected.

KIMBORAGA YAMMERANA SP. NOV.
(Plate 82d-f; Figs 204a-c, 210a-e)

Comparative remarks

Kimboraga yammerana is easily recognised by its open umbilicus (**Fig. 204c**) and total lack of radial ribbing. The other umbilicated species, *K. mccorryi* from west of Barker River Gorge, has prominent radial ribs above the periphery, although the shell base is smooth. *K. micromphala* (Gude, 1907), from the vicinity of Windjana Gorge, has a nearly closed umbilicus (**Figs 206f, 207c**) and much greater H/D ratio (**Table 83**). The westernmost species, *K. exanimus* and *K. yampiensis,* both have closed umbilici and radial ribs that continue onto the shell base. Anatomically, *K. yammerana* (**Figs 210a-e**) has a long vas deferens (VD) inside the very thick-walled sheath, extremely fine penis wall pustules, and a very prominent, long principal pilaster (PT). None of the other *Kimboraga* have an equivalent sized pilaster or such a thick walled sheath (**Figs 208c, 209b, 211b**), and thêir wall pustules are much, much larger.

Holotype

WAM 603.80, Sta. WA-337, cliff base 6.4 km east of Yammera Gap, south side of Napier Range, east of Derby, Kimberley, Western Australia (1:100,000 'Lennard' map sheet 3863 – 991:807). Collected by L. Price and C. Christensen 23 December 1976. Height of shell 13.4 mm, diameter 20.05 mm, H/D ratio 0.668, whorls 4½, umbilical width 1.7 mm, D/U ratio 11.8.

Paratopotypes

WAM 662.80, WAM 663.80, FMNH 199270, FMNH 199816, FMNH 200118, 23 live, 16 dead adults, 3 live juveniles from the type locality.

Diagnosis

Shell of average size, diameter 18.4-22.5 mm (mean 19.87 mm), with 4+ to 4⅝ (mean 4¼+) normally coiled whorls. Apex and spire moderately and evenly elevated **(Fig. 204b)**, not rounded above, height of shell 11.95-16.35 mm (mean 13.33 mm), H/D ratio 0.618-0.729 (mean 0.671). Apex nearly smooth, with faint pustules visible on fresh specimens. Postapical whorls without radial sculpture other than faint growth lines, fresh specimens with same incised spiral lines found in *Amplirhagada percita* (Iredale, 1939) (Solem, 1981a: 160, pl. 14f). Shell periphery rounded, body whorl somewhat inflated, descending moderately just behind aperture, which is inclined significantly from the shell axis. Lip rather strongly expanded, slightly thickened. Parietal wall **(Figs 204b-c)** with thickened callus. Umbilicus narrowly open, regularly decoiling, partly to more than half covered by reflected columellar lip, width 1.5-2.95 mm (mean 2.07 mm), D/U ratio 7.09-13.6 (mean 9.78). Periostracal colour light yellow horn, lip white. Based on 40 measured adults.

Genitalia **(Figs 210a-f)** with short vagina (V) and rather long penis (P). Vas deferens (VD) entering thick-walled penis sheath apically, coiled or kinked both before and after insertion of penial retractor muscle (PR). Vas opening (DP) simple, just before start of high, long principal pilaster (PT), which has greatly widened pustules **(Fig. 210c)**. No vergic papilla. Accessory protrusions below bottom of pilaster in Dissection A, absent in Dissection B. Walls of penis chamber with very fine, squarish pustules **(Fig. 210d)**, arranged in regular rows. Basal quarter of penis with simple longitudinal ridges, penis wall thick in this area. Jaw and radular teeth **(Plate 82d-f)** typical. Based on two dissected adults.

Remarks

Kimboraga yammerana is named for Yammera Gap, a narrow strip of dirt plains that marks the distributional limits for some *Amplirhagada,* but that is ignored by species of *Westraltrachia.*

Only one collection of this species could be made, as the type locality becomes isolated by black mud plains during the wet season. It is located at the west end of the line of cliffs on the south side of the Napier Range extending east from Windjana Gorge. All living adult examples were taken sealed to roofs of limestone caverns, with juveniles found in boulder fissures.

The size and shape differences between live and dead collected adults (**Table 85**) are negligible.

Kimboraga yammerena is nearest in anatomical structure to *Amplirhagada,* differing primarily in its lack of a verge and much shorter vas deferens.

KIMBORAGA MICROMPHALA (GUDE, 1907)
(Plate 83a-e; Figs 206d-f, 207a-c, 211a-b)

Chloritis micromphala Gude, 1907, Proc. Malac. Soc. London, **7** (4): 231, pl. 21, figs 6a-d – Barrier Range (= Napier Range), north-west Australia; Hedley, 1916, Jour. Roy. Soc. Western Australia, **1**: 68; Iredale, 1933, Rec. Australian Mus., **19** (1): 50.

Kimboraga micromphala (Gude), Iredale, 1938, Australian Zool., **9** (2): 99; Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 47, pl. 3, fig. 12.

Comparative remarks

Kimboraga micromphala (Gude 1907) lacks radial ribbing, which differentiates it from *K. exanimus* and *K. yampiensis* to the west, while the other two Napier Range species, *K. mccorryi* from west of the Barker River Gorge and *K. yammerana* from 6.4 km east of Yammera Gap, have open umbilici and much lower H/D ratios (**Figs 204b-c, 206b-c**). *Parglogenia pelodes* (Pfeiffer, 1846) from near Darwin, Northern Territory is almost identical in shape (**Figs 207d-f**), but differs in its setose microsculpture (Solem 1979: 132, pl. 11b). Anatomically, the large vergic papilla (PPV), reduced principal pilaster (PT), rather large wall pustules (**Fig. 211b**) and very short vagina (V) are diagnostic.

Holotype

AM C.101132, Barrier Range (= Napier Range), Western Australia. Type locality here restricted to the south-east corner of Windjana Gorge, Napier Range. Probably collected by W.W. Froggatt. Height of shell 17.5 mm, diameter 21.0 mm, H/D ratio 0.833, whorls 4¼+, umbilicus a narrow lateral crack.

Paratypes or type lot specimens

AM C.64881, AM C.64925, WAM 48.40, 10 dead adults with the locality 'Barrier Range'.

Other material

Napier Range: Windjana Gorge (1 dead juvenile, WAM 1539.70, collected by A.M. Douglas and G.W. Kendrick 2 July 1966); 1-1.2 km south-east of Windjana Gorge entrance (14 dead, 6 broken adults, WAM 840.76, WAM 842.76-844.76, collected by B.R. Wilson and S. Slack-Smith August-September 1975); 100 metres north-west of south-west entrance to Windjana

Gorge (1 dead, 2 broken adults, WAM 841.76, collected by B.R. Wilson and S. Slack-Smith 31 August 1974); Sta. WA-193, south-west corner of Windjana Gorge ('Lennard' 3863 – 063:743) (3 dead adults, FMNH 199431, FMNH 199651, FMNH 200040); Sta. WA-194, south-east corner Windjana Gorge ('Lennard' 3863 – 065:737) (27 live, 50 dead adults, 9 live, 5 dead juveniles, WAM 658.80-661.80, FMNH 199182, FMNH 199195, FMNH 199851, FMNH 200019, FMNH 200053, FMNH 200060, FMNH 200369, collected October 1976 through March 1977).

Diagnosis

Shell large, diameter 18.15-23.55 mm (mean 21.00 mm), with 3⅞+ to 4¾ (mean 4⅜–) normally coiled whorls. Apex and spire strongly and evenly elevated **(Figs 206e, 207b)**, not rounded above, height of shell 15.2-20.6 mm (mean 17.85 mm), H/D ratio 0.758-0.968 (mean 0.849). Apical sculpture not observed. Postapical whorls with vague radial growth striae and incised spiral lines as in *K. yammerana.* Shell periphery rounded, body whorl inflated, descending moderately behind aperture, which is steeply inclined from shell axis. Lip slightly expanded, not thickened, parietal callus usually thin. Umbilicus minute to a lateral crack, nearly covered by reflection of columellar lip **(Figs 206f, 207c)**. Periostracal colour light yellow horn, lip white. Based on 108 measured adults.

Genitalia **(Figs 211a-b)** with short vagina (V) and relatively long penis (P). Vas deferens (VD) entering thin-walled penis sheath subapically, kinked or coiled before reflection after insertion of penis retractor muscle (PR), then very short in length to penis apex. Penis (P) thick-walled with large pustules (PPR), reduced principal pilaster (PT), a large vergic papilla (PPV) at apex. Jaw and radular teeth **(Plate 83a-e)** typical. Based upon three dissected adults.

Remarks

Kimboraga micromphala (Gude, 1907) is found on both sides of the Lennard River at the south entrance to Windjana Gorge. Dead specimens have been taken in the dry season from the cliffs on the west bank, but this area cannot be visited once the wet season has arrived. The four dead adults range in H/D ratio from 0.784-0.815, while the 77 east bank specimens range from 0.808-0.968. The former are slightly smaller in diameter and with a reduced whorl count **(Table 85)**, but the number of specimens is too small to permit assigning statistical significance to this difference. The type specimens are intermediate in size and shape. The smallest specimens **(Table 85)** are those collected about 1 km south-east of Windjana Gorge.

Living specimens were collected between 4 January and 21 March 1977, which date marked the end of Napier Range fieldwork. Quick inspection of genitalia in specimens from the last sample showed that the standard pattern of late wet season size reduction for the apical and pallial genitalia had occurred.

KIMBORAGA KOOLANENSIS (IREDALE, 1939)
(Figs 212a-c)

Parrhagada koolanensis Iredale, 1939, Jour. Roy. Soc. Western Australia, 25: 65, pl. 5, fig. 1 – Koolan Island, Yampi Sound.

Comparative remarks

All known specimens of *Kimboraga koolanensis* (Iredale, 1939) are long dead and mostly bleached. Traces of clear periostracum are left on parts of the shell. The absence of radial ribbing on the spire and shell base separate it from both *K. yampiensis* and *Amplirhagada astuta* Solem (1981a: 219, fig. 46) from Koolan Island. The latter has an angulated periphery, prominent sculpture on the spire, and much less reflected lip.

Holotype

AM C.64873, Koolan Island, Yampi Sound, Kimberley, Western Australia (1:250,000 'Yampi' map sheet SE 51-3 – ca 135:963). Collector and date of collection unknown. Height of shell 14.8 mm, diameter 21.0 mm, H/D ratio 0.705, whorls 5⅞+, umbilical width 0.8 mm, D/U ratio 26.3.

Paratopotypes

AM C.64914, FMNH 201561, 3 dead adults from the type locality.

Diagnosis

Shell large, diameter 20.8-21.7 mm (mean 21.24 mm), with 5⅝– to 5⅞+ (mean 5¾–) rather tightly coiled whorls. Apex and spire strongly and almost evenly elevated, not rounded above, whorls slightly flattened, shell height 13.3-14.8 mm (mean 14.01 mm), H/D ratio 0.639-0.705 (mean 0.660). Apex and most of spire with surface eroded, but enough patches of thin periostracum remain to determine that there is no sculpture of radial ribbing. Shell periphery rounded, body whorl not inflated, and not descending behind aperture. Lip strongly reflected and moderately thickened, reflexing to cover nearly all of umbilicus (**Fig. 212c**). Umbilicus barely open, width 0.7-1.05 mm (mean 0.88 mm), D/U ratio 20.4-29.7 (mean 24.8). Based on four measured adults.

Anatomy unknown.

Remarks

Kimboraga koolanensis (Iredale, 1939) never should have been described. The available material is so badly worn that reference to a genus with any degree of certainty is impossible. It has been dumped here, not because I have a strong conviction that it actually is a *Kimboraga,* but because I have run out of options. When I was revising first *Amplirhagada* and then *Westraltrachia,* I could think of good reasons why these shells from Koolan Island probably did not belong to either genus. The large number of whorls, reflected lip, lack of body whorl inflation, and lack of body whorl descension also suggest that it is not a *Kimboraga*. This is the last potential Kimberley genus in which they can be placed, and thus this is as good an unsuitable repository for this problematic form as I can find.

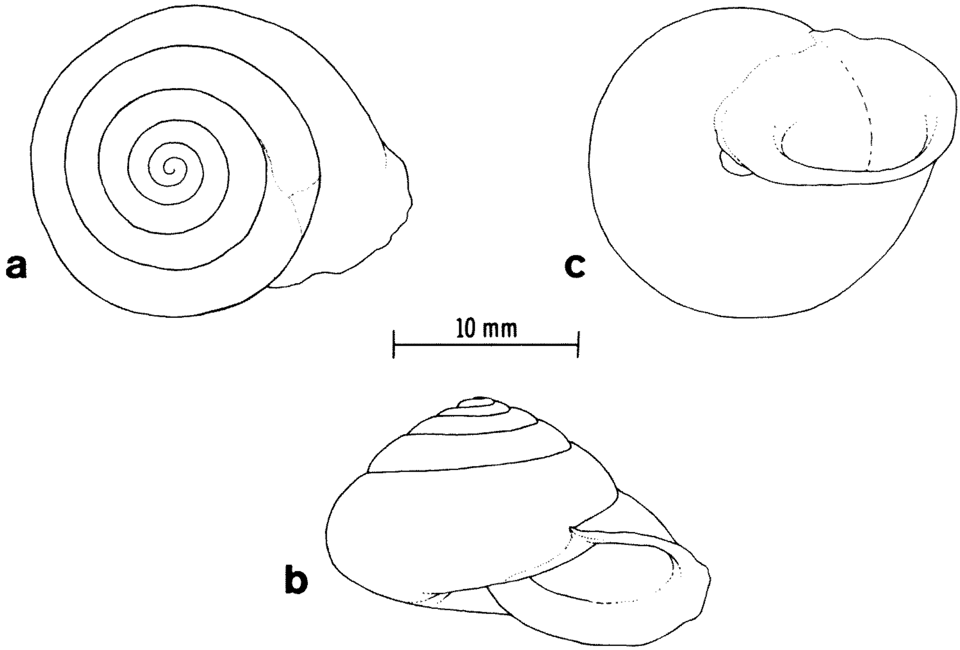

Fig. 212: Shell of *Kimboraga koolanensis* (Iredale, 1939). Koolan Island, Yampi Sound, AM C. 64873, holotype. Scale line equals 10 mm. Drawings by Elizabeth A. Liebman.

GENUS *QUISTRACHIA* IREDALE, 1939

Quistrachia Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 51-52 – type species *Trachia monogramma* Ancey, 1898 by original destination.

Comparative remarks

Most species of *Quistrachia* are found in the area from the Pilbara to Carnarvon, and are undescribed. The features that distinguish *Q. monogramma* from other Kimberley genera are the vas deferens (VD, **Figs 214a, c**) entering the penis sheath near its base, the absence of a principal pilaster with pustules, and the presence of a single elongated pilaster (PT) that has smooth upper edges and a median groove. The shell of *Quistrachia monogramma* (Ancey, 1898) is without macroscopic sculpture, generally has a brown to reddish peripheral colour band, reflected but not thickened lip, moderately elevated spire, and narrow umbilicus (**Figs 213a-c**). It most closely resembles *Amplirhagada percita* (Iredale, 1939) from the western Napier Range, but that species lacks the colour band and has very different anatomy (Solem, 1981a: 219, figs 47a-j, 237, fig. 51b).

Distribution and basic ecology

Quistrachia monogramma (Ancey, 1898) has a modest distribution in the eastern Napier and western Oscar Ranges, and *Q. leptogramma* (Pfeiffer, 1846) ranges from Broome northwards nearly to Cape Leveque in Dampierland. Other species are found inland of Port Hedland and Roebourne, on both the Dampier Archipelago and Barrow Island, then the North West Cape, and south nearly to Carnarvon (Solem, unpublished). Several are known from single collecting stations. The entire pattern seems to be that of a relict group.

Some species are free-sealers, with a sheet of calcified mucus secreted across the aperture of the shell; others aestivate tightly sealed to boulders in large rock talus.

Remarks

Shell form is highly varied within *Quistrachia*. The globular shell with inflated body whorl of *Q. leptogramma* (Pfeiffer, 1846) (see Iredale 1939: pl. 5, fig. 18) is very different from the shell of *Q. monogramma* (**Figs 215d-f**). Anatomically, the genus is rather uniform, with some variational trends discernable. The only other Kimberley genus in which the vas deferens enters the base of the penis sheath is *Turgenitubulus* from the Ningbing Ranges north of Kununurra. The enormously swollen vas deferens and short penis with a tubular verge (Solem 1981b: 378-9, figs 95-96) immediately differentiate it from *Quistrachia*.

QUISTRACHIA MONOGRAMMA (ANCEY, 1898)
(Plate 84a-d; Figs 213a-c, 214a-d, 215d-f)

Trachia monogramma Ancey, 1898, Proc. Linn. Soc. N.S.W., **22** (4): 775-776, pl. 36, fig. 3 – Oscar Range, 100 miles inland, Derby, King's Sound, N.W. Australia (W.W. Froggatt).

Planispira monogramma (Ancey), Hedley, 1916, Jour. Roy. Soc. Western Australia, **1**: 69 – mention in a check list.

Westraltrachia monogramma (Ancey), Iredale, 1938, Australian Zool., **9** (2): 115 – mention in a check list.

Quistrachia monogramma (Ancey), Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 51-52, pl. 3, fig. 20.

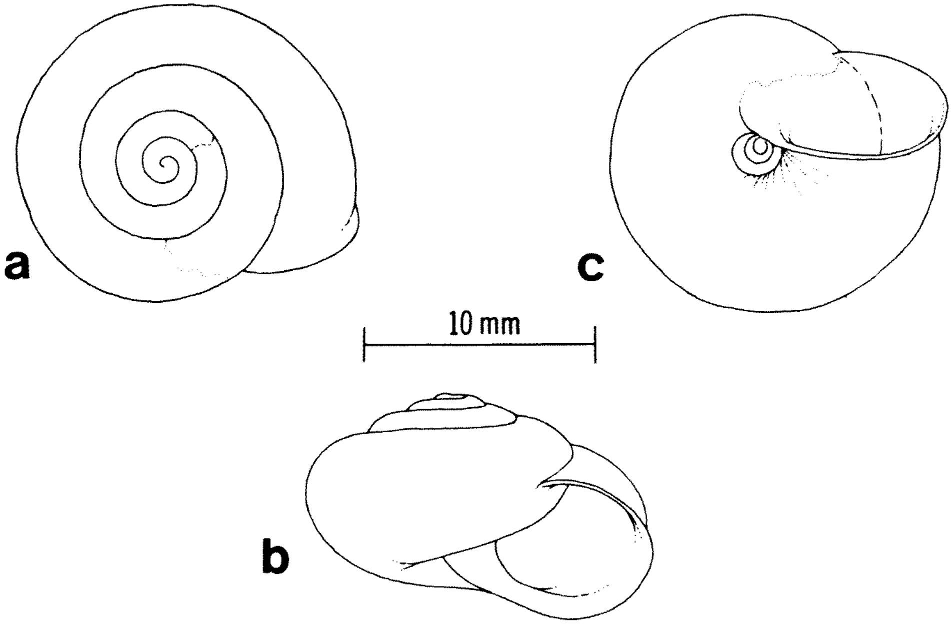

Fig. 213: Shell of *Quistrachia monogramma* (Ancey, 1898), Oscar Range, Northwest Australia, AM C.64890, holotype. Scale line equals 10 mm. Drawings by Elizabeth A. Liebman.

Comparative remarks

Quistrachia monogramma (Ancey, 1898) is characterised by its lack of shell sculpture, rounded periphery, open umbilicus that decoils regularly, reddish brown spiral band and simple expanded lip. *Westraltrachia cunicula* Solem (1984: figs 138a-c) and *W. alterna* Iredale, 1939 (Solem 1984: figs 133a-f) are closest in shell shape, but the latter has a much narrower umbilicus, and both species have variegated spire colour and a peripheral white zone. *W. oscarensis* (Cox, 1892) (Solem 1984: figs 136a-f) has an angulated periphery, a nearly closed umbilicus, and is much larger with a higher whorl count, while *W. institita* Solem (1984: figs 141a-c) has heavy surface sculpture and an angulated periphery. Some populations of *Amplirhagada percita* (Iredale, 1939) have shells that look very similar, but the spiral shell sculpture of that species (Solem 1981a: 160, pl. 14f) and more flattened spire whorls are obvious differences. Anatomically, the fact that the vas deferens (VD) enters the base of the penis sheath **(Figs 214a-b)**, and the very unusual principal pilaster (PT, **Fig. 214b**) distinguish *Quistrachia monogramma* from any other Kimberley camaenid dissected to date. *Turgenitubulus* from the Ningbing Ranges north of Kununurra also has a basal entrance of the vas deferens into the penis sheath, but the tubular verge, lack of wall pustules in the penis chamber, and the enormously swollen vas deferens (Solem 1981b: 378-9, figs 95-96) immediately separate it from *Quistrachia*. Comparisons with the Pilbara *Quistrachia* will be presented when they are described in a subsequent study.

Holotype

AM C.64890, Oscar Range. Collected by W.W. Froggatt. Height of holotype 10.7 mm, diameter 15.5 mm, H/D ratio 0.690, whorls 4½+, umbilical width 1.9 mm, D/U ratio 8.16.

Paratopotype

WAM 56.40, 1 dead adult from the type locality.

Other material

Napier Range: Sta. WA-712, 100 m east of McSherry Gap, south side ('Leopold Downs' 3962 – 228:566) (3 live, 15 dead adults, WAM 7.84, WAM 8.84, FMNH 205317-8, collected 19 June 1980); Sta. NR XXIV, just south of McSherry Gap (3 dead adults, 2 live juveniles, WAM 854.76, WAM 856.76, collected 2 September 1975); Sta. WA-273, 0.8 km east of McSherry Gap ('Leopold Downs' 3962 – 232:563) (4 live, 14 dead adults, WAM 677.80, FMNH 199196, FMNH 199473, collected 1 January 1977); Sta. NR XIX, 2.2 km south of McSherry Gap (1 live, 7 dead adults, WAM 846.76); Sta. WA-275, 5 km west of Tunnel Creek turnoff, north side ('Leopold Downs' 3962 – 554:244) (20 dead adults, WAM 678.80, FMNH 199224 collected 3 December 1976); Sta. WA-583, 2.4 km west of Tunnel Creek Cave turnoff, north side ('Leopold Downs' 3962 – 256:533) (8 dead adults, WAM 11.84, FMNH 204716, collected 7 May 1980); Sta. NR XX, just west of north end of The Tunnel (12 dead adults, WAM 848.76); Sta. WA-195, near north entrance of The Tunnel ('Leopold Downs' 3962 – 518:275) (25 dead adults, 1 live juvenile, WAM 680.80, FMNH 200080-1, collected 10 October 1976); The Tunnel, collapsed doline (17 live, 2 dead adults, WAM 108.68, WAM 276.80, WAM 651.77); Sta. NR XXI, north bank Tunnel Creek, south side (23 dead adults, WAM 849.76, WAM 851.76; Sta. WA-274, near south entrance to The Tunnel ('Leopold Downs' 3962 – 510:270) (32 live, 44 dead adults, WAM 679.80, WAM 1.84, FMNH 199242, FMNH 199886, collected 3 December 1976); Sta. WA-272, 1.7 km east of Tunnel Creek turnoff, north side ('Leopold Downs' 3962 – 508:287) (2 live, 21 dead adults, WAM 3.84, FMNH 199449, FMNH 200202, collected 2 December 1976); Sta. WA-279, cliffs north of Chestnut Creek, east of Wine Spring track, south side ('Leopold Downs' 3962 – 332:447) (55 dead adults, WAM 2.84, FMNH 199234, collected 4 December 1976); 7 km south-east of Tunnel turnoff (3 dead adults, WAM 850.76); Sta. WA-270, 21.8 km east of Tunnel Creek turnoff, eastern outlier of Napier Range ('Leopold Downs' 3962 – ca 416:441) (8 live, 145 dead adults, WAM 681.80, FMNH 199256, FMNH 200215, collected 2 December 1976).

Oscar Plateau: Sta. WA-277, Elimberrie Spring ('Leopold Downs' 3962 – 169:458) (2 live, 22 dead adults, WAM 4.84, FMNH 200195-6, collected 4 December 1976); Sta. WA-278, cliffs 0.5 km east of Elimberrie Spring ('Leopold Downs' 3962 – 241:442) (11 live, 138 dead adults, WAM 5.84, WAM 6.84, FMNH 199235, FMNH 200219, collected 4 December 1976).

Oscar Range: OR VII, north of Palm Spring, Le Lievres Ridge ('Ellendale' 3862 – ca 095:425) (18 dead adults, 3 live, 23 dead juveniles, WAM 852.76, WAM 855.76, collected 3 September 1975); OR III, west of Stumpy's Spring, Le Lievres Ridge (7 dead adults, 2 dead juveniles, WAM 858.76); Sta. WA-264, 0.4 km west of Mt Wynne Creek, south side, west of Fitzroy Crossing ('Leopold Downs' 3962 – 243:312) (7 live, 34 dead adults, WAM 9.84, WAM 10.84, FMNH 199499, FMNH 200227).

Distribution limits

Quistrachia monogramma (Ancey, 1898) has been found from the east side of McSherry Gap to the last outcrops of limestone in the Napiers, almost 22 km east of The Tunnel turnoff in the Napier Range. It is not present at Cycad Hill, 3.5 kilometres north of McSherry Gap. It has been found in the elevated cliff segment of the Oscar Plateau, but not in the flatlands of Fairfield Valley between the Oscar Plateau and the Napier Range, where *Westraltrachia oscarensis* (Cox, 1892) is common (Solem 1984: 568). It also has been found in the western Oscar Ranges between Palm Spring, Le Lievres Ridge and Mt Wynne Creek. This range overlaps with several species of *Westraltrachia* – *W. alterna* Iredale, 1939, *W. cunicula* Solem, 1984, *W. oscarensis* (Cox, 1892), and *W. instita* Solem, 1984 – and *Mouldingia occidentalis* Solem, 1984, but *Quistrachia* is allopatric to *Amplirhagada b. burnerensis* (Smith, 1894). The nearest approach of that genus and species is at Sta. WA-336, 4.3 km south-east of Carpenter Gap, where the Devonian limestone cliffs extending south-east from Windjana Gorge end. From McSherry Gap to Sta. WA-270 is an air distance of 26 km; the distance from Palm Spring to Mt Wynne Creek in the Oscar Ranges is 17 km; and the straight line distance between the Napier and Oscar Range localities is 16-18 km. The Elimberrie Spring region is intermediate, but most of the Napier to Oscar Gap consists of mud plains that are not inhabitable by *Quistrachia*.

Diagnosis

Shell average in size, diameter 14.1-20.65 mm (mean 17.03 mm), with $3\frac{7}{8}$ – to $4\frac{7}{8}$ – (mean $4\frac{3}{8}$) normally coiled whorls. Apex and spire usually moderately and evenly elevated **(Fig. 213b)**, not rounded above, sometimes slightly elevated, height of shell 7.75-12.8 mm (mean 10.21 mm), H/D ratio 0.549-0.874 (mean 0.638). Apex with vague remnants of pustules. Postapical whorls with radial growth striae at irregular intervals, no major sculptural elements. Shell periphery rounded, body whorl not inflated, descending very slightly behind aperture. Lip moderately expanded and slightly thickened, columellar portion reflected. Umbilicus **(Fig. 213c)** open, regularly decoiling, partly closed by columellar lip reflexion, width 1.65-3.9 mm (mean 2.68 mm), D/U ratio 4.39-10.4 (mean 6.45). Colour light yellow horn, a faint to prominent reddish or reddish brown peripheral or slightly supra-peripheral spiral band, lip white. Based on 662 measured adults.

Genitalia **(Figs 214a-d)** with short spermatheca (S) whose head is bound to base of prostate-uterus by fibres, long vagina (V). Vas deferens (VD) entering thick walled penis sheath **(Figs 214a-b)** just above atrium (Y), ascending free of wall to insertion of penial retractor muscle (PR), then reflexing to simple pore (DP), or through a circle of raised pustules in some specimens. Penis rather short, thick walled, upper portion with fine pustules **(Figs 214b-c)**, lower portion with simple longitudinal pilasters. Principal pilaster (PT) with smooth upper edges and a central groove, merging into the longitudinal pilaster zone basally. Atrium (Y) very short. Jaw **(Plate 84d)** with prominent vertical ribs. Radular teeth **(Plate 84a-c)** without unusual features. Based upon 10 dissected adults.

Remarks

Designating a precise type locality for *Quistrachia monogramma* (Ancey, 1898) is not possible. Ancey (1898) did not have accurate locality data with the specimen he described. Previously I have indicated that a mixture of specimens and labels had occurred, so that *Westraltrachia froggatti* was described by Ancey (1898) as coming from the Oscar Range. Actually this species is restricted to the area between near Yammera Gap and the west margin of Windjana Gorge in the Napier Range (Solem 1984: 433-4). According to Iredale (1939: 58), Froggatt did collect on the north-east side of the Oscar Ranges. The dimensions of the holotype correspond with the size of adults from the Oscar Range **(Table 87)**, and it probably came from this region. Since *Westraltrachia oscarensis* (Cox, 1892) also was collected by Froggatt (Solem 1984: 563-4), eventual designation of type localities at some point of joint occurrence would be logical, but available data is inadequate to permit this action.

The three main areas of distribution for *Quistrachia monogramma* are isolated from each other by basically snail-free open plains. There is regional size variation **(Table 87)**. Specimens from the Napier Range are larger and with a greater H/D ratio. The few exceptions to this involve local conditions. Stas WA-583 and WA-279 are barren hillsides fully exposed to the sun. No live material was obtained at either station, and the specimens are small in size. The few examples from WA-583 have a normal whorl count, and thus actual dwarfing may be involved, but the larger sample from WA-279 suggests that the small size here resulted from early cessation of growth, since the mean whorl count is reduced. The sample from Sta. WA-270, at the eastern limit of the Napier Range, also consists of relatively small sized individuals.

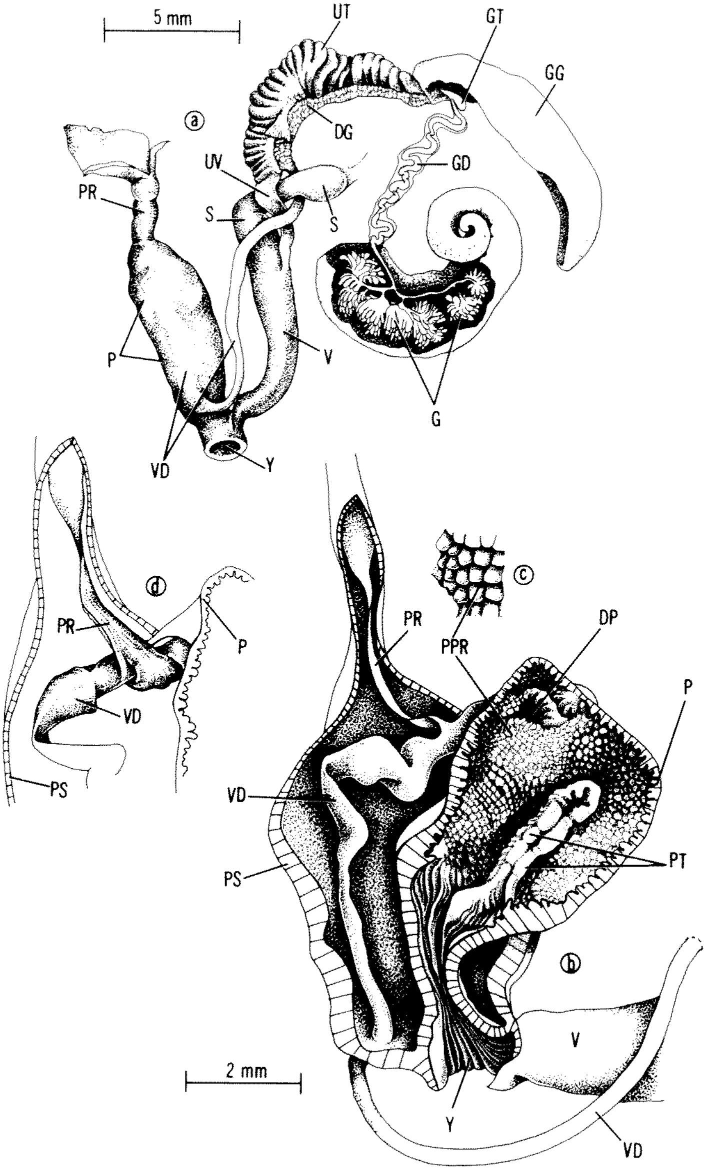

Fig. 214: Genitalia of *Quistrachia monogramma* (Ancey, 1898): Sta. WA-278, cliffs 0.5 km east Elimberrie Spring, Oscar Ranges, 4 December 1976, FMNH 200219, (a) whole genitalia, Dissection B, (b) interior of penis, Dissection C, (c) detail of penis chamber wall pustulations, Dissection C, (d) detail of penial retractor muscle insertion, Dissection C. Scale lines as marked. Drawings by Marjorie M. Connors.

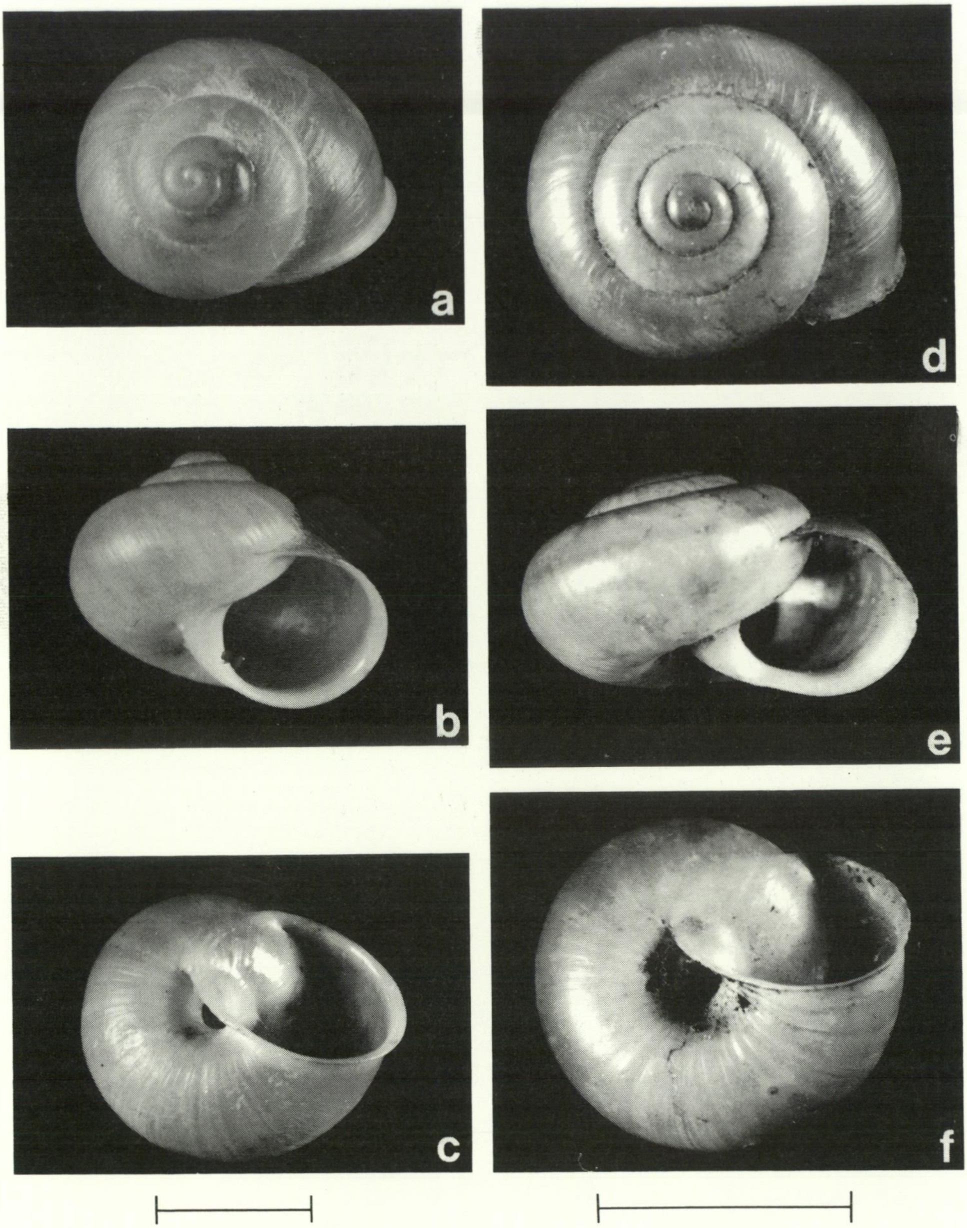

Fig. 215: Shells of *Kimboraga micromphala* (Gude, 1907) and *Quistrachia monogramma* (Ancey, 1898): (a-c) *K. micromphala* (Gude, 1907), Barrier (= Napier Range), Western Australia, paratype, AM C.64881; (d-f) *Q. monogramma* (Ancey, 1898), Oscar Range, Western Australia, holotype, AM C.64890. Scale lines equal 10 mm.

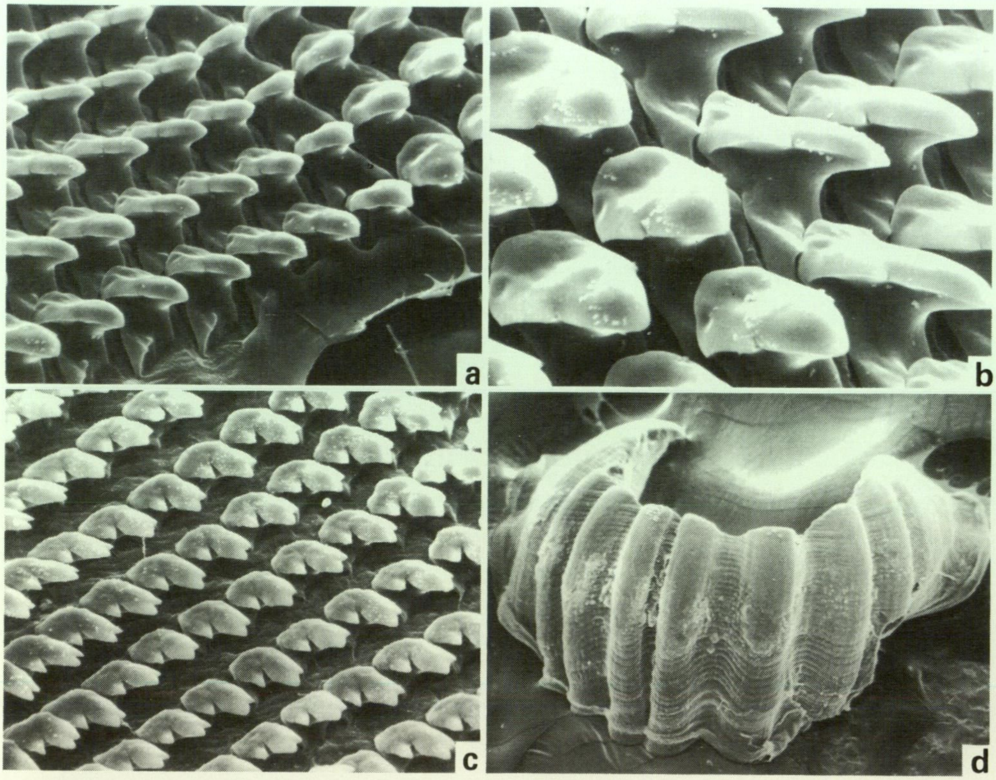

Plate 84: Radular teeth and jaw of *Quistrachia monogramma* (Ancey, 1898): Sta. WA-278, east of Elimberrie Spring, Oscar Ranges, 4 December 1976, FMNH 200219, Dissection **C**, (a) medium angle rear view of central and laterals at 735X; (b) low angle view of mid-lateral teeth at 735X; (c) early to mid-marginal teeth at 680X; (d) jaw at 69X.

Specimens from the edge of the Oscar Plateau are slightly smaller than the Napier Range specimens. These samples came from north facing cliff areas, thus subject to greater solar insolation, but the difference is very minor.

Oscar Range populations **(Table 87)** are distinctly smaller in diameter and with variable spire elevation among populations. They also show slightly reduced whorl numbers.

Dissection of specimens from all three areas showed no geographic differences. The illustrated specimen had the penis slightly contracted and the drawing gives an impression of shortness that is misleading. Fully extended individuals had the penis longer in appearance. Most available anatomical material had been collected late in November or early in December. All dissected specimens conformed to the pattern of seasonal variation

Table 87: Local Variation in *Quistrachia monogramma* (Ancey, 1898)

Station	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
Napier Range				
WA-712, FMNH 205318	15D	11.48±0.148 (10.6–12.3)	18.84±0.214 (17.7–20.2)	0.609±0.005 (0.591–0.661)
WA-273, FMNH 199196	4D	11.78±0.452 (11.0–12.7)	18.71±0.467 (17.5–19.7)	0.630±0.020 (0.576–0.668)
WA-273, FMNH 199473	14D	11.05±0.217 (9.75–12.7)	17.93±0.255 (16.25–19.5)	0.616±0.006 (0.577–0.651)
WA-275, FMNH 199224	20D	11.34±0.150 (10.2–12.5)	18.48±0.161 (16.95–19.65)	0.614±0.005 (0.583–0.653)
WA-583, FMNH 204716	8D	10.02±0.288 (8.6–11.0)	16.73±0.262 (15.7–17.6)	0.599±0.013 (0.551–0.654)
WA-195, FMNH 200080	25D	11.18±0.150 (9.85–12.7)	18.08±0.180 (16.5–20.0)	0.618±0.005 (0.575–0.669)
NR XIX, WAM 846.76	8D	11.32±0.219 (10.6–12.2)	19.06±0.325 (18.1–20.65)	0.594±0.009 (0.567–0.634)
WA-274, FMNH 199886	32L	10.67±0.098 (9.3–11.9)	17.29±0.117 (16.0–18.85)	0.617±0.004 (0.581–0.659)
WA-274, FMNH 199242	44D	10.84±0.082 (9.5–11.85)	17.66±0.091 (16.4–18.75)	0.614±0.004 (0.555–0.669)
WA-272, FMNH 199449	21D	10.73±0.124 (9.8–11.7)	17.75±0.141 (16.9–18.95)	0.605±0.004 (0.566–0.631)
WA-279, FMNH 199234	55D	9.39±0.072 (8.1–10.4)	16.06±0.083 (15.05–17.7)	0.584±0.003 (0.528–0.639)
WA-270, FMNH 200215	8L	9.32–0.128 (8.7–9.8)	16.24±0.138 (15.45–16.8)	0.574±0.007 (0.555–0.605)
WA-270, FMNH 199256	145D	9.95±0.056 (8.1–12.3)	16.77±0.717 (14.35–19.1)	0.594±0.002 (0.510–0.647)
Edge of Oscar Plateau				
WA-277, FMNH 200195	22D	10.19±0.094 (9.3–11.1)	17.09±0.156 (15.7–18.35)	0.597±0.004 (0.561–0.634)
WA-278, FMNH 199235	138D	10.31±0.049 (8.6–11.45)	17.10±0.065 (15.35–19.1)	0.603±0.002 (0.538–0.666)
Oscar Range				
OR III, WAM 858.76	7D	8.94±0.206 (8.3–9.7)	15.99±0.357 (14.1–17.05)	0.560±0.008 (0.528–0.589)
WA-264, FMNH 200227	7L	8.41±0.129 (7.85–9.0)	15.07±0.161 (14.2–15.5)	0.558±0.006 (0.541–0.590)
WA-264, FMNH 199499	34D	8.73±0.070 (7.75–9.45)	15.80±0.092 (14.8–16.9)	0.553±0.003 (0.509–0.581)
OR VII, WAM 855.76	18D	10.83±0.192 (9.7–12.8)	16.42±0.228 (15.0–18.35)	0.661±0.011 (0.559–0.753)

Table 87: Local Variation in *Quistrachia monogramma* (Ancey, 1898) (continued)

Station	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
Napier Range				
WA-712, FMNH 205318	15D	4¾ (4⅝– –4⅞–)	2.79±0.055 (2.55–3.23)	6.79±0.127 (5.87–7.51)
WA-273, FMNH 199196	4D	4½+ (4⅜–4⅝)	2.64±0.155 (2.45–3.1)	7.15±0.378 (6.16–7.88)
WA-273, FMNH 199473	14D	4½– (4¼–4⅝)	2.56±0.059 (2.0–3.0)	7.06±0.193 (6.25–8.95)
WA-275, FMNH 199224	20D	4½ (4¼–4¾)	2.82±0.041 (2.5–3.1)	6.58±0.124 (5.58–7.28)
WA-583, FMNH 204716	8D	4⅝+ (4½– –4¾+)	2.61±0.107 (2.1–2.9)	6.50±0.294 (5.54–7.85)
WA-195, FMNH 200080	25D	4⅜+ (4⅛–4⅝)	2.97±0.065 (2.2–3.6)	6.14±0.135 (5.06–7.5)
NR XIX, WAM 846.76	8D	4½+ (4½–4¾)	2.79±0.112 (2.3–3.4)	6.88±0.245 (5.74–7.87)
WA-274, FMNH 199886	32L	4⅜ (4⅛–4⅝)	2.80±0.055 (2.0–3.65)	6.23±0.113 (4.85–8.35)
WA-274, FMNH 199242	44D	4½– (4¼–4¾)	2.85±0.047 (2.25–3.7)	6.26±0.096 (5.07–7.91)
WA-272, FMNH 199449	21D	4⅜ (4¼–4½)	3.00±0.082 (2.2–3.85)	6.01±0.162 (4.49–7.68)
WA-279, FMNH 199234	55D	4¼+ (4⅛–4⅝)	2.70±0.042 (1.9–3.5)	6.03±0.091 (4.39–8.24)
WA-270, FMNH 200215	8L	4⅜– (4¼–4⅜)	2.81±0.088 (2.35–3.1)	5.83±0.194 (5.29–6.83)
WA-270, FMNH 199256	145D	4⅜– (4–4½)	2.86±0.026 (2.1–3.6)	5.92±0.049 (4.73–7.77)
Edge of Oscar Plateau				
WA-277, FMNH 200195	22D	4⅜ (4⅛–4⅝)	2.59±0.055 (2.2–3.2)	6.64±0.116 (5.73–7.50)
WA-278, FMNH 199235	138D	4⅜ (4⅛–4⅞)	2.43±0.028 (1.7–3.8)	7.14±0.081 (4.79–10.4)
Oscar Range				
OR III WAM 858.76	7D	4¼ (4–4⅜)	2.35±0.093 (2.0–2.7)	6.85±0.267 (6.19–7.98)
WA-264, FMNH 200227	7L	4¼– (4⅛–4¼)	2.28±0.064 (2.1–2.6)	6.62±0.130 (5.96–7.10)
WA-264, FMNH 199499	34D	4¼– (3⅞–4⅜)	2.30±0.029 (2.0–2.75)	6.89±0.089 (5.86–8.05)
OR VII, WAM 855.76	18D	4⅜+ (4¼–4¾)	2.40±0.140 (1.65–3.9)	7.10±0.300 (4.71–10.3)

outlined by Solem and Christensen (1984). Specimens collected in mid-June 1980 (FMNH 205317) had the ovotestis and hermaphroditic duct greatly reduced in size, and the prostate-uterus somewhat smaller. These are typical dry season conditions.

GENUS *CARINOTRACHIA* NEW GENUS

Diagnosis

Shell a little smaller than average, with normal whorl count. Apex and spire **(Fig. 216b)** strongly and usually evenly elevated, whorls of spire slightly laterally compressed, body whorl noticeably descending just before aperture. Umbilicus **(Fig. 216c)** narrowly open, very slightly decoiling, partly covered by reflexion of columellar lip. Apical whorls with reduced sculpture of pustules **(Plate 85a)**. Postapical sculpture of prominent radial ribs **(Plate 85b-c)**, with extremely fine microsculpture of anatomosing periostracal folds **(Plate 85d)**. No reduction in sculptural prominence on shell base. Lip weakly expanded **(Figs 216a-c)**, slightly thickened, with no trace of nodes. Parietal wall with a heavy callus rim **(Fig. 216c)**. Shell periphery with a protruded keel, ribs denticulating keel edge **(Fig. 216b)**. Colour light yellow-horn, lip white. Genitalia **(Figs 217a-f)** with typical apical and pallial structures. Spermatheca (S) short, head anchored to base of prostate-uterus by fibres, free oviduct (UV) sinuated, vagina (V) short. Vas deferens (VD) entering thin-walled penis sheath near apex, reflexing as weakly differentiated epiphallus (E) after insertion of penial retractor muscle (PR). Penis (P) thin walled, receiving opening from epiphallus through a simple pore with a complex valve-pilaster **(Figs 217d-f)**. Jaw **(Plate 86a)** typical, radular teeth **(Plate 86b-d)** with mesocones of laterals short, blunt, elevated at about a 45° angle, with very prominent anterior flare. Lateromarginal transition and marginals typical.

Type species: *Carinotrachia carsoniana* sp. nov.

Comparative remarks

Carinotrachia carsoniana is characterised by its keeled periphery **(Fig. 216b)**, very narrow umbilicus **(Fig. 216c)**, sculpture of radial ribs on the spire and body whorl **(Plate 85b-c)**, simple lip that is barely reflected **(Figs 216a-c)**, and microsculpture of periostracal folds **(Plate 85d)**. The most similar species is *Turgenitubulus pagodulus* from the Ningbing Ranges, north of Kununurra **(Figs 246d-f)**. It shares the keel, pattern of sculpture, and umbilical form, but differs most obviously in its very strongly reflected and thickened lip with prominent basal lip node. Its sculpture is also much more crowded in spacing. None of the *Amplirhagada* Iredale, 1933 (Solem 1981a) or *Westraltrachia* Iredale, 1933 (Solem 1984) with angulated peripheries have a protruded keel. Such taxa as *Mouldingia* (Solem 1984: 640, figs 163, 639, 645, pls 52-53) and *Ordtrachia* (Solem 1984: 651-667, figs

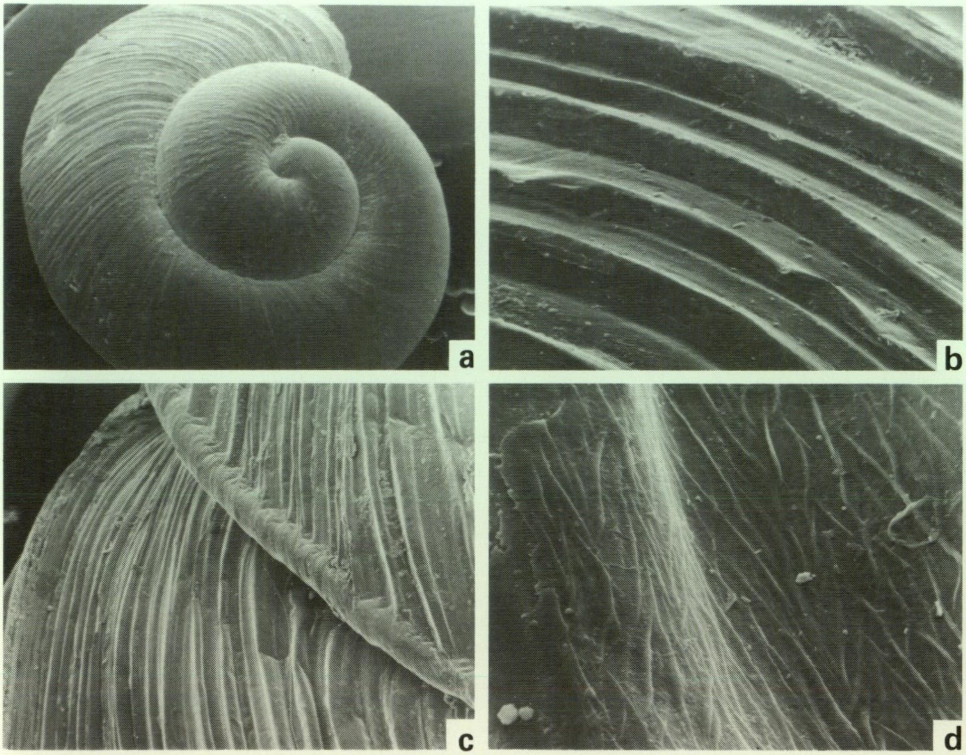

Plate 85: Shell sculpture of *Carinotrachia carsoniana:* 1 km from Gibb River Road, ca 2 km north-east of Carson River Crossing, south of Kalumburu Mission, NMV F51479, Dissection A, (a) apex and early spire at 15.5X; (b) sculpture on penultimate whorl at 42.1X; (c) lip of shell and portions of penultimate and body whorl at 16.2X; (d) microsculpture on major ribs just behind shell lip at 435X.

166, 171, 172, pls 54-56) that have keels, also possess very complex microsculpture, generally much more open umbilici, and different apertural configurations. Anatomically, the short spermatheca (S), vagina (V), and presence of a penis sheath (PS) in *Carinotrachia carsoniana* **(Figs 217a, d)** are shared with the *Westraltrachia* complex (Solem 1984) and several other Kimberley genera. In having the vas deferens enter the thin-walled sheath almost apically, then reflexing immediately as a slightly differentiated epiphallus; absence of wall pustules in the upper half of the penis chamber; and in lacking either a verge or a principal pilaster – *Carinotrachia* is immediately separable from *Amplirhagada* Iredale, 1933 (Solem 1981a) or *Kimboraga* Iredale, 1939 (p. 819). *Quistrachia* Iredale, 1939 **(Figs 214a-d)** differs in the basal entry of the vas deferens into a very thick-walled penis

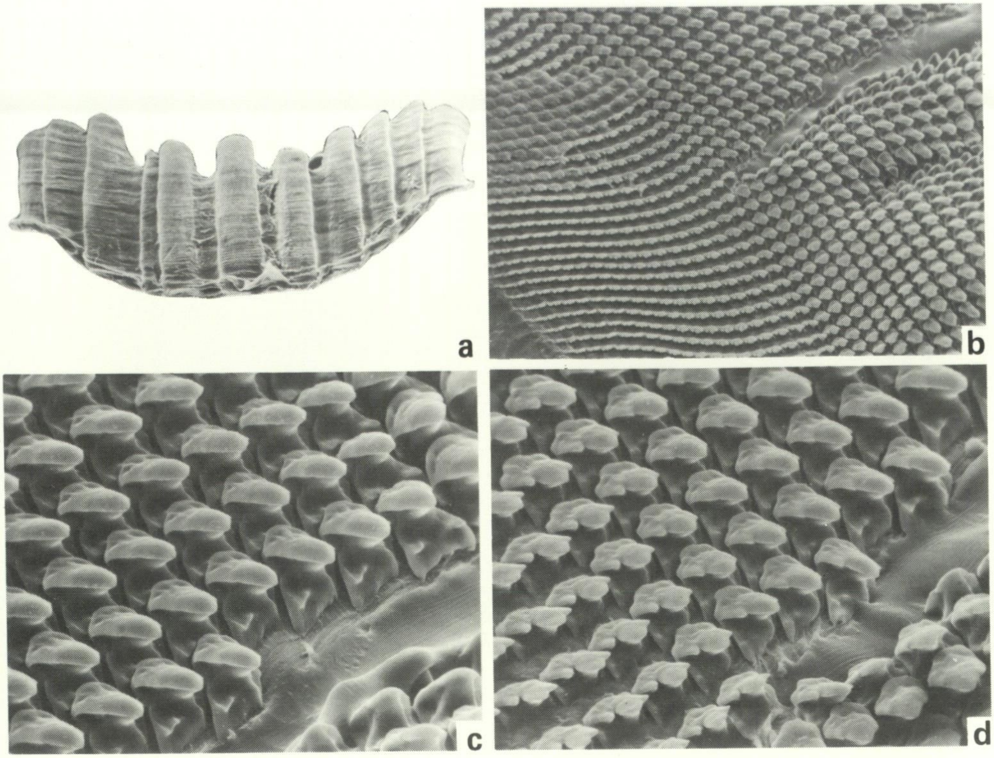

Plate 86: Jaw and radular teeth of *Carinotrachia carsoniana:* 1 km from Gibb River Road, ca 2 km north-east of Carson River Crossing, south of Kalumburu Mission, NMV F51479, Dissection A, (a) jaw at 50.6X; (b) part row of teeth at 92.8X; (c) central and early lateral teeth at 330X; (d) lateromarginal transition at 330X.

sheath, unique grooved principal pilaster (PT), and heavy wall pustules. The absence of specialised wall sculpture and the unique valve and pilaster arrangement where the epiphallus opens into the penis chamber **(Figs 217d-f)**, are features of *Carinotrachia* that are found in other Kimberley genera.

Distribution and basic ecology

Only the one collection, from near the Carson River crossing south of Kalumburu, is known. No details have been recorded concerning the ecology of *Carinotrachia carsoniana.* Both juveniles and adults of the type set have mucoid rings around the apertural edge. Their presence suggests that *Carinotrachia* aestivates sealed to a rock or wood surface. There is no indication of calcification in the epiphragm, although preservation of the specimens in formalin might well have removed any trace of calcium prior to my study of the specimens.

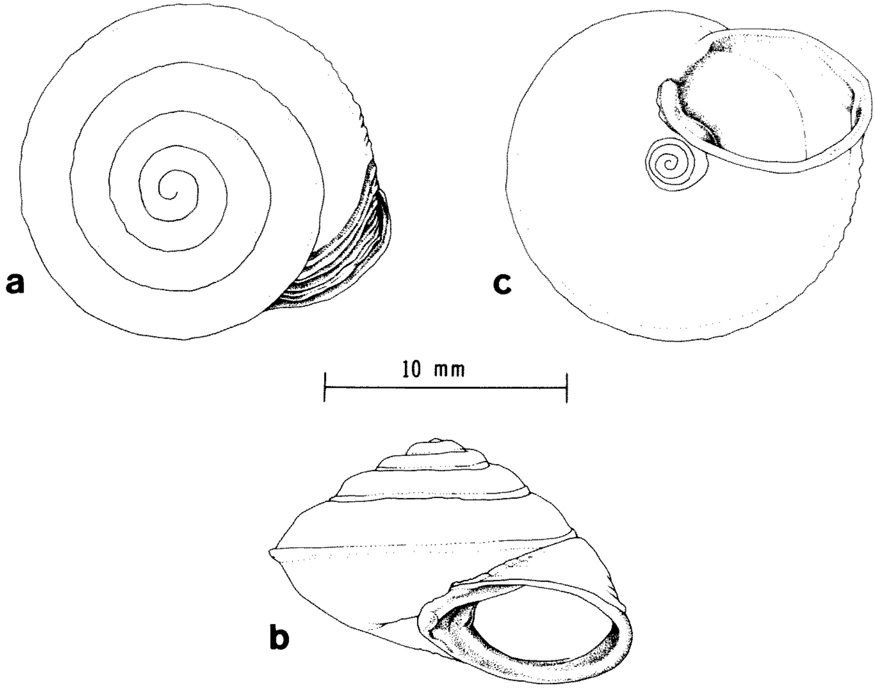

Fig. 216: Shell of *Carinotrachia carsoniana,* 1 km from Gibb River Road, ca 2 km north-east of Carson River crossing, south of Kalumburu Mission, NMV F51478, holotype. Scale line equals 10 mm. Drawings by Linnea Lahlum.

Relationships of *Carinotrachia*

The combination of keeled periphery, prominent ribbing, simple lip, and valvular entrance of the epiphallus into the penis are the major differentiating features of *Carinotrachia.* The absence of any major wall sculpture in the penis chamber, apical entrance of the vas deferens into the sheath, with then no coiling or kinking of the vas, also differentiate it from previously discussed Kimberley genera. The penis sheath structure, short spermatheca, sinuated free oviduct, and short vagina combine to relate it to the main Kimberley radiation, but discussion of exact phylogeny requires completing reviews of other taxa.

The name *Carinotrachia* indicates both the unusual threadlike keel on the shell, and the fact that the anatomy shows a number of similarities to the *Westraltrachia* complex of genera.

CARINOTRACHIA CARSONIANA SP. NOV.
(Plates 85a-d, 86a-d; Figs 216a-c, 217a-f)

Comparative remarks

The species most apt to be confused with *Carinotrachia carsoniana* is *Turgenitubulus pagodula* from the Ningbing Ranges, north of Kununurra **(Figs 246d-f)**. It differs most obviously in having more closely spaced radial sculpture, and a broadly expanded lip with a very prominent basal lip node. The anatomy of *Turgenitubulus* and *Carinotrachia* differ most obvously in the grossly enlarged vas deferens and shortened penis of the former **(Figs 244-5)**. Differences from other taxa have been reviewed under the generic discussion.

Holotype

NMV F51478, 1 km from Gibb River-Kalumburu Road, ca 2 km north-north-east of Carson River Crossing, outlier of Putairta Hill, ca 16 km south of Kalumburu Mission, Kimberley, Western Australia (1:100,000 'Drysdale' map sheet 4269-grid reference 491:029). Collected by A. C. Beauglehole 3 June 1976. Height of holotype 10.45 mm, diameter 16.0 mm, H/D ratio 0.653, whorls 5⅛, umbilical width 2.5 mm, D/U ratio 6.40.

Paratopotypes

NMV F51479, FMNH 205812-3, 3 live, 17 dead adults, 12 live, 5 dead juveniles from the type locality.

Diagnosis

Shell of average size, diameter 11.9-18.6 mm (mean 16.61 mm), with 4¾ to 5¼ (mean 5⅛ –) normally coiled whorls. Apex and spire strongly and evenly elevated, at most slightly rounded above **(Fig. 216b)**, height of shell 9.1-11.75 mm (mean 10.53 mm), H/D ratio 0.549-0.874 (mean 0.638). Apical sculpture of reduced pustules at top, latter portion almost smooth **(Plate 85a)**. Postapical whorls with prominent radial ribs, whose interstices are three to five times their width **(Plate 85b-c)**, microsculpture of anatomosing periostracal folds **(Plate 85d)**. Shell periphery with a thread-like, protruded keel **(Fig. 216b)**, body whorl descending noticeably just behind aperture. Lip slightly expanded, not thickened, no trace of nodes. Parietal wall **(Figs 216b-c)** with heavy callus, basal and palatal lips curving into callus. Umbilicus narrowly open, barely decoiling, partly covered by reflexion of columellar lip **(Fig. 216c)**, width 1.6-2.95 mm (mean 2.25 mm), D/U ratio 5.17-10.9 (mean 7.60). Colour light yellow horn, lip white. Based on 21 measured adults.

Genitalia **(Figs 217a-f)** with short spermatheca (S) and vagina (V), free oviduct (UV) sinuated. Penis sheath (PS) very thin, vas deferens (VD) entering apically, reflexing as epiphallus (E) to enter penis (P) through a valvular-pilaster pore **(Figs 217d-f)**. Penis with thin walls, indistinct wall

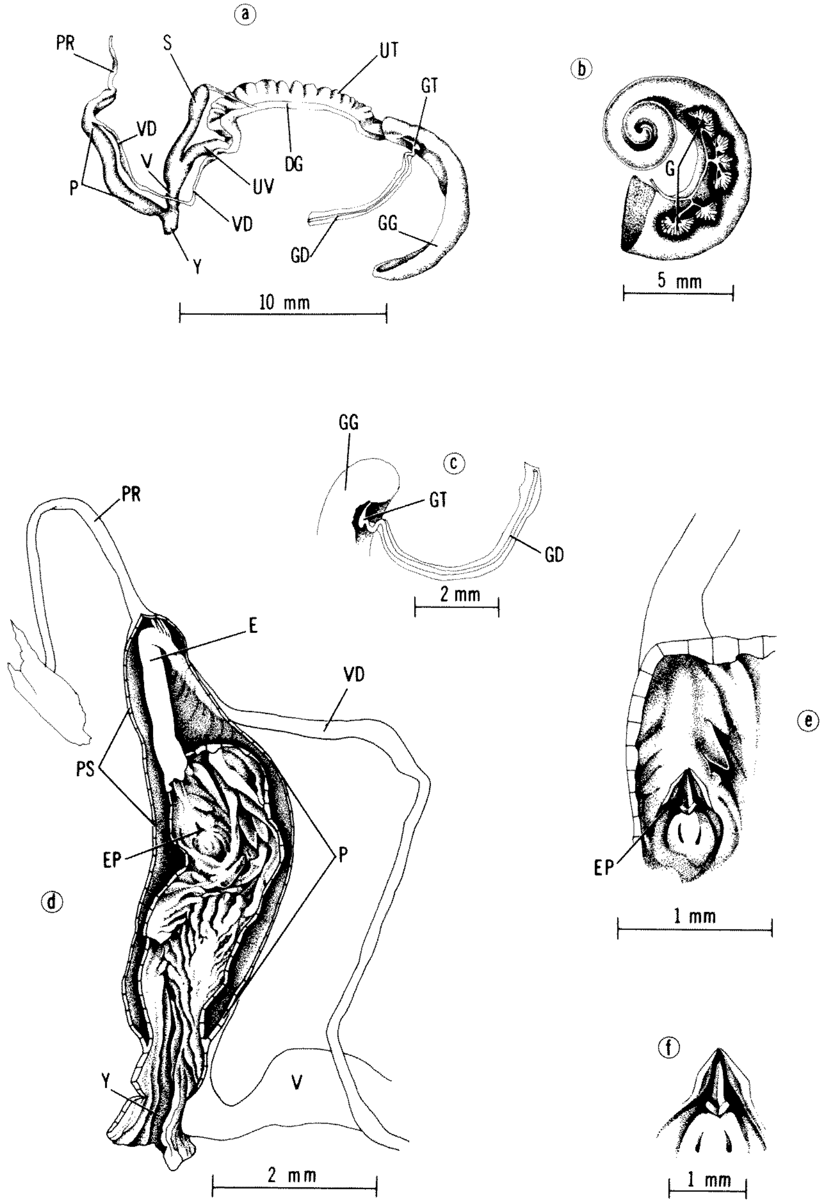

Fig. 217: Genitalia of *Carinotrachia carsoniana*, 1 km from Gibb River Road, ca 2 km north-east of Carson River crossing, south of Kalumburu Mission, 3 June 1976, NMV F51479, (a-c) Dissection A, a, whole genitalia, b, ovotestis, c, detail of talon, (d-f) Dissection B, d, interior of penis complex, e, detail of pilasters around epiphallic pore (EP), f, valvular ridge in epiphallic pore. Scale lines as marked. Drawings by Linnea Lahlum.

pilasters, no verge or vergic papilla. Jaw **(Plate 86a)** typical. Radular teeth **(Plate 86b-d)** with mesocones of laterals blunt tipped, elevated at about a 45° angle. Based on two dissected adults.

Remarks

A few specimens of the spectacular *Damochlora spina* (p. 933) were taken sympatrically with *Carinotrachia carsoniana.*

The remnants of the epiphragm on several shells indicates that *Carinotrachia* seals to other objects during aestivation.

Turgenitubulus pagodula is convergent in shell features, but the differences in shell lip and anatomy easily separate the two species.

The name *carsoniana* is taken from the Carson River.

GENUS *MESODONTRACHIA* NEW GENUS

Diagnosis

Shell of average size, with normal whorl count. Apex and spire **(Figs 218b, 220b)** slightly to strongly elevated, somewhat rounded above, whorls of spire not compressed, body whorl barely or not descending before aperture. Umbilicus narrowly **(Fig. 218c)** to very narrowly **(Fig. 220c)** open, barely decoiling, covered in part by reflexion of columellar lip. Apical whorls with prominent, elongated pustules **(Plate 87a-b)** or nearly smooth **(Plate 88d).** Postapical whorls with a dense covering of prominent pustules and short micro-ridges on early spire, changing to pustules on lower spire and body whorl, continuing undiminished on shell base *(desmonda),* or reduced to minute pustules on lower spire and body whorl above periphery *(fitzroyana).* Lip slightly *(desmonda)* to moderately expanded *(fitzroyana),* not significantly thickened, without trace of nodes, reflexion over umbilicus moderate to great. Parietal wall with a thin callus. Shell periphery rounded or weakly angulated, body whorl not *(fitzroyana)* to somewhat inflated *(desmonda).* Colour light yellow horn, often with darker spire suffusions, shell base lighter, lip white. Genitalia **(figs 219a-e, 221a-c)** with very short spermatheca (s), vagina (V) and atrium (Y), free oviduct (UV) of medium length. Vas deferens (VD) loosely bound to outside of penis sheath by long fibres, entering sheath subapically. Penial retractor muscle (PR) extending well into sheath to insert directly onto head of penis. Penis sheath (PS) very thin walled, extending from near atrium *(desmonda)* or part way up penis *(fitzroyana)* to point part way up penial retractor muscle. Penis (P) probably thick-walled when mature, internally with wide longitudinal ridges, no verge or vergic papilla, entrance of vas deferens into penis through a simple pore. Jaw **(Plates 87c, 88a-c)** with very prominent vertical ribs. Radular teeth **(Plates 87d-f, 88e-f)** with rather short, blunt mesocones on laterals, marginals and lateromarginal transition without unusual features.

Type species: *Mesodontrachia fitzroyana* sp. nov.

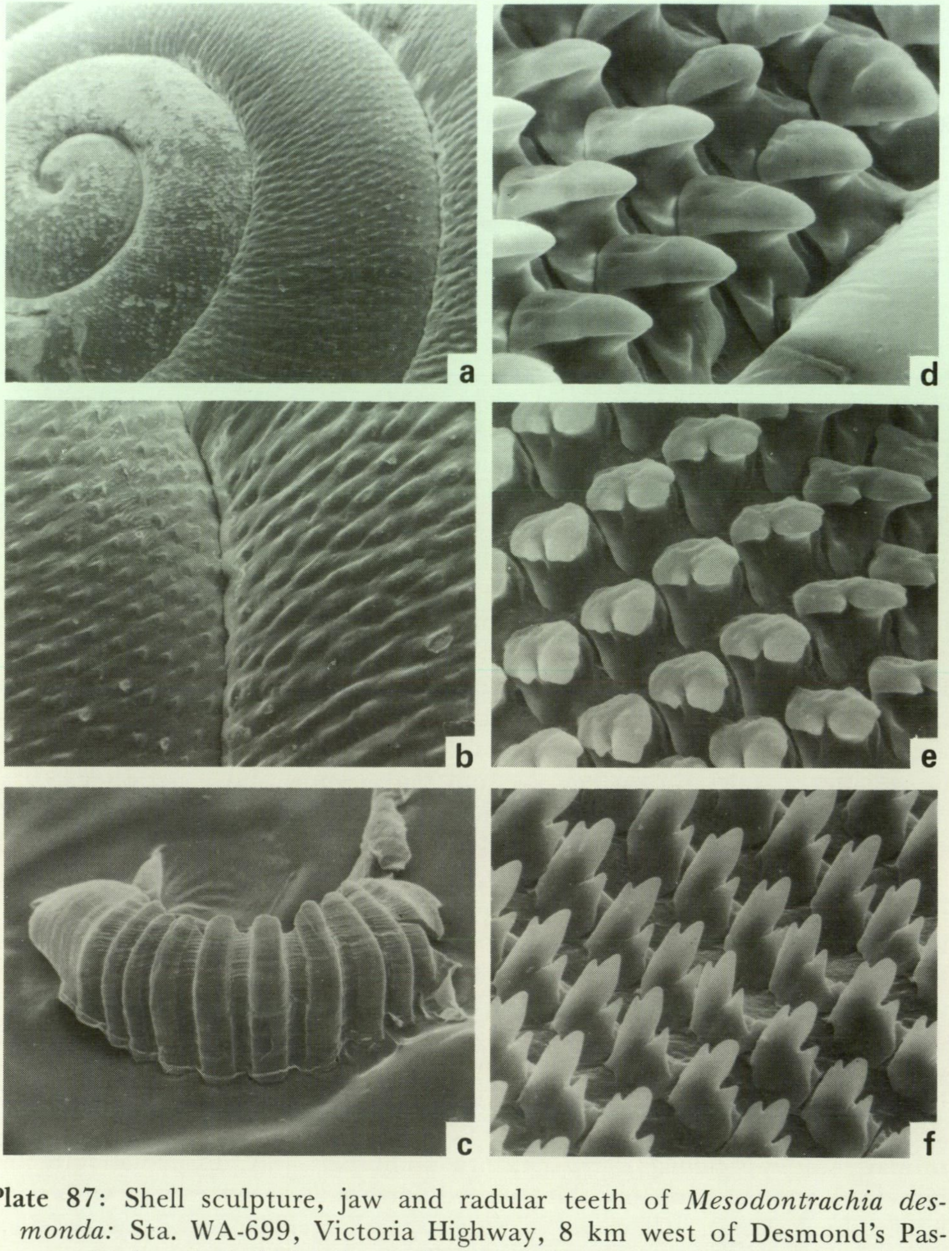

Plate 87: Shell sculpture, jaw and radular teeth of *Mesodontrachia desmonda:* Sta. WA-699, Victoria Highway, 8 km west of Desmond's Passage, 11 km east of Fish Creek, Northern Territory, 14 June 1980, FMNH 205256, Dissection A, (a) apex and early spire at 16.0X; (b) detail of apex and early spire at 39.0X; (c) jaw at 54.2X; (d) central and early lateral teeth at 660X; (e) lateromarginal transition at 650X; (f) early and midmarginal teeth at 680X.

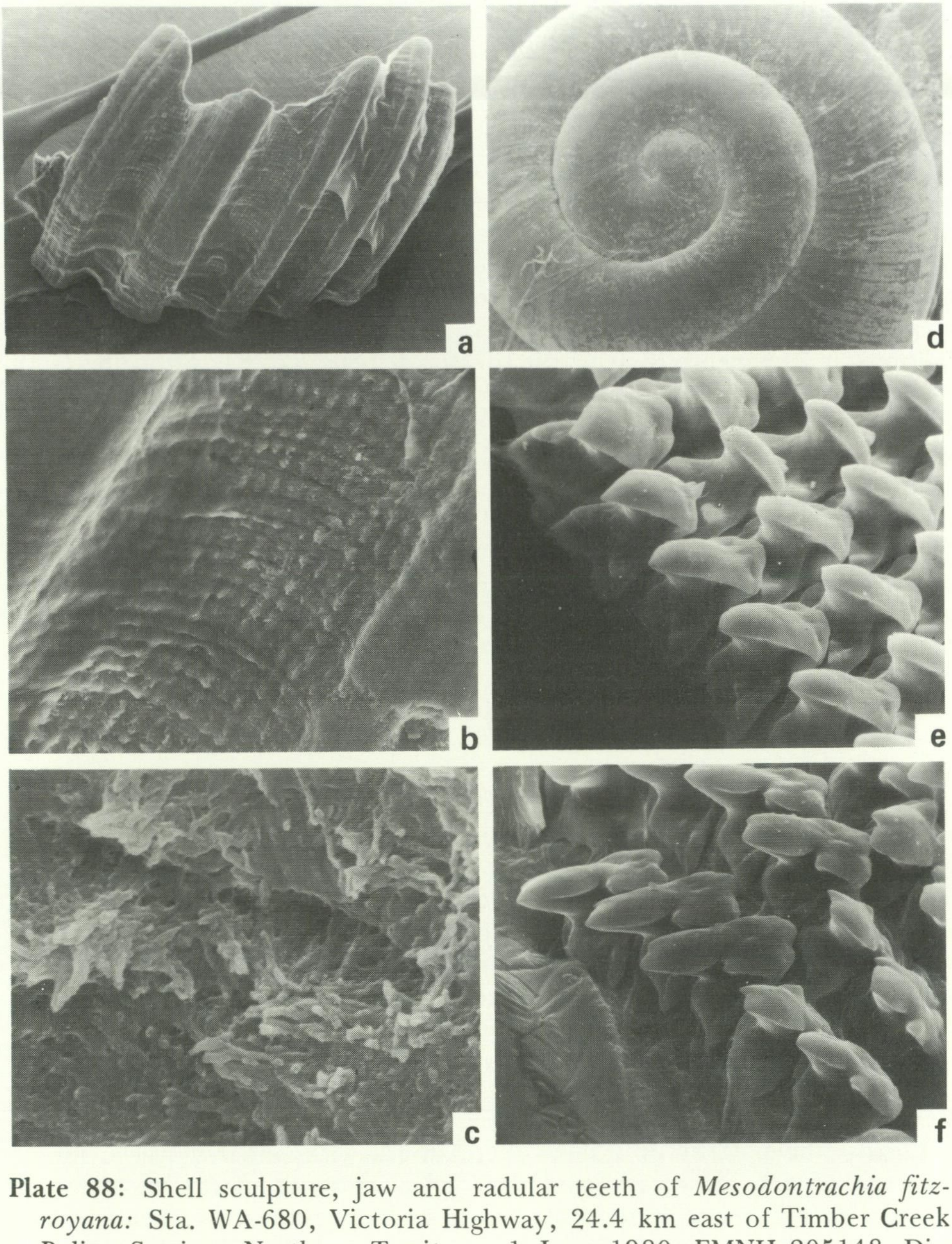

Plate 88: Shell sculpture, jaw and radular teeth of *Mesodontrachia fitzroyana:* Sta. WA-680, Victoria Highway, 24.4 km east of Timber Creek Police Station, Northern Territory, 1 June 1980, FMNH 205148, Dissection A, (a) jaw at 60.9X; (b) interrib area on jaw showing unworn surface at 320X; (c) detail of unworn surface at 3,200X; (d) apex and early spire at 13.7X; (e) central and early lateral teeth at 500X; (f) latero-marginal transition at 695X.

Comparative remarks

The absence of any radial ribbing, rounded shell periphery, and dense pustulose microsculpture of *Mesodontrachia* effectively separate this genus from both *Ningbingia* Solem, 1981 and *Cristilabrum* Solem, 1981 from the Ningbing Ranges north of Kununurra. *Pymnbriareus* Solem (1981b: 418, figs 107a-c, 390, pl. 18d-f) from El Questro Station south-west of Wyndham has very similar sculpture, shell shape and lip, but is smaller, has a more open umbilicus, and shows many anatomical differences. *Prototrachia sedula* Solem, 1984 differs in its angulated periphery, very complex microsculpture and variegated colour pattern. Anatomically, two *(Ningbingia, Prymnbriareus)* of the three genera mentioned above have complexly ornamented pilasters in the penis (Solem 1981b: figs 79-80, 82, 84, 86, 108, 109), while *Cristilabrum* is characterised by a very long, slender, folded penis that at times greatly exceeds the penis sheath in length, and the vas deferens entering the base of the penis sheath (Solem 1981b: figs 101-105). The significant features of *Mesodontrachia* include the loose fibre attachment of the vas deferens to the outside of the penis sheath **(Figs 219a, 221a)**, simple ridges inside the penis and female terminalia, absence of any verge or vergic papilla, and insertion of the penial retractor muscle on the penis apex, rather than the vas deferens or epiphallus. *Prototrachia sedula* Solem, 1984 is sympatric with *M. fitzroyana.* It differs in its very long penis with complex pilasters, long vagina, and different vas deferens entrance into the sheath (Solem 1984: 689-90, figs 177-178).

Distribution and basic ecology

Both species are known from single localities by the Victoria Highway in the Northern Territory. *Mesodontrachia fitzroyana* has been taken 24.4 km east of Timber Creek Police Station and is limestone associated. It aestivates in basal talus or fissures of an exposed cliff area on both sides of the Victoria Highway. It is a 'free sealer', with a rather thin, calcified epiphragm. *M. desmonda* is from a non-calcareous cliff area south-west of the Pinkerton Range in the Saddle Creek drainage of the West Baines River. The few live juveniles were found under a large boulder perched on a rock ledge. No information is available as to its adult aestivation strategy.

Relationships of *Mesodontrachia*

Clearly the pattern of a short spermatheca with sinuated free oviduct, presence of a penis sheath, and near apical entrance of the vas deferens into the sheath, relate *Mesodontrachia* to such diverse taxa as *Carinotrachia, Prototrachia* Solem, 1984, *Prymnbriareus* Solem, 1981, *Ningbingia* Solem, 1981, and possibly *Cristilabrum* Solem, 1981. The simple internal penis pilasters and distinctive shell sculpture easily separate it on the generic level. Phyletic discussion must wait until some other groups have been reviewed.

The name *Mesodontrachia* comes from the conchological similarity of the type species to the North American polygyrid genus *Mesodon* Rafinesque, 1821, and its relationship to the *Westraltrachia-Prototrachia* series of genera.

MESODONTRACHIA DESMONDA SP. NOV.
(Plate 87a-f; Figs 218a-c, 219a-e)

Comparative remarks

Mesodontrachia desmonda differs from *M. fitzroyana* in having a more elevated spire **(Figs 218b, 220b)**, much more prominent pustulations that continue onto the shell base undiminished in size, and in having a more open umbilicus **(Figs 218c, 220c)**. *Prymnbriareus nimberlinus* Solem, 1981 from El Questro Station on the Pentecost River south-west of Wyndham is smaller, more depressed in shape, and with a much more open umbilicus (Solem 1981b: 418, figs 107a-c), although very similar in sculpture. The very long vagina, complex penial pilasters, and mid sheath entrance of the vas deferens immediately separate *Prymnbriareus* from *M. desmonda.*

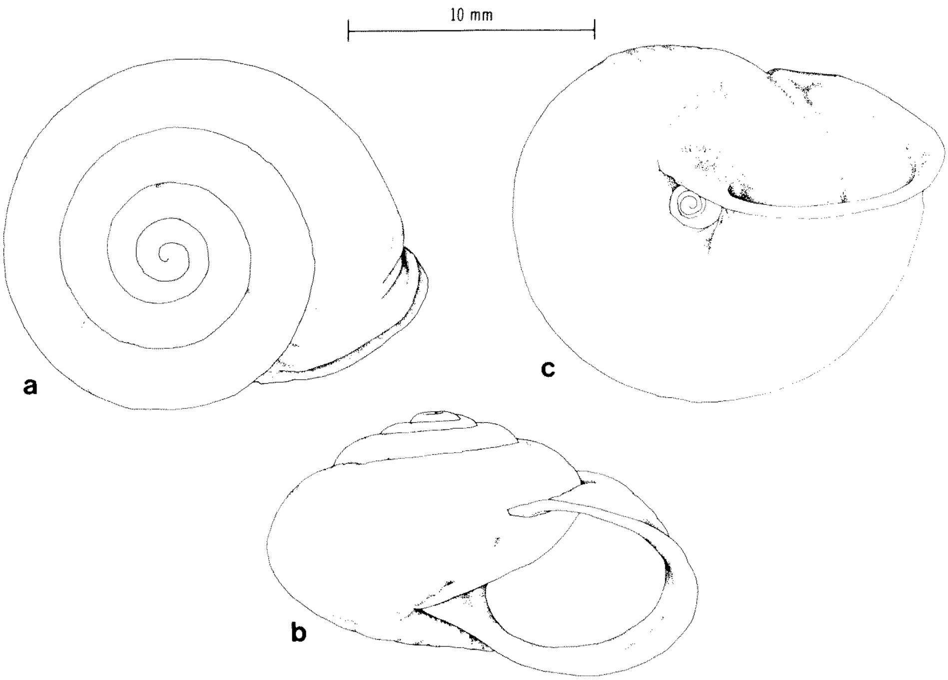

Fig. 218: Shell of *Mesodontrachia desmonda,* Sta. WA-699, Victoria Highway, 11 km east of Fish Creek, Northern Territory, WAM 670.80, holotype. Scale line equals 10 mm. Drawings by Linnea Lahlum.

Holotype

WAM 670.80, Sta. WA-699, sandstone cliffs south of Victoria Highway, ca 8 km west of Desmonds Passage, upper Saddle Creek drainage, West Baines River, south-west of Pinkerton Range, Northern Territory (1:100,000 'Pinkerton' map sheet 4866 – grid reference ca 595:345). Collected by A. Solem, L. Price and B. Duckworth 14 June 1980. Height of holotype 13.05 mm, diameter 19.5 mm, H/D ratio 0.669, whorls 5–, umbilical width 1.5 mm, D/U ratio 13.0.

Paratopotypes

WAM 671.80, WAM 672.80, FMNH 205255-6, 27 dead adults, 5 live, 13 dead juveniles from the type locality.

Diagnosis

Shell larger than average, diameter 17.3-21.7 mm (mean 19.06 mm), with $4\frac{3}{8}$ + to 5 (mean $4\frac{7}{8}$ –) normally coiled whorls. Apex and spire strongly elevated **(Fig. 218b)**, often rounded above, height of shell 10.9-15.45 mm (mean 12.74 mm), H/D ratio 0.610-0.716 (mean 0.668). Apical sculpture **(Plate 87a-b)** of elongated pustules. Postapical sculpture **(Plate 87b)** initially of short ridglets, changing to pustules on lower spire and body whorl, continuing onto shell base and into umbilicus. No radial ribbing present. Shell periphery rounded or at most slightly angulated, body whorl slightly inflated, not descending behind aperture. Lip moderately expanded, slightly thickened, without trace of nodes. Parietal callus thin. Umbilicus narrowly open **(Fig. 218c)**, barely decoiling, partly covered by reflexion of columellar lip, width 0.85-2.1 mm (mean 1.61 mm), D/U ratio 8.95-22.1 (mean 12.2). Colour light yellow horn, lip white. Based on 27 measured adults.

Genitalia **(Figs 219a-e)** with very short spermatheca (S) and vagina (V), free oviduct (UV) curved, internally with simple ridged pilasters. Vas deferens (VD) connected to penis by long fibres, entering penis sheath subapically, kinked to point where penial retractor muscle (PR) inserts onto head of penis. Penis sheath (PS) and penis (P) thin-walled, latter with a near basal diverticulum **(Fig. 219b, e, PL)**. Interior of penis with longitudinal pilasters, no trace of a verge or vergic papilla. Jaw **(Plate 87c)** typical. Mesocone of central and lateral teeth **(Plate 87d)** with blunt, rounded tip, lateromarginal transition **(Plate 87e)** and marginal teeth **(Plate 87f)** typical. Based on one dissected subadult.

Remarks

The name *desmonda* is taken from the major nearby landmark, Desmonds Passage, where the Victoria Highway cuts through the Pinkerton Range outliers.

The type locality is in the drainage of Saddle Creek, a minor tributary of the West Baines River, which in turn flows into the Victoria River about 43 km north-west of Timber Creek Police Station. *Mesodontrachia fitzroyana*

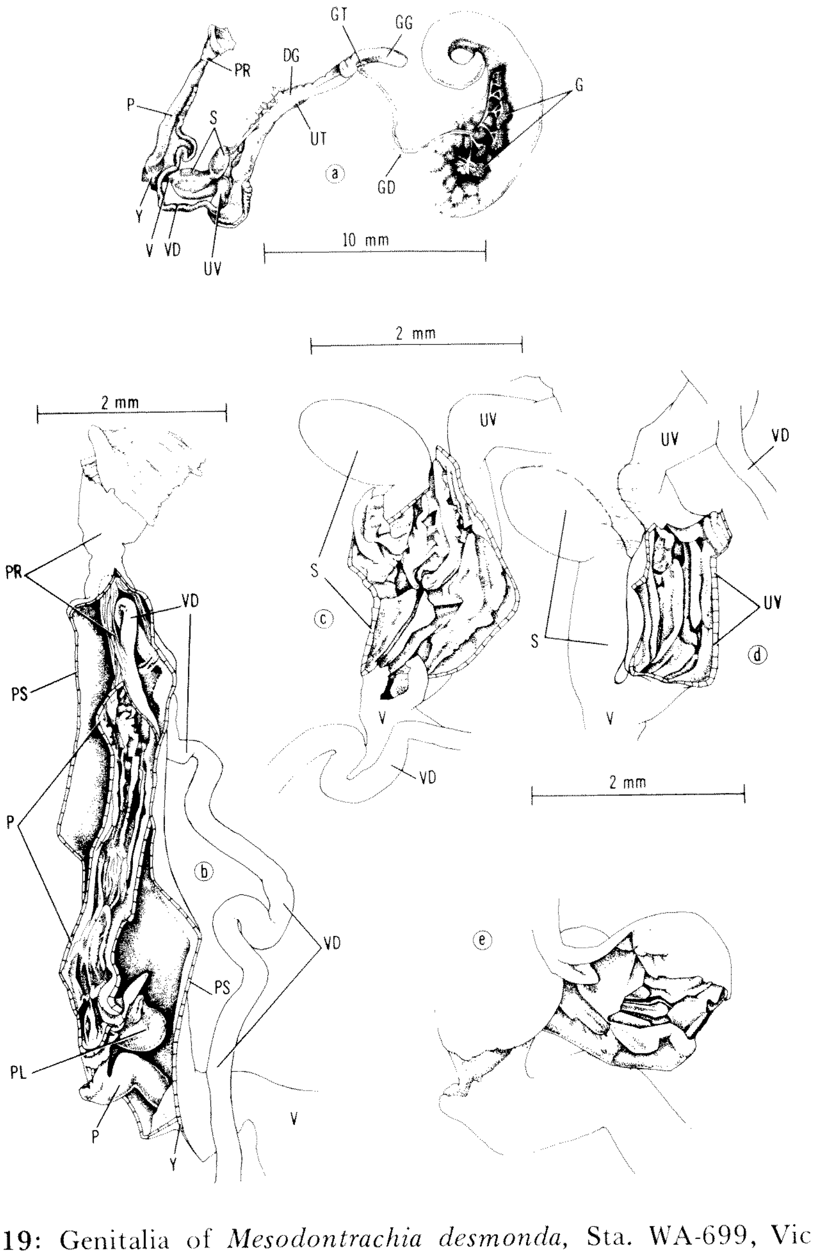

Fig. 219: Genitalia of *Mesodontrachia desmonda*, Sta. WA-699, Victoria Highway, 11 km east of Fish Creek, Northern Territory, 14 June 1980, FMNH 205255, Dissection A, (a) whole genitalia, (b) interior of penis, (c) interior of spermatheca, (d) interior of free oviduct, (e) interior of penial diverticulum. Scale lines as marked. Drawings by Linnea Lahlum.

is found considerably to the east, on an unnamed outcrop that forms the divide between Timber Creek to the west and Skull Creek to the east, both minor tributaries of the Victoria River that lie west of the Stokes Range. An air distance of about 115 km separates the two populations.

The cliffs of the type locality are marked by an unusual number of larger trees and variety of plant cover compared with other rock masses along the highway. Laurie Price suggested the stop, and managed to find a few live juveniles in a two hour hunt. The one subadult was 16.1 mm in diameter with 4¾– whorls (FMNH 205255). The lip had not started to reflect, and the shell size is almost 3 mm below mean adult size. It is, nevertheless, male adult with the possible exception of the penis pilaster size. The very small albumen gland (GG) and uterus **(Fig. 219a)** are typical of 2nd dry-early 3rd wet season specimens (Solem and Christensen 1984). This specimen was unfortunate enough to aestivate in a place that dried out before it could complete adult shell growth, and then could be reached by the hands of Laurie Price. Few moveable rocks exist at this locality, and undoubtedly the bulk of the population is hidden deep in fissures and under huge boulders.

Because the genitalia is not fully adult, the significance of the penial diverticulum **(Figs 219d-e)** remains uncertain.

MESODONTRACHIA FITZROYANA SP. NOV.
(Plate 88a-f; Figs 220a-c, 221a-c)

Comparative remarks

Mesodontrachia fitzroyana is easily separated from *M. desmonda* by its much lower spire **(Fig. 221b)**, narrower umbilicus that is more fully covered by the reflected columellar lip **(Fig. 220c)**, nearly smooth apex and early spire **(Plate 88d)**, reduced size of the pustules on the lower spire and body whorl, plus their absence from the shell base, and increased whorl count. The absence of radial ribbing distinguishes *Mesodontrachia* from the species of *Ningbingia* Solem, 1981 and *Cristilabrum* Solem, 1981 that lack prominent lip nodes, and the absence of colour bands easily differentiates *Amplirhagada questroana* Solem, 1981 from south-west of Wyndham. The sympatric *Prototrachia sedula* Solem (1984: 688, figs 176a-c, pl. 57) is smaller in diameter, has an angulated periphery with white zone, variegated colour on the spire, and quite spectacular microsculpture. Anatomically, the long fibres binding the vas deferens to the penis sheath **(Fig. 221a)**, simple ridged pilasters inside the penis **(Fig. 221b)**, direct insertion of the penial retractor muscle (PR) on the penis head, and absence of any verge or vergic papilla easily separate *M. fitzroyana* from any of the Ningbing genera and *Prymnbriareus* from El Questro Station, south-west of Wyndham. *Prototrachia sedula* differs in its complex sculpture on the penial pilasters, long vagina

(V), very long penis coiled within the sheath, vas deferens insertion of the penial retractor muscle, and absence of fibres binding the vas deferens to the outside of the penis sheath (Solem 1984: 689-90, figs 177-178).

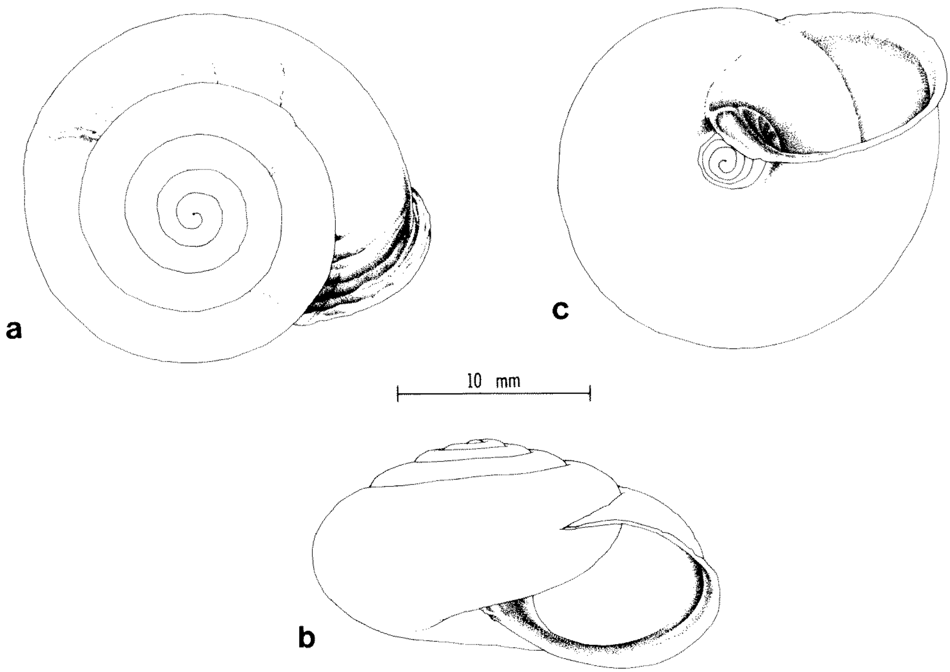

Fig. 220: Shell of *Mesodontrachia fitzroyana,* Sta. WA-680, Victoria Highway, east of Timber Creek Police Station, between Kununurra and Katherine, Northern Territory, WAM 669.80, holotype. Scale line equals 10 mm. Drawings by Linnea Lahlum.

Holotype

WAM 669.80, Sta. WA-680, limestone outcrop on north side of Victoria Highway, 24.4 km east of Timber Creek Police Station, 44.1 km west of Fitzroy Station turnoff, Northern Territory (1:100,000 'Stokes' map sheet 5066 – grid reference ca 721:581). Collected by A. Solem, L. Price and B. Duckworth 14 June 1980. Height of holotype 11.7 mm, diameter 20.2 mm, H/D ratio 0.579, whorls 5¼, umbilical width 1.9 mm, D/U ratio 10.6.

Paratopotypes

WAM 673.80-676.80, FMNH 205146-9, FMNH 205156, 62 live, 296 dead adults, 68 live, 13 dead juveniles from the type locality.

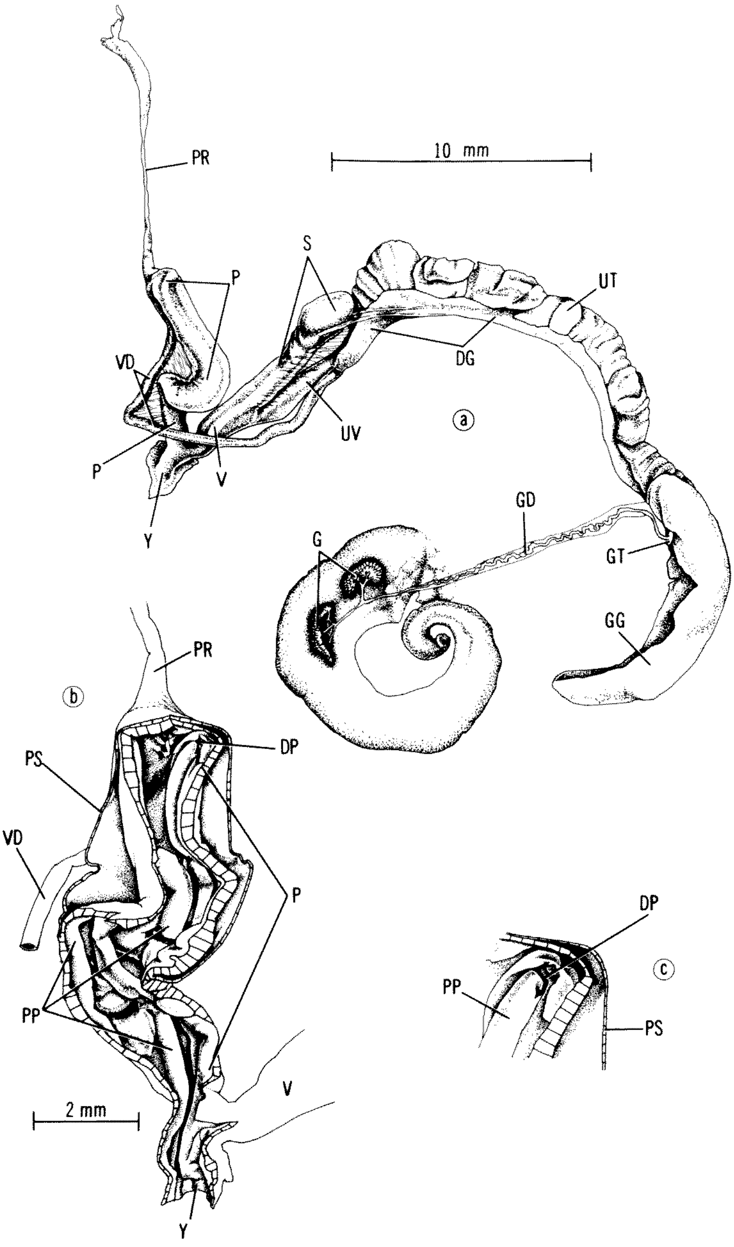

Fig. 221: Genitalia of *Mesodontrachia fitzroyana,* Sta. WA-680, Victoria Highway, east of Timber Creek Police Station, between Kununurra and Katherine, Northern Territory, 1 June 1980, FMNH 205148, Dissection B, (a) whole genitalia, (b) interior of penis, (c) detail of vas deferens entrance into penis. Scale lines as marked. Drawings by Linnea Lahlum.

Diagnosis

Shell relatively large, diameter 17.3-23.1 mm (mean 20.07 mm), with 5 to 5⅞ – (mean 5⅜ +) normally coiled whorls. Apex and spire slightly to moderately elevated, somewhat rounded above **(Fig. 220b)**, height of shell 10.3-14.25 mm (mean 12.07 mm), H/D ratio 0.522-0.682 (mean 0.601). Apex nearly smooth, trace of small tubercles in sutures **(Plate 88d)**. Upper spire also with traces of micro-pustules, latter becoming conspicuous on lower spire and body whorl, but absent from below periphery. No radial ribbing present. Shell periphery rounded, body whorl not descending behind aperture. Lip moderately expanded, slightly thickened, columellar portion strongly reflexed over umbilicus. Parietal callus thin. Umbilicus narrowly open **(Fig. 220c)**, barely decoiling, width 0.4-2.5 mm (mean 1.23 mm), D/U ratio 7.96-50 (mean 18.0). Colour medium yellow horn, lip white. Based on 359 measured adults.

Genitalia **(Figs 221a-c)** with short vagina (V) and spermatheca (S), free oviduct not sinuated. Vas deferens (VD) bound to penis sheath by long fibres, entering sheath slightly subapically, reflexing immediately to head of penis, entering **(Fig. 221c)** through a simple pore (DP) just above a ridge pilaster (PP). Penial retractor muscle (PR) entering sheath apically, extending downward a short distance to the penis-vas deferens junction. Penis sheath very thin-walled, starting more than one-third distance from atrium (Y) to vas deferens entrance **(Fig. 221b)**, continuing a short distance above penis-vas junction around penial retractor muscle (PR). Penis with thick walls, no verge or vergic papilla, walls of chamber with short to medium long, rather sharply delineated longitudinal ridged pilasters with smooth surfaces **(Figs 221b-c)**. Jaw **(Plate 88a-c)** typical in structure and gross appearance. Radular teeth **(Plate 88e-f)** with typical lateromarginal transition, mesocone of lateral teeth short and blunt-tipped, anterior flare prominent. Based on 5 dissected adults.

Remarks

The name *fitzroyana* honours not only the early explorer of north-western Australia, after whom Fitzroy Crossing was named, but also the nearby Fitzroy Station itself.

Two collections were made of this species. The first was a hurried stop on 1 June 1980 with Fred and Jan Aslin, Laurie Price, the author and a ranger from the Conservation Commission of the Northern Territory. On this date, specimens were taken from the exposed limestone on both sides of Victoria Highway. On 14 June 1980, the author, L. Price and Barbara Duckworth concentrated on the bigger exposure on the north side of the Victoria Highway in a successful search for live *Prototrachia sedula* Solem, 1984, and the holotype was selected from this material. There is no significant difference in size or shape among the live and dead samples **(Table 88)**.

Table 88: Local Variation in *Carinotrachia carsoniana, Mesodontrachia desmonda* and *M. fitzroyana*

Taxon	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
C. carsoniana				
NMVF 51479	3L	10.68±0.306 (10.2–11.25)	16.75±0.482 (15.85–17.5)	0.638±0.019 (0.604–0.669)
NMVF 51478-9	18D	10.50±0.176 (9.1–11.75)	16.59±0.365 (11.9–18.6)	0.638±0.016 (0.549–0.874)
M. desmonda				
WA-699, FMNH 205256	27D	12.74±0.160 (10.9–15.45)	19.06±0.156 (17.3–21.7)	0.668±0.005 (0.610–0.716)
M. fitzroyana				
WA-680, FMNH 205148	51L	12.48±0.107 (10.45–13.8)	20.04±0.117 (18.0–21.2)	0.623±0.004 (0.560–0.677)
WA-680, FMNH 205146	150D	12.06±0.054 (10.3–14.3)	20.03±0.071 (18.2–23.1)	0.603±0.002 (0.522–0.673)
WA-680, FMNH 205147	142D	11.97±0.060 (10.6–13.95)	20.15±0.078 (17.3–22.3)	0.594±0.002 (0.544–0.682)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
C. carsoniana				
NMVF 51479	3L	5⅛– (5+–5¼–)	2.12±0.060 (2.0–2.2)	7.93±0.374 (7.20–8.45)
NMVF 51478-9	18D	5⅛– (4¾–5¼)	2.27±0.096 (1.6–2.95)	7.54±0.370 (5.17–10.9)
M. desmonda				
WA-699, FMNH 205256	27D	4⅞– (4⅜+–5)	1.61±0.026 (0.85–2.10)	12.2±0.479 (8.95–22.1)
M. fitzroyana				
WA-680, FMNH 205148	51L	5⅜ (5+–6⅝)	1.46±0.054 (0.8–2.5)	14.5±0.640 (7.96–26.5)
WA-680, FMNH 205146	150D	5⅜+ (5–5¾–)	1.10±0.027 (0.4–2.1)	20.0±0.557 (9.7–50)
WA-680, FMNH 205147	142D	5⅜+ (5–5⅞–)	1.28±0.035 (0.5–2.3)	17.5±0.507 (8.50–36.2)

One jaw prepared exceptionally well (**Plate 88a-c**), with fine detail preserved in the inter-rib troughs, thus enabling illustration of the fact that the jaw is composed of a fibrous matrix. This appears structurally identical to the jaw of *Humboldtiana fullingtoni* Cheatum, 1972 (Solem 1974: fig. 5), a North American member of the Helminthoglyptidae, and suggests that a fibrous composition may be characteristic of jaws in the entire helicoid lineage. The fact that *Mesodontrachia* has a ribbed jaw, while they are absent in *Humboltiana* is trivial; the fact that the jaws consist of microfibres is significant.

GENUS *RHAGADA* ALBERS, 1860

Rhagada Albers, 1860, Die Heliceen nach natürlicher Verwandtschaft, Zweite Ausgabe (Eduard von Martens). Leipzig: Engelmann. pp. 108-109 – type species *Helix reinga* 'Gray' Pfeiffer, 1946 by original designation; Pilsbry, 1894, Man. Conch., (2) **9**: 135-6, pl. 27, figs 11-18 (part), pl. 51, figs 7-12 (part); Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 58-63 – review of Western Australian taxa; Zilch, 1960, Handbuch der Paläozoologie, Gastropoda, Euthyneura, **6**, 2 (4): 616 – as a subgenus of *Thersites* Pfeiffer, 1855.

Bellrhagada Iredale, 1938, Australian Zool., **9**: 114 – type species *Rhagada plicata* Preston, 1914 by original designation; Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 71-72.

Previous Studies and nomenclature

Most Australian *Rhagada* live in the Dampierland to Carnarvon region and will be reviewed in Part VII. Thus formal diagnosis is postponed.

It is desirable to comment on the basic composition of the genus, and indicate that, as previously outlined, it is an artificial unit. Although von Martens (1860: 108-109), quoting from Alber's manuscript, based the genus on Western Australian taxa, *R. reinga* (Pfeiffer, 1846), *R. tescorum* (Benson, 1853) and *R. dringi* (Pfeiffer, 1846), the only previously recorded anatomical data is on an Indonesian species, *Rhagada solorensis* (von Martens, 1863), as given by Wiegmann (1893: 169-171, pl. 12, figs. 15-19) and copied by Pilsbry (1894). The sketch given by Wiegmann (1893: pl. 12, fig. 19) is subject to multiple interpretations, but suggests to me that the Indonesian taxa are convergent in shell features and should not be included in *Rhagada*. The following anatomical features of *solorensis* do not agree with any of the Australian *Rhagada:* 1) a long, uncoiled spermatheca; 2) a very slender penis-epiphallus with a long and slender epiphallic caecum (or did Wiegmann mistake the penial retractor muscle for a caecum?); 3) the uncoiled nature of the terminal genitalia. In other genital illustrations in the same paper (Wiegmann 1893: pl. 9, fig. 15, pl. 11, fig. 14, pl. 12, fig. 12, pl. 13, fig. 7), species in which there is complex folding and coiling of the terminal organs were shown with these organs folded and coiled. Thus the illustration of *'Rhagada' solorensis* as having simple, uncoiled genitalia strongly suggests that this is the actual condition of that species. All of the studied Australian *Rhagada* have: 1) a coiled or kinked spermatheca when it is long; 2) a short penis with a heavy penial retractor muscle attaching to the epiphallus, which has a variable caecum; and 3) the vas deferens, epiphallus and epiphallic caecum complexly folded and coiled. This suggests that the Australian and Indonesian species are not congeneric. Unfortunately, I have been unable to locate any preserved examples of the Indonesian species.

The early reports on Western Australian land snails by Smith (1894) and Hedley (1916) made several references to *Rhagada* species. It is not possible, in most cases, to be certain as to what species they actually saw, and thus most of these references are not allocated to synonymy.

Iredale (1939), as usual, had a variety of taxa grouped together. *Bellrhagada* Iredale, 1938, is based upon the small, generally coastal species of *Rhagada* in which the radial ribbing on the spire is accentuated. Elsewhere I have shown that *Rhagada astuta* Iredale, 1938 is an *Amplirhagada* (Solem 1981a: 208-211) and that *Rhagada oscarensis* (Cox, 1892) plus *R. o. perca* Iredale, 1939 belong to *Westraltrachia* (Solem 1984: 563-570).

Distribution and basic ecology

If I am correct in considering that the four Indonesian species belong elsewhere, then *Rhagada* is an Australian endemic, ranging from the Mitchell Plateau south to Carnarvon. There is inland Kimberley extension through the Napier and much of the Oscar Ranges, and a few lesser inland extensions in the Roebourne-Port Hedland area, at least as far east as Millstream. If I am not correct, and the Indonesian species do belong to *Rhagada,* the colonisation by typhoons from Indonesia should be considered as a possible origin for the genus in Australia.

At least in the Kimberley, *Rhagada* is the land snail genus that has been most affected by pastoral activities. Indeed, on many stations it is now nearly extinct. Whereas other genera of camaenids are primarily, if not exclusively, rock associated, the preferred habitat of *Rhagada* is under large spinifex or grass clumps, especially those located downslope from a rock mass, where litter washed off the slopes can be caught and accumulate under the spinifex clumps.

Many Kimberley pastoralists indulge in an annual pyromania in which almost every square inch of the countryside is burned over in the mid to late dry season. This is in hopes that an early, out of season, rain will produce a flush of green for the stock. When burning is done on an annual basis, spinifex cannot reach 15 cm in diameter, much less the huge two to five metre clumps that can shelter a colony of *Rhagada* and occasionally other snail genera washed down from nearby limestone masses.

The only places in which we were successful in finding *Rhagada* in fair quantity were in portions of the Oscar Ranges that had not been burned in more than 20 years, and a few places in the Napier Range where accidents of topography sheltered some spinifex from the annual fires. Occasional specimens of *Rhagada* will be found in rock crevices or in limestone talus, but this is a secondary habitat compared with the open area niche. While the collections of *Rhagada* by Froggatt in the 1880s and Basedow in the 1910s from the Napier and Oscar Ranges (Iredale 1939: 61) numbered in the hundreds of specimens, our efforts in 1976-7 and 1980 only occasionally produced any specimens, and very rarely resulted in obtaining a good sample. In the years since the 1910s, the habitat that would yield *Rhagada* had been basically destroyed throughout most of this region.

All species of *Rhagada* secrete a calcified epiphragm across the aperture during aestivation. Most adults will be found with the aperture of the shell turned up, presumably so that initial awareness of moisture will be quicker. Under large spinifex or bushes, they lie in the litter or are a few cm down into the soil. In sandy areas near the West Coast, they are known to burrow 15-20 cm into the sand, clustering on the south side of termite mounds, or even aestivate in home lawns.

Patterns of shell variation

With the exception of the more heavily sculptured, small, *Bellrhagada* taxa, mainly from the coastal region and off shore islands, the shells of *Rhagada* are relatively featureless. Only a few taxa show a slight umbilical opening **(Figs 223f, 225c)**. There is significant variation in the extent to which the basal lip is raised to form a distinct ridge. This is especially prominent in *R. mimika* Iredale, 1939 **(Fig. 223f)**.

The colour pattern of a more prominent, very slightly supraperipheral red spiral band, with several narrower ones on both the spire and shell base, is modified in *R. crystalla* and *R. basedowana* Iredale, 1939 by loss of first the narrow bands and then the main band. In these taxa, the loss seems to be complete, whereas in *R. tescorum* (Benson, 1853) from the North West Cape, the loss seems to be of pigment, with the bands visible as translucent marks on the shell (Solem, unpublished).

Size and shape variation among species **(Table 89)** and within species **(Tables 90-91)** involves whorl count differences and minor changes in coiling pattern. Small size correlates with reduced whorl count.

Patterns of anatomical variation

None of the Kimberley *Rhagada* are sympatric. In addition, they have a structure not present in other Kimberley camaenids, a head wart that presumably is used in mate recognition. Similar structures have long been known in various Japanese helicoids, and a major spectacular radiation of such devices has occurred in some groups of African urocyclids. Full discussion of this will be given in Part VII, when the other Australian species

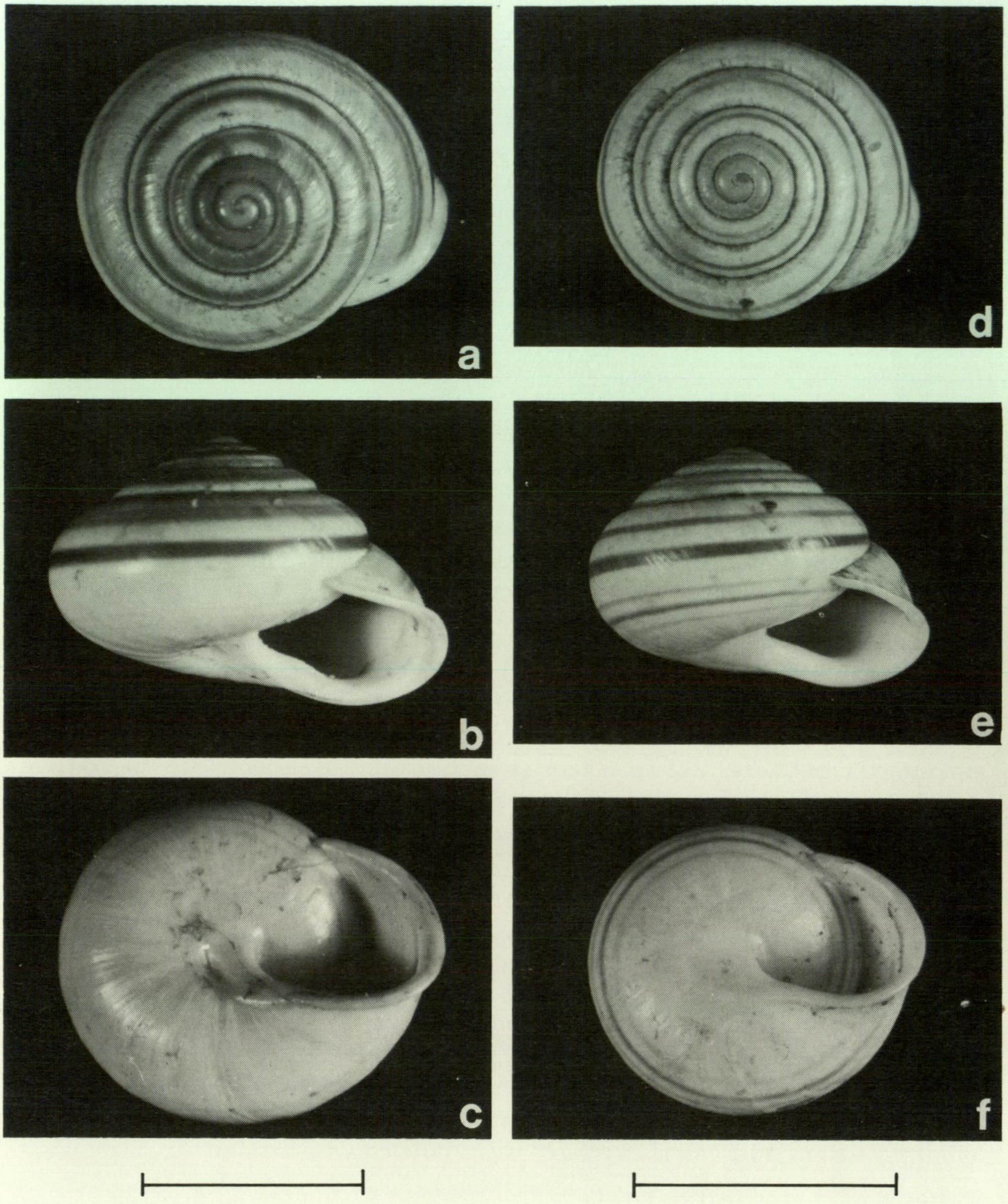

Fig. 222: Shells of *Rhagada gatta* Iredale, 1939 and *R. construa* Iredale, 1939: (a-c) *R. gatta* Iredale, 1939, about the middle of the Napier Range (= Oscar Range), AM C.64853, holotype; (d-f) *R. construa* Iredale, 1939, Oscar Range (= about middle of Napier Range), AM C.64851, holotype. Scale lines equal 10 mm.

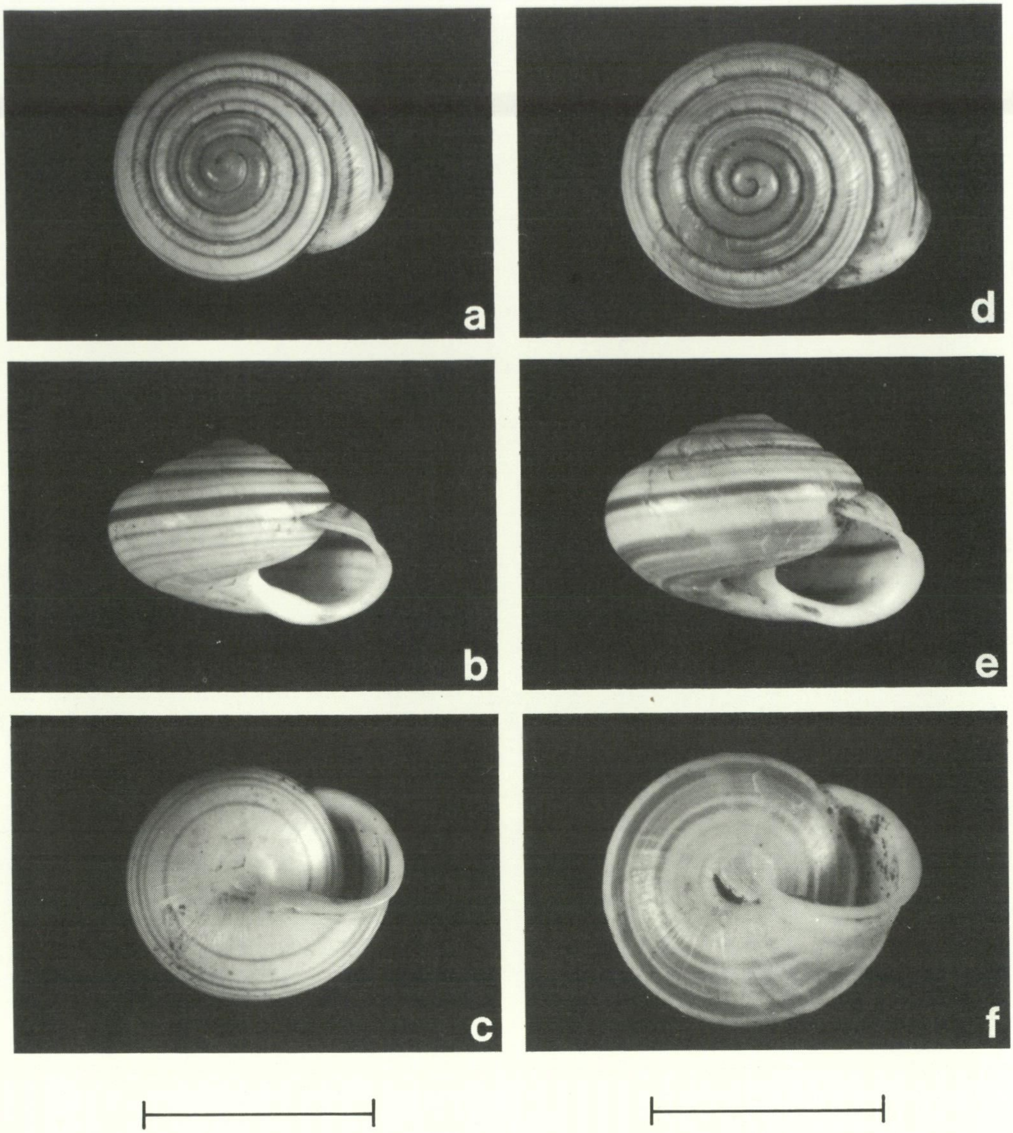

Fig. 223: Shells of *Rhagada mimika* Iredale, 1939 and *R. sutra* Iredale, 1939: (a-c) *R. mimika* Iredale, 1939, Napier Range, AM C.64855, holotype; (d-f) *R. sutra* Iredale, 1939, Napier Range, AM C.64858, holotype. Scale lines equal 10 mm.

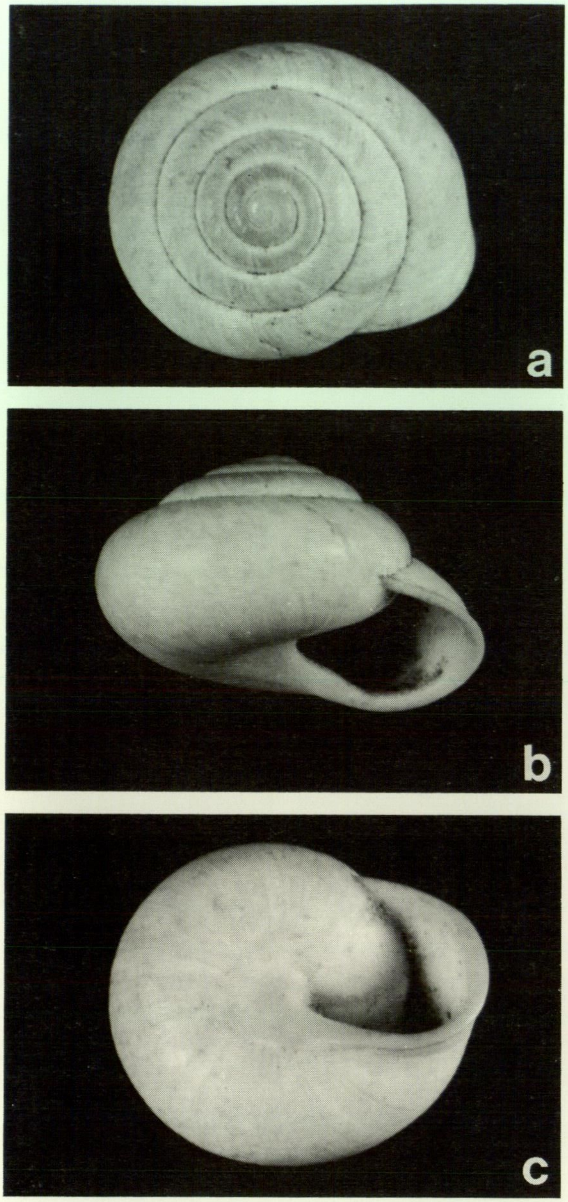

Fig. 224: Shell of *Rhagada basedowana* Iredale, 1939, off the limestone caves at north end of Napier Range, AM C.64880, holotype. Scale line equals 10 mm.

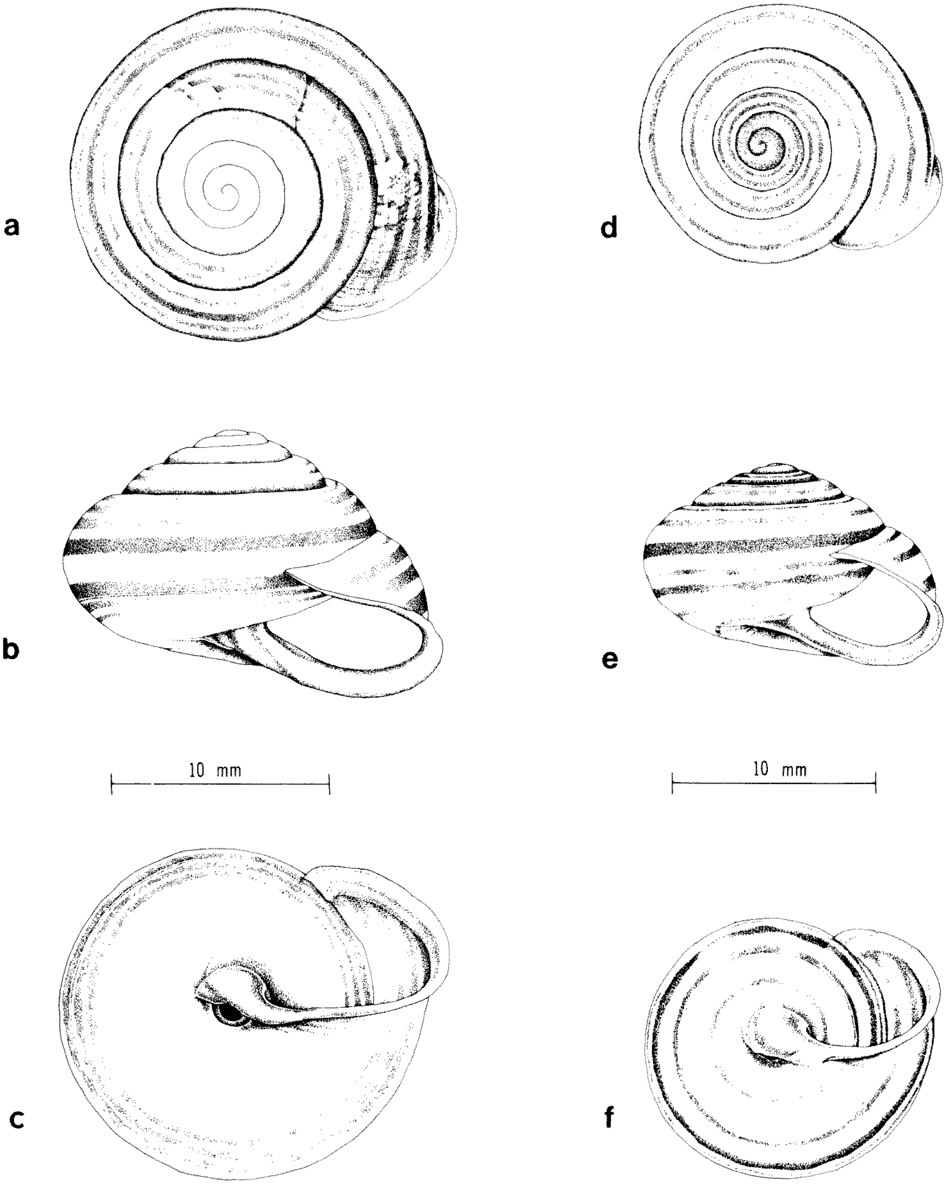

Fig. 225: Shells of *Rhagada gibbensis* and *R. harti:* (a-c) *R. gibbensis,* Sta. WA-379, ca 6 km north-east Macs Jumpup, King Leopold Ranges, WAM 75.84, holotype; (d-f) *R. harti,* Sta. WA-316, garden of Mt Hart Homestead, King Leopold Ranges, WAM 73.84, holotype. Scale line equals 10 mm. Drawings by Linnea Lahlum.

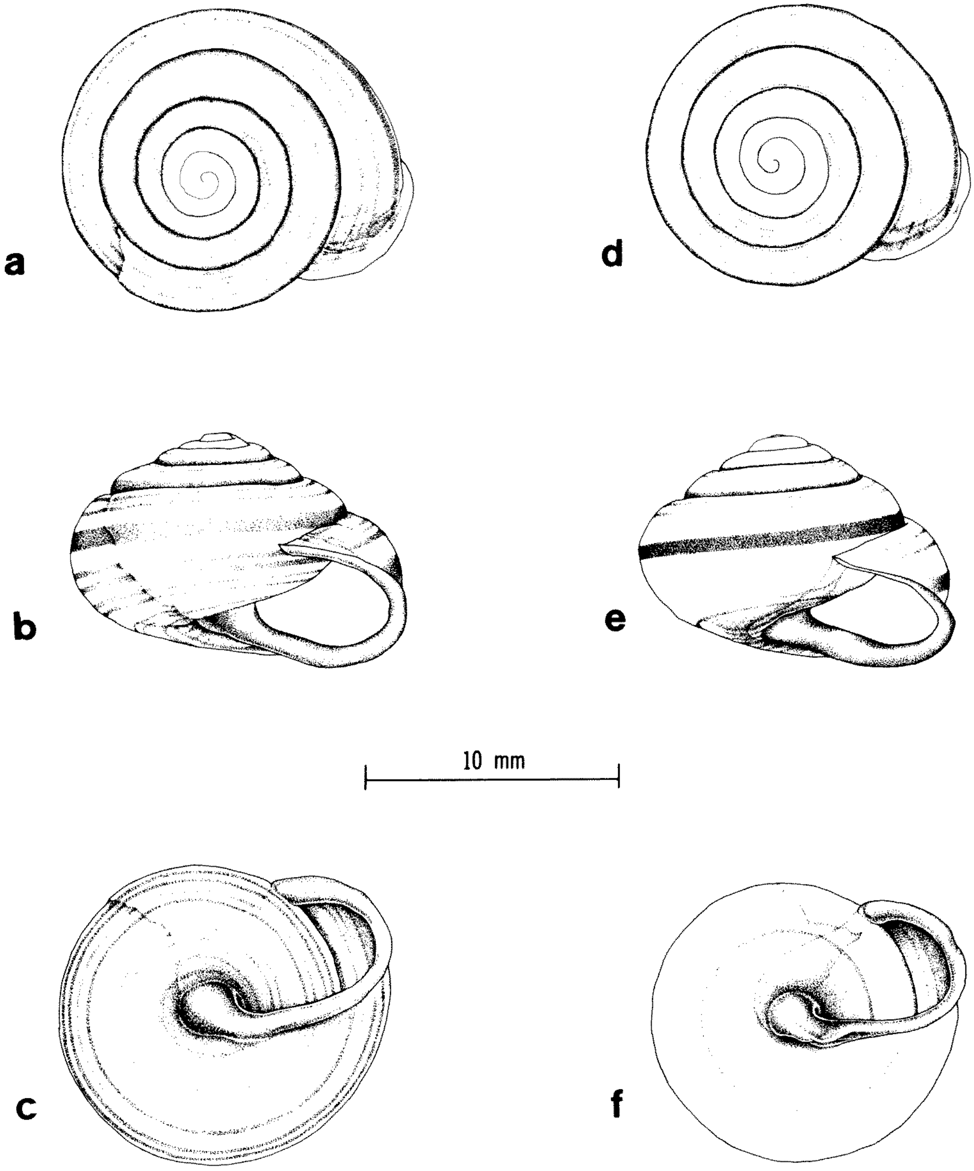

Fig. 226: Shells of *Rhagada crystalla* and *R.* sp.: (a-c) *R. crystalla,* Sta. 3, Crystal Creek, Mitchell Plateau, WAM 71.84, holotype; (d-f) *R.* sp., Sta. E5 (3), Enid Falls, Rufous Creek, Roe River, Prince Regent River Reserve, WAM 308.75. Scale line equals 10 mm. Drawings by Linnea Lahlum.

Table 89: Range of Variation in Kimberley *Rhagada*

Taxon	Number of Adults Measured	Mean and Range of: Shell Height	Shell Diameter	H/D Ratio
RHAGADA				
gatta Iredale, 1939	511	11.55 (8.5–14.9)	16.79 (12.8–20.0)	0.685 (0.568–0.796)
construa Iredale, 1939	159	10.04 (8.05–12.5)	14.58 (12.2–16.9)	0.689 (0.602–0.791)
sutra Iredale, 1939	45	9.56 (7.5–11.7)	14.07 (11.1–16.6)	0.686 (0.627–0.796)
mimika Iredale, 1939	49	8.11 (7.1–9.15)	12.97 (11.5–14.75)	0.626 (0.556–0.701)
basedowana Iredale, 1939	309	10.03 (7.5–13.8)	14.49 (11.3–18.9)	0.692 (0.556–0.830)
gibbensis	26	11.81 (10.3–13.1)	18.30 (16.8–20.15)	0.646 (0.591–0.734)
harti	218	10.56 (8.95–12.85)	15.62 (13.3–18.6)	0.677 (0.607–0.776)
crystalla	28	9.48 (8.1–10.9)	13.76 (12.6–15.7)	0.690 (0.633–0.765)
sp.	7	9.26 (8.8–9.5)	12.93 (12.4–13.5)	0.713 (0.680–0.752)

Taxon	Number of Adults Measured	Whorls	Umbilicus
RHAGADA			
gatta Iredale, 1939	511	5⅝ (5–6⅜)	Closed
construa Iredale, 1939	159	5⅜– (4¾+–5⅞)	Closed
sutra Iredale, 1939	45	5¼+ (4½+–5¾)	Closed or Cracked
mimika Iredale, 1939	49	5⅛+ (4¾–5½+)	Closed
basedowana Iredale, 1939	309	5⅜+ (4⅜–6⅛)	Closed
gibbensis	26	5½+ (5¼–6)	Cracked
harti	218	5½– (4¾–6)	Rarely Cracked
crystalla	28	5½+ (5– –5⅞+)	Usually Cracked
sp.	7	5¼– (4⅞+–5⅜–)	Usually Closed

of *Rhagada* will be reviewed. Here it is sufficient to point out that the head wart of each species differs in detail (see **Figs 228-235**).

Because no two Kimberley species are sympatric, the significance of the anatomical differences can be debated. The fact that they are consistent among widely separated populations of *R. gatta* Iredale, 1939 and *R. basedowana* Iredale, 1939, the only two species for which multiple populations could be dissected, strongly suggests that these are species differences. Full discussion is postponed until the West Coast radiation is reviewed. Only a brief summary follows.

None of the *Rhagada* have a penis sheath, and the massive penial retractor muscle (PR) inserts on the epiphallus (E) at a point ranging from just above the base of the verge (**Fig. 231d**) to a point considerably higher (**Figs 227a-b**). There is considerable variation in the thickness of the penis wall and the length of the penis chamber. The ratio of penis-vaginal length differs among species. The epiphallus ranges from short to long, with the caecum varying from a reduced nub (**Figs 231a, d**), long with a wide base (**Fig. 229a**) to slender and elongated (**Fig. 228b**).

Both the size and shape of the verge show important differences. In *R. basedowana* (**Fig. 232c**) it is slender and almost spatulate, while in other species it is nearly tubular with a prominent sperm groove that reaches part way or nearly to the tip. The verge can be long and slender with a narrow tip (**Fig. 228a**), short, broad and truncated (**Fig. 231d**), or with a bulbous tip (**Figs 233b, 235a, b**). In the latter situation, the groove termination point is variable.

Length of the terminal female organs is quite variable, especially in regard to the spermatheca (S). Typically (**Figs 227a-b, 229a, 233a**) it is long, coiled or kinked, and bound to the lower portion of the prostate-uterus by fibres. This is very similar to the situation seen in *Baudinella regia* (**Fig. 196a**) and *Retroterra* (**Figs 198, 201**). It can, however, be extremely short (**Fig. 232a**) and intermediate conditions are known.

The genitalia thus shows a considerable amount of structural variation that is considered to be indicative of speciation, even though shell features are quite uniform.

Data on seasonal variation in the genitalia and on the maturation pattern in *Rhagada* are fragmentary. Maturation probably conforms basically to the camaenid pattern outlined by Solem and Christensen (1984), with snails entering their third wet season being male adult, or nearly functional males. Examples of *Rhagada gatta* Iredale, 1939 collected 30 November, about the normal start of the wet season in that locality, include a third wet season new adult (**Fig. 227a**) with small ovotestis (G) and very slender hermaphroditic duct (GD), but large male terminalia, and fully mature specimens (**Fig. 227b**) with enlarged ovotestis, but the hermaphroditic duct quite small. Specimens collected in December from the Napier Range, *R. sutra* Iredale, 1939 on 12 December (**Figs 231a-b**), also have a small hermaphroditic duct and an enlarged ovotestis, while on 23 December, an example of *R. construa* Iredale, 1939 has both organs enlarged (**Figs 229a-b**). Mid-wet season examples of *R. harti* (**Fig. 233a**), collected 25 January, are clearly fully functional. In contrast, dry season examples of *R. basedowana* Iredale, 1939, collected 21 June (**Figs 232a-b**), have both ovotestis and hermaphroditic duct shrunken.

Special notice must be taken of the situation in *R. crystalla* collected 2 November 1976 (**Fig. 234b**). Both ovotestis and hermaphroditic duct are partly enlarged. Specimens of *Xanthomelon prudhoensis* (Smith, 1894) collected on the same date at the same station (Solem 1979: 27, fig. 8a), and examples of *Amplirhagada mitchelliana* Solem, 1981 and *A. castra* Solem (1981a: 276-277, figs 62a, 63a), collected on the Mitchell Plateau in mid-October, 1976, have the ovotestis and the hermaphroditic duct proportionately much larger. Since the wet season at the Mitchell Plateau was late in 1976, this suggests that *Rhagada* may not have the same 'biological clock' as seems to trigger male activation of the other camaenids at the normal start of the wet season at that locality. The Napier Range specimens collected in late November and early December, before the wet season had arrived, both had the hermaphroditic duct underdeveloped. The data are fragmentary, but suggestive of further work.

Systematic review

The following treatment of species is very uneven. Collections from much of the Napier Range are entirely too fragmentary to permit adequate revision of the species. The scattered examples of *Rhagada construa* Iredale, 1939, *R. sutra* Iredale, 1939, and *R. mimika* Iredale, 1939 do not allow proper systematic treatment. Data on *R. gatta* Iredale, 1939 and *R. basedowana* Iredale, 1939 are adequate for interpretation, with enough information available concerning *R. gibbensis, R. harti* and *R. crystalla* to permit description on the basis of their anatomical peculiarities.

Yet another problem relates to type localities of the species described by Iredale (1939). *Rhagada basedowana* was collected with *Amplirhagada percita* (Iredale, 1939) at the 'Limestone Caves', and this locality has been restricted by Solem (1981a: 218) to a northern section of the Napier Range. *R. gatta* probably was collected with *Westraltrachia oscarensis* (see Solem 1984: 563-70), but the precise locality is uncertain. The vague phrases 'on grass, etc.' and 'found under logs and damp stones' for *R. mimika* and *R. sutra* give no data, and collections are so fragmentary that no guess as to the actual locality is possible. *R. construa* is known from the Napier, not the 'Oscar Range'. In the absence of new collections, questions of type localities must be left unsolved. As mentioned above, the annual burning in much of the Napier Range area has probably driven several of the species to (or over) the brink of extinction.

The following key to the species is based upon adult shells in good condition, and will not work with juveniles or worn examples.

KEY TO THE KIMBERLEY SPECIES OF *RHAGADA*

1. Shell spire with low ribs; coastal areas 2
   Shell spire with weak growth undulations to smooth; inland areas 3

2. Umbilicus usually a narrow crack; radial sculpture rather weak; Mitchell Plateau . . . . *Rhagada crystalla* sp. nov. (p. 915)
   Umbilicus usually closed; radial sculpture prominent; Prince Regent River Reserve . . . . *Rhagada* sp. (p. 919)

3. Umbilicus open or a lateral crack 4
   Umbilicus normally completely closed 5

4. Shell diameter 16.8-20.2 mm; King Leopold Ranges . . . . *Rhagada gibbensis* sp. nov. (p. 912)
   Shell diameter 11.1-16.6 mm; central Napier Range . . . . *Rhagada sutra* Iredale, 1939 (p. 902)

5. Body whorl not or slightly descending before aperture **(Figs 223b, e, 224b)** 6
   Body whorl moderately descending before aperture **(Figs 222b, e, 225e)** 7

6. Shell white or with only one spiral red band; no basal lip ridge . . . . *Rhagada basedowana* Iredale, 1939 (p. 908)
   Shell with many colour bands; basal lip ridge prominent **(Fig. 223b)** *Rhagada mimika* Iredale, 1939 (p. 907)

7. Napier or Oscar Ranges 8
   King Leopold Ranges; Mt Hart Station . . . *Rhagada harti* sp. nov. (p. 913)

8. Oscar Ranges; Napier Range east of Windjana Gorge or north-west tip near Hawkstone Creek . . . . *Rhagada gatta* Iredale, 1939 (p. 886)
   Central Napier Range, 7 km east of Yammera Gap to Wombarella Gap *Rhagada construa* Iredale, 1939 (p. 897)

RHAGADA GATTA IREDALE, 1939
(Plates 89a-b, 90a-b, 92a; Figs 222a-c, 227a-b, 228a-c)

Rhagada gatta Iredale, 1939, Jour. Roy. Soc. Western Australia, 25: 60-61, pl. IV, fig. 5 – about the middle of the Napier Range (H. Basedow) and towards the south end of the same range (W.W. Froggatt).

Comparative remarks

Rhagada gatta Iredale, 1939 is exceeded in size only by *R. gibbensis* **(Table 89)**, which differs in having a distinctly open umbilicus **(Fig. 225c)**, often a more prominent lip ridge **(Fig. 225b)**, and a less elevated spire. The moderate descension of the body whorl, full colour pattern, and closed umbilicus in *R. construa* Iredale, 1939, *R. gatta* and *R. harti* make them difficult to distinguish on shell features. *R. construa* is smaller **(Table 89)**, usually lacks any trace of the lip ridge, which is often fairly prominent in *R. gatta*, and tends towards a less inflated body whorl **(Fig. 222e)**. *R. harti* is smaller **(Table 89)** and with an accentuated colour pattern. Anatomically, *R. gatta* has the vagina (V) much longer than the penis (P, **Figs 227a-b**), the epiphallus (E) very long, coiled, and with a long slender caecum (EC), a complexly coiled spermatheca (S) and a rather thick walled penis with long, slender verge (PV, **Fig. 228a**). The head wart **(Fig. 228d)** is nearly circular and composed of many pustules. Of the conchologically similar species, *R. construa* has the vagina (V) shorter than the penis (P, **Fig. 229a**), a shorter epiphallus (E) with a thick-based epiphallic caecum (EC), and a short verge with large basal diameter **(Fig. 230)**; and *R. harti* **(Figs 233a-b)** has a very long vagina, shorter epiphallus (E), and the penis has a shorter verge with a rounded tip.

Holotype

AM C.64853, Napier Range. Height of holotype 12.2 mm, diameter 17.1 mm, H/D ratio 0.713, whorls 5⅞–, umbilicus completely closed by a broad callus.

Paratopotypes

AM C, WAM 59.40, FMNH 201568, 10 dead adults from the type locality.

Other material

Organised geographically east to west, NR material collected September 1975; NR II material collected August 1976; WA-259 to WA-356 collected late November 1976 to March 1977; WA-582-3 and WA-712 collected May and June 1980.

Oscar Ranges: Sta. WA-268, 6.2 km east of WA-261, near Brooking Gorge ('Fitzroy Crossing' 4061 – 679:034) (16 live, 47 dead adults, 2 live juveniles, WAM 103.84-104.80, FMNH 199502, FMNH 200220); Sta. WA-267, limestone gully 1 km east of WA-261, ('Cunningham' 3961 – 634:014) (21 dead adults, 1 dead juvenile, WAM 102.84, FMNH 199462); Sta. WA-261, 6.7 km east-south-east of Two Mile Bore ('Cunningham' 3961 – 628:013) (5 live, 10 dead adults, 5 live, 2 dead juveniles, WAM 100.84-101.84, FMNH 199466, FMNH 200231); Sta. WA-259, 1.5 km north-west of Two Mile Bore ('Cunningham' 3961 – 573:057) (1 live, 5 dead adults, WAM 99.84, FMNH 199581, FMNH 200234, FMNH 200869); Sta. WA-260, north-north-east of Kundra Bore ('Leopold Downs' 3962 – 511:112) (2 dead adults, WAM 98.84, FMNH 199467); OR II, pass through range near Twelve Mile Bore ('Leopold Downs' 3962 – ca 418:177) (4 dead adults, WAM 927.76); OR VI, near Palm Spring (14 dead adults, WAM 928.76); OR VII, north of Palm Spring (4 dead adults, WAM 926. 76).

Between Oscar and Napier Ranges: Sta. WA-356, 1.3 km north-east of yard north of Wine Spring, 0.3 km south of Chestnut Creek, plains area ('Leopold Downs' 3962 – 284:437) (12 live, 6 dead adults, 2 live juveniles, WAM 96.84, FMNH 199101, FMNH 200164); Sta. WA-276, 3.6 km north-west of Wine Spring, plains area ('Leopold Downs' 3962 – 241:442) (3 live, 67 dead adults, 5 live juveniles, WAM 95.84, FMNH 199238, FMNH 200191).

Eastern Napier Rnage: NR XXVII, north-west of Pigeon Creek, near south-east end of Napier Range (9 dead adults, WAM 924.76); Sta. WA-270, 21.8 km east of Tunnel Creek turnoff ('Leopold Downs' 3962 – ca 441:416) (1 live, 2 dead adults, WAM 94.84, FMNH 199256, FMNH 200213); Sta. WA-271, 11.3 km east of Tunnel Creek turnoff ('Leopold Downs' 3962 – 342:449) (5 dead adults, WAM 93.84, FMNH 199451); NR XXVI, ca 7 km south-east of Tunnel Creek Cave (1 live, 2 dead adults, WAM 923. 76, WAM 925.76); Sta. WA-279, cliffs north of Chestnut Creek, south face Napier Range, east of Wine Spring Road ('Leopold Downs' 3962 – 322: 447) (6 dead adults, WAM 97.84, FMNH 199232); NR XXI, NR XXII, near south end of Tunnel Creek Cave (1 live, 43 dead adults, WAM 909. 76-910.76, WAM 914.76, WAM 917.76); Sta. WA-583, 2.4 km west of Tunnel Creek turnoff, north side Napier Range ('Leopold Downs' 3962 – 256:533) (4 dead adults, WAM 92.84, FMNH 204713); Sta. WA-275, 5 km west of Tunnel Creek turnoff, north side Napier Range ('Leopold Downs' 3962 – 244:554) (1 live, 13 dead adults, 2 live juveniles, WAM 91.84, FMNH 199226, FMNH 199931); NR XIX, 2.2 km south-east of McSherry Gap (8 live, 1 dead adult, WAM 920.76); Sta. WA-273, 0.8 km east of McSherry Gap, south side Napier Range ('Leopold Downs' 3962 – 232:563) (21 dead adults, WAM 90.84, FMNH 199203, FMNH 199471); NR XXIII, just south-east of McSherry Gap (6 live adults, WAM 921.76); Sta. WA-712, 100 m east of McSherry Gap, south side Napier Range ('Leopold Downs' 3962 – 566:228) (1 dead adult, FMNH 205321); NR II-34, north corner, McSherry Gap (1 dead adult, WAM); Sta. WA-582, north slope Cycad Hill, base of ledge and talus, under spinifex, south side Napier Range ('Leopold Downs' 3962 – 603:221) (6 live, 16 dead adults, WAM 88.84-89.84, FMNH 204711-2).

North-western Napier Range: NR II-6, near north corner of Napier Range at junction with Van Emmerick Range (27 dead adults, WAM 367.80); Sta. WA-300, cliffs at north-west end Napier Range, west of Van Emmerick (= Patterson) Range, ca 18.3 km by bush track from Red Bull Bore ('Lennard' 3863 – ca 660:110) (41 live, 89 dead adults, 2 live juveniles, WAM 85.84-87.84, FMNH 199210, FMNH 199255, FMNH 199941, FMNH 200259); Sta. WA-323, cliff base east side of hill, ca 1 km north-west Hawkstone

Peak, south-west of Napier Range, north-north-east of Kimberley Downs Homestead ('Meda' 3763 – 527:933) (2 dead adults, WAM 84.84, FMNH 199121).

Distribution limits

Rhagada gatta has a discontinuous distribution extending from near the mouth of Brooking Gorge in the eastern Oscar Ranges to the pass through the Oscar Range near Twelve Mile Bore. It then appears to be absent from the western Oscar Ranges until reappearing near Palm Spring at the western tip. It was not collected near Elimberrie Spring on the edge of the Oscar Plateau, but is fairly common in the drainage of Chestnut Creek in the plains between the Oscar and Napier Ranges. It has been found from the eastern tip of the Napier Range limestone (WA-270) to Cycad Hill (WA-582), west of McSherry Gap. This station marks the beginning of a limestone free zone of rolling hills that leads to the cliffs extending from Windjana Gorge. *R. gatta* is absent from the central and western Napier Ranges, where it is replaced by other species of *Rhagada,* but then turns up at the very north-western tip of the Napiers (NR II-6, WA-300). Two dead, worn adult shells from near Hawkstone Peak in the lower drainage of Hawkstone Creek just before it joins with the Lennard River to form the Meda River (WA-323) may represent the western limit of distribution.

Diagnosis

Shell large, diameter 12.8-20.0 mm (mean 16.79 mm), with 5 to 6⅜ (mean 5⅝) normally coiled whorls. Apex and spire moderately and almost evenly elevated, somewhat rounded above **(Fig. 222b)**, height of shell 8.5-14.9 mm (mean 11.55 mm), H/D ratio 0.568-0.796 (mean 0.685). Postapical whorls basically smooth, with at most very weak irregular growth striae, base smooth. Periphery rounded, body whorl descending moderately just before aperture. Lip narrow, not thickened, rarely with any trace of a basal ridge. Umbilicus closed by a broad callus. Colour typical, normally several narrow and one prominent spiral red bands. Based on 511 measured adults.

Genitalia **(Figs 227a-b, 228a-d)** with long vagina (V), very short free oviduct (UV), spermatheca (S) complexly coiled and fastened to lower part of prostate-uterus by fibres. Penis (P) rather short, thick-walled, verge as long as chamber, with side groove nearly reaching the narrow tip **(Figs 228a, c)**. Epiphallus (E) much longer than penis, slender, complexly coiled, with a long and slender caecum (EC, **Figs 227a-b, 228a-b)**. Penial retractor muscle (PR) attaching just above penis apex. Head wart **(Fig. 228d)** nearly circular, composed of many small pustules. Jaw **(Plate 89a-b)** typical. Radula with mesocone of laterals **(Plate 90a)** elevated at a high angle and sharp tipped, laterals few in number **(Plate 92a)**, lateromarginal transition typical **(Plate 90b)**, marginal **(Plate 92e)** typical. Based on eight dissected adults.

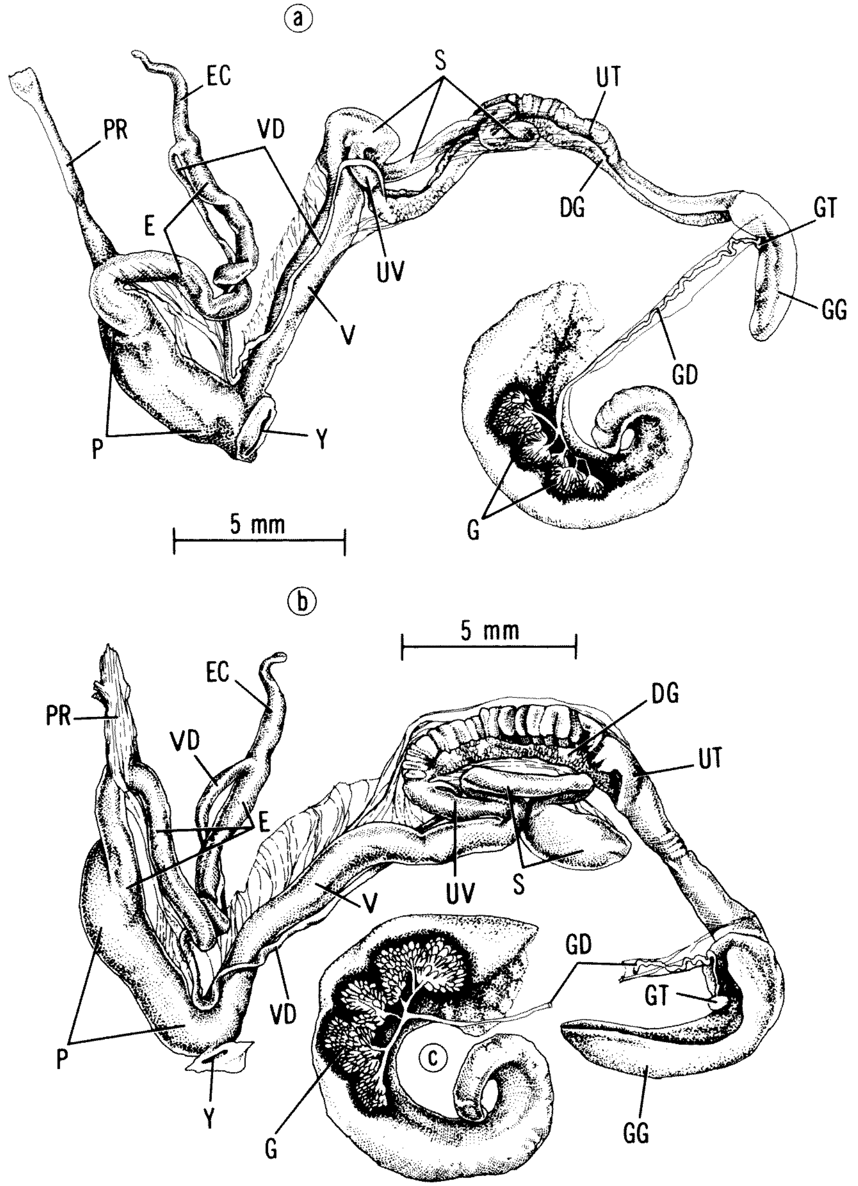

Fig. 227: Age variation in genitalia of *Rhagada gatta* Iredale, 1939. Sta. WA-268, 6.2 km west of Sta. WA-261, Oscar Ranges, west of Fitzroy Crossing, 30 November 1976, FMNH 200220: (a) whole genitalia of snail entering its third wet season, Dissection A: (b-c) Dissection C, genitalia of snail entering at least its fourth wet season, b is whole genitalia, c is ovotestis. Scale lines equal 5 mm. Drawings by Linnea Lahlum.

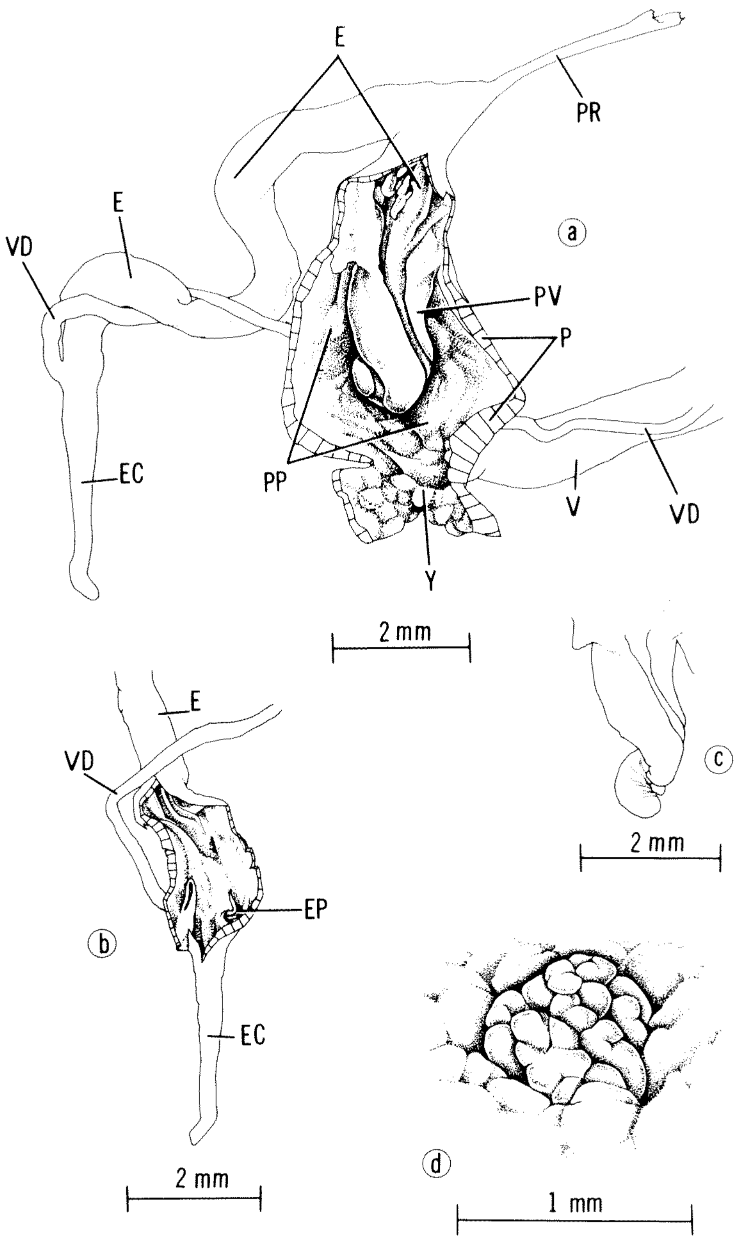

Fig. 228: Penis complex of *Rhagada gatta* Iredale, 1939. Sta. WA-268, 6.2 km west of WA-261, Oscar Ranges, west of Fitzroy Crossing, 30 November 1976, FMNH 200220, Dissection B: (a) interior of penis; (b) interior of epiphallus apex; (c) detail of verge; (d) head wart. Scale lines as marked. Drawings by Linnea Lahlum.

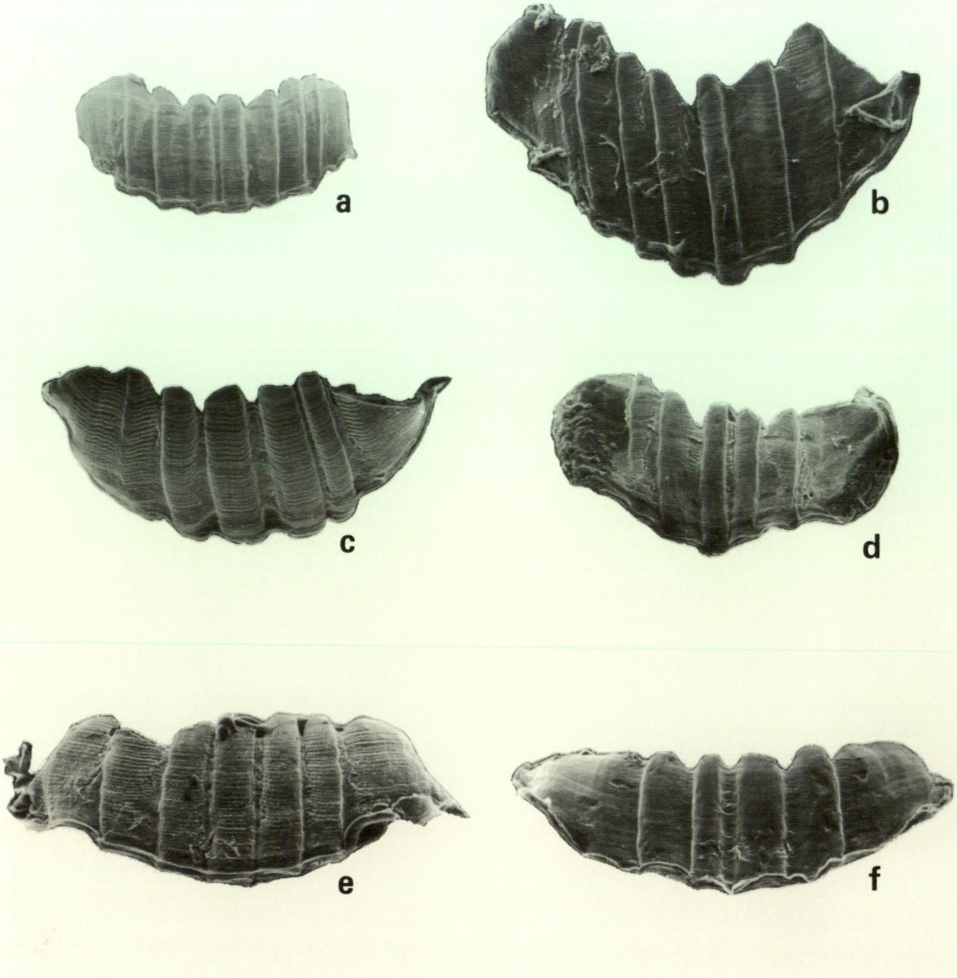

Plate 89: Jaws of Kimberley *Rhagada:* (a) *R. gatta* Iredale, 1939, Sta. WA-268, Oscar Ranges, FMNH 200220, 30 November 1976, Dissection B, at 31.4X; (b) *R. gatta,* Sta. WA-276, 3.6 km north-west of Wine Spring, north of Oscar Ranges, FMNH 200191, 4 December 1976, Dissection A, at 47.5X; (c) *R. sutra* Iredale, 1939, Sta. WA-312, 3.2 km west of Barker Gorge, Napier Range, FMNH 200188, 12 December 1976, Dissection A, at 50.7X; (d) *R. harti,* Sta. WA-316, Mt Hart Homestead garden, King Leopold Ranges, FMNH 200050, 13 December 1976, Dissection A, at 49.3X; (e) *R. basedowana* Iredale, 1939, Sta. WA-715, 7.6 km north of Original Napier Downs Homestead, Napier Range, FMNH 205340, Dissection A, at 58.6X; (f) *R. crystalla,* Sta. 3, Crystal Creek, Mitchell Plateau, FMNH 209069, 2 November 1976, Dissection A, at 60.0X.

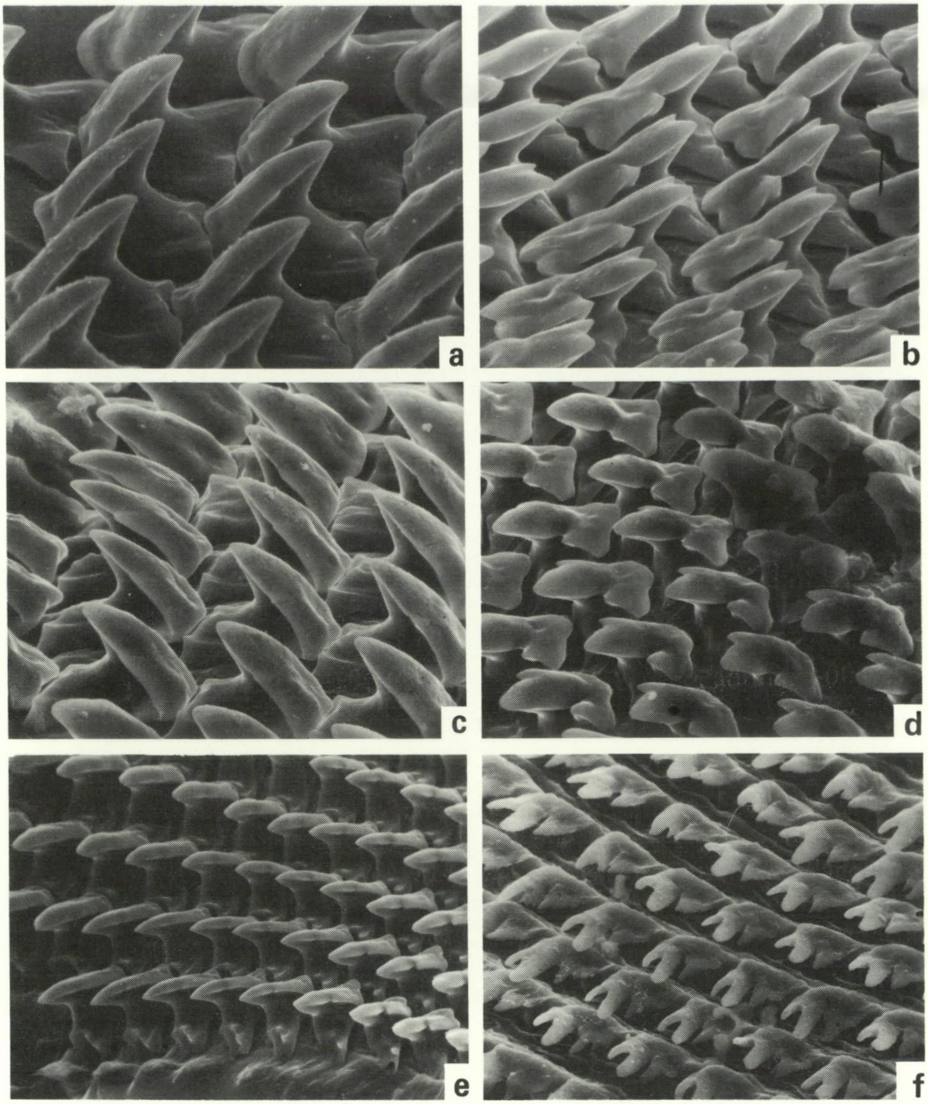

Plate 90: Radular teeth of *Rhagada gatta* Iredale, 1939 and *R. harti:* (a-b) *R. gatta,* Sta. WA-268, Oscar Ranges, FMNH 200220, 30 November 1976, Dissection B, a is central and lateral teeth from a high angle side view at 620X, b is lateromarginal transition from same angle at 653X; (c-f) *R. harti,* Sta. WA-316, Mt Hart Homestead garden, King Leopold Ranges, FMNH 200050, 13 December 1976, Dissection A, c is high angle side view of central and early laterals at 618X, d is lateromarginal transition at 645X, e is front angle view of lateromarginal transition at 375X, f is outer marginals at 625X.

Table 90: Local Variation in *Rhagada gatta* Iredale, 1939

Station	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
Oscar Range				
WA-268, FMNH 200220	16L	11.66±0.186 (9.85–12.7)	16.96±0.125 (16.0–18.25)	0.688±0.010 (0.590–0.740)
WA-268, FMNH 199502	47D	11.80±0.109 (10.4–13.7)	17.31±0.115 (15.5–19.6)	0.682±0.004 (0.619–0.741)
WA-267, FMNH 199462	10D	12.30±0.260 (10.85–13.6)	17.64±0.319 (16.3–19.0)	0.691±0.012 (0.632–0.743)
WA-261, FMNH 200231	5L	12.78±0.284 (12.25–13.85)	17.75±0.309 (17.15–18.8)	0.720±0.007 (0.702–0.737)
WA-261, FMNH 199466	21D	12.42±0.144 (11.45–13.7)	18.15±0.169 (16.6–19.7)	0.684±0.009 (0.603–0.770)
WA-259, FMNH 199581	4D	13.51±0.348 (12.65–14.15)	18.66±0.275 (17.9–19.2)	0.724±0.010 (0.707–0.751)
OR II, WAM 927.76	4D	11.90±0.108 (11.7–12.2)	16.66±0.500 (15.4–17.8)	0.716±0.020 (0.685–0.773)
OR VI, WAM 928.76	14D	11.49±0.216 (9.8–13.0)	16.40±0.165 (15.4–17.4)	0.700±0.009 (0.636–0.758)
OR VII, WAM 926.76	4D	11.65–0.388 (10.8–12.6)	16.20±0.284 (15.45–16.8)	0.719±0.017 (0.699–0.768)
Fairfield Valley				
WA-356, FMNH 199101	6D	11.27±0.178 (10.55–11.9)	16.59±0.266 (15.4–17.3)	0.680±0.017 (0.624–0.734)
WA-276, FMNH 199238	67D	11.73±0.086 (10.45–13.0)	17.22±0.091 (15.5–19.4)	0.681±0.004 (0.591–0.757)
Napier Range				
NR XXVII, WAM 924.76	9D	9.27±0.235 (8.5–10.5)	14.48±0.355 (12.8–16.15)	0.641±0.015 (0.568–0.705)
WA-271, FMNH 199451	5D	11.30±0.248 (10.8–12.1)	16.54±0.300 (15.55–17.25)	0.684±0.014 (0.637–0.720)
WA-279, FMNH 199232	6D	11.62±0.295 (10.9–12.7)	16.64±0.331 (15.85–17.9)	0.698±0.005 (0.679–0.711)
NR XXII, WAM 910.76	12D	11.13±0.229 (9.35–12.1)	16.13±0.074 (15.75–16.55)	0.690±0.013 (0.592–0.739)
NR XXII, WAM 917.76	31D	11.06±0.117 (9.9–12.4)	16.24±0.142 (15.0–17.8)	0.682±0.005 (0.621–0.743)
WA-583, FMNH 204713	4D	10.40±0.624 (9.4–12.2)	15.71±0.279 (15.3–16.5)	0.661±0.028 (0.611–0.740)
WA-275, FMNH 199226	14D	10.39±0.123 (9.6–11.1)	16.08±0.139 (15.4–17.1)	0.646±0.007 (0.598–0.708)

Table 90: Local Variation in *Rhagada gatta* Iredale, 1939 (continued)

Station	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
NR XIX, WAM 920.76	9D	10.56±0.197 (9.9–11.6)	15.99±0.178 (15.25–16.7)	0.656±0.119 (0.624–0.734)
WA-273, FMNH 199471	21D	10.99±0.155 (9.85–12.3)	19.76±0.163 (14.5–16.9)	0.697±0.007 (0.655–0.788)
NR XXIII, WAM 921.76	6L	10.75±0.276 (9.8–11.8)	16.53±0.329 (15.65–17.45)	0.652±0.017 (0.595–0.690)
WA-582, FMNH 204711	6L	11.25±0.184 (10.5–11.75)	16.49±0.312 (15.15–17.2)	0.683±0.012 (0.644–0.722)
WA-582, FMNH 204712	16D	10.99±0.180 (9.35–12.2)	16.51±0.189 (15.75–18.55)	0.666±0.009 (0.578–0.718)
WA-300, FMNH 199941	37L	11.91±0.118 (10.5–13.9)	17.15±0.136 (15.15–18.7)	0.695±0.006 (0.620–0.762)
WA-300, FMNH 199210	12D	11.65±0.182 (10.5–12.65)	17.11±0.331 (15.4–18.9)	0.683±0.013 (0.568–0.745)
WA-300, FMNH 199255	77D	11.63±0.098 (10.05–13.9)	16.91±0.126 (14.85–20.0)	0.688±0.004 (0.609–0.771)
N end Napier Range, WAM 367.80	27D	11.99±0.205 (10.25–14.9)	16.99±0.256 (13.35–19.9)	0.706±0.009 (0.646–0.796)

Station	Number of Adults Measured	Whorls	Umbilicus
Oscar Range			
WA-268, FMNH 200220	16L	5½+ (5–6–)	Closed
WA-268, FMNH 199502	47D	5⅝– (5⅛–6⅛–)	Closed
WA-267, FMNH 199462	10D	5⅝+ (5⅛–6)	Closed
WA-261, FMNH 200231	5L	5⅞ (5⅝–6¼–)	Closed
WA-261, FMNH 199466	21D	5⅝+ (5⅜–6+)	Closed
WA-259, FMNH 199581	4D	5⅞– (5¾–6–)	Closed
OR II, WAM 927.76	4D	5⅝– (5⅜–5¾)	Closed
OR VI, WAM 928.76	14D	5½+ (5⅛–5¾)	Closed

Table 90: Local Variation in *Rhagada gatta* Iredale, 1939 (continued)

Station	Number of Adults Measured	Whorls	Umbilicus
OR VII, WAM 926.76	4D	5½ (5¼–5⅝+)	Closed
Fairfield Valley			
WA-356, FMNH 199101	6D	5⅜+ (5¼– –5½)	Closed
WA-276, FMNH 199238	67D	5½+ (5⅛– –6+)	Closed
Napier Range			
NR XXVII, WAM 924.76	9D	5⅛+ (5–5¼+)	Closed
WA-271, FMNH 199451	5D	5⅜ (5¼– –5⅝–)	Closed
WA-279, FMNH 199232	6D	5½+ (5⅜–5¾–)	Closed
NR XXII, WAM 910.76	12D	5½+ (5⅛+–5⅞)	Closed
NR XXII, WAM 917.76	31D	5½+ (5¼– –5¾)	Closed
WA-583, FMNH 204713	4D	5¾ (5⅝– –6⅛–)	Closed
WA-275, FMNH 199226	14D	5⅜+ (5¼–5⅝–)	Closed
NR XIX, WAM 920.76	9D	5⅜ (5⅛–5¾+)	Closed
WA-273, FMNH 199471	21D	5½+ (5⅛+–6+)	Closed
NR XXIII, WAM 921.76	6L	5⅜+ (5¼–5⅝–)	Closed
WA-582, FMNH 204711	6L	5¾– (5⅝+–5⅞–)	Closed
WA-582, FMNH 204712	16D	5¾– (5½– –6⅛–)	Closed
WA-300, FMNH 199941	37L	5⅞– (5⅜–6⅜)	Closed
WA-300, FMNH 199210	12D	5¾+ (5¼–6+)	Closed
WA-300, FMNH 199255	77D	5⅝+ (5⅛–6¼–)	Closed
N end Napier Range, WAM 367.80	27D	5¾+ (5⅜–6⅜)	Closed

Remarks

Rhagada gatta Iredale, 1939 shows moderate size variation **(Table 90)**. It reaches its largest size at Sta. WA-261 and WA-259 in the Oscars, becoming reduced in size both to the east and west. The plains populations from between the Oscar and Napier Ranges are average to large in size, while in the eastern Napier Ranges the shells are consistently smaller. The north-western Napier samples again contain larger specimens, and the two examples from near Hawkstone Peak are 16.55 and 17.1 mm in diameter. Throughout the range, diameter and whorl count variation is correlated – larger diameter = increased whorl number.

Specimens from several populations were dissected without finding any significant differences. Generally, so few live collected adults were available that only one or two individuals from a station could be checked.

Mating pairs were collected 30 December 1976 at Sta. WA-300 in the north-west Napiers. Data on these will be reported elsewhere.

RHAGADA CONSTRUA IREDALE, 1939
(Plate 91d; Figs 222d-f, 229a-c, 230)

Rhagada construa Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 60, pl. IV, fig. 3 – among the limestone, Oscar Range, north-west Australia.

Comparative remarks

Rhagada construa Iredale, 1939 **(Figs 222d-f)** has a closed umbilicus, no radial sculpture, either a very weak lip ridge or none at all, moderate descension of the body whorl, and is larger than the other central and western Napier Range species. *R. sutra* Iredale, 1939 has a narrow umbilical opening **(Fig. 223f)** and some radial sculpture; the smaller **(Table 89)** *R. mimika* Iredale, 1939 has a closed umbilicus **(Fig. 223c)**, very strong lip ridge, and a depressed shape; *R. basedowana* Iredale, 1939 has a closed umbilicus, usually lacks colour bands, and lacks a basal lip ridge. *R. gatta* Iredale, 1939 from the eastern Napier and Oscar Ranges has a more prominent lip ridge, is larger **(Table 89)**, and shows anatomical differences. Anatomically, *R. construa* **(Figs 229a-c, 230)** has the penis (P) longer than the vagina (V), a comparatively short epiphallus (E) whose caecum (EC) is short with a wide base, the penis is relatively thin-walled, and the verge (PV) is almost the length of the penis chamber and quite broad **(Fig. 230)**. The much longer penis, slender verge, very long epiphallus, and slender epiphallic caecum of *R. gatta* **(Figs 227a-c, 228a-c)** easily distinguish that species. *R. harti* **(Figs 233a-b)** has a long vagina, shortened epiphallus with slender caecum, and the slender verge has a bulbous tip, rather than the narrow tip of *R. construa*.

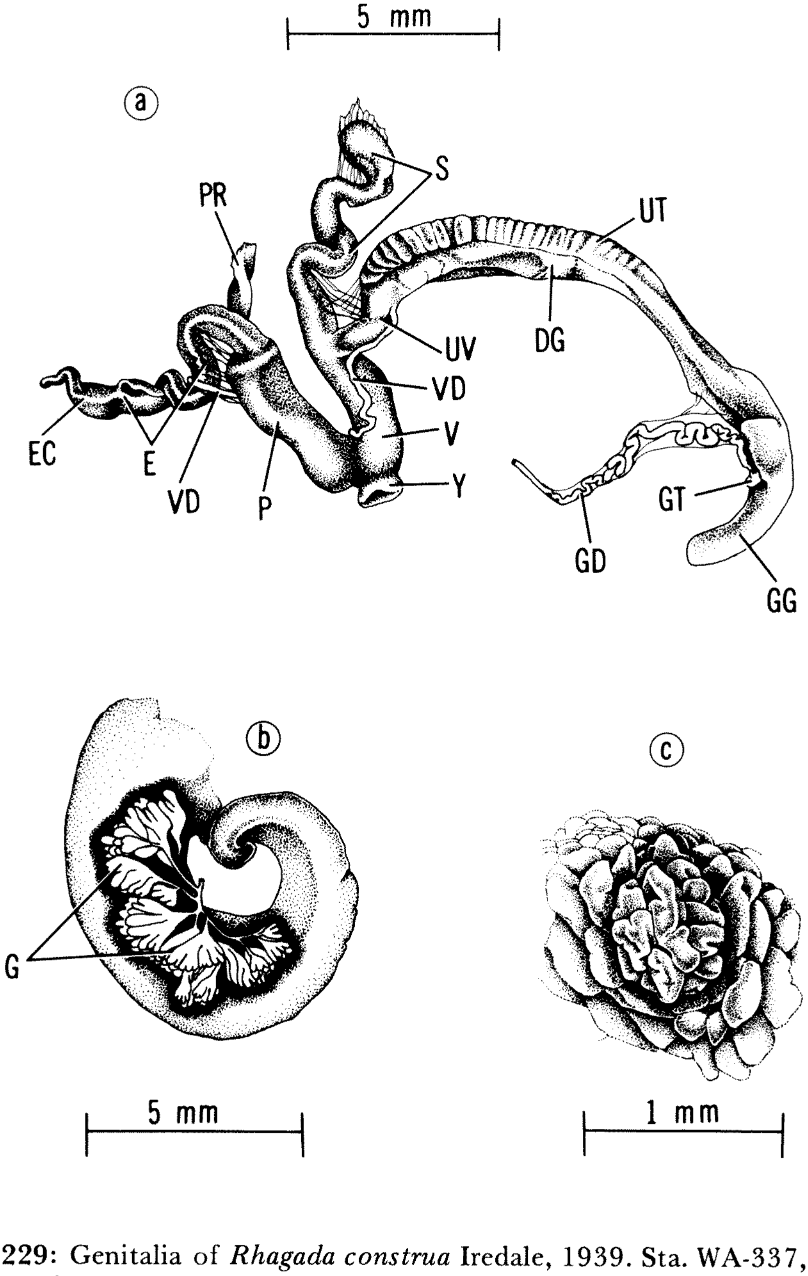

Fig. 229: Genitalia of *Rhagada construa* Iredale, 1939. Sta. WA-337, 6.4 km east of Yammera Gap, Napier Ranges, 23 December 1976, FMNH 200119, Dissection A: (a) whole genitalia; (b) ovotestis; (c) head wart. Scale lines as marked. Drawings by Linnea Lahlum.

Holotype

AM C.64851, Oscar Range among the limestone. Collected by W.W. Froggatt. Height of holotype 11.5 mm, diameter 15.5 mm, H/D ratio 0.742, whorls 5¾–, umbilicus completely closed by broad callus.

Paratopotypes

AM C.79564, WAM 58.40, 52 dead adults, 6 dead juveniles from the type locality.

Other material

Central Napier Ranges (all specimens collected December 1976 to March 1977): Sta. WA-337, cliff base 6.4 km east-south-east of Yammera Gap ('Lennard' 3863 – 991:786) (2 live, 90 dead adults, WAM 81.84, WAM 83.84, FMNH 199268, FMNH 199281, FMNH 199815, FMNH 200119); Sta. WA-343, 3.6 km south-east Yammera Gap ('Lennard' 3863 – 964: 807) (2 dead adults, FMNH 199114); Sta. WA-344, north-east side low cliff, 3.2 km south-east of Yammera Gap ('Lennard' 3863 – 960:807)

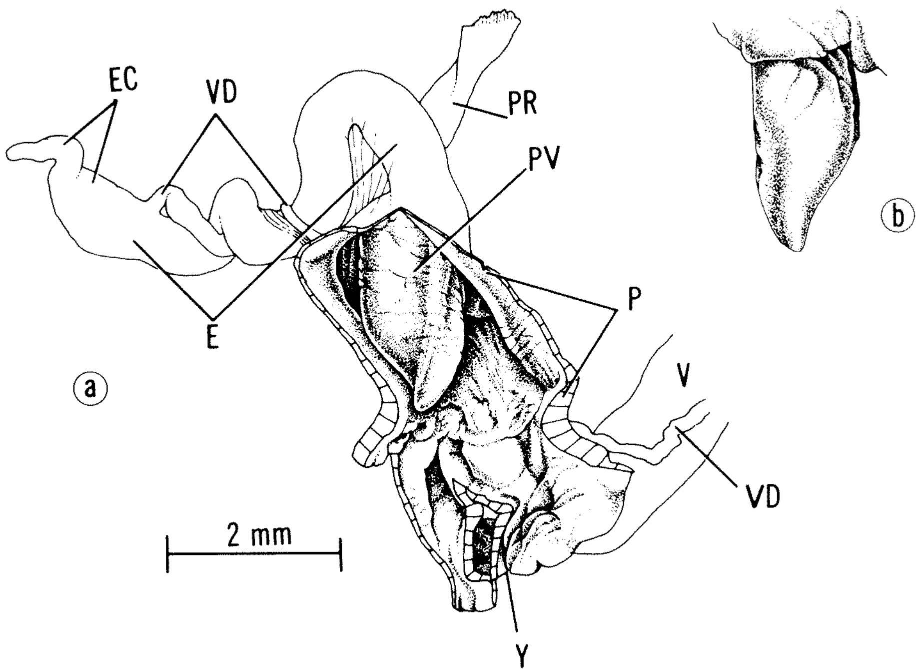

Fig. 230: Penis interior of *Rhagada construa* Iredale, 1939. Sta. WA-337, 6.4 km east of Yammera Gap, Napier Ranges, 23 December 1976, FMNH 200119, Dissection A: (a) penis interior; (b) reverse side of verge. Scale line equals 2 mm. Drawings by Linnea Lahlum.

Table 91: Local Variation in Other Kimberley *Rhagada*

Taxon	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
R. construa Iredale, 1939				
AM C.79564, paratopotypes	48D	10.36±0.145 (8.4–12.5)	14.91±0.163 (12.2–16.9)	0.695±0.006 (0.602–0.791)
WA-337, FMNH 199268	24D	9.67±0.137 (8.25–11.1)	14.35±0.183 (12.9–16.05)	0.675±0.006 (0.616–0.719)
WA-337, FMNH 199281	66D	9.79±0.092 (8.05–12.2)	14.37±0.095 (12.45–16.1)	0.682±0.005 (0.604–0.777)
WA-376, FMNH 199303	12D	11.03±0.186 (10.1–12.2)	14.98±0.179 (14.1–16.3)	0.737±0.104 (0.654–0.787)
R. sutra Iredale, 1939				
WA-312, FMNH 199338	9D	9.39±0.211 (8.5–10.5)	13.71±0.284 (12.8–15.3)	0.685±0.007 (0.645–0.704)
Old Napier Downs Cave, WAM 226.74	8D	9.63±0.249 (9.05–11.2)	14.46±0.374 (13.2–16.45)	0.666±0.007 (0.634–0.687)
R. mimika Iredale, 1939				
NR VII, WAM 922.76	45D	8.12±0.071 (7.1–9.15)	13.04±0.100 (11.5–14.75)	0.623±0.004 (0.556–0.701)
R. basedowana Iredale, 1939				
AM C.42212, paratopotypes	45D	8.92±0.090 (7.65–10.7)	13.54±0.096 (12.0–14.6)	0.660±0.006 (0.591–0.748)
NR II-14, WAM 369.80	15D	10.57±0.188 (9.4–11.9)	14.92±0.278 (13.35–17.7)	0.709±0.008 (0.657–0.757)
NR II, WAM 911.76	43D	9.52±0.154 (7.5–11.5)	13.36±0.174 (11.3–15.9)	0.713±0.009 (0.620–0.830)
WA-715, FMNH 205340	11L	10.42±0.219 (9.6–11.95)	14.87±0.233 (13.6–16.05)	0.702±0.013 (0.626–0.799)
NR IX, WAM 907.76	62D	10.74±0.132 (8.2–13.0)	15.15±0.169 (12.75–18.9)	0.709±0.005 (0.603–0.808)
WA-717, FMNH 205351	28D	9.48±0.117 (8.0–10.5)	14.48±0.114 (13.05–15.5)	0.655±0.006 (0.556–0.702)
Red Bull Mill, WAM 368.80	23D	11.12±0.202 (9.5–13.8)	15.40±0.194 (13.6–17.0)	0.722±0.008 (0.665–0.817)
R. gibbensis				
WA-379, FMNH 199287	19D	11.99±0.151 (11.0–13.1)	18.43±0.199 (17.0–20.15)	0.651±0.008 (0.591–0.734)
R. harti				
WA-316, FMNH 200189	49L	10.67±0.067 (9.4–12.2)	15.78±0.111 (13.25–17.7)	0.677±0.003 (0.624–0.731)
WA-316, FMNH 199294	103D	10.69±0.070 (9.0–12.85)	15.75±0.081 (13.5–18.6)	0.679±0.003 (0.607–0.776)
R. crystalla				
Mitchell Plateau, WAM 336.80	10D	9.42±0.146 (8.85–10.35)	13.29±0.173 (12.6–14.3)	0.709±0.011 (0.661–0.765)
Crystal Creek, WAM 376.80	7L	9.49±0.152 (8.9–10.1)	13.80±0.268 (13.1–15.3)	0.688±0.008 (0.662–0.729)

Table 91: Local Variation in Other Kimberley *Rhagada* (continued)

Taxon	Number of Adults Measured	Whorls	Umbilical Width
R. construa Iredale, 1939			
AM C.79564, paratopotypes	48D	5⅜ (5– –5¾+)	Closed
WA-337, FMNH 199268	24D	5⅜ – (5–5⅞)	Closed
WA-337, FMNH 199281	66D	5¼+ (4¾+–5¾–)	Closed
WA-376, FMNH 199303	12D	5½+ (5¼–5⅞)	Closed
R. sutra Iredale, 1939			
WA-312, FMNH 199338	9D	5¼– (4⅞–5½–)	Cracked
Old Napier Downs Cave, WAM 226.74	8D	5⅜+ (5¼+–5¾–)	Cracked
R. mimika Iredale, 1939			
NR VII, WAM 922.76	45D	5¼– (4⅞–5½+)	Closed
R. basedowana Iredale, 1939			
AM C.42212, paratopotypes	45D	5⅛+ (4⅞– –5⅝–)	Closed
NR II-14, WAM 369.80	15D	5⅜+ (5⅛–5¾)	Closed
NR II, WAM 911.76	43D	5¼– (4⅜–5⅞)	Closed
WA-715, FMNH 205340	11L	5¾– (5¼–6–)	Closed
NR IX, WAM 907.76	62D	5½– (5⅛–6)	Closed
WA-717, FMNH 205351	28D	5⅜ – (5+–5⅝+)	Closed
Red Bull Mill, WAM 368.80	23D	5½ (5–6⅛)	Closed
R. gibbensis			
WA-379, FMNH 199287	19D	5½ (5¼–6)	Cracked To open
R. harti			
WA-316, FMNH 200189	49L	5⅝ – (5¼+–5⅞–)	Closed
WA-316, FMNH 199294	103D	5½+ (5⅛+–6)	Closed
R. crystalla			
Mitchell Plateau, WAM 336.80	10D	5⅜ – (5– –5⅝–)	Cracked
Crystal Creek, WAM 376.80	7L	5¾+ (5⅝– –5⅞+)	Cracked

(3 dead adults, 1 dead juvenile, WAM 82.84, FMNH 199078); Sta. WA-376, south-east of Wombarella Gap ('Lennard' 3863 – 878:871) (1 live, 11 dead adults, WAM 80.84, FMNH 199303, FMNH 200151).

Distribution limits

The few collections of *Rhagada construa* Iredale, 1939 are between Wombarella Gap and 6.4 km south-east of Yammera Gap, a total distance of less than 15 km.

Diagnosis

Shell average in size, diameter 12.2-16.9 mm (mean 14.58 mm), with 4¾+ to 5⅞ (mean 5⅜ –) normally coiled whorls. Apex and spire moderately and almost evenly elevated **(Fig. 222e)**, height of shell 8.05-12.5 mm (mean 10.04 mm), H/D ratio 0.602-0.791 (mean 0.689). Postapical whorls smooth, without radial ribbing. Periphery rounded, body whorl descending moderately just before aperture. Lip narrow, not thickened, with very weak or no basal ridge. Umbilicus closed by a broad callus. Colour typical, several narrow and one wider spiral red bands. Based on 159 measured adults.

Genitalia **(Figs 229a-c, 230)** with short vagina (V) and free oviduct (UV), relatively short spermatheca (S). Epiphallus (E) barely longer than penis (P), epiphallic caecum (EC) short and with a wide base. Penial retractor muscle (PR) inserts near base of verge. Walls of penis **(Fig. 230a)** rather thin, verge (PV) short and broad, with narrow tip. Head wart **(Fig. 229c)** nearly circular, composed of a few bumps that do not differ greatly from the surrounding skin surface. Jaw and teeth typical. Lateromarginal transition **(Plate 91d)** occurs rapidly. Based on one dissected adult.

Remarks

Although the type locality was cited as 'Oscar Ranges', the specimens that most closely match the types come from the central Napier Ranges. This is another example of Froggatt's material having become disassociated from the original locality data during subsequent handling, see also *Quistrachia monogramma* (Ancey, 1898) (p. 851).

Size variation **(Table 91)** is moderate.

RHAGADA SUTRA IREDALE, 1939
(Plates 89c, 91e-f, 92b; Figs 223d-f, 231a-e)

Rhagada sutra Iredale, 1939, Jour. Roy. Soc. Western Australia, **25**: 61, pl. IV, fig. 9 – found under logs and damp stones, Napier Range (W.W. Froggatt).

Comparative remarks

Rhagada sutra Iredale, 1939 lacks any trace of a lip ridge, usually has an umbilical crack, the sculpture on the spire is very weak, and it normally retains the typical colour pattern. *R. basedowana* Iredale, 1939 from the north-western part of the Napier Range, differs in generally having lost the spiral colour bands (**Figs 224a-c**), having a closed umbilicus, and a smooth shell surface. *R. construa* Iredale, 1939 from east of Wombarella Gap, has a closed umbilicus, the shell surface is smooth, and there is at most a weak lip ridge. Anatomically, *R. sutra* (**Figs 231a-e**) has all the terminal organs relatively short: the vagina (V) equals the penis (P) in length, the epiphallus (E) is short, and the epiphallic caecum (EC) reduced to a nub (**Fig. 231d**). The verge (PV) is short and blunt-tipped, occupying less than half the length of the rather thick-walled penis (P, **Fig. 231d**). The spermatheca (S) is short and kinked, rather than coiled. The longer terminal organs and slender verges of *R. gatta* (**Figs 227a-b, 228a**) and *R. basedowana* (**Figs 232a, c**) easily separate those two species.

Holotype

AM C.64858, found under logs and limestone, Napier Range. Collected by W.W. Froggatt. Height of holotype 9.8 mm, diameter 13.9 mm, H/D ratio 0.705, whorls $5^3/_8$, umbilicus a narrow crack caused by incomplete reflexion of columellar lip.

Paratopotypes

AM C.64858-9, WAM 62.40, FMNH 201567, 8 dead adults from the type locality.

Other material

Central-west Napier Range (NR II material collected May 1976; WA-301, WA-312, WA-354 material collected December 1976; others as indicated): Sta. WA-301, north-west side Yammera Gap ('Lennard' 3863 – 933:819) (1 dead adult, FMNH 199184); NR II-7a, east entrance to Wombarella Gap (1 dead adult, WAM); NR II-2a-c, north-east facing cliffs, north corner, west of Barker River-Wombarella Creek junction (8 dead adults, WAM); Sta. WA-354, north-west side Barker Gorge, 0.7 km south of Barker River ford ('Lennard' 3863 – 832:913) (1 dead adult, FMNH 199111); Sta. WA-312, 3.2 km west of Barker Gorge ('Lennard' 3863 – 808:914) (2 live, 9 dead adults, 1 live, 1 dead juvenile, WAM 80.84, FMNH 199338, FMNH 200188); under spinifex on plains at Old Napier Downs Cave (4 live, 8 dead adults, 8 dead juveniles, WAM, WAM 226.74, collected by A.M. Douglas and G.W. Kendrick 9 June 1966); NR II-5b, ca 9 km north-west of Barker River crossing (1 dead adult, WAM).

Distribution limits

Rhagada sutra has been taken in a few localities between Yammera Gap and 9 km north-west of the Barker River.

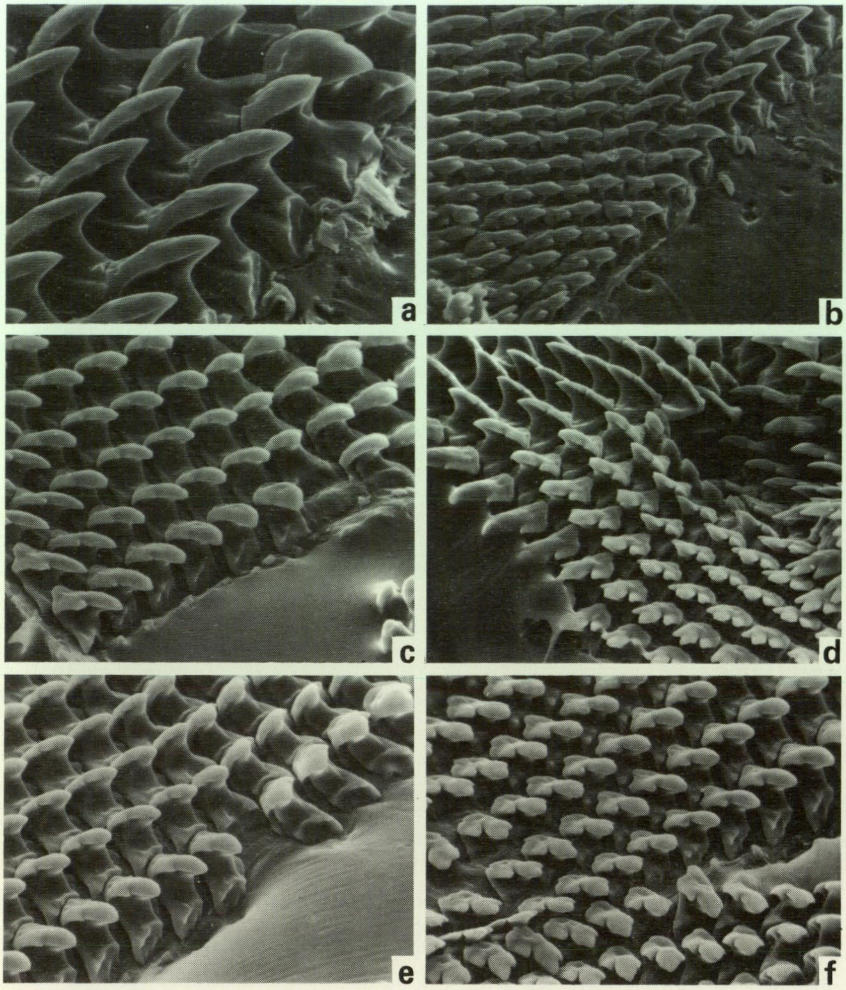

Plate 91: Radular teeth of Kimberley *Rhagada:* (a-b) *R. crystalla,* Sta. 3, Crystal Creek, Mitchell Plateau, FMNH 209069, 2 November 1976, Dissection A, a is central and early lateral teeth from a high side view at 650X, b is lateromarginal transition from a high side angle view at 365X; (c) *R. basedowana* Iredale, 1939, Sta. WA-715, 7.6 km north of Original Napier Downs Homestead, Napier Range, FMNH 205340, 20 June 1980, Dissection A, central and lateral teeth from a medium front angle view at 350X; (d) *R. construa* Iredale, 1939, Sta. WA-337, 6.4 km south-east Yammera Gap, Napier Range, FMNH 200119, 23 December 1976, Dissection A, lateromarginal transition at 333X; (e-f) *R. sutra* Iredale, 1939, Sta. WA-312, 3.2 km west of Barker Gorge, Napier Range, FMNH 200188, 12 December 1976, Dissection A, e is central and lateral teeth from high near side angle at 355X, f is lateromarginal transition at 365X.

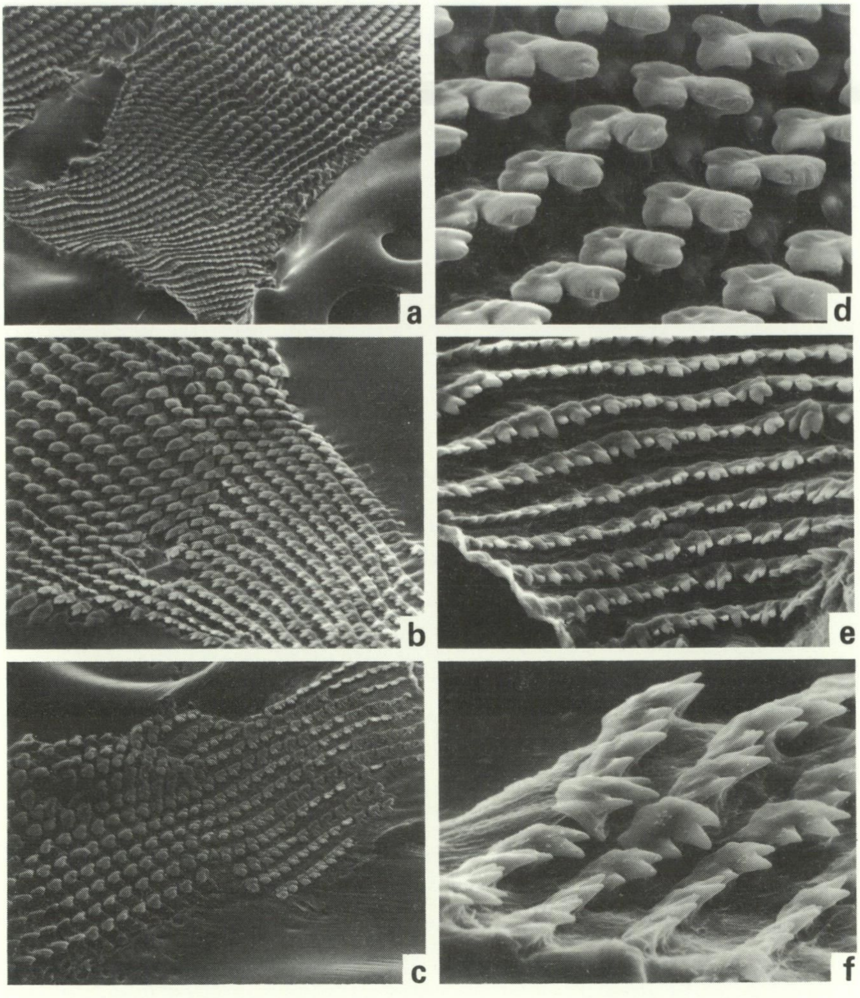

Plate 92: Part rows and marginal radular teeth of Kimberley *Rhagada:* (a) *R. gatta* Iredale, 1939, Sta. WA-276, 3.6 km north-west of Wine Spring, north of Oscar Ranges, FMNH 200191, 4 December 1976, part row at 74.7X; (b) *R. sutra* Iredale, 1939, Sta. WA-312, west of Barker Gorge, Napier Range, FMNH 200188, 12 December 1976, Dissection A, part row at 141X; (c) *R. crystalla,* Sta. 3, Crystal Creek, Mitchell Plateau, FMNH 209069, 2 November 1976, Dissection A, part row at 138X; (d) *R. sutra* Iredale, 1939, Sta. WA-312, worn early marginal teeth at 360X; (e) *R. gatta* Iredale, 1939, Sta. WA-276, outer marginals at 405X; (f) *R. basedowana* Iredale, 1939, Sta. WA-715, 7.6 km north of Original Napier Downs Homestead, Napier Range, FMNH 205340, 20 June 1980, Dissection A, outer marginal teeth from low side angle view at 665X.

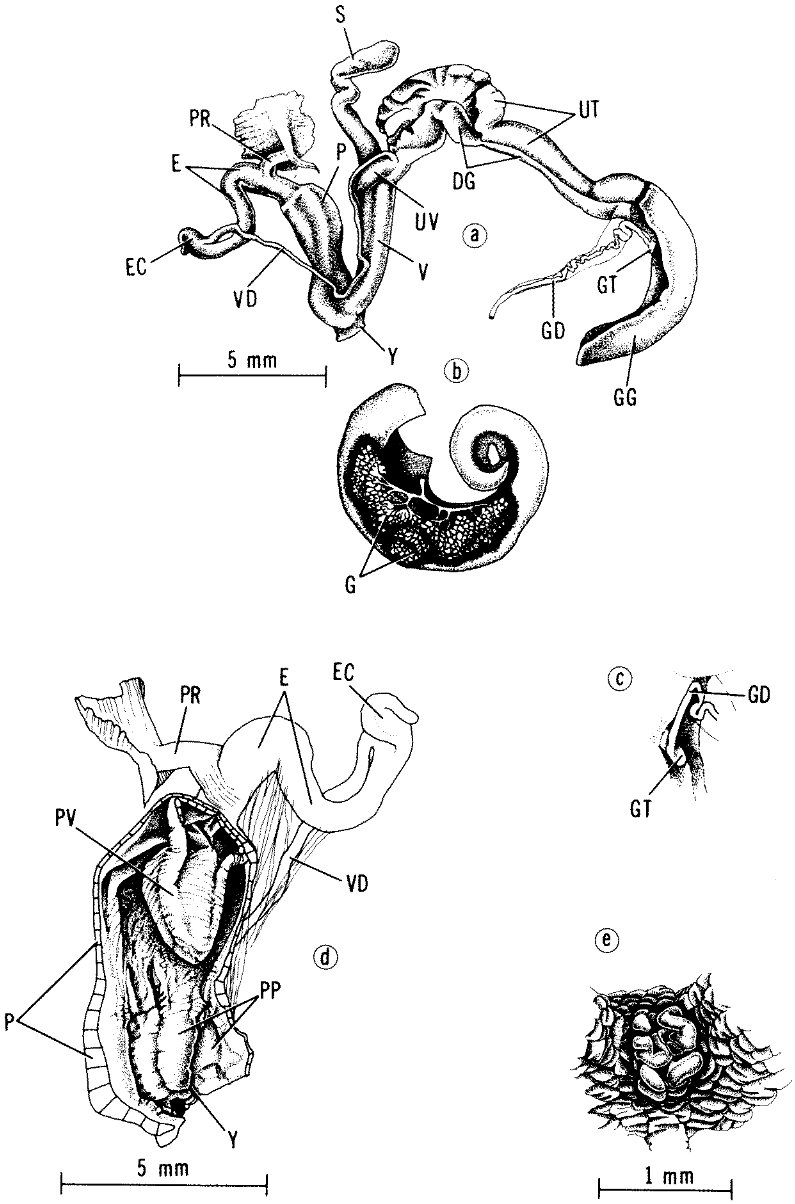

Fig. 231: Genitalia of *Rhagada sutra* Iredale, 1939. Sta. WA-312, 3.2 km west of Barker Gorge, Napier Range, 12 December 1976, FMNH 200188, Dissection A: (a) whole genitalia; (b) ovotestis; (c) detail of talon; (d) interior of penis; (e) head wart. Scale lines as marked. Drawings by Linnea Lahlum.

Diagnosis

Shell of medium size, diameter 11.1-16.6 mm (mean 14.07 mm), with 4½+ to 5¾ (mean 5¼+) normally coiled whorls. Apex and spire moderately and evenly elevated, slightly rounded above **(Fig. 223e)**, height of shell 7.5-11.7 mm (mean 9.56 mm), H/D ratio 0.627-0.796 (mean 0.686). Postapical whorls with faint, irregular radial growth lines, base of shell smooth. Periphery rounded, body whorl barely descending before lip, which lacks any trace of a lip ridge. Lip narrow, not thickened. Umbilicus normally with a narrow lateral crack, rarely closed. Colour pattern normal, several fine spiral bands above and below main peripheral band. Based on 45 measured adults.

Genitalia **(Figs 231a-e)** with penis (P) and vagina (V) equal in length, spermatheca (S) short and kinked. Epiphallus (E) rather short, penial retractor muscle (PR) inserting well above base of verge, epiphallic caecum (EC) reduced to a nub. Walls of penis medium in thickness **(Fig. 231d)**, verge (PV) short, wide and with blunt tip. Head wart **(Fig. 231e)** almost square in shape, composed of a few elongated pustules. Jaw **(Plate 89c)** typical, ribs absent from outer margins. Radula **(Plate 92b)** with many marginal teeth, laterals **(Plate 91e)** and lateromarginal transition **(Plate 91f)** typical. Based on one dissected adult.

Remarks

Rhagada sutra Iredale, 1939 differs from *R. mimika* in having a slightly open umbilicus, no lip ridge, and in being larger and more elevated **(Table 89)**. So little material is known of the latter species that this may be an incorrect separation. The partial overlap of known examples also suggests that they may indeed be the same species. Present material is not adequate to answer this problem. Size variation among samples is moderate **(Table 91)**.

RHAGADA MIMIKA IREDALE, 1939
(Figs 223a-c)

Rhagada mimika Iredale, 1939, Jour. Roy. Soc. Western Australia, 25: 61, pl. IV, fig. 4 – on grass, etc., Napier Range (W.W. Froggatt).

Comparative remarks

Rhagada mimika Iredale, 1939 is very small, has a closed umbilicus, prominent ridge on the basal lip, and an almost smooth shell surface. *R. sutra* Iredale, 1939 lacks the lip ridge, almost always has the umbilicus present as a narrow lateral crack **(Fig. 223f)**, and is slightly larger. *R. basedowana* Iredale, 1939 normally lacks the colour bands, always has the umbilicus closed, is larger **(Table 89)**, and lacks a basal lip ridge. Anatomy unknown.

Holotype

AM C.64855, in grass, Barrier Range. Collected by W.W. Froggatt. Height of holotype 8.4 mm, diameter 12.2 mm, H/D ratio 0.689, whorls 4⅞, umbilicus completely closed by a broad callus.

Paratopotypes

AM C.79565, WAM 60.40, 3 dead adults from the type locality.

Other material

North-west Napier Range: Sta. WA-331, 1.6 km south-east Barker Gorge ('Lennard' 3863 – 844:893) (1 dead adult, FMNH 199087, collected by L. Price and C. Christensen 21 December 1976); NR VII, south-west facing embayment at north-west end of Napier Range ('Lennard' 3863 – ca 674: 119) (45 dead adults, WAM 922.76, FMNH 209071).

Distribution limits

The only two known localities are 1.6 km south-east of Barker Gorge and then at the extreme north-west tip of the Napier Range. *Rhagada basedowana* Iredale, 1939 and *R. sutra* Iredale, 1939 are recorded from intermediate localities.

Diagnosis

Shell small, diameter 11.5-14.75 mm (mean 12.97 mm), with 4¾ to 5½+ (mean 5⅛+) normally coiled whorls. Apex and spire slightly and evenly elevated **(Fig. 223b)**, shell rather depressed, height of shell 7.1-9.15 mm (mean 8.11 mm), H/D ratio 0.556-0.701 (mean 0.626). Postapical whorls nearly smooth. Periphery rounded, body whorl barely descending just before aperture. Lip narrow, not thickened, with a prominent basal ridge. Umbilicus closed by a broad callus. Colour typical, with many spiral red bands. Based on 49 measured adults.

Anatomy unknown.

Remarks

The depressed shape, small size, prominent basal lip ridge, closed umbilicus and retention of spiral banding are the main features separating *R. mimika* from the neighbouring *R. basedowana* Iredale, 1939 and *R. sutra* Iredale, 1939. So little material is available, that the status of these as separate species seems uncertain. Size variation among populations of these species exceeds the between species differences **(Table 91)**.

RHAGADA BASEDOWANA IREDALE, 1939

(Plates 89e, 91c, 92f; Figs 224a-c, 232a-d)

Rhagada basedowana Iredale, 1939, Jour. Roy. Soc. Western Australia, 25: 61, pl. IV, fig. 6 – on trees and on *Triodia* tussocks, off the limestone caves, north end of Napier Range (H. Basedow).

Comparative remarks

Except for the lack of colour bands in most populations (**Figs 224a-c**), *Rhagada basedowana* Iredale, 1939 is very similar in size and shape to *R. construa* Iredale, 1939 (**Table 89**). The latter has a greater descension of the body whorl and there is a full colour pattern developed. *R. mimika* Iredale, 1939 (**Figs 223a-c**) is significantly smaller, more depressed, has a strong basal lip ridge, and slight descension of the body whorl. *R. sutra* Iredale, 1939 (**Figs 223d-f**) differs in its slightly open umbilicus, full colour pattern, and slight descension of the body whorl. Anatomically, *R. basedowana* is characterised by its very short spermatheca (S), long and slender verge (PV) in a very thin-walled penis (P), thick-based epiphallic caecum (EC), and in having the penis and vagina (V) both short and nearly equal in length (**Figs 232a-c**). No other Kimberley *Rhagada* matches the combination of short spermatheca and very long verge.

Holotype

AM C.64880, on trees off limestone caves, Napier Range. Collected by H. Basedow. Height of holotype 9.9 mm, diameter 14.5 mm, H/D ratio 0.683, whorls 5⅜, umbilicus completely covered by a broad callus.

Paratopotypes

AM C.42219, WAM 61.40, FMNH 200800, 59 dead adults, 100+ dead juveniles from the type locality.

Other material

North-west Napier Range, organised geographically south-east to north-west (NR collected August 1975; NR II collected August 1976; WA-714-7 collected June 1980): Sta. WA-714, 2.1 km into south side Wagon Pass ('Lennard' 3863 – 730:001) (2 live, 6 dead adults, 4 live juveniles, WAM 109.84-110.84, FMNH 205317-8, FMNH 205337); NR II-15, ca 4 km north-east of east end Wagon Pass (4 dead adults, WAM); NR II-14, north of Wagon Pass (15 dead adults, WAM 369.80); NR II, north-east of Wagon Pass near Original Napier Downs Homestead ruins (44 dead adults, WAM 911.76, WAM 916.76); NR III-1, 5 km north of Original Napier Downs Homestead ('Lennard' 3863 – 710:049) (6 dead adults, WAM 370.80); NR V, north-west of Stumpy's Well ('Lennard' 3863 – 695:082) (3 dead adults, WAM 913.76); Sta. WA-715, 7.6 km north of Original Napier Downs Homestead ('Lennard' 3863 – ca 707:064) (17 dead adults, 4 dead juveniles, WAM 105.84-106.84, FMNH 205339-40); south-east of NR IX (62 dead adults, WAM 907.76); NR IX, near Barnet Cave (7 dead adults, WAM 908.76, WAM 918.76); Sta. WA-717, 2.1 km south of Hawkstone Creek crossing, 1 km in from track ('Lennard' 3863 – 674:147) (35 dead adults, 6 dead juveniles, WAM 107.84-108.84, FMNH 205350-1); NR II-6, north end Napier Range bearing 115° on van Emmerick Range ('Lennard River' SE 51-8 – 234:855)

(1 dead adult, WAM); under grass tussocks, Red Bull Mill ('Lennard River' SE 51-8 – 248:848) (3 live, 23 dead adults, WAM, WAM 368.80).

Distribution limits

Rhagada basedowana Iredale, 1939 appears to be generally distributed from Wagon Pass to the north-west end of the Napier Range. It is not universally distributed, as comparing the records of *Westraltrachia woodwardi* (Fulton, 1902) (Solem 1984: 495-6) and *Amplirhagada napierana* Solem (1981a: 227-9) and *A. percita* (Iredale, 1939) (Solem 1981a: 220-221) will demonstrate. There are a number of stations at which the latter have been taken from which there are no records of *R. basedowana.* This section of the range has been less affected by fire than the region between Windjana Gorge and Barker River Gorge, so that *R. basedowana* remains comparatively plentiful, while the others are nearly extinct.

Diagnosis

Shell of average size, diameter 11.3-18.9 mm (mean 14.49 mm), with 4⅜ to 6⅛ (mean 5⅜+) relatively tightly coiled whorls. Apex and spire strongly and almost evenly elevated **(Fig. 224b)**, not rounded above, height of shell 7.5-13.8 mm (mean 10.03 mm), H/D ratio 0.556-0.830 (mean 0.692). Postapical whorls without significant radial sculpture. Periphery rounded or occasionally bluntly angulated, body whorl barely descending just before aperture. Lip narrow, not expanded, without a basal lip ridge. Umbilicus closed by a thick callus. Colour chalky white, some specimens with a single slightly supraperipheral, narrow red spiral band, most without any red banding. Based on 309 measured adults.

Genitalia **(Figs 232a-d)** with spermatheca (S) and free oviduct (UV) both very short. Vagina (V) and penis (P), short, nearly equal in length. Walls of penis very thin, verge (PV) quite long and slender, spatulate rather than tubular in form. Epiphallus (E) coiled around vas deferens, rather long, epiphallic caecum rather short, base wide. Head wart **(Fig. 232d)** composed of two rows of small pustules, almost circular in shape. Jaw **(Plate 89e)** typical. Radular teeth **(Plates 91c, 92f)** without unusual features. Based on three dissected adults.

Remarks

The loss of spiral red banding in *Rhagada basedowana* is remarkable. It parallels the chalky white colour of both *Amplirhagada napierana* Solem, 1981 and *Westraltrachia woodwardi* (Fulton, 1902) in the same region. The latter two mark the end of a gradual pattern of conchological convergence that starts east of Windjana Gorge (see Solem, in press). The reasons for this change are unknown. Variation in size and shape among the several large samples is fairly extensive **(Table 91)**.

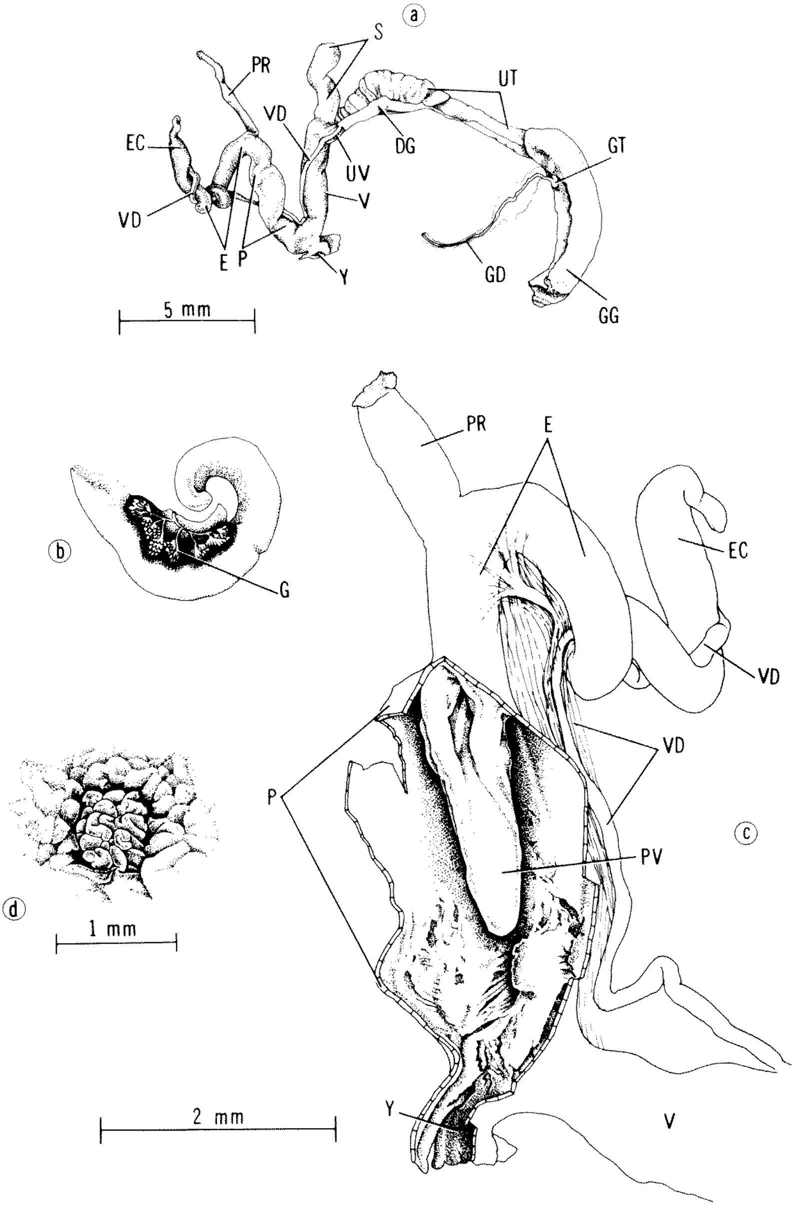

Fig. 232: Genitalia of *Rhagada basedowana* Iredale, 1939. Sta. WA-717, near north end Napier Range, east of Derby, 21 June 1980, FMNH 205350: (a) whole genitalia, Dissection A; (b) ovotestis, Dissection A; (c) interior of penis, Dissection B; (d) head wart, Dissection A. Scale lines as marked. Drawings by Linnea Lahlum.

RHAGADA GIBBENSIS SP. NOV.
(**Figs 225a-c**)

Comparative remarks

Rhagada gibbensis is most similar to *R. gatta* Iredale, 1939 (**Figs 222a-c**), but is easily recognised by its slightly open or cracked umbilicus, more depressed shape, and generally more prominent basal lip ridge. *R. harti* (**figs 225d-f**) is smaller (**Table 89**) and more elevated, with a closed umbilicus and no trace of a basal lip ridge. The other Kimberley species are much smaller. The anatomy of *R. gibbensis* is unknown.

Holotype

WAM 75.84, Sta. WA-379, north slope of hill, 1 km south of Gibb River Road, ca 6 km north-east Macs Jumpup, King Leopold Ranges, Western Australia (1:100,000 'Richenda' map sheet 3963 – grid reference 165: 023). Collected by L. Price and C. Christensen 28 February 1977. Height of holotype 12.6 mm, diameter 18.2 mm, H/D ratio 0.692, whorls 5½–, umbilicus a narrow lateral crack.

Paratopotypes

WAM 457.77, WAM 76.84, FMNH 199287, FMNH 204694, 25 dead adults from the type locality (Stas WA-379 and WA-576).

Diagnosis

Shell large, diameter 16.8-20.2 mm (mean 18.30 mm), with 5¼ to 6 (mean 5½+) normally coiled whorls. Apex and spire moderately and almost evenly elevated (**Fig. 225b**), height of shell 10.3-13.1 mm (mean 11.81 mm), H/D ratio 0.591-0.734 (mean 0.646). Postapical whorls with irregular radial growth lines, almost of rib strength, base of shell smooth. Periphery rounded, body whorl at most descending slightly. Lip narrow, not thickened, without trace of basal ridge. Umbilicus a narrow lateral crack (as in holotype) to slightly open, widest only 1.8 mm wide, never completely closed. Colour typical, a wider slightly supraperipheral spiral red band, several narrower spiral bands on upper palatal wall and shell base. Based on 26 measured adults.

Anatomy unknown.

Remarks

Despite attempts in August 1975 by B. Wilson and S. Slack-Smith, February 1977 by Price and Christensen, and May 1980 by Solem and Price, no live specimens of *Rhagada gibbensis* have been collected. On each occasion one or more fresh specimens have been collected, so that I assume there is a viable population deeply hidden in the fissured boulders or burrowed in the soil nearby. The area in which they have been found is limited in extent, and all collectors have sampled from the same rock mass. No significant variation was detected among the samples.

The name *gibbensis* honours the Gibb River beef road and its residents.

RHAGADA HARTI SP. NOV.
(Plates 89d, 90c-f; Figs 225d-f, 233a-c)

Comparative remarks

In having a closed umbilicus (**Fig. 225f**), moderate body whorl descension (**Fig. 225e**), full colour pattern, no significant radial sculpture, and little or no trace of a lip ridge, *Rhagada harti* agrees with *R. gatta* Iredale, 1939 and *R. construa* Iredale, 1939. Its accentuated colour pattern and anatomical differences are the main differentiating features. The neighbouring *R. gibbensis* (**Figs 225a-c**) has an open umbilicus, more depressed shape, and is much larger in size (**Table 89**). *R. mimika* Iredale, 1939, *R. sutra* Iredale, 1939 and *R. basedowana* Iredale, 1939 differ in their lack or comparative lack of body whorl descension before the aperture and details of size and shape. Anatomically, *R. harti* has a slender verge (PV) with bulbous tip (**Fig. 233b**), very long vagina (V) and spermatheca (S, **Fig. 233a**), and very slender epiphallic caecum (EC). *R. crystalla* (**Figs 235a-b**) has the only equivalent verge among the Kimberley species, but differs dramatically in the proportions of the terminal genitalia (**Fig. 234a**). *R. gatta* (**Figs 227a-b, 228a-c**) has a much longer vagina and spermatheca, and the verge has a very narrow tip.

Holotype

WAM 73.84, Sta. WA-316, yard and garden of Mt Hart Homestead, King Leopold Ranges, Western Australia (1:100,000 'Matthew' map sheet 3864 – grid reference 390:040). Collected by L. Price and C. Christensen 13 December 1976. Height of holotype 10.3 mm, diameter 15.35 mm, H/D ratio 0.671, umbilicus completely closed.

Paratopotypes

WAM 74.84, WAM 77.84-79.84, FMNH 199294, FMNH 200189, FMNH 200239-40, FMNH 200048-50, 107 live, 109 dead adults from the type locality.

Paratypes

King Leopold Ranges: Mt Hart (8 adults, 12 juveniles, mostly live collected, but not preserved, WAM 223.74, collected by A.M. Douglas 1-15 February 1965).

Diagnosis

Shell average in size, diameter 13.27-18.6 mm (mean 15.62 mm), with 4¾ to 6 (mean 5½–) normally coiled whorls. Apex and spire strongly and

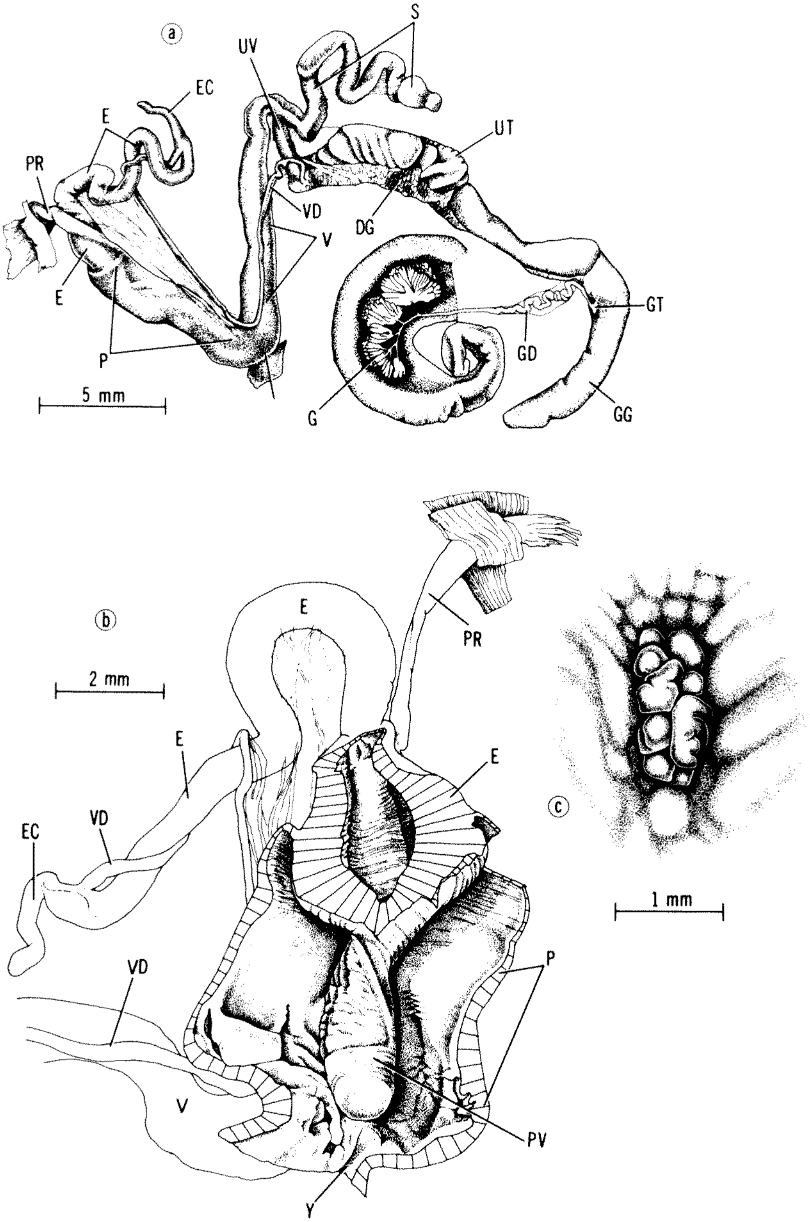

Fig. 233: Genitalia of *Rhagada harti*. Sta. WA-316, garden of Mt Hart Homestead, King Leopold Ranges, 25 January 1977, FMNH 200189: (a) whole genitalia, Dissection A; (b) interior of penis, Dissection B; (c) head wart, Dissection A. Scale lines as marked. Drawings by Linnea Lahlum.

almost evenly elevated (**Fig. 225e**), height of shell 8.95-12.85 mm (mean 10.58 mm), H/D ratio 0.607-0.776 (mean 0.677). Postapical whorls smooth to with weak growth irregularities, never ribbed, base smooth. Periphery rounded, body whorl moderately descending just before aperture. Lip narrow, not thickened, basal-columellar lip with a weak to slight ridge. Umbilicus closed by callus, rarely a very narrow lateral slit. Colour typical, many spiral red lines, some specimens with a tendency for expansion of band width above periphery. Based on 218 measured adults.

Genitalia (**Figs 233a-b**) with vagina (V) much longer than penis (P), spermatheca (S) very long and coiled, free oviduct (UV) long. Epiphallus (E) slender, much longer than penis (P), epiphallic caecum (EC) long and slender. Penial retractor muscle (PR) inserts just above base of verge. Penis with thick walls, verge (PV) massive, equal in length to penis, tip bulbous. Head wart (**Fig. 233c**) narrow, elongated, composed of very few bumps. Jaw (**Plate 89d**) and radular teeth (**Plate 90c-f**) without unusual features. Based on five dissected adults.

Remarks

Rhagada harti has been collected only on the grounds of Mt Hart Homestead, which suggests that this could be an introduced species. So little collecting has been done in the King Leopold Ranges, that it is equally possible that it is endemic to this region. The unusual vergic structure and proportions of the terminal genitalia are such that I have described it as a species, since no other *Rhagada* comes close in structure. Size and shape variation between live and dead collected individuals is minimal (**Table 91**).

The name *harti* is after Mt Hart Station in the King Leopold Ranges.

RHAGADA CRYSTALLA SP. NOV.

(Plates 89f, 91a-b, 92c; Figs 226a-c, 234a-b, 235a-b)

Comparative remarks

The small size, slightly open umbilicus, and relatively prominent radial sculpture on the spire separate *Rhagada crystalla* from the other described Kimberley species. *R. sutra* Iredale, 1939 from the Napier Range and *R. gibbensis* from the King Leopold Ranges are the only other umbilicated species: the former lacks the basal lip ridge, has one-quarter whorl less at the same diameter, and has greatly reduced sculpture; the latter is 4.5 mm larger at the same whorl count and has a more open umbilicus and reduced sculpture. Anatomically, *R. crystalla* is most readily distinguished by the long, bulbous tip on the verge (**Figs 235a-b**), rather high insertion of the penial retractor muscle (PR) on the epiphallus (E, **Fig. 234a**), and intermediate length of the spermatheca (S). The only other species with a similar shaped

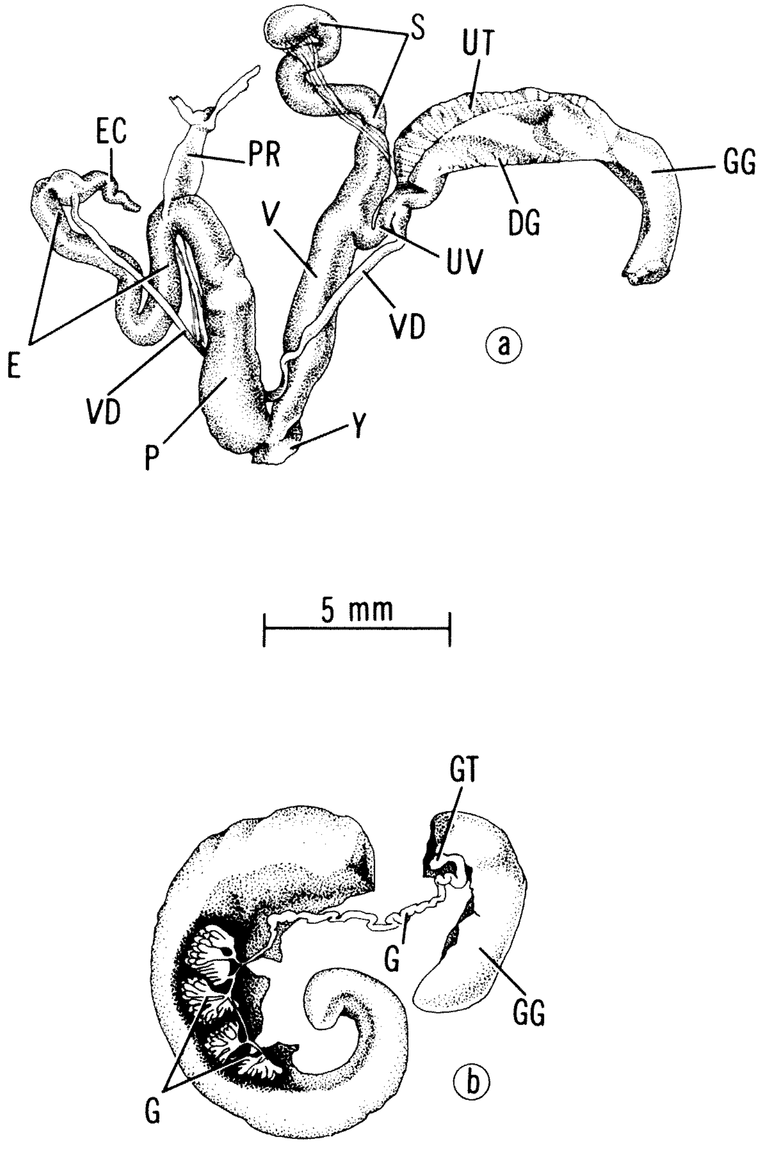

Fig. 234: Genitalia of *Rhagada crystalla.* Sta. 3, Crystal Creek, Mitchell Plateau, 2 November 1976, FMNH 209069, Dissection A: (a) whole genitalia; (b) ovotestis. Scale line equals 5 mm. Drawings by Linnea Lahlum.

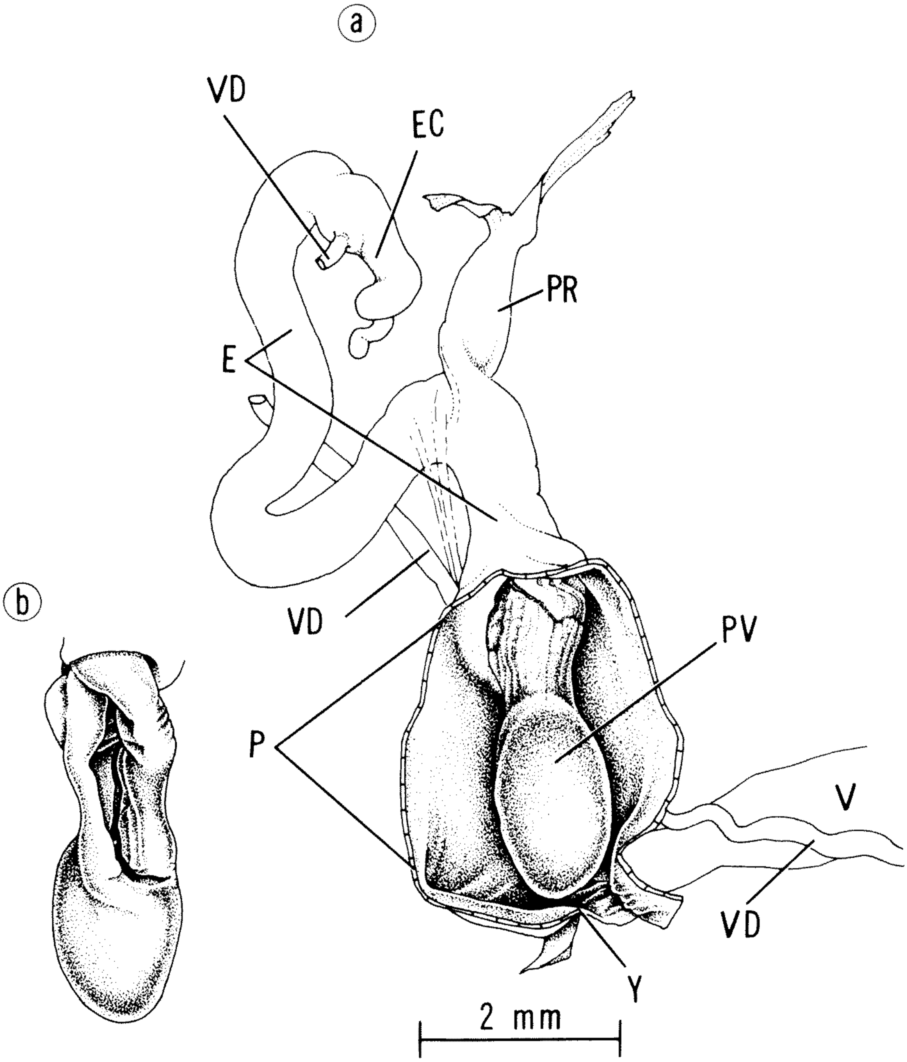

Fig. 235: Penis interior of *Rhagada crystalla*. Sta. 3, Crystal Creek, Mitchell Plateau, 2 November 1976, FMNH 209069, Dissection A: (a) interior of penis; (b) other side of verge. Scale line equals 2 mm. Drawings by Linnea Lahlum.

verge, *R. harti* (**Fig. 233b**), differs in its very long spermatheca (S), much longer vagina (V, **Fig. 233a**), and very thick-walled penis.

Holotype

WAM 71.84, Sta. 3, under sandstone boulders at base of a baobab tree, above guaging station pool, Crystal Creek, Mitchell Plateau, Western Australia (1:100,000 'Warrender' map sheet 4069 – grid reference 965:013). Collected by Barry R. Wilson and Clayton Bryce 2 November 1976. Height of holotype 9.5 mm, diameter 13.8 mm, H/D ratio 0.688, whorls 5½–, umbilicus closed by a callus.

Paratopotypes

WAM 1120.80, WAM 72.84, FMNH 209069, 6 live, 2 dead adults, 1 dead juvenile from the type locality.

Paratypes

Mitchell Plateau: Sta. 1, west side Crystal Creek, King Leopold sandstones ('Admiralty Gulf' 4069 – 968:011) (1 live, 1 dead adult, WAM 375.80); Crystal Creek Pool (1 dead adult, WAM 469.77); Guaging Station, Crystal Creek (1 dead adult, WAM 456.77); Sta. MP-7, near Camp Creek ('Warrender' 4068 – 047:552) (1 dead adult, WAM 328.80, collected by B.R. Wilson and S. Slack-Smith 23 August 1975); Mitchell Plateau under leguminous plants (12 dead adults, WAM 336.80, collected by W.H. Butler 27 September to 6 October 1978); Sta. WA-394, sandstone boulders south-east side Crystal Creek, north-east of road, 8.2 km from Walsh Point Road ('Warrender' 4068 – 946:001) (1 live, 2 dead adults, FMNH 199352, FMNH 200011, FMNH 200782, collected by L. Price and C. Christensen 15 March 1977); Sta. WA-399, sandstone rocks and baobab tree above guaging station pool, Crystal Creek ('Admiralty Gulf' 4069 – 013:965) (2 dead adults, FMNH 199357, collected by L. Keller 18-19 March 1977).

Distribution limits

Rhagada crystalla has been collected from a few stations on the Mitchell Plateau, mostly along Crystal Creek, with one specimen from an inland area near Camp Creek. The full extent of its distribution is unknown.

Diagnosis

Shell relatively small, diameter 12.6-15.72 mm (mean 13.76 mm), with 5– to 5⅞+ rather tightly coiled whorls. Apex and spire strongly and almost evenly elevated (**Fig. 226b**), height of shell 8.1-10.9 mm (mean 9.48 mm), H/D ratio 0.633-0.765 (mean 0.690). Postapical whorls with rib-like growth lines, base of shell smooth. Periphery rounded, body whorl descending very slightly just before aperture. Lip narrow, not thickened, basal-columellar lip margin with a raised ridge of variable prominence. Umbilicus normally a narrow lateral slit, rarely closed, widest opening 1.05 mm. Colour typical, a broader, supraperipheral red spiral band, with narrower spiral bands above and on shell base, some specimens with only the major band. Based on 28 measured adults.

Genitalia **(Figs 234a-b, 235a-b)** with short vagina (V) and free oviduct (UV), spermatheca (S) of intermediate length. Penial retractor muscle (PR) inserting rather high on epiphallus (E), which is fairly long and slender. Epiphallic caecum (EC) intermediate in length. Penis (P) short, very thin-walled, verge (PV) huge, equalling length of penis, sperm groove not reaching near tip, which is bulbously swollen. Jaw **(Plate 89f)** and radular teeth **(Plates 91a-b, 92c)** without unusual features. Based on one dissected adult.

Remarks

Only two samples were large enough to warrant separate listing **(Table 91)**. They are nearly identical in size, although very different in colour, with WAM 336.80 having only the one spiral band and WAM 71.84-72.84 having a full complement of colour bands. The holotype is unusual in having the umbilicus closed, but approximates average size for this species.

The name *crystalla* is taken from the type locality, Crystal Creek.

RHAGADA SP.

Material

Prince Regent River Reserve (all specimens collected in August 1974: Sta. E5 (3), campsite on top of Enid Falls, Rufous Creek, Roe River ('Prince Regent' SD 51-16 – 347:087) (7 dead adults, 4 dead juveniles, WAM 307.75-309.75, FMNH 209070).

Remarks

These few specimens differ from *Rhagada dringi* (Pfeiffer, 1846) from further south in having reduced sculpture and a closed umbilicus. They are similar to *R. crystalla* from the Mitchell Plateau in general appearance, but the sculpture on the spire of the shell is stronger, size much smaller **(Table 89)**, and they are more depressed in shape. In the absence of any anatomical material, it seems best to call attention to their existence, but withhold naming of what appears to be another new species.

ADDENDA TO KIMBERLEY CAMAENIDS

The following notes and descriptions supplement the reviews of genera presented in Parts I-III. They are based primarily on collections made by the author and assistants, plus materials belatedly located in museum collections or picked up in the last few years during non-malacological field work by others. Only data that change taxonomic understanding of species or genera, and records that expand significantly our knowledge of Kimberley land snail biogeography are presented. Observations on generic affinities and limits will be presented elsewhere. Review of about 3,000 specimens is summarised below.

The following new species are described:

Torresitrachia deflecta (Prince Regent River Reserve) (p. 925)
Torresitrachia thedana (Old Theda Station homestead ruins, north Kimberley (p. 930)
Damochlora spina (Carson River Crossing, south of Kalumburu, north Kimberley (p. 933)
Ningbingia dentiens (north Ningbing Ranges, north of Kununurra) (p. 943)
Turgenitubulus tanmurrana (central Ningbing Ranges, north of Kununurra) (p. 947)
Turgenitubulus aslini (The Gorge, central Ningbing Ranges, north of Kununurra) (p. 951)
Turgenitubulus pagodula (The Gorge, central Ningbing Ranges, north of Kununurra) (p. 957)
Cristilabrum monodon (south Ningbing Ranges, north of Kununurra) (p. 959)
Cristilabrum spectaculum (Jeremiah Hills, north of Kununurra) (p. 966)
Cristilabrum isolatum (between Ningbing Ranges and Jeremiah Hills, north of Kununurra) (p. 972)

Both the *Damochlora* and *Torresitrachia thedana* were picked up in casual collecting. They serve to indicate how little is known of the Kimberley land snails, and that these monographs can be only an introduction to this marvellously diverse fauna.

The order of treatment below follows the sequence of taxa in Parts I-III.

GENUS *XANTHOMELON* VON MARTENS, 1860

Xanthomelon von Martens, Solem, 1979, Rec. Western Aust. Mus., Suppl. No. **10**: 9-45.

Remarks

Xanthomelon is one of the few northern camaenids that is found away from rocky or forested areas. Within the general range of each species, it is common to find specimens many kilometres away from a hill system or on open ground well removed from a water course. Apparently the species will bury themselves in sandy or loamy soil for aestivation. They thus face potential spread by the occasional catastrophic floods, and this probably explains the generally wide distributions.

Material of only one species is discussed, since the other sets do not extend known ranges.

XANTHOMELON OBLIQUIRUGOSA (SMITH, 1894)

Xanthomelon obliquirugosa (Smith), Solem, 1979, Rec. West. Aust. Mus., Suppl. No. **10**: 35-42, pl. la, figs 2a-b, 10a-b, 11a-d.

Other material

Ningbing Ranges, north of Kununurra (all specimens collected in May and June 1980): Sta. WA-633, 5.8 km north of No. 8 Bore ('Knob Peak' 4668 – 545:500) (2 dead adults, FMNH 204890); Sta. WA-636, hill 0.8 km north of No. 8 Bore ('Knob Peak' 4668 – 559:453) (1 dead adult, FMNH 204913); Sta. WA-637, hill near No. 8 Bore ('Knob Peak' 4668 – 564:448) (1 dead adult, FMNH 204917); Sta. WA-662, south-east corner Utting Gap ('Knob Peak' 4668 – 567:419) (1 dead adult, FMNH 205061); Sta. WA-639, 400 m south of Utting Gap ('Carlton' 4667 – 568:416) (1 broken adult, FMNH 204929); Sta. WA-642, 1.3 km south of Utting Gap ('Carlton' 4667 – 569:407) (3 dead adults, FMNH 204946); Sta. WA-644, 2.9 km south of Utting Gap ('Carlton' 4667 – 566:387) (3 dead adults, FMNH 204957); Sta. WA-668, 2.9 km north of Tanmurra Creek ('Carlton' 4667 – 573:378) (1 dead adult, FMNH 205094); Sta. WA-654c, peak 1.5 km north of Tanmurra Bore ('Carlton' 4667 – 595:325) (1 dead adult, FMNH 205015); Sta. WA-653, 1.1 km north of Tanmurra Bore ('Carlton' 4667 – 597:321) (2 dead adults, FMNH 205004); Sta. WA-632, 5.2 km south of Tanmurra Bore ('Carlton' 4667 – 615:264) (1 dead juvenile, FMNH 204883); Sta. WA-648, north side corner of The Gorge ('Carlton' 4667 – 598:220) (1 dead adult, FMNH 204979); Sta. WA-651, plains 2.5 km east of The Gorge ('Carlton' 4667 – 628:218) (2 dead adults, FMNH 204997); Sta. WA-645, plains on bank of Station Creek, east of The Gorge ('Carlton' 4667 – 606:217) (1 dead adult, FMNH 204958); Sta. WA-646, east end of The Gorge ('Carlton' 4667 – 602:215) (3 dead adults, FMNH 204963); Sta. WA-609, 4.55 km south of Ningbing Bore ('Carlton' 4667 – 659:105) (1 dead adult, FMNH 204823); WA-616, plains by paddock fence, west of Eight Mile Hill ('Carlton' 4667 – 606:070) (2 dead adults, FMNH 204-838).

Sorby Hills, north of Kununurra: Sta. WA-677, east side of hills on limestone exposures ('Carlton' 4667 – 958:901) (1 dead adult, FMNH 205132).

Remarks

Although hundreds of shells belonging to the endemic genera *Ningbingia, Turgenitubulus* or *Cristilabrum* were taken from the above localities, no more than three dead examples of *Xanthomelon* were taken at any locality – more often only single examples were found. This suggests that *Xanthomelon* is not living in the limestone masses.

The specimen ranged in diameter from 18.35 to 24.78 mm (mean of 25 adults 23.10 mm), with the two smallest specimens from the northernmost locality. This confirms the observation in Solem (1979: 31, table 3) that the Ningbing Ranges have very small examples of this species.

GENUS *TORRESITRACHIA* IREDALE, 1939

Torresitrachia Iredale, Solem, 1979, Rec. West. Aust. Mus., Suppl. No. **10**: 45-92 – review of genus.

Remarks

Material accumulated since publication of the above review enables describing two new species, *T. thedana* and *T. deflecta,* and adds range data for several other species. In addition, worn or juvenile specimens of what apparently may be other new species suggest where additional collecting might be profitable.

A very worn and bleached adult from Augustus Island, Camden Sound (15°22'S, 124°28'E) (WAM 415.77, collected by a WAM survey party 12 May 1972) is distinctive in size and shape – height 8.0 mm, diameter 17.1 mm, H/D ratio 0.468, whorls $5^3/_8$+, umbilical width 3.5 mm, D/U ratio 4.89. The specimen is far too worn to detect the nature of its sculpture, but almost certainly an undescribed species lives on Augustus Island. Two equally worn examples (WAM 458.77, collected by a WAM survey party 14 June 1972) from Borda Island, Admiralty Gulf (14°15'S, 126° 00'E) are probably related to *T. deflecta,* but distinguished by an angulated periphery and possible radial sculpture. It is evident from the above that speciation in *Torresitrachia* is far more extensive than has been described to date.

The following comments follow the species order in Solem (1979).

TORRESITRACHIA BATHURSTENSIS (SMITH, 1894)

Torresitrachia bathurstensis (Smith), Solem, 1979, Rec. West. Aust. Mus., Suppl. No. **10**: 67-71, pl. 6a-c, figs 13a-b, 14a.

Other material

Cockatoo Island, Yampi Sound (16°06'E, 123°37'E) (1 dead adult, WAM 235.74, collected by G. Shaw August 1968); north side of western arm of Secure Bay, east of Walcott Inlet (16°26'S, 124°21'E) (2 dead adults, WAM 239.74, collected by G.I. Crawford 25 August 1965).

Remarks

The Cockatoo Island specimen is 15.1 mm in diameter; the Secure Bay examples 15.3 and 16.9 mm. In size, shape and sculptural remnants they are typical of this species.

TORRESITRACHIA MONTICOLA IREDALE, 1939

Torresitrachia monticola Iredale, Solem, 1979, Rec. West. Aust. Mus., Suppl. No. **10**: 71-76, pls 2a-b, 5a-c, figs 13c-e, 14b.

Other material

Napier Range: Sta. WA-581 (= WA-194), south-east corner Windjana Gorge ('Lennard' 3863 – 065:737) (3 dead adults, FMNH 204703, collected 7 May 1980); Sta. WA-713, 4th cleft from floodline, south-west corner Windjana Gorge, ca 50 m west of WA-193 (1 live adult, FMNH 205323, collected 19 June 1980).

King Leopold Ranges: Sta. WA-576 (= WA-379), ca 6.5 km north of Macs Jumpup, 1 km east of Gibb River Road (1 dead adult, 1 dead juvenile, FMNH 204695, collected 6 May 1980).

Remarks

The live adult was taken in shallow talus, whereas the only previous live collection of this species in the Napier Range was in a pocket of debris under a fissured limestone slab on a cliff face (Solem 1979: 73). *Torresitrachia monticola* remains a rare species in the Napier Range.

TORRESITRACHIA AMAXENSIS SOLEM, 1979

Torresitrachia amaxensis Solem, 1979, Rec. West. Aust. Mus., Suppl. No. **10**: 79-84, pls 4e-f, 5g-i, figs 15a-c, 16a-b.

Other material

Bonaparte Archipelago: Bigge Island (14°32'S, 125°11'E) (1 dead adult, 1 dead juvenile, WAM 413.77, collected by L.C. Smith 6 June 1972); Kater's Island (14°28'S, 125°32'E) (1 dead adult, WAM 412.77, collected by a WAM survey party 10 June 1972).

Remarks

Both adults are 15.7 mm in diameter, which is small for this species. The Kater's Island shell is more depressed and more widely umbilicated than most examples, but at least tentatively both specimens can be classed as this species. These are the first island records for *Torresitrachia amaxensis*.

TORRESITRACHIA WEABERANA SOLEM, 1979

Torresitrachia weaberana Solem, 1979, Rec. West. Aust. Mus., Suppl. No. **10**: 84-86, pls 3a-g, 6d-f, figs 15d, 16c.

Other material

Northern Territory: Sta. WA-678, scorched limestone hill, Spirit Hill Station, west of Keep River ('Keep' 4766 – 082:793) (21 dead adults, 7 dead juveniles, WAM 64.84, FMNH 205138, collected by 30 May 1980).

Western Australia: Sta. WA-633, at base of large baobab 20 metres from limestone hill, 5.8 km north of No. 8 Bore, north end Ningbing Ranges ('Knob Peak' 4668 – 545:500) (1 dead adult, 1 dead juvenile, WAM 67.84, FMNH 204889, collected 21 May 1980); Sta. WA-677, limestone exposures east side of Sorby Hills, north of Kununurra ('Carlton' 4667 – 958:901) (7 live, 109 dead adults, 10 live, 20 dead juveniles, WAM 65-84-66.84, FMNH 205130-1).

Remarks

Local variation in the populations is summarised in **Table 94.** The specimens from Spirit Hill are most similar in size and shape to the Weaber Range types (Solem 1979: 74-75, table 7), but are represented by only dead examples. The Sorby Hills station yielded a few live adults, but the bottle containing them was accidentally broken during transit, and the specimens dried out. Treatment with tri-sodium phosphate restored them enough that dissection revealed the unusual epiphallus-penis contours of *Torresitrachia weaberana* Solem (1979: 82, fig. 15b) and thus confirmed placement in this species.

The record from the north end of the Ningbing Range is quite significant. Despite the considerable amount of collecting done in the limestone areas of the Ningbings **(Fig. 241)**, no trace of any *Torresitrachia* has been discovered. The collection from a baobab tree located away from the limestone masses suggests that *Torresitrachia* may be excluded from the Ningbings by the camaenid radiation, and that colonies should be sought in the sandstone hills that parallel the Ningbings to the east.

TORRESITRACHIA UMBONIS SOLEM, 1981

Torresitrachia umbonis Solem, 1979, Rec. West. Aust. Mus., Suppl. No. **10**: 87-91, pls 4a-d, 7a-c, figs 17e-f, 18a.

Other material

Prince Regent River Reserve (all specimens collected in August 1974): Sta. E5 (4), west slope of main gorge below Enid Falls, Rufous Creek, Roe River ('Prince Regent' SD 51-16 – 348:086) (1 dead juvenile, WAM 161.75); Sta. E5 (8), 2-3 km west of Enid Falls campsite, Rufous Creek, Roe River

('Prince Regent' SD 51-16 – 343:084) (1 dead juvenile, WAM 198.75).

Prince Regent River Reserve (all specimens collected July 1977): Sta. 3, vine thicket on basalt/sandstone scree, north side, mouth of Hunter River estuary, Prince Frederick Harbour (15°02'S, 125°23'E) (1 dead adult, 2 dead juveniles, WAM 351.80, WAM 359.80).

Mitchell Plateau area: deep in caves (3 dead adults, WAM 323.80, collected by W.H. Butler 27 September to 6 October 1978); west side Mitchell River estuary ('Warrender' 4068 – 838:778) (1 dead adult, WAM 345.80, collected by Barry R. Wilson 21 July 1977).

Remarks

The range extension of *Torresitrachia umbonis* Solem, 1979 from the Prince Regent River area to the Mitchell Plateau is significant. Of the few widely distributed Kimberley species, only *Xanthomelon prudhoensis* (Smith, 1894) inhabits both the Mitchell Plateau and the Prince Regent River Reserve (Solem 1979: 25-28). *Torresitrachia umbonis* is the first restricted range species to indicate any faunal affinities between the two regions.

All of the adult *Torresitrachia umbonis* were 20.7-22.2 mm in diameter, well within the range of previously listed material (Solem 1979: 48, table 5).

TORRESITRACHIA DEFLECTA SP. NOV.

(Plates 93a-d, 94a-e; Figs 236a-c, 237a-c)

Comparative remarks

Torresitrachia deflecta is the third species from the Prince Regent River Reserve-Walcott Inlet area with a basal lip node and a sharply deflected body whorl (Solem 1979: 56, pl. 7a-f). Both *T. umbonis* Solem, 1981 and *T. crawfordi* Solem, 1981 are much larger in size, diameters 16.8-24.6 mm, compared with the 11.3-14.4 mm range for *T. deflecta,* their lip nodes are much more sharply defined, and they differ in shell sculpture. *T. umbonis* (Solem, 1979: 52, pl. 4a-d) has a microsculpture of pustules and *T. crawfordi* has these almost completely lost, while *T. deflecta* **(Plate 93a-d)** has relatively long periostracal setae and short micro-ridglets. No other *Torresitrachia* has a lip node, a deflected lip, or periostracal setae. Anatomically, *T. deflecta* **(Figs 237a-c)** shows characters intermediate between *T. umbonis* (Solem, 1979: 88-89, figs 17b, 18a) and other *Torresitrachia.* The change from a pustulose to pilaster wall sculpture in the penis chamber is like *umbonis,* but the retained collar, nature of the epiphallic entrance of the vas deferens, and shorter penis are more like the other species.

Holotype

WAM 504.75, Sta. W6 (1), valley slope on north side of Youwanjela Creek, Upper Prince Regent River (1:250,000 'Prince Regent' map sheet

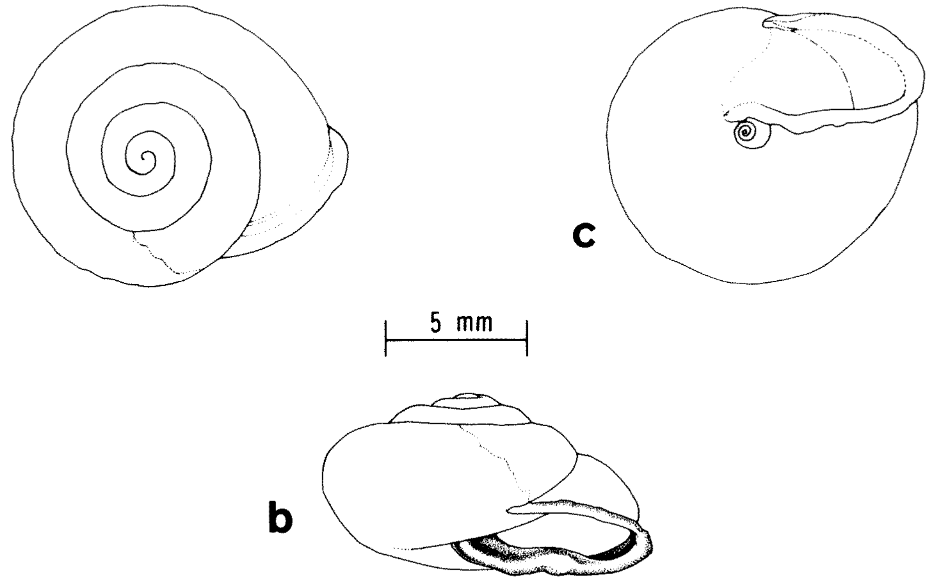

Fig. 236: Shell of *Torresitrachia deflecta.* Sta. 1, west bank of Roe River, Prince Regent River Reserve, WAM 504.75, holotype. Scale line equals 5 mm. Drawings by Linnea Lahlum.

SD 51-16 – grid reference 332:032). Collected by Barry R. Wilson and Peter Smith 19 August 1974. Height of holotype 6.35 mm, diameter 11.3 mm, H/D ratio 0.562, whorls 4½, umbilical width 1.3 mm, D/U ratio 8.69.

Paratypes

Prince Regent River Reserve: Sta. E5 (1), north-east corner of main gorge below Enid Falls, Rufous Creek, Roe River ('Prince Regent' SD 51-16 – 348:086) (1 live juvenile, WAM 502.75, collected by Barry R. Wilson and Peter Smith 16 August 1974); Sta. W6 (5), valley slopes on south side of Youwanjela Creek, Prince Regent River ('Prince Regent' SD 51-16 – 332:032) (1 live adult, WAM 646.77, collected by Peter Smith 23 August 1977); Sta. 1, west bank Roe River (15°15′S, 125°33′E) (2 dead adults, 1 broken adult, WAM 325.80); Sta. 2, west of Purulba Creek (15°30′S, 125°09.5′E) (1 dead adult, WAM 335.80).

Diagnosis

Shell small, diameter 11.3-14.4 mm (mean 12.63 mm), with 4½ to 4⅞ – (mean 4⅝ +) rather loosely coiled whorls. Apex and spire moderately and evenly elevated, not rounded above **(Fig. 236b)**, height of shell 6.35-7.7 mm (mean 6.86 mm). Apical sculpture **(Plate 93a)** of small, radially elongated ridglets, rather widely spaced. Postapical sculpture **(Plate 93b-d)** of rather widely spaced, long periostracal setae with elongated bases. Microsculpture of very fine periostracal ridglets (**Plate 93c-d**). Shell periphery weakly angulated to bluntly rounded, body whorl descending rather sharply just behind aperture (**Fig. 235b**). Lip expanded, slightly thickened, with basal lip node that is variable in prominance, not with sharp outlines. Umbilicus very narrow, nearly covered by reflection of columellar lip, width 0.5-1.3 mm (mean 0.96 mm), D/U ratio 8.69-23.8 (mean 14.8). Based on five measured adults.

Genitalia (**Figs 237a-c**) with short, wide epiphallic caecum (EC), very thick epiphallus (E), rather long penis (P), vagina (V) and free oviduct (UV) rather short. Interior of penis (**Fig. 237c**) with modified sculpture of longitudinal pilasters rather than any pustulose area, simplified entrance of vas deferens into epiphallus (EP), and a collar marking the epiphallus-penis

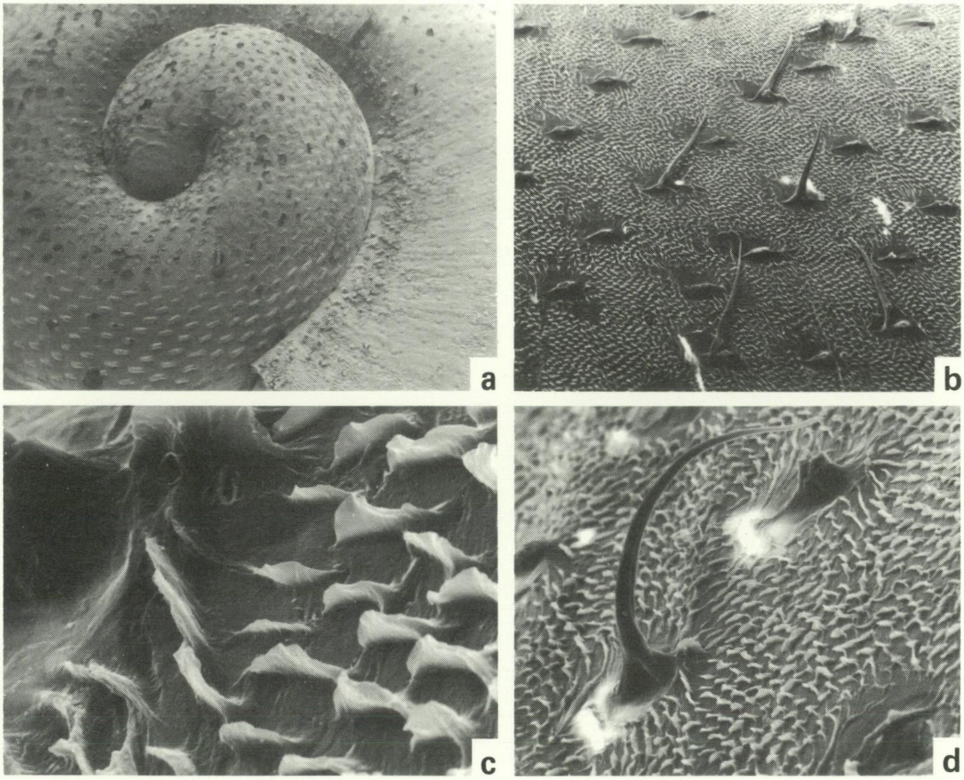

Plate 93: Shell sculpture of *Torresitrachia deflecta.* Sta. W6 (5), Prince Regent River Reserve, Kimberley, WAM 646.77, Dissection A: (a) apex and early spire at 38.9X; (b) sculpture on body whorl at 46.3X; (c) microsculpture on body whorl at 860X; (d) single periostracal seta on body whorl at 175X.

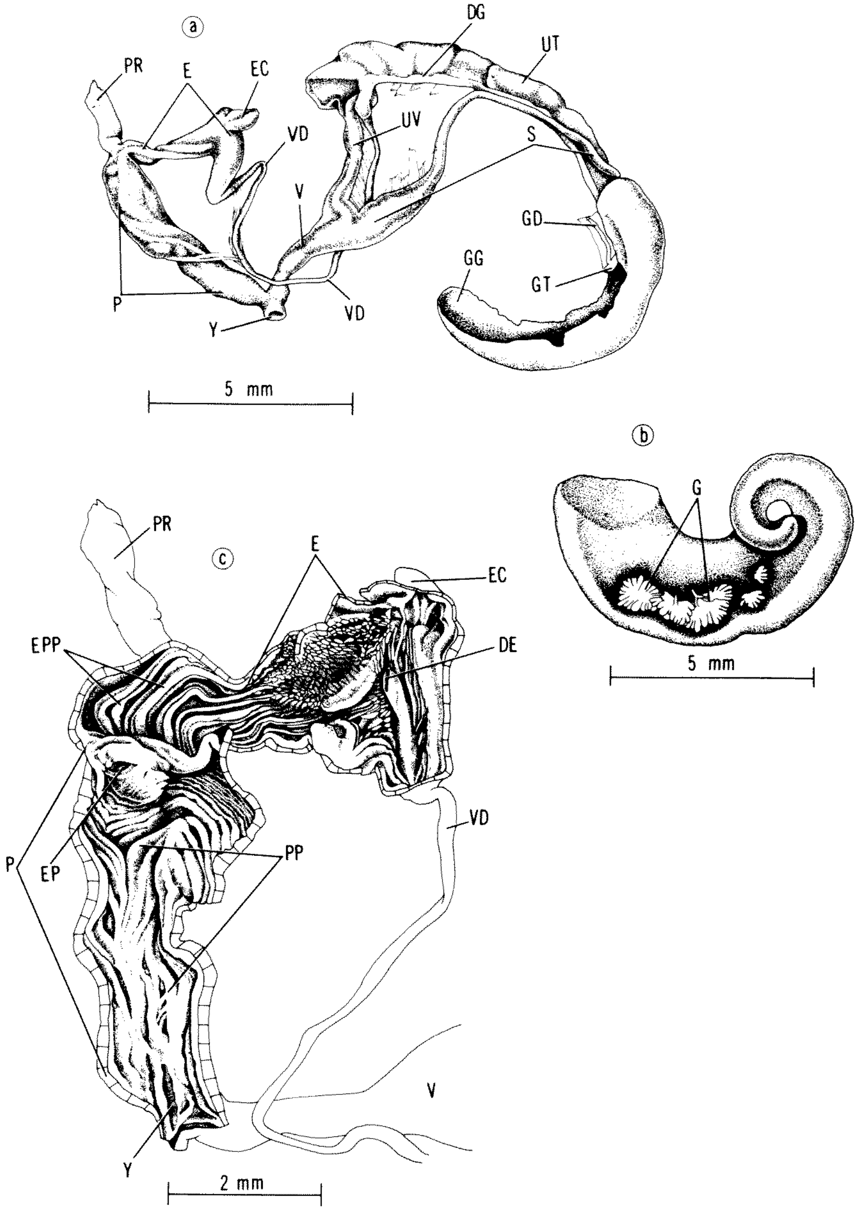

Fig. 237: Genitalia of *Torresitrachia deflecta.* Sta. W6 (5), south side of Youwanjela Creek, upper Prince Regent River, 23 August 1974, WAM 646.77, Dissection A, (a) whole genitalia, (b) part of ovotestis, (c) interior of penis complex. Scale lines as marked. Drawings by Linnea Lahlum.

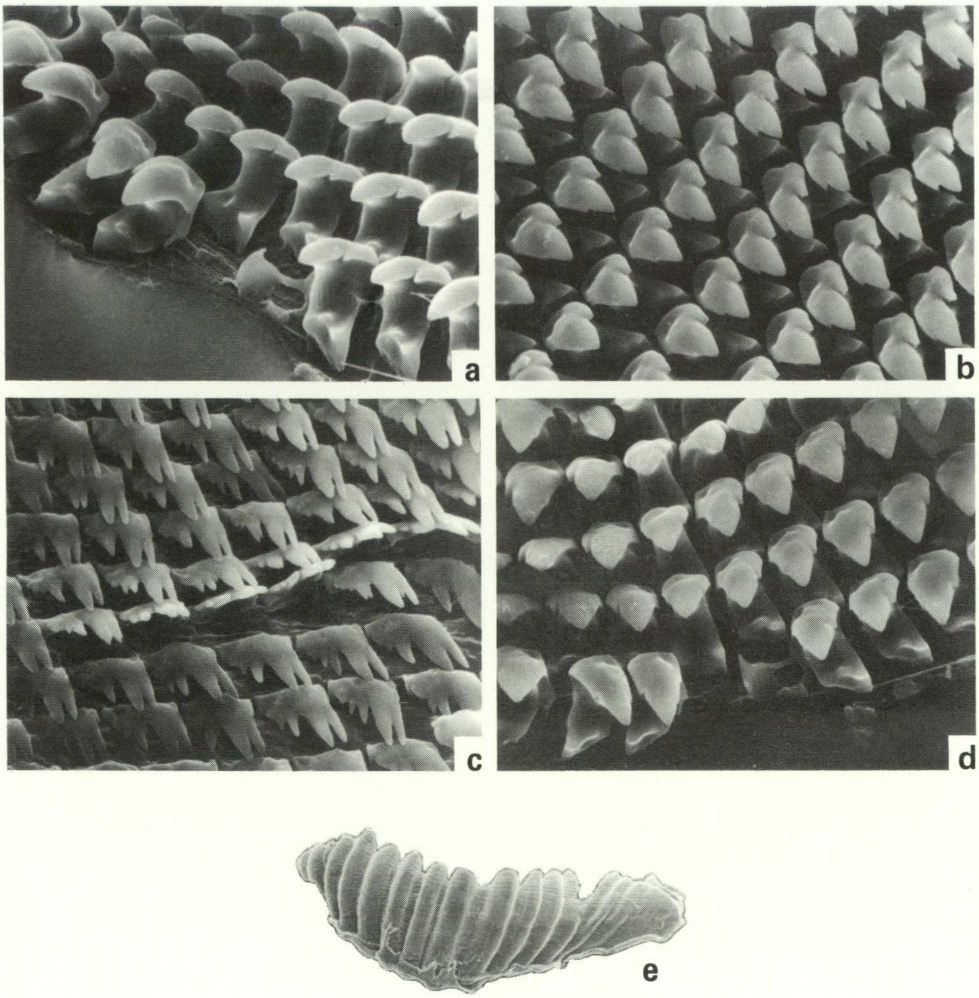

Plate 94: Jaw and radular teeth of *Torresitrachia deflecta.* Sta. W6 (5), Prince Regent River Reserve, Kimberley, WAM 646.77, 23 August 1974, Dissection A: (a) central and early lateral teeth from high front angle view at 845X; (b) near vertical view of lateromarginal transition at 710X; (c) outer marginal teeth from near vertical view at 710X; (d) very high angle front view of central and lateral teeth at 650X; (f) jaw at 66.7X.

junction. Walls of penis thick. Based on one dissected adult that had been preserved in formalin.

Jaw **(Plate 94e)** with reduced ribs on lateral margins. Central and lateral teeth **(Plate 94a, d)** with mesocone at high angle, bluntly rounded and curved, asymmetrical in relation to mid-line. Lateromarginal transition **(Plate 94b)** typical, outer marginals **(Plate 94c)** multicuspid and very thin.

Remarks

The periostracal setae and unusual form of the shell were puzzling until dissection indicated that this was a *Torresitrachia* modified in the same general direction as *T. umbonis* Solem, 1979. The limited material, which unfortunately had been preserved in formalin, also hindered study. Shells from Borda Island that were mentioned above (p. 922) appear similar and may indicate a fairly wide range for this complex.

The name *deflecta* refers to the sharp apertural inclination of the shell.

TORRESITRACHIA THEDANA SP. NOV.
(Figs 238a-c, 239a-d)

Comparative remarks

Torresitrachia thedana is most similar to *T. amaxensis* Solem (1979: 53, pl. 5g-i, 79-84, figs 15a-b, 16a-b) from the Mitchell Plateau, but differs in being smaller, with less prominent sculpture on the spire, and in anatomical details. The absence of radial sculpture below the periphery, very narrow

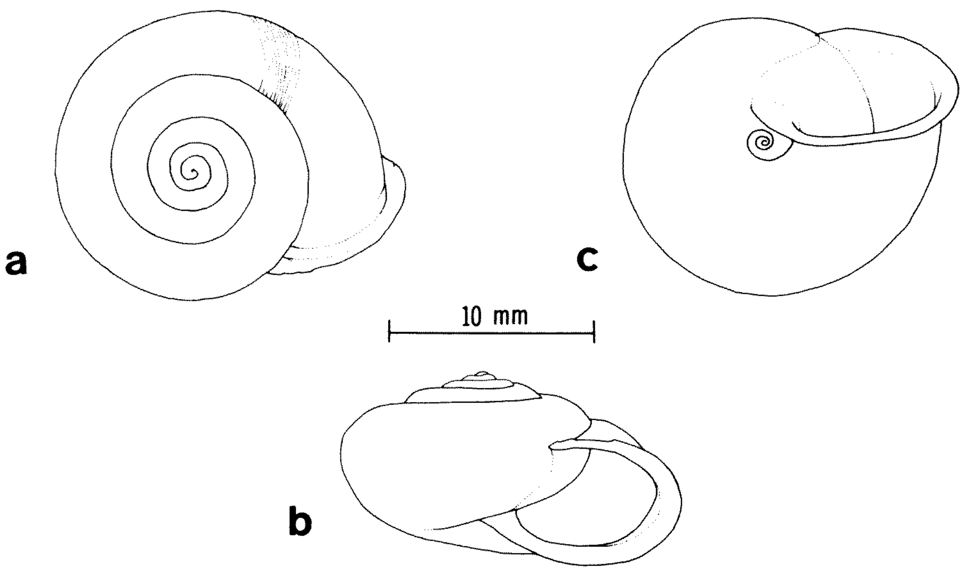

Fig. 238: Shell of *Torresitrachia thedana.* Junction of Palmoondoora Creek and Morgan River, Old Theda Station Homestead ruins, north Kimberley, WAM 618.80, holotype. Collected by W.H. Butler in 1976. Scale line equals 10 mm. Drawings by Linnea Lahlum.

umbilicus (**Fig. 238c**), and rather globose shape (**Fig. 238b**) readily differentiate it from the other described *Torresitrachia*. Anatomically (**Figs 239a-d**), the long epiphallic caecum (EC) that has a large basal diameter (**Figs 239a-b**), long and relatively slender penis (P), rather long free oviduct (UV), absence of a long free pilaster (EV) by the entrance of the vas into the epiphallus (E), and longer pustulose area in the penis are the main features separating *T. thedana* from *T. amaxensis*. Other species differ more dramatically (see Solem, 1979: 47-54).

Holotype

WAM 618.80, Old Theda Station Homestead, junction of Palmoondoora Creek and Morgan River, north Kimberley, Western Australia (1:100,000 'Carson' map sheet 4268 – grid reference ca 490:600). Collected by W.H. Butler in 1976. Height of holotype 10.05 mm, diameter 17.3 mm, H/D ratio 0.581, whorls $5\frac{1}{8}$, umbilical width 1.6 mm, D/U ratio 10.8.

Paratopotypes

WAM 608.79, FMNH 209067, 13 live adults, 2 live juveniles from the type locality.

Diagnosis

Shell of average size, diameter 15.3-19.3 mm (mean 16.99 mm), with 5 to $5\frac{1}{2}$ (mean $5\frac{1}{4}$–) normally coiled whorls. Apex and spire moderately and evenly elevated, not rounded above (**Fig. 238b**), height of shell 9.05-11.0 mm (mean 9.83 mm), H/D ratio 0.534-0.611 (mean 0.579). Apical sculpture typical. Postapical sculpture of low radial ribs that stop at shell periphery, shell base almost smooth, some irregular growth lines. Shell periphery rounded, body whorl descending very slightly just before aperture (**Fig. 238b**). Lip moderately expanded, not thickened. Umbilicus minute, last whorl decoiling more rapidly (**Fig. 238c**), partly covered by reflexion of columellar lip, width 1.3-1.95 mm (mean 1.7 mm), D/U ratio 8.72-11.8 (mean 10.1). Colour light greenish-yellow horn, lip white. Based on 14 measured adults.

Genitalia (**Figs 239a-d**) typical of *Torresitrachia;* its distinguishing features are the long and broad-based epiphallic caecum (EC), long and slender penis (P), high circular ridge at apex of penis (**Fig. 239c**), which was not cut open, long pustulose zone on the penis chamber walls (**Fig. 239b**), and unusual entrance of the vas deferens into the epiphallus (EP, **Figs 239b, d**). Jaw and radula typically camaenid. Based on two dissected adults.

Remarks

Some hesitation is felt in describing this as a new species, rather than referring it to *Torresitrachia amaxensis* Solem, 1981, from the Mitchell Plateau. The differences in the epiphallic caecum (EC) and penis (P) are equivalent to those seen in other species of the genus, and have tipped the

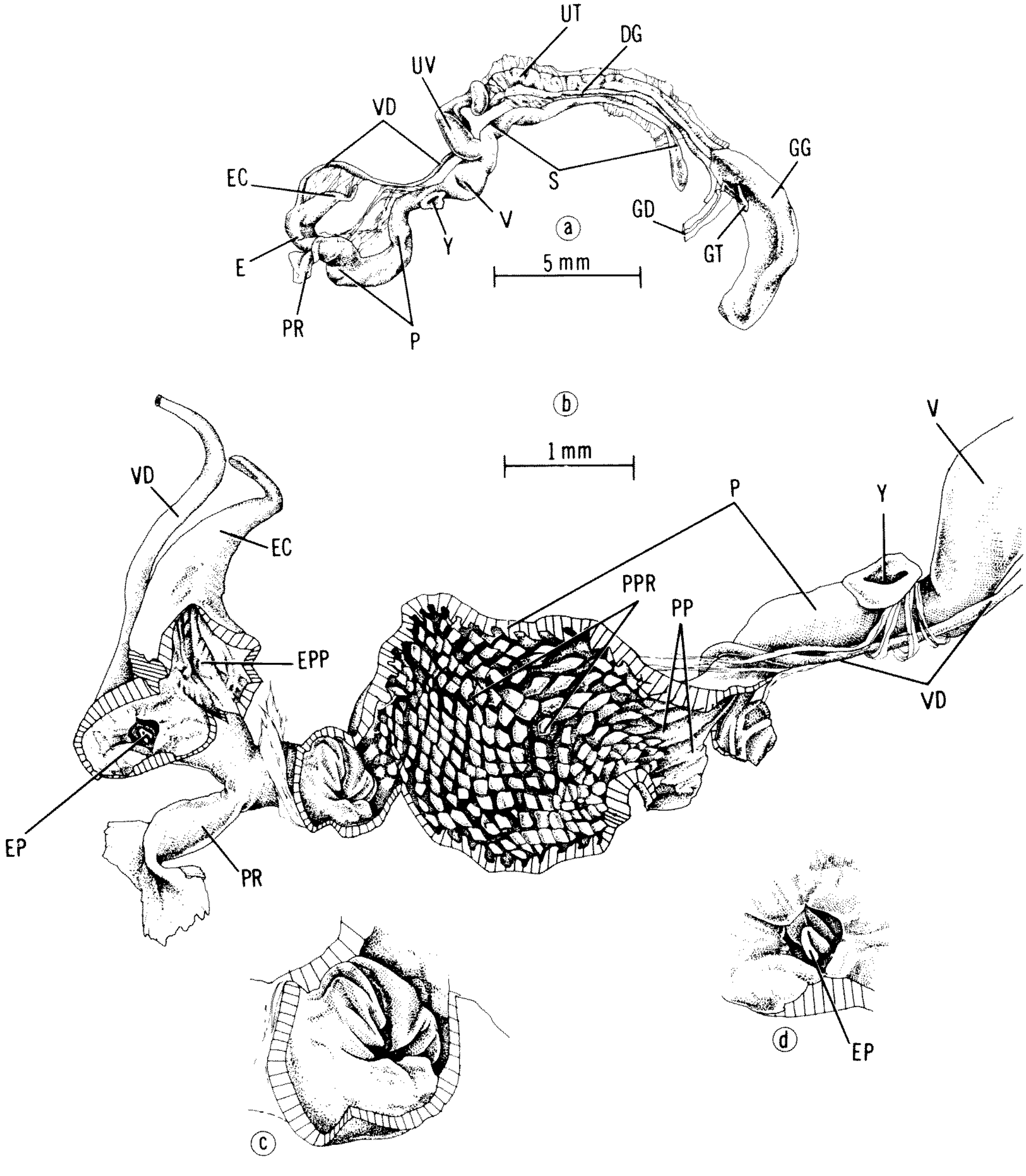

Fig. 239: Genitalia of *Torresitrachia thedana.* Junction of Palmoondoora Creek and Morgan River, Old Theda Station Homestead ruins, north Kimberley, WAM 608.79, paratypes: (a) Dissection A, whole genitalia; (b-d) Dissection B, b is interior of penis complex, c is detail of penis ridge, d is epiphallic pore detail. Scale lines as marked. Drawings by Linnea Lahlum.

balance against the very similar shell form. The radial sculpture of *T. thedana* is noticeably less prominent than in *T. amaxensis*, which also is a probably significant change within the context of the genus.

The name *thedana* is after the Station on which this species was collected.

GENUS *DAMOCHLORA* IREDALE, 1938

Damochlora Iredale, Solem, 1979, Rec. West. Aust. Mus. Suppl. No. **10**: 101-113.

Remarks

A new species from near Kalumburu, which has perhaps the most spectacular periostracal adornment of any Australian land snail **(Figs 240a-c)**, is described despite the absence of anatomical data. It is placed in *Damochlora* on the basis of its having the same very unusual radial microridges found in *D. rectilabrum* (Smith, 1894) (Solem 1979: 94, pl. 8b-c).

DAMOCHLORA SPINA SP. NOV.
(Figs 240a-c)

Comparative remarks

The very long periostracal setae, that are clustered around the periphery **(Figs 240a-c)**, and the strongly deflected aperture **(Fig. 240b)** are the most obvious features separating *Damochlora spina* from the previously described *D. rectilabrum* (Smith, 1894) and *D. millepunctata* (Smith, 1894). In addition, its umbilicus is wider and the lip is more expanded. The apical sculpture agrees with the other *Damochlora*, and the spire shows the same radially oriented periostracal ridglets (Solem 1979: 94, pl. 8b-c), which are not duplicated in any other Kimberley camaenid.

Holotype

NMV F51480, ca 1 km from Gibb River-Kalumburu Road, ca 2 km north-north-east of Carson River Crossing, outlier of Putairta Hill, ca 16 km south of Kalumburu Mission, Kimberley, Western Australia (1:100,000 'Drysdale' map sheet 4269 – grid reference 491:029). Collected by A.C. Beauglehole 3 June 1976. Height of holotype 5.05 mm, diameter 10.25 mm, H/D ratio 0.493, whorls 4⅜ –, umbilical width 1.6 mm, D/U ratio 6.41.

Paratopotypes

NMV 51481, NMV, FMNH 205814, 5 adults, 3 juveniles, 1 broken adult from the type locality.

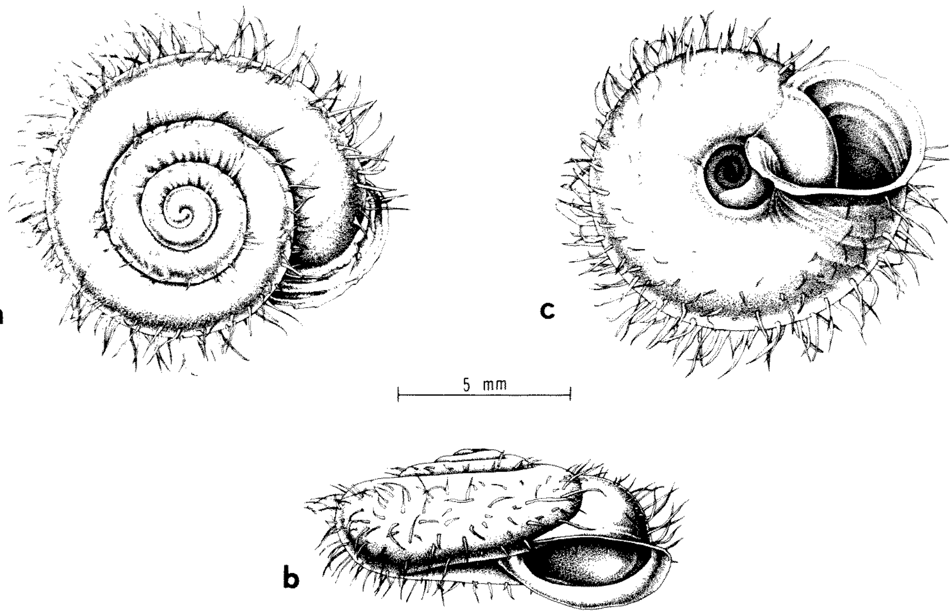

Fig. 240: Shell of *Damochlora spina.* 1 km from Gibb River Road, ca 2 km north-east Carson River crossing, south of Kalumburu Mission, NMV F51480, holotype. Scale line equals 5 mm. Drawings by Linnea Lahlum.

Diagnosis

Shell small, diameter 10.25-11.75 mm (mean 10.86 mm), with 4⅜ – to 4⅝ – (mean 4½–) normally coiled whorls. Apex and spire slightly and evenly elevated, not rounded above **(Fig. 240b)**, height of shell 5.05-5.9 mm (mean 5.26 mm), H/D ratio 0.459-0.502 (mean 0.485). Apical sculpture typical of genus (Solem 1979: 94, pl. 8a). Early postapical whorls with the typical *Damochlora* radial micro-ridges (Ibid, p. 94, pl. 8b-c), lower spire with periostracal setae that start near the periphery, rapidly increase in size, present below periphery, but disappearing from base **(Figs 240a-c).** Base of setae are enlarged versions of the micro-ridges. Periphery rounded, body whorl deflected sharply just before aperture. Lip moderately expanded, not thickened, parietal callus thin. Umbilicus open, regularly decoiling, width 1.6-2.4 mm (mean 2.11 mm), D/U ratio 4.58-6.41 (mean 5.25). Shell thin, periostracal colour very light yellow horn, lip white. Based on six measured adults.

Anatomy unknown.

Remarks

Damochlora spina is immediately recognisable by the very long setae, which are eroded in older specimens. The short setae in such taxa as *Seto-*

baudinia and *Baudinella* (see above, **Plates 64-69, 77**) are basically the same in structure, and the basal micro-ridges compare well with the expanded bases seen in *S. anatispretia* (**Plate 68d-f**). The name *spina* refers to the very long setae near the shell periphery.

Some of the specimens were alive when collected, but they had partly dried out subsequently. It proved impossible to obtain any anatomical data. Two juveniles had remnants of calcified epiphragms inside the shell, suggesting that this species is a free sealer, rather than attaching to an object.

Damochlora spina differs from other congeneric species in its much wider lip, sharply deflected aperture, wider umbilicus, and more loosely coiled whorls, but probably is correctly classified.

GENUS *AMPLIRHAGADA* IREDALE, 1933

Amplirhagada Iredale, Solem, 1981, Rec. West. Aust. Mus., Suppl. No. **11**: 148-320.

Remarks

Field work in the Napier Range during 1980 provides data on the exact transition point between *Amplirhagada percita* (Iredale, 1939) and *A. napierana* Solem, 1981 near Yammera Gap. It was indicated in a previous report (Solem 1981a: 225, 232) that the transition takes place about 1.5-1.6 km west of the gap. This was based on collections made over a period of several months and there was some confusion as to the exact sequence of stations.

Material taken by A. Solem and L. Price in early May 1980 gives some precision to the transition point and yields data on the nature of the transition. The preceding wet season at Napier Downs was 'about half of normal' (personal communication from Station personnel), and we were able to find only one living juvenile within the zone of change. The area is not 'good snail habitat', and, when combined with a poor wet season, made the lack of live material almost inevitable.

AMPLIRHAGADA PERCITA (IREDALE, 1939)

Amplirhagada percita Iredale, 1939, Solem, 1981, Rec. West. Aust. Mus., Suppl. No. **11**: 211-225, pl. 14e-f, figs 47a-j, 50c, 51b-c.

Other material

Napier Range (organised from east to west, starting at Yammera Gap): Sta. 570, north-east corner, 'garbage dump valley', 1.58 km west of Yammera Gap (15 dead adults, WAM 115.84, FMNH 204680); Sta. WA-571, west slope of 'garbage dump valley' (9 dead adults, WAM 116.84, FMNH 204683); Sta. WA-572, west entrance of 'garbage dump valley' (28 dead adults, WAM 117.84, FMNH 204684); Sta. WA-574, isolated hill on left side, 1.83 km west of Yammera Gap (15 dead adults, WAM 118.84, FMNH 204689).

Remarks

Amplirhagada percita (Iredale, 1939) is a geographically variable species, with rather depressed and widely umbilicated shells in the populations just west of Yammera Gap (Solem 1981a: 225, tables 19-21). The four populations here assigned to *A. percita,* Stas WA-570-2, WA-574, show negligible differences in size and shape **(Table 92)**, but the specimens from WA-574 have the umbilicus slightly narrowed, compared with the first three samples.

The major changes are in *A. napierana* Solem, 1981, and the full discussion is presented just below.

Table 92: Transition Between *Amplirhagada percita* (Iredale, 1939) and *A. napierana*

Station	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
A. percita				
WA-570, FMNH 204680	15D	11.08±0.268 (9.75–12.8)	17.73±0.261 (16.1–19.9)	0.625±0.010 (0.573–0.704)
WA-571, FMNH 204683	9D	10.58±0.226 (9.75–11.45	17.92±0.208 (16.85–18.75)	0.590±0.007 (0.552–0.617)
WA-572, FMNH 204684	28D	10.72±0.164 (8.9–12.8)	17.77±0.204 (15.7–19.6)	0.603±0.005 (0.552–0.674)
WA-574, FMNH 204689	15D	11.35±0.168 (10.0–12.4)	18.05±0.161 (17.05–19.25)	0.628±0.007 (0.585–0.675)
A. napierana				
WA-575, FMNH 204690	34D	11.84±0.180 (9.6–13.9)	18.50±0.164 (16.6–21.0)	0.640±0.007 (0.570–0.735)
WA-573, FMNH 204688	24D	13.10±0.175 (11.3–14.5)	19.06±0.157 (17.1–20.35)	0.687±0.007 (0.617–0.760)
WA-577, FMNH 204697	10D	13.5±0.240 (11.8–14.4)	19.45±0.218 (18.65–20.75)	0.694±0.010 (0.635–0.742)

Table 92: Transition Between *Amplirhagada percita* (Iredale, 1939) and *A. napierana* (continued)

Station	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
A. percita				
WA-570, FMNH 204680	15D	5⅝+ (5½– –5⅞–)	2.07±0.094 (1.35–2.8)	8.88±0.503 (6.46–13.2)
WA-571, FMNH 204683	9D	5¾– (5–5⅞+)	2.19±0.114 (1.45–2.6)	8.42±0.604 (6.78–12.7)
WA-572, FMNH 204684	28D	5¾– (5⅛+–6⅛–)	2.13±0.079 (1.65–3.6)	8.61±0.306 (5.01–11.7)
WA-574, FMNH 204689	15D	6– (5¾+–6⅛–)	1.79±0.090 (1.15–2.45)	10.5±0.540 (7.48–14.9)
A. napierana				
WA-575, FMNH 204690	34D	6– (5⅝– –6⅜–)	1.10±0.079 (0.5–2.5)	19.4±1.22 (7.1–35.3)
WA-573, FMNH 204688	24D	6+ (5⅝+–6½+)	Cracked	---
WA-577, FMNH 204697	10D	6+ (5⅛+–6⅜–)	Closed	---

AMPLIRHAGADA NAPIERANA SOLEM, 1981

Amplirhagada napierana Solem, 1981, Rec. West. Aust. Mus., Suppl. No. 11: 225-232, pl. 14d, figs 36b, 48a-b, 50, 51a.

Other material

Napier Range (organised from east to west, starting with station nearest to Yammera Gap): Sta. WA-575, rear of valley and west side to within 50 metres short of headland, 1.93 km west of Yammera Gap (34 dead adults, WAM 119.84, FMNH 204690); Sta. WA-573, promontory 2.08 km west of Yammera Gap (24 dead adults, WAM 120.84, FMNH 204688); Sta. WA-577, heavy vegetation cover, slopes 3.05 km west of Yammera Gap (10 dead adults, WAM 121.84, FMNH 204697).

Remarks

In contrast with *Amplirhagada percita* (Iredale, 1939), populations of *A. napierana* are rather uniform in size, shape and structure. The closed umbilicus, higher spire, white colour, and thicker shell of *A. napierana* usually enable immediate separation from the lower spired, horn coloured, thinner shelled, and umbilicated *A. percita.* Possible hybrid or intermediate populations were reported from near Barker Gorge (Stas WA-354-5) and also near Yammera Gap by Solem (1981a: 231-2).

Specimens from Sta. WA-577, 3.05 km west of Yammera Gap, are typical *A. napierana* **(Table 92).** Those from Sta. WA-573, 2.08 km west of Yammera Gap, have the high spire, but in most examples the umbilicus is a slight lateral crack; only three specimens have a completely closed umbilicus. At Sta. WA-575, 1.93 km west of Yammera Gap, most specimens have a lower spire and the umbilicus ranges from a narrow crack to moderately

Table 93: Range of Variation in Addenda Taxa

Taxon	Number of Adults Measured	Mean and Range of: Shell Height	Shell Diameter	H/D Ratio
TORRESITRACHIA				
deflecta	5	6.86 (6.35–7.7)	12.63 (11.3–14.4)	0.544 (0.515–0.562)
thedana	14	9.83 (9.05–11.0)	16.99 (15.3–19.3)	0.579 (0.534–0.611)
DAMOCHLORA				
spina	6	5.26 (5.0–5.9)	10.86 (10.25–11.75)	0.485 (0.459–0.502)
NINGBINGIA				
dentiens	627	7.95 (6.75–10.95)	16.71 (14.65–18.4)	0.480 (0.426–0.637)
TURGENITUBULUS				
tanmurrana	483	9.01 (6.95–10.9)	15.50 (13.65–17.45)	0.582 (0.478–0.684)
aslini	374	9.99 (8.45–11.6)	19.02 (16.35–21.85)	0.539 (0.454–0.595)
pagodula	228	8.53 (6.65–10.4)	16.83 (13.95–18.7)	0.507 (0.435–0.613)
CRISTILABRUM				
monodon	418	8.93 (7.6–10.4)	17.45 (15.4–19.5)	0.509 (0.455–0.582)
bilarnium Solem, 1981	57	10.84 (9.65–12.3)	19.51 (17.2–21.6)	0.559 (0.470–0.634)
spectaculum	565	11.49 (9.0–14.2)	20.80 (16.9–24.5)	0.551 (0.481–0.641)
isolatum	195	10.75 (7.5–13.2)	19.80 (15.2–22.5)	0.543 (0.449–0.601)

Table 93: Range of Variation in Addenda Taxa (continued)

Taxon	Number of Adults Measured	Mean and Range of: Whorls	Umbilical Width	D/U Ratio
TORRESITRACHIA				
deflecta	5	4⅝+ (4½–4⅞–)	0.96 (0.5–1.3)	14.8 (8.69–22.8)
thedana	14	5¼– (5–5½)	1.70 (1.3–1.95)	10.1 (8.72–11.8)
DAMOCHLORA				
spina	6	4½– (4⅜– –4⅝–)	2.11 (1.6–2.4)	5.25 (4.58–6.41)
NINGBINGIA				
dentiens	627	4⅞+ (4½– –5¼–)	3.23 (2.05–3.9)	5.15 (4.15–8.07)
TURGENITUBULUS				
tanmurrana	483	5⅜+ (5–6)	2.29 (1.05–3.4)	6.83 (4.94–13.0)
aslini	374	5⅝– (5⅛– –6⅛+)	2.77 (1.16–3.45)	6.99 (5.34–15.9)
pagodula	228	5⅛– (4¾– –5½+)	2.94 (1.9–3.75)	5.78 (4.28–9.35)
CRISTILABRUM				
monodon	418	5½– (5⅛– –6+)	2.60 (1.05–3.6)	6.78 (4.70–16.6)
bilarnium Solem, 1981	57	5⅞ (5½– –6¼)	2.11 (1.55–3.0)	9.43 (6.75–12.2)
spectaculum	565	5¾+ (5⅛– –6⅜+)	3.36 (2.55–4.5)	6.18 (5.04–8.79)
isolatum	195	5⅝+ (5–6⅛+)	3.33 (2.1–4.1)	5.98 (5.10–7.44)

open (diameter up to 2.5 mm). Specimens with the latter trait are almost typical *percita.* They are, in general, the older specimens, very worn and with calcium deposits on the shell surface. About one-third of the specimens are of this type. The remainder have a narrow lateral crack and resemble typical *napierana,* except for the lack of a completely closed umbilicus. The only 'fresh' specimens are of this type.

Thus the shift between species occurs over a very short distance, with populations about 100 m apart assignable to each species, but with some indication of hybridisation. The presence of long dead *percita* and more recently dead *napierana* at Sta. WA-575 suggests a possible minor shift in range. The change in umbilical characters in the zone of change suggests possible hybridisation between the species. Since this is an area with sparse talus availability, it is probable that during short term dry periods, the populations would die off and then be recolonised during a wetter phase of the cycle. With a low density situation, the possibility of encountering only a few other snails is rather high. Thus occasional hybridisation seems a quite possible event.

A similar shift between *Westraltrachia turbinata* Solem, 1984 and *W. commoda* (Iredale, 1939) occurs slightly further west, at 2.7-2.95 km west of Yammera Gap (Solem 1984: 507). Thus both genera have species shifts in this region, but in *Amplirhagada* it occurs between 1.83 and 1.93 km and in *Westraltrachia* between 2.7 and 2.95 km west of Yammera Gap.

Table 94: Local Variation in *Torresitrachia weaberana* Solem, 1981, *T. thedana, Damochlora spina* and *Cristilabrum isolatum*

Taxon	Number of Adults Measured	Mean, SEM and Range of: Shell Height	Shell Diameter	H/D Ratio
T. weaberana Solem, 1981				
WA-633, FMNH 204889	1D	8.14	14.5	0.563
WA-677, FMNH 205130	7L	7.42±0.158 (6.9–8.0)	14.72±0.453 (13.8–15.1)	0.504±0.010 (0.459–0.533)
WA-677, FMNH 205131	109D	7.13±0.042 (6.1–8.5)	14.28±0.057 (12.5–15.8)	0.499±0.002 (0.450–0.607)
WA-678, FMNH 205138	21D	8.38±0.120 (7.3–9.25)	15.35±0.192 (13.3–16.7)	0.546±0.004 (0.515–0.573)
T. thedana				
WAM 608.79	14L	9.83±0.170 (9.05–11.0)	16.99±0.277 (15.3–19.3)	0.579±0.006 (0.534–0.611)
D. spina				
NMV F51480-1	6	5.26±0.136 (5.05–5.9)	10.86±0.208 (10.25–11.75)	0.485±0.018 (0.459–0.502)
C. isolatum				
WA-676, FMNH 205127	4L	9.48±0.482 (8.8–10.9)	17.51±0.872 (16.1–20.0)	0.542±0.002 (0.538–0.545)
WA-676, FMNH 205126	57D	9.56±0.111 (7.5–10.9)	18.06±0.190 (15.2–20.7)	0.528±0.003 (0.449–0.577)
WA-675, FMNH 205124	16L	11.49±0.163 (10.4–12.6)	20.60±0.218 (19.7–22.1)	0.558±0.014 (0.506–0.595)
WA-675, FMNH 205123	118D	11.27±0.056 (10.1–13.2)	20.60±0.077 (18.4–22.5)	0.549±0.003 (0.487–0.607)

Table 94: Local Variation in *Torresitrachia weaberana* Solem, 1981, *T. thedana*, *Damochlora spina* and *Cristilabrum isolatum* (continued)

Taxon	Number of Adults Measured	Mean, SEM and Range of: Whorls	Umbilical Width	D/U Ratio
T. weaberana Solem, 1981				
WA-633, FMNH 204889	1D	5 1/8+	1.7	8.51
WA-677, FMNH 205130	7L	5 3/8− (5¼− −5 3/8+)	2.75±0.045 (2.6−2.9)	5.36±0.078 (5.17−5.77)
WA-677, FMNH 205131	109D	5¼ (4 7/8+−5 5/8−)	2.67±0.018 (2.2−3.1)	5.36±0.033 (4.61−6.67)
WA-678, FMNH 205138	21D	5½− (5 1/8−5¾−)	2.52±0.042 (2.3−2.9)	6.11±0.086 (5.50−6.94)
T. thedana				
WAM 608.79	14L	5¼− (5−5½)	1.70±0.055 (1.3−1.95)	10.1±0.263 (8.72−11.8)
D. spina				
NMV F51480-1	6	4½− (4 3/8− −4 5/8−)	2.11±0.134 (1.6−2.4)	5.25±0.785 (4.58−6.41)
C. isolatum				
WA-676, FMNH 205127	4L	5 3/8 (5 1/8+−5 5/8+)	3.12±0.178 (2.9−3.7)	5.62±0.113 (5.41−5.95)
WA-676, FMNH 205126	57D	5 3/8− (5−5 5/8+)	3.10±0.045 (2.1−3.7)	5.91±0.057 (5.10−7.44)
WA-675, FMNH 205124	16L	5¾ (5½+−6+)	3.51±0.073 (3.12−4.05)	5.89±0.095 (5.27−6.57)
WA-675, FMNH 205123	118D	5¾ (5½−6 1/8+)	3.42±0.019 (2.94−3.76)	6.03±0.029 (5.44−6.93)

THE NINGBING RADIATION

The Ningbing Ranges and Jeremiah Hills, located between 33 and 100 km north of Kununurra, in the lower Ord River drainage, have an extraordinary radiation of camaenid land snails. The Ningbing Ranges extend about 43 km, and rarely are more than 2 km wide, usually much less. The ranges are far from being continuous limestone, with significant gaps at both Tanmurra Creek and Surprise Creek. The main mass ends just north of Four Mile Creek **(Fig. 241)**. A few scattered limestone pimples occur in the southern drainage of Sandy Creek (Stas WA-624, WA-675, WA-676), then the 5.5 km extent of the Jeremiah Hills (Stas WA-601, WA-672-4) mark the southern

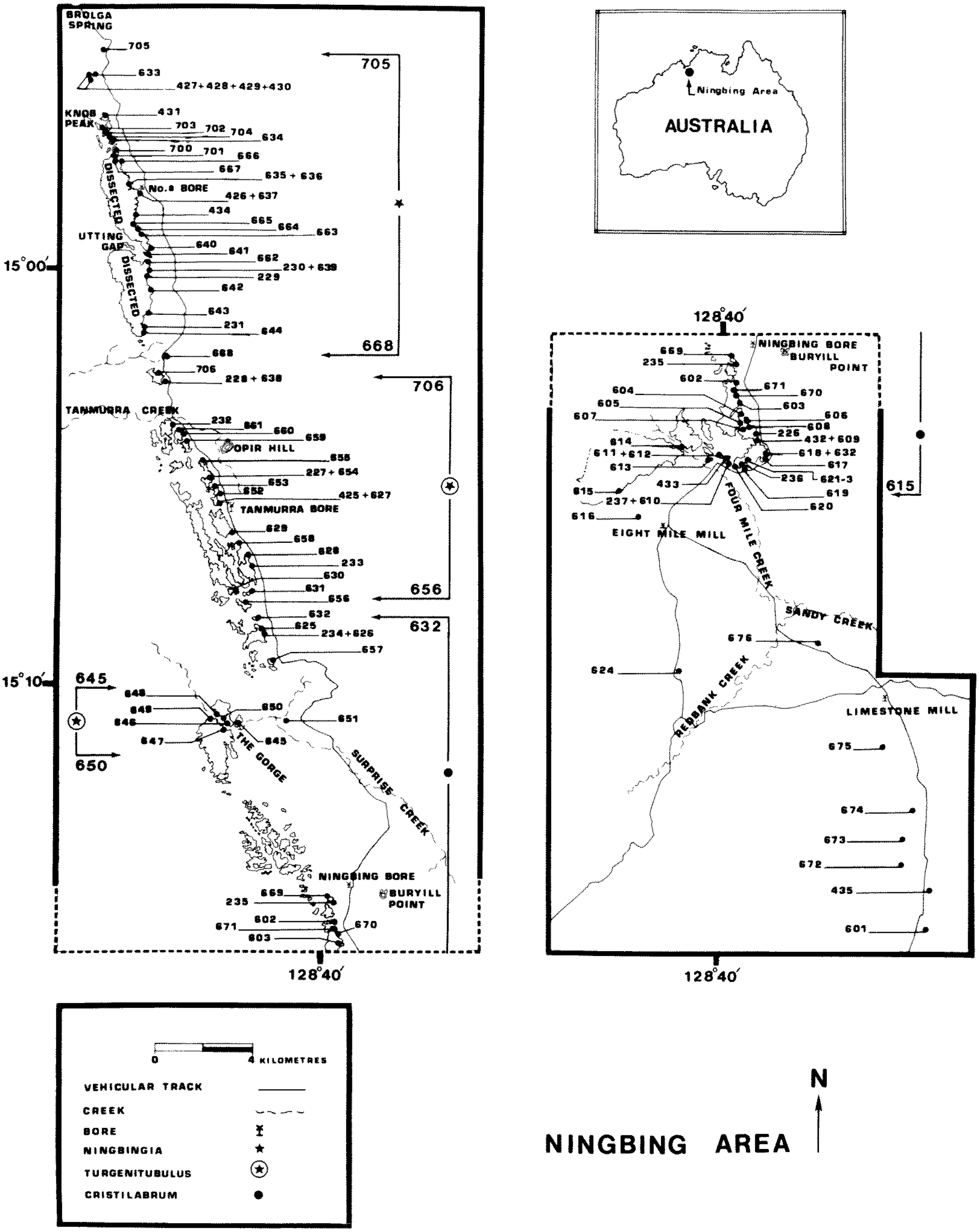

Fig. 241: Collecting stations in the Ningbing Range and Jeremiah Hills area, north of Kununurra. Drafted by Elizabeth Lizzio and Linnea Lahlum.

limit of limestone, occurring about 33 km directly north of Kununurra. There is a gap of about 16.5 air km from the southern bulge of the Ningbings to the north end of the Jeremiah Hills. A total of 24 species of endemic camaenids have now been described from these exposed Devonian limestone reefs.

The initial 1976-7 collections of this radiation, involving 17 new species in three new genera, were reported on previously (Solem 1981a). Intensive field work in the Ningbing area during May and June 1980 increased the number of known species to 24 and compiled extensive data on exact species ranges and local variation patterns. The change in collecting coverage is indicated by comparing the number of stations shown in Solem (1981b:424, fig. 110) with **Fig. 241**, which includes all stations.

Data on variation and species ranges will be discussed elsewhere. At this time, only descriptions and illustrations of the new species are presented, together with enough information on their ranges and comparisons with the previously described species to permit identification. Some data on *Cristilabrum buryillum* Solem, 1981 and *C. bilarnium* Solem, 1981 are presented in order to provide necessary comparative data. At times reference is made to ranges of previously described species based on data from the 1980 collections, although this information has not been published yet. The possible confusion caused by this procedure is less than the difficulties that would result from not making use of this data.

The sequence of the species is north to south.

NINGBINGIA DENTIENS SP. NOV.
(Figs 242a-c, 243a-b)

Comparative remarks

Ningbingia dentiens is immediately recognisable by its large basal lip node situated medially just inside the lip **(Fig. 242b)**, depressed shape, angulated periphery, and smooth shell surface. The shell lip is also much more expanded than in previously described *Ningbingia* (Solem 1981b: 335-340, figs 74-78). The other *Ningbingia* with a lip knob, *N. res* (Solem 1981b: 78, figs 78b, d) and some populations of *N. octava* (Solem unpublished), have a lip knob that is deeply recessed, slanted inwards, and located near the columella. The lack of prominent shell sculpture and anatomical features separate *N. dentiens* from any of the *Turgenitubulus* and *Cristilabrum* from the Ningbing Ranges. Anatomically, *N. dentiens* **(Figs 243a-b)** is most similar to *N. octava* (Solem 1981b: 346-347, figs 82-83) in having a very slender penis that is significantly longer than the penis sheath and the terminal female genitalia are quite slender. It differs in having fairly large, but smooth, basal pilasters **(Fig. 243b)**, no area of corrugated pilasters, and the penis sheath (PS) starting higher up from the

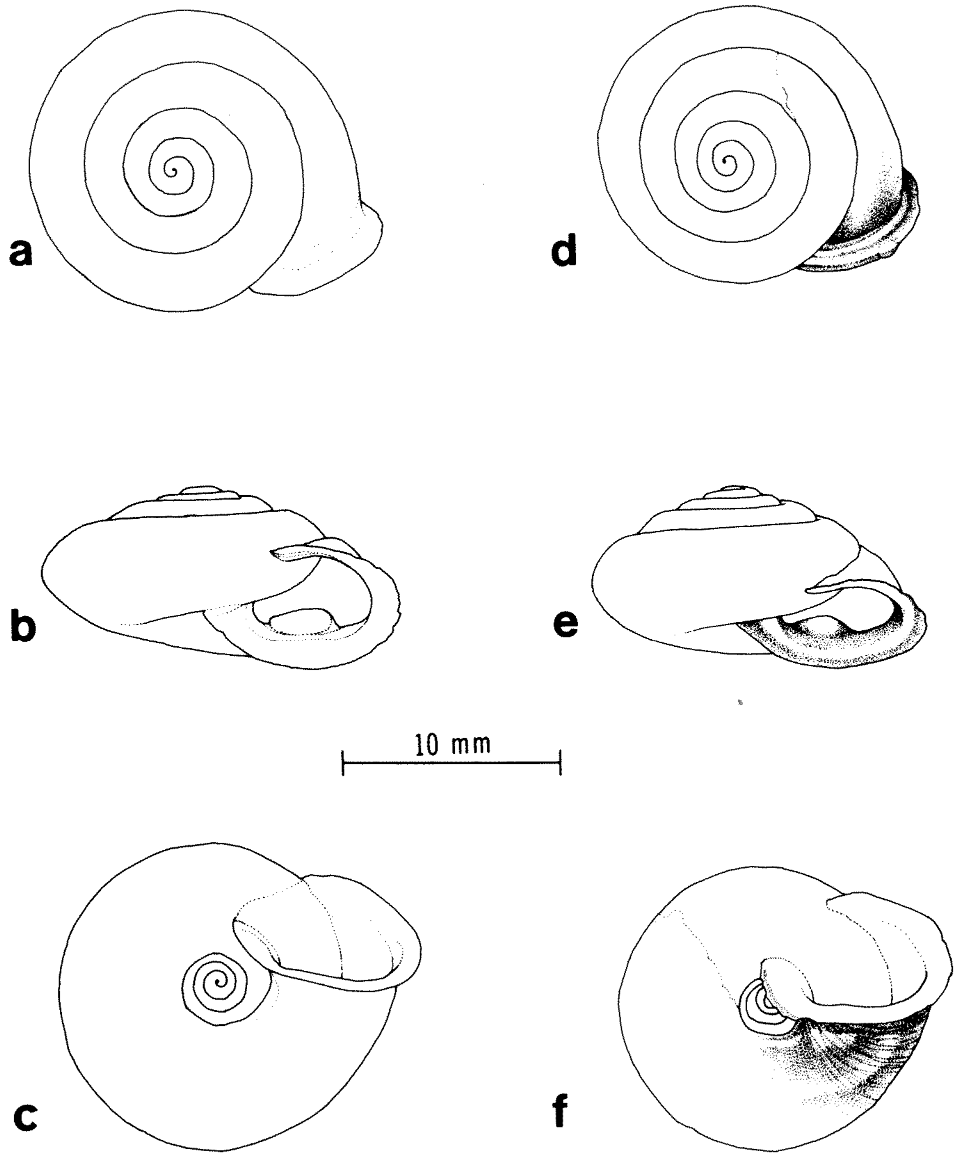

Fig. 242: Shells of *Ningbingia dentiens* and *Turgenitubulus tanmurrana:* (a-c) *N. dentiens,* WA-700, 2.2 km north of No. 8 Bore, Ningbing Ranges, north of Kununurra, WAM 617.80, holotype; (d-f) *T. tanmurrana,* Sta. WA-631, 2.8 km south of Tanmurra Bore, Ningbing Ranges, north of Kununurra, WAM 619.80, holotype. Scale line equals 10 mm. Drawings by Linnea Lahlum.

atrium than in *N. octava.* All other *Ningbingia* have the junction area of the terminal female organs greatly swollen, and the penis is much shorter and larger in diameter.

Holotype

WAM 617.80, Sta. WA-700, 2.2 km north of No. 8 Bore, 0.7 km west of track, north Ningbing Ranges, north of Kununurra, Western Australia (1:100,000 'Knob Peak' map sheet 4668 – grid reference 554:468). Collected by A. Solem, L. Price, B. Duckworth 15 June 1980. Height of holotype 8.55 mm, diameter 16.8 mm, H/D ratio 0.509, whorls 5, umbilical width 3.8 mm, D/U ratio 4.42.

Paratopotypes

WAM 13.84-14.84, FMNH 205269-70, 60 live, 174 dead adults, 2 live, 3 dead juveniles from the type locality.

Paratypes

North Ningbing Ranges: Sta. WA-704, hill to south of minor gap, ca 2.8 km north of No. 8 Bore ('Knob Peak' 4668 – 551:473) (9 live, 130 dead adults, 1 live, 7 dead broken and juveniles, WAM 15.84-16.84, FMNH 205286, FMNH 205290); Sta. WA-634, large ridge 2.7 km north of No. 8 Bore ('Knob Peak' 4668 – 552:472) (8 live, 203 dead adults, 5 live, 13 dead juveniles, WAM 17.84-18.84, FMNH 204899-900); Sta. WA-700a, 100 m south of WA-700, side of promontory by big cave ('Knob Peak' 4668 – 554:468) (9 live, 20 dead adults, 1 broken juvenile, WAM 19.84-20.84, FMNH 205271-2); Sta. WA-701, 1.9 km north of No. 8 Bore, 300 m south of WA-700 ('Knob Peak' 4668 – 553:466) (13 dead adults, WAM 21.84, FMNH 205275).

Distributional limits

Ningbingia dentiens has a total range of about 0.7 km in the north Ningbing Ranges. It is known to overlap with both *N. bulla* and *N. laurina. N. dentiens* has not yet been collected alone, nor have all three species been found at a single station.

Diagnosis

Shell relatively small, diameter 14.65-18.4 mm (mean 16.71 mm), with 4½– to 5¼– (mean 4⅞+) normally coiled whorls. Apex and spire moderately and evenly elevated **(Fig. 242b)**, height of shell 6.75-10.95 mm (mean 7.95 mm), H/D ratio 0.426-0.637 (mean 0.480). Postapical whorls with irregular growth striae, no significant radial sculpture. Shell periphery bluntly rounded to slightly angulated **(Fig. 242b)**, body whorl at most slightly descending behind aperture. Lip broadly and sharply expanded, basal section with a large, slightly recessed, centrally located, ridged node **(Fig. 242b)**, that often inclines backwards into the aperture. Umbilicus

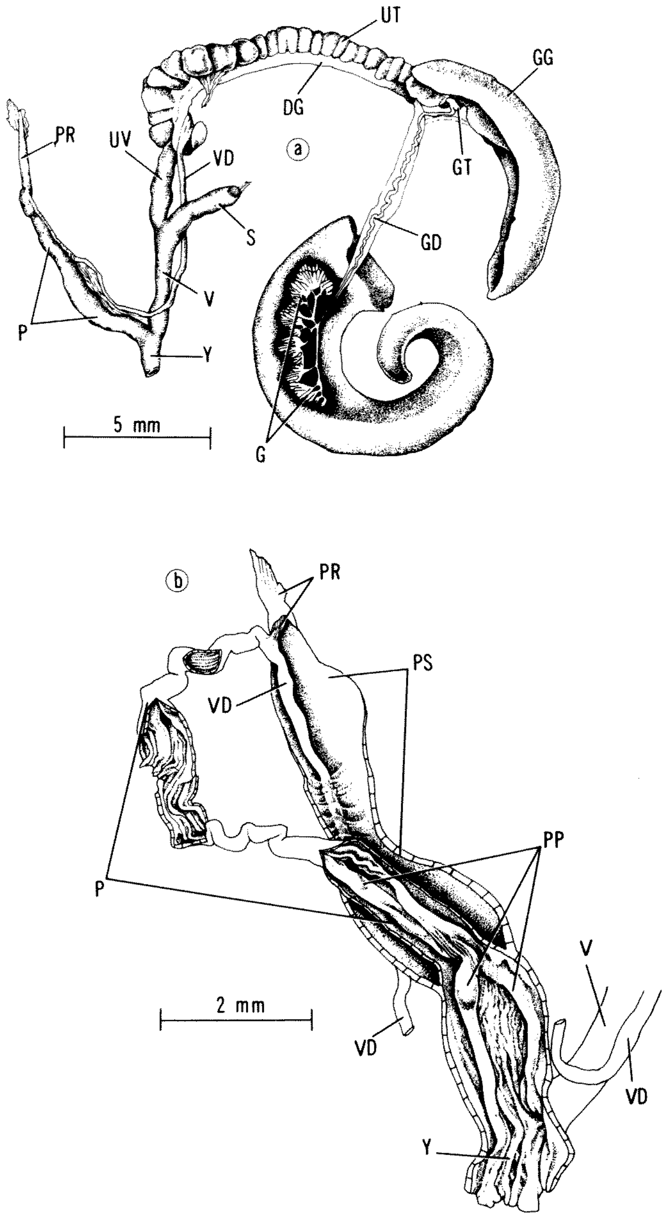

Fig. 243: Genitalia of *Ningbingia dentiens.* Sta. WA-700, 2.2 km north of No. 8 Bore, northern Ningbing Ranges, north of Kununurra, 15 June 1980, FMNH 205270, paratypes: (a) whole genitalia, Dissection A; (b) interior of penis complex, Dissection C. Scale lines as marked. Drawings by Linnea Lahlum.

open, regularly decoiling (**Fig. 242c**), width 2.05-3.9 mm (mean 3.23 mm), H/D ratio 4.15-8.07 (mean 5.15). Colour light yellow horn, lip white. Based on 627 measured adults.

Genitalia (**Figs 243a-b**) with free oviduct (UV), spermatheca (S) and vagina (V) slender. Vas deferens (VD) entering penis sheath above mid-point. Penis sheath (PS) relatively thin-walled, starting well above atrium (Y). Penis (P) slender, about twice length of penis sheath, lower portion internally with two large, narrow, longitudinal, smooth-topped pilasters, no corrugated area. One pilaster (**Fig. 243b, left**) with swollen area, other very narrow and high. Based on four dissected adults.

Remarks

Ningbingia dentiens occupies less than a kilometre of hillsides between the ranges of *N. bulla* and *N. laurina* (**Fig. 241**). At each station where it has been collected, it is predominant in numbers, but nowhere has it been found to be the only species present.

The small size, depressed shape, and large, centrally located, basal lip node immediately identify this species. Both *N. bulla* (Solem 1981b: 335-6, figs 74-75) and *N. laurina* (Solem 1981b: 339, figs 77a-c) have the shell much more globose and lack any trace of a lip node. Those two flanking species both have the junction of the female terminalia enlarged, and their penes are shorter, larger in diameter, and internally with complex, corrugated pilasters (Solem 1981b: 342-344, figs 79-81, figs 84a-b).

The name *dentiens* refers to the lip node, which is an unusual structure within the genus *Ningbingia.*

TURGENITUBULUS TANMURRANA SP. NOV.
(Figs 242d-f, 244a-c, 245)

Comparative remarks

Turgenitubulus tanmurrana is characterised by the smooth shell base, relatively high and sharply defined lip knob (**Fig. 242b**), and weak radial sculpture on the spire. *T. costus* Solem, 1981, its nearest neighbour, differs in having strong sculpture on the shell base, the lip knob broader and with more rounded edges (Solem 1981b: 362, fig. 90b), and stronger sculpture on the spire. The two species from The Gorge, *T. aslini* (**Figs 246a-c**) and *T. pagodula* (**Figs 246d-f**) differ strikingly in shell form and sculpture, the former being smooth surfaced and with a flared lip, the latter keeled and with prominent radial sculpture. The more northern species of *Turgenitubulus* differ primarily in genital features. Anatomically, the short free oviduct (UV, **Fig. 244a**) and slender vagina (V), presence of two large pilasters (PP, **Figs 244b, 245**), large apical plug, and absence of any circular ridge in the penis chamber are the distinguishing features of *T. tanmurrana. T. costus* Solem (1981b: 379, figs 96a-b) differs in its extremely

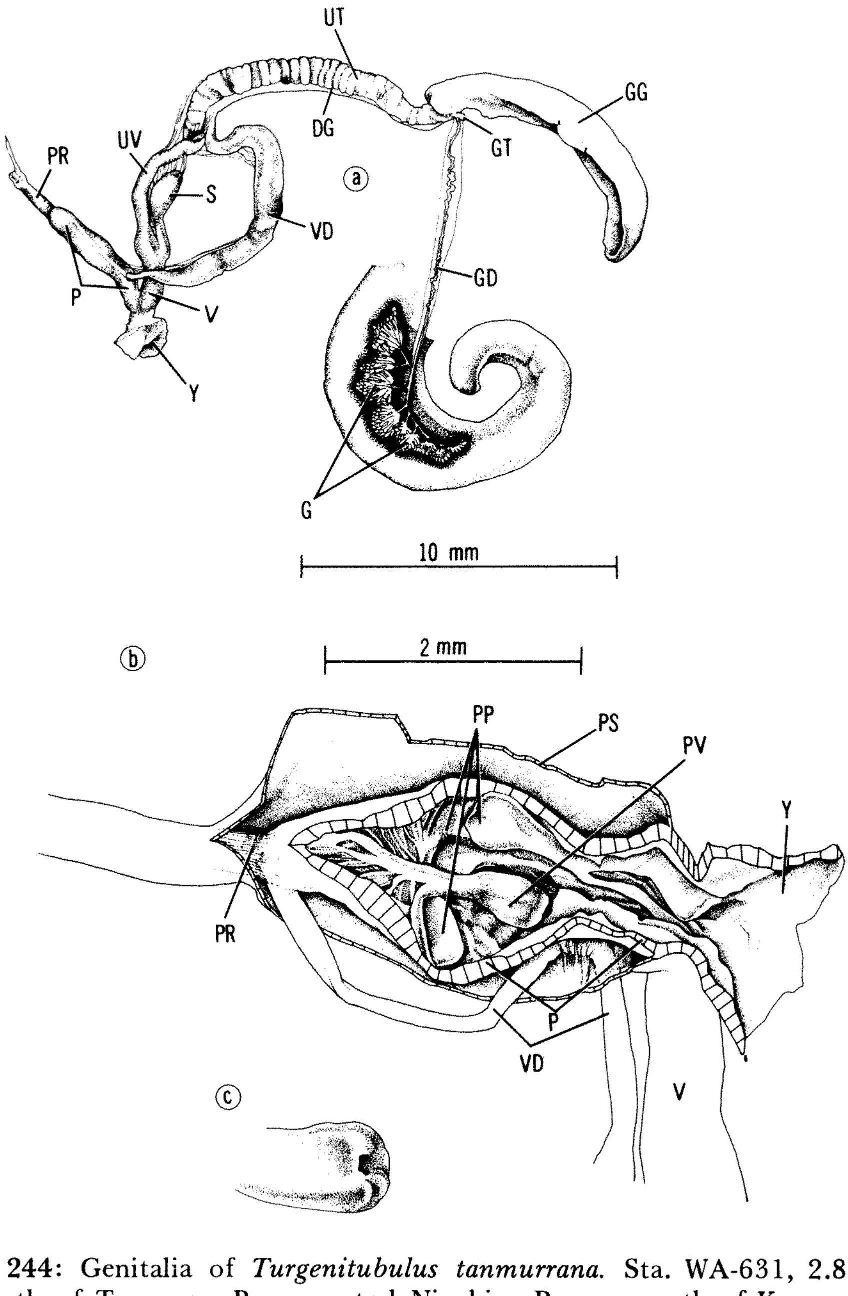

Fig. 244: Genitalia of *Turgenitubulus tanmurrana.* Sta. WA-631, 2.8 km south of Tanmurra Bore, central Ningbing Ranges, north of Kununurra, 20 May 1980, FMNH 204880: (a) Dissection B, whole genitalia; (b-c) Dissection A, b is interior of penis, c is detail of verge. Scale lines as marked. Drawings by Linnea Lahlum.

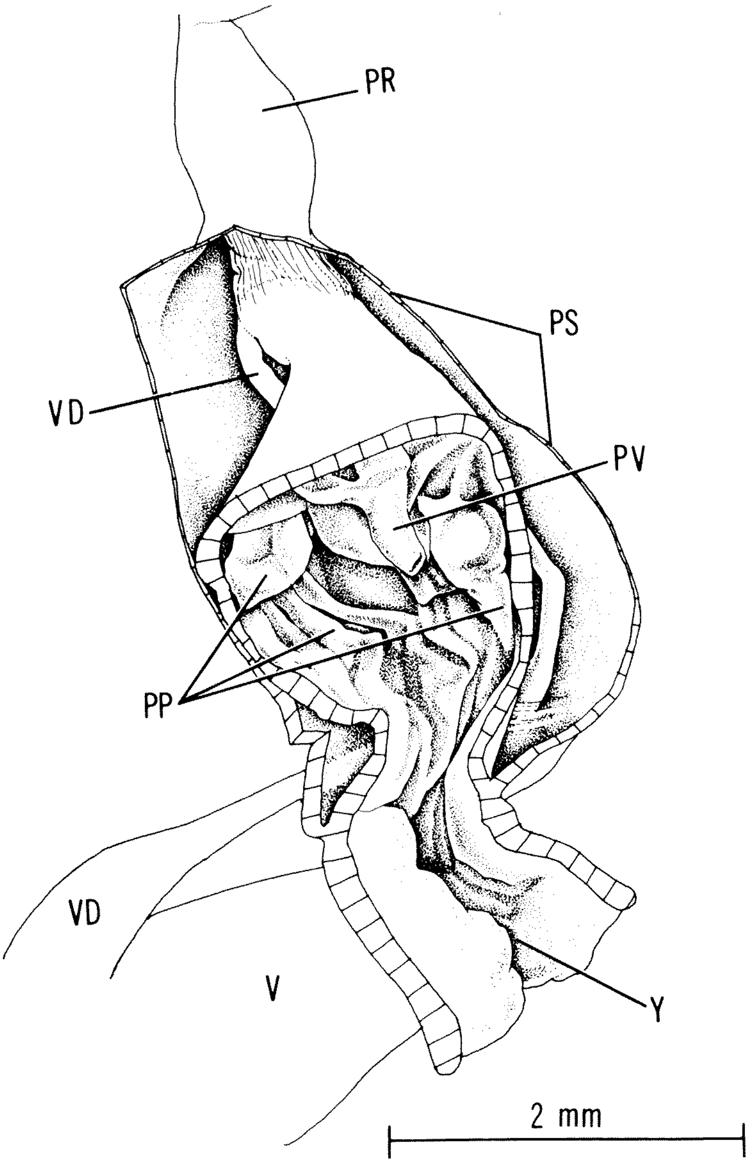

Fig. 245: Penis interior of *Turgenitubulus tanmurrana*. Sta. WA-656, 4.8 km south of Tanmurra Bore, central Ningbing Ranges, north of Kununurra, 25 May 1980, FMNH 205027, Dissection A. Scale line equals 2 mm. Drawings by Linnea Lahlum.

long and slender free oviduct (UV), presence of only one main pilaster in the penis chamber, shorter penis complex, and very thick vagina (V). *T. foramenus* Solem (1981b: 378, figs 95a-c) has a comparable free oviduct (UV), but differs in the presence of a circular ridge, only one main pilaster, and the enormous descending arm of the vas deferens (VD). The other species show equivalent differences.

Holotype

WAM 619.80, Sta. WA-631, main ridge, 2.8 km south of Tanmurra Bore, central Ningbing Ranges, north of Kununurra, Western Australia (1:100,000 'Carlton' map sheet 4667 – grid reference 613:275). Collected by A. Solem, L. Price, F. and J. Aslin 20 May 1980. Height of holotype 8.9 mm, diameter 15.5 mm, H/D ratio 0.574, whorls $5^3/_8$, umbilical width 1.7 mm, D/U ratio 9.12.

Paratopotypes

WAM 54.84-55.84, FMNH 204879-80, 28 live, 68 dead adults, 13 dead juveniles from the type locality.

Paratypes

Central Ningbing Ranges: Sta. WA-630, isolated knob near track, 2.8 km south of Tanmurra Bore ('Carlton' 4667 – 607:275) (3 live, 66 dead adults, 3 dead juveniles, WAM 56.84-57.84, FMNH 204877-8); Sta. WA-656, southeast corner main ridge, ca 4.8 km south of Tanmurra Bore, 800 m west of track ('Carlton' 4667 – 610:270) (55 live, 262 dead adults, 18 dead juveniles, WAM 58.84-59.84, FMNH 205025-7).

Distributional limits

Turgenitubulus tanmurrana is known from a rather isolated small group of hills in the central Ningbing Ranges, lying between the ranges of *T. costus* Solem, 1981 from Stas WA-233, WA-628 and WA-658 to the north, and *Cristilabrum solitudum* Solem, 1981 from Stas WA-632, WA-234, WA-626 and WA-657 to the south. While it has a potential total range of up to 1.4 km, in fact much of this area consists of open plains that will be free of live snails. Its actual linear range probably is considerably less than 1 km.

Diagnosis

Shell of average size, diameter 13.65-17.45 mm (mean 15.50 mm), with 5 to 6 (mean $5^3/_8$+) normally coiled whorls. Apex and spire moderately to strongly elevated **(Fig. 242e)**, rarely slightly rounded above, height of shell 6.95-10.9 mm (mean 9.01 mm), H/D ratio 0.478-0.684 (mean 0.582). Apical sculpture typical. Postapical whorls with moderately prominent radial ribs that stop at periphery, shell base smooth except for some trace of ribbing just behind aperture. Shell periphery bluntly angulated **(Fig. 242e)**, body whorl descending slightly just before aperture. Lip broadly and sharply reflected and expanded, columellar section partly rolled over umbilicus (**Fig. 242f**). Basal section with a somewhat recessed, high, sharply outlined knob located near columellar margin, variable in size and shape, but typically as illustrated (**Fig. 242e**), a prominent depression behind the lip. Umbilicus narrowly open, slightly decoiling (**Fig. 242f**), partly covered by reflected lip, width 1.05-3.4 mm (mean 2.29 mm), D/U ratio 4.94-13.0 (mean 6.83). Colour brownish-yellow horn, lip white. Based on 483 measured adults.

Genitalia (**Figs 244a-c, 245**) typical of *Turgenitubulus*, distinctive in that vas deferens (VD) less swollen, free oviduct (UV), short, vagina (V) slender, and spermatheca (S) short. Penis complex rather long, with typical, long, tubular verge (PV, **Figs 244b-c, 245**), large apical plug, two prominent main pilasters, and rather thick walls. Based on four dissected adults.

Remarks

Turgenitubulus tanmurrana takes its name from both Tanmurra Creek and Tanmurra Bore, despite other species in the genus being geographically closer to these landmarks.

One aspect of the measurements requires explanation. Umbilical width in Parts I-IV was measured differently than the dimension cited here. In the earlier studies, the narrow width from edge to maximum lip reflection was recorded. This was subject to considerable individual variation because of differences in the degree of columellar lip reflexion over the umbilicus. Currently the umbilical width is recorded as the maximum width, measured *parallel* to the lip reflexion. For series consistency, the holotypes are all measured as in the early parts, but the summed measurements here reflect the difference in technique. The new pattern records a better indication of actual size as opposed to degree of covering by the lip. The apparent larger umbilicus in *T. tanmurrana* (**Table 93**), compared with the other species (Solem 1981b: 330-1, table 35), is thus an artefact caused by a difference in measuration.

TURGENITUBULUS ASLINI SP. NOV.
(Figs 246a-c, 247a-b)

Comparative remarks

Turgenitubulus aslini is characterised by its lack of radial ribbing on the shell, absence of a peripheral sulcus, often high and almost conical, rather deeply recessed basal lip node, and very strongly expanded lip. *T. depressus* (Solem, 1981b: 361, figs 89d-f) is most similar in shape and lip node, but obviously differs in its strong radial sculpture and very prominent peripheral sulcus. The remaining *Turgenitubulus* have the lip node very low and broad. Both *Ningbingia dentiens* (**Figs 246b-c**) and *Cristilabrum buryillum* (Solem, 1981b: figs 98b-c) are similar in shape and have prominent lip nodes,

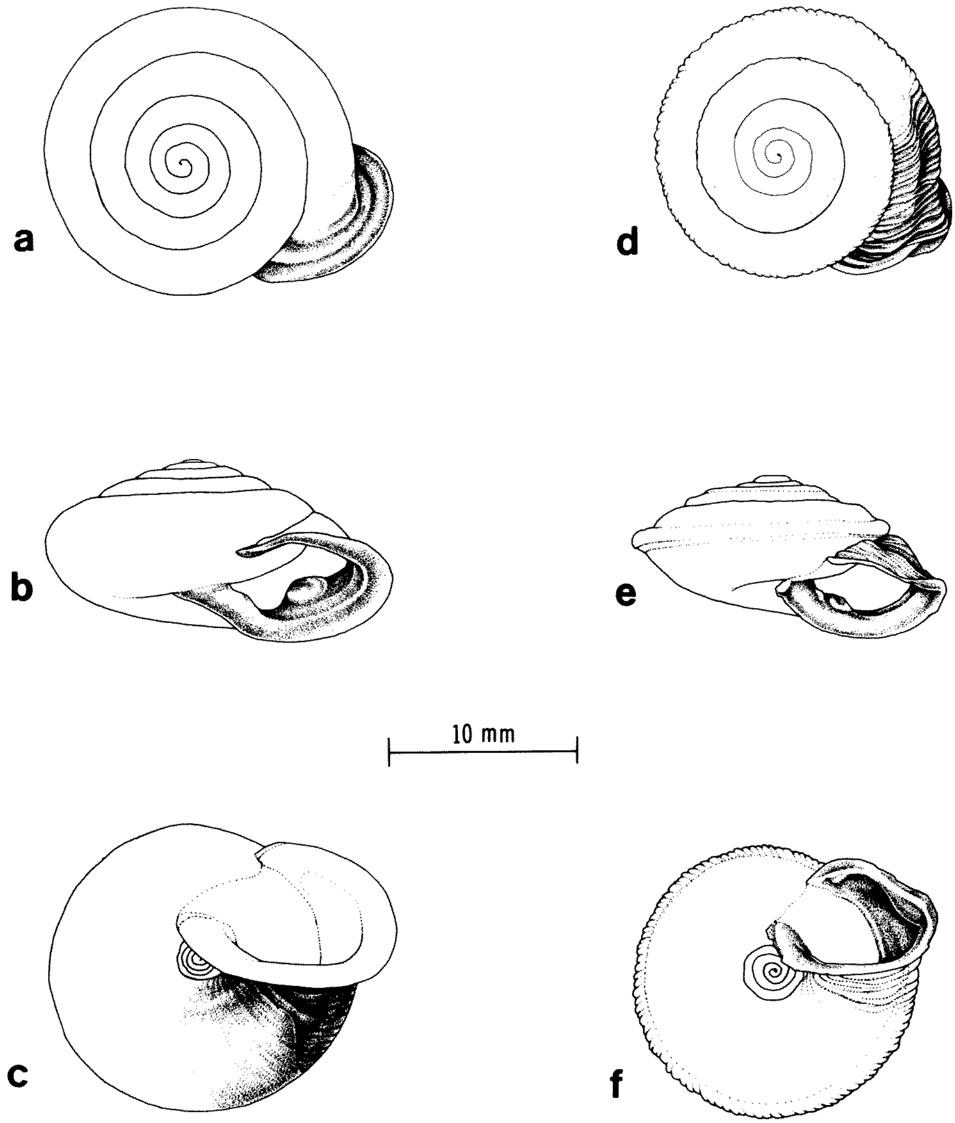

Fig. 246: Shells of *Turgenitubulus aslini* and *T. pagodula:* (a-c) *T. aslini,* Sta. WA-650, The Gorge, Ningbing Ranges, north of Kununurra, WAM 620.80, holotype; (e-f) *T. pagodula,* Sta. WA-646, The Gorge, Ningbing Ranges, north of Kununurra, WAM 621.80, holotype. Scale line equals 10 mm. Drawings by Linnea Lahlum.

but the shape of the node is different, their umbilici are much more widely open, and the shells are distinctly smaller. The sympatric *T. pagodula* **(Figs 246d-f)** is immediately recognisable by its keeled periphery, strong radial ribbing, and greatly reduced lip node that has shifted almost onto the columellar lip. Anatomically **(Figs 247a-b)**, *T. aslini* lacks the enormously swollen vas deferens (VD) that is characteristic of *Turgenitubulus*, although being otherwise typical in that the vas deferens enters the base of the penis sheath, and in structures of the penis interior. *T. pagodula* **(Figs 248a-d)** differs in almost every detail of the terminal genitalia.

Holotype

WAM 620.80, Sta. WA-650, north side of The Gorge, just east of middle where cliff comes near Station Creek, central Ningbing Ranges, north of Kununurra, Western Australia (1:100,000 'Carlton' map sheet 4667 – grid reference 600:218). Collected by Fred Aslin and Laurie Price 23 May 1980. Height of shell 10.15 mm, diameter 19.15 mm, H/D ratio 0.530, whorls 5½, umbilical width 1.6 mm, D/U ratio 12.0.

Paratopotypes

WAM 22.84-23.84, FMNH 204990-2, 8 live, 24 dead adults, 2 dead juveniles from the type locality.

Paratypes

Central Ningbing Ranges: Sta. WA-646, east end of The Gorge, north side Station Creek ('Carlton' 4667 – 602:215) (6 live, 110 dead adults, 8 live, 7 dead juveniles, WAM 24.84-25.84, FMNH 204961-2); Sta. WA-647, east end, south side of The Gorge, 200 m south-west of WA-646 ('Carlton' 4667 – 602:215) (4 live juveniles, 33 dead adults, 11 dead juveniles, WAM 26.84, FMNH 204968-9); Sta. WA-648, rock scree on north side corner, The Gorge ('Carlton' 4667 – 598:220) (4 live, 76 dead adults, 3 live, 4 dead juveniles, WAM 27.84-28.84, FMNH 204977-8); Sta. WA-649, south corner, west end of The Gorge, ca 150 m south-west of WA-648 ('Carlton' 4667 – 596:219) (7 live, 106 dead adults, 6 live, 16 dead juveniles, WAM 29.84-30.84, FMNH 204982-3).

Distributional limits

Turgenitubulus aslini and the sympatric *T. pagodula* have been collected within The Gorge, central Ningbing Ranges. The large rock mass extending south from Station Creek, and the smaller massif to the north have not been sampled for land snails. Thus the actual range of this species is unknown.

Diagnosis

Shell large, diameter 16.35-21.85 mm (mean 19.02 mm), with 5⅛– to 6⅛+ (mean 5⅝–) normally coiled whorls. Apex and spire strongly elevated,

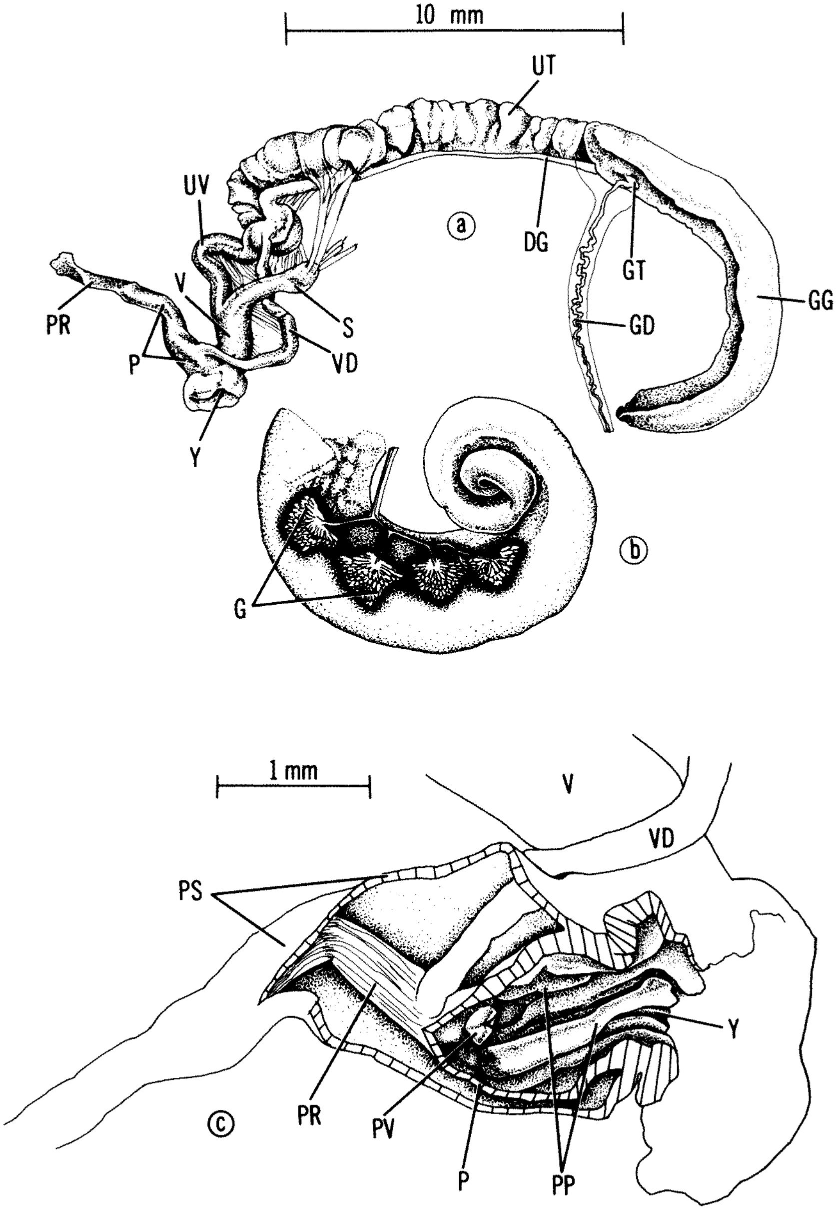

Fig. 247: Genitalia of *Turgenitubulus aslini*. Sta. WA-650, north side of The Gorge, central Ningbing Ranges, north of Kununurra, 23 May 1980, FMNH 204992, Dissection B: (a) whole genitalia; (b) ovotestis; (c) interior of penis. Scale lines as marked. Drawings by Linnea Lahlum.

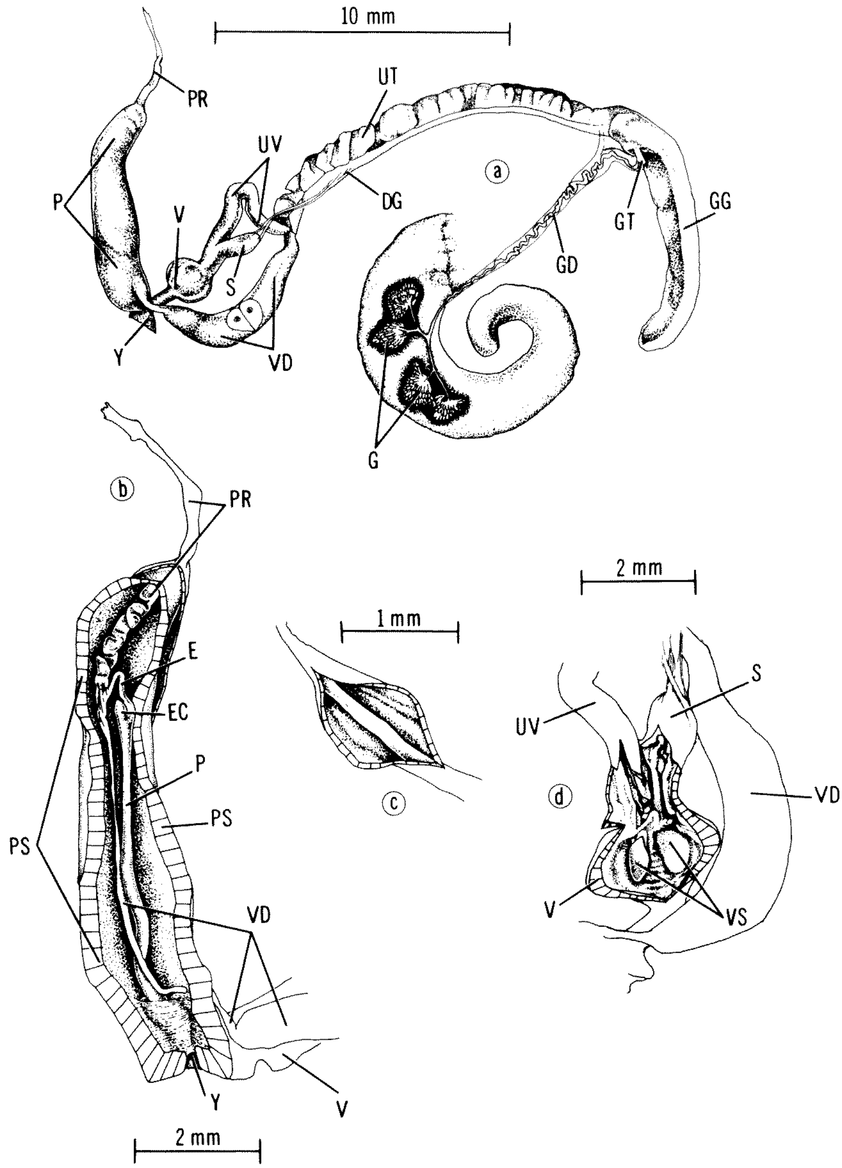

Fig. 248: Genitalia of *Turgenitubulus pagodula.* Sta. WA-646, east end of The Gorge, central Ningbing Ranges, north of Kununurra, 23 May 1980, FMNH 204959: (a) whole genitalia, Dissection A; (b) open penis sheath, Dissection B; (c) interior of penis, Dissection A; (d) interior of terminal female genitalia, Dissection A. Scale lines as marked. Drawings by Linnea Lahlum.

not rounded above (**Fig. 246b**), height of shell 8.45-11.6 mm (mean 9.99 mm). H/D ratio 0.454-0.595 (mean 0.539). Apical sculpture typical. Postapical whorls with vague irregular radial growth lines, no radial ribbing. Body whorl laterally compressed above and below bluntly rounded periphery, only slightly descending behind aperture (**Fig. 246b**). Lip very strongly reflected and expanded, deeply indented behind basal margin (**Fig. 246c**), slightly thickened internally, columellar section covering half of umbilicus (**Fig. 246c**). Basal lip with a moderately recessed, at times high and almost conical lip node, situated near lower palatal-basal margin (**Fig. 246b**). Parietal callus thin. Umbilicus narrowly open, barely decoiling, half covered by reflexion of columellar lip (**Fig. 246c**), width 1.16-3.45 mm (mean 2.77 mm), D/U ratio 5.34-15.9 (mean 6.99). Based on 374 measured adults.

Genitalia (**Figs 247a-b**) with short, swollen vagina (V) and short spermatheca (S), free oviduct (UV) sinuated. Vas deferens (VD) slightly swollen, entering base of penis sheath (PS), then ascending and reflexing to enter apex of penis at insertion of penial retractor muscle (PR). Verge (PV) short, two main longitudinal pilasters on rather thick walled penis. Apical plug very small to absent, no circular collar present around verge. Based on three dissected adults.

Remarks

Turgenitubulus aslini is named after its first collector, Fred Aslin of Mt Gambier, South Australia, in token appreciation of his invaluable help on several field trips in Australia.

The Gorge has two camaenids in residence – *T. aslini* and *T. pagodula*, found at all of the limestone rock stations sampled. The proportions of each species among the populations suggest that there may be slight habitat differences, but collecting bias could be the explanatory factor. The proportions are:

	Species and numbers of adults collected	
Station	*T. aslini*	*T. pagodula*
WA-646	6 L, 110 D	23 L, 92 D
WA-647	33 D	6 L, 49 D
WA-648	4 L, 76 D	6 L, 31 D
WA-649	7 L, 106 D	4 L
WA-650	8 L, 25 D	2 L, 15 D

Size and shape of *T. aslini* did not differ significantly among the stations.

The vas deferens is unusual in that the degree of swelling is a fraction of that found in other species of *Turgenitubulus* (Solem 1981b: 366-379, figs 91a, 92a, 93a, 94a, 95a, 96a). The vas is less swollen in the illustrated example of *T. depressus* (Ibid, fig. 94a), but that specimen is newly 'male adult' and thus the vas may not be at maximum size. All dissected *T. aslini* were fully adult individuals, as indicated by the large size of their albumen glands.

TURGENITUBULUS PAGODULA SP. NOV.
(Figs 246d-f, 248a-d)

Comparative remarks

Turgenitubulus pagodula is easily separated from the sympatric *T. aslini* and any other Ningbing camaenid by its protruded, thread-like keel (**Fig. 246e**), small node on the basal lip near the columellar margin, and prominent radial ribs. *T. aslini* has a smooth shell surface, rounded periphery, and huge, recessed lip node located near the outer basal lip margin (**Figs 246a-c**). The most similar species is *Carinotrachia carsoniana* from near Kalumburu (**Plate 85a-d, Figs 216a-c**), which differs in its less crowded sculpture, lack of a lip node, and much less expanded shell lip. Anatomically, *T. pagodula* shows extremely specialised genital structures (**Figs 248a-d**). Although it retains the characteristic swollen vas deferens of *Turgenitubulus,* the penis sheath (PS) has become very thick-walled; the penis (P) is reduced to a tube but little larger in diameter than the vas deferens and has only one simple pilaster (**Fig. 248c**) inside; the mid-portion of the vagina (V) is swollen with two vaginal stimulators (VS, **Fig. 248d**); the spermatheca is extremely short; and the free oviduct (UV) is elongated. No other Kimberley camaenid comes close to this combination of structures.

Holotype

WAM 646.80, Sta. WA-646, east end of The Gorge, 80 m off cliff on north side Station Creek, central Ningbing Ranges, north of Kununurra, Western Australia (1:100,000 'Carlton' map sheet 4667 – grid reference 602:215). Collected by Laurie Price and Fred Aslin 23 May 1980. Height of shell 9.0 mm, diameter 16.8 mm, H/D ratio 0.536, whorls $5^1/_8$, umbilical width 2.75 mm, D/U ratio 6.11.

Paratopotypes

WAM 31.84-32.84, FMNH 204959-60, 23 live, 91 dead adults, 19 dead juveniles from the type locality.

Paratypes

Central Ningbing Ranges: Sta. WA-647, east end, south side of The Gorge, 200 m south-west of WA-646 ('Carlton' 4667 – 602:215) (6 live, 49 dead adults, 2 live, 13 dead juveniles, WAM 33.84-34.84, FMNH 204970-1); Sta. WA-648, rock scree on north side corner, The Gorge ('Carlton'

4667 – 598:220) (6 live, 31 dead adults, 2 live, 6 dead juveniles, WAM 35.84-36.86, FMNH 204975-6, FMNH 204980); Sta. WA-649, south corner, west end of The Gorge ('Carlton' 4667 – 596:219) (4 live, 1 dead adults, WAM 37.84, FMNH 204984); Sta. WA-650, north side of The Gorge, just east of middle where outcrop comes near to Station Creek ('Carlton' 4667 – 600:218) (2 live, 15 dead adults, 1 live, 1 dead juvenile, WAM 38.84, FMNH 204993-4).

Distributional limits

Turgenitubulus pagodula has only been collected within The Gorge, Central Ningbing Ranges. No snails have been collected from the limestone masses extending north and south of The Gorge, so that its total range is unknown.

Diagnosis

Shell larger than average, diameter 13.95-18.7 mm (mean 16.83 mm), with 4¾– to 5½+ (mean 5⅛–) normally coiled whorls. Apex and spire moderately and evenly elevated, not rounded above **(Fig. 246d)**, height of shell 6.65-10.4 mm (mean 8.53 mm), H/D ratio 0.435-0.613 (mean 0.507). Apex with typical sculpture of prominent pustules. Postapical whorls with crowded, sharp edged, prominent radial ribs that continue onto shell base without change in size. No distinctive microsculpture. Shell periphery with a thread-like, protruded keel that is denticulated by the ribs, body whorl descending moderately just before aperture. Lip strongly expanded, columellar edge rolled over part of umbilicus. A small to medium sized node located on basal lip near columellar margin, very slightly recessed. Parietal callus moderately thick, but not completely eliminating contours of ribs. Umbilicus narrowly open, regularly decoiling, partly covered by reflexed columellar lip **(Fig. 246f)**, width 1.9-3.75 mm (mean 2.94 mm), D/U ratio 4.28-9.35 (mean 5.78). Colour dark yellow horn, lip white. Based on 228 measured adults.

Genitalia **(Figs 248a-d)** modified from *Turgenitubulus* pattern. Vas deferens (VD) and free oviduct (UV) typical. Spermatheca (S) extremely short. Vagina (V) with globose mid-section containing large vaginal stimulators protruding from a muscular ring (VS, **Fig. 248d**). Penis (P) and penis sheath (PS) greatly elongated, latter with very thick walls **(Fig. 248b)**. Vas deferens (VD) entering base of penis sheath, reflexing after insertion of penial retractor muscle (PR) as a possible weakly differentiated epiphallus (E). Latter joined by a short epiphallic caecum (EC, **Fig. 248b**) in simple entry into penis chamber, which contains one longitudinal pilaster **(Fig. 248c)**. Penis tube greatly reduced in diameter, little larger than vas deferens. Penial retractor muscle (PR, **Fig. 248b**) coiled and kinked after entrance into sheath, extending up to one-quarter of sheath length before inserting on vas deferens. Based on three dissected adults.

Remarks

The name *pagodula* is at the request of Laurie Price, collector of this species, and refers to the unusual form of the shell.

The modifications of the genitalia described above are the most extensive departure from a generic pattern that I have seen in any Australian camaenid. Presumably the vaginal stimulatory apparatus substitutes for the ridges that normally occupy the lower part of the penis chamber in other *Turgenitubulus* (**Fig. 247b**, *T. aslini*). The thickening of the penis sheath, reduction in size and elongation of the penis, addition of an apical caecum to the penis apex, and extreme shortening of the spermatheca are other very unusual features. **Fig. 248b** is somewhat misleading in that it gives an impression that a second penis sheath occurs near the apex. A thin layer of muscle pulled loose and we misinterpreted this during preparation of the illustration. There is only one penis sheath in *T. pagodula.*

No significant shell size or shape differences were noted among the several populations sampled.

CRISTILABRUM BURYILLUM SOLEM, 1981
(Figs 249a-b, 250)

Cristilabrum buryillum Solem, 1981, Rec. West. Aust. Mus., Suppl. No. **11**: 398-399, pl. 17c-d, figs 98d-f – 1.7 km south of Ningbing Bore, south Ningbing Ranges, north of Kununurra, Western Australia.

Remarks

This species is sympatric with *Cristilabrum simplex* Solem, 1981 throughout its 1.6 km range in the south Ningbing Ranges. It was described without dissection on the basis of striking shell differences and analogous situations regarding species in *Ningbingia* and *Turgenitubulus.*

Dissection of 1980 collected material from essentially the type locality (**Figs 249a-b, 250**) shows that the penis of *C. simplex* (Solem 1981b: 401, figs 102a-b) is twice as long as that of *C. buryillum,* and that the penis sheath of the latter is much thicker at the base. These differences are considered sufficient, combined with the shell changes, to indicate that the species are distinct.

Details on local variation will be presented elsewhere.

CRISTILABRUM MONODON SP. NOV.
(Figs 251a-c, 252a-c)

Comparative remarks

Cristilabrum monodon is very similar to *C. bubulum* Solem (1981b: 393, figs 99d-f), differing primarily in having very weak sculpture on the

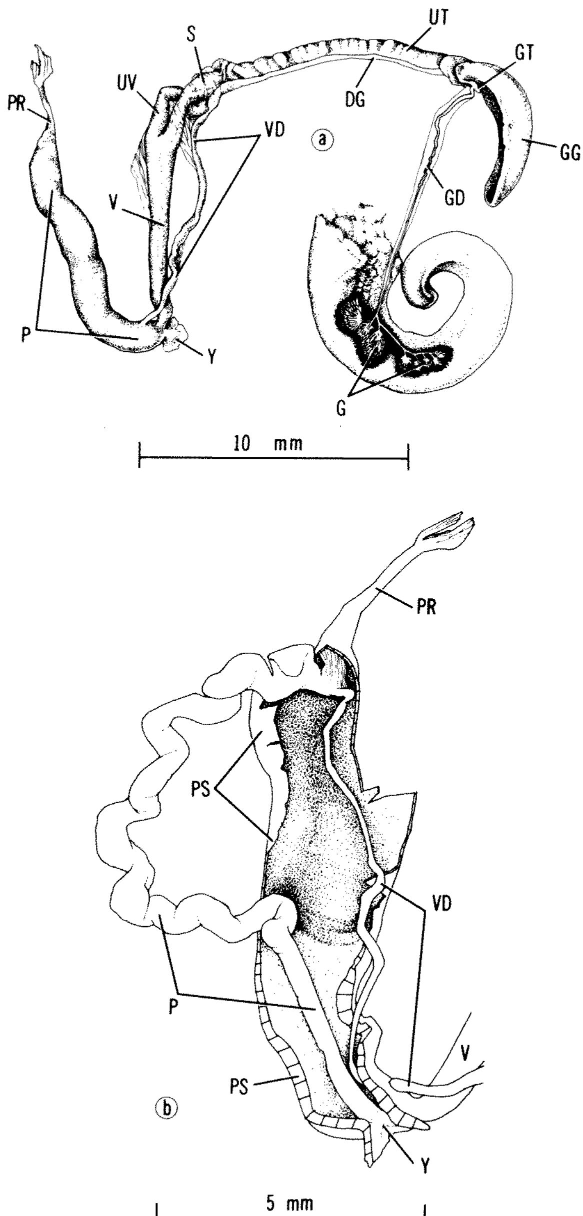

Fig. 249: Genitalia of *Cristilabrum buryillum* Solem, 1981. Sta. WA-602, 1.7 km south of Ningbing Bore, south Ningbing Ranges, north of Kununurra, 16 May 1980, FMNH 204797, Dissection A: (a) whole genitalia; (b) open penis sheath. Scale lines as marked. Drawings by Linnea Lahlum.

Fig. 250: Penis interior of *Cristilabrum buryillum* Solem, 1981. Sta. WA-602, 1.7 km south of Ningbing Bore, south Ningbing Ranges, north of Kununurra, 16 May 1980, FMNH 204797, Dissection A. Scale line equals 2 mm. Drawings by Linnea Lahlum.

spire, whereas most populations of *C. bubulum* have rather prominent sculpture. In general, the lip knobs of *C. monodon* are slightly more recessed and sharper in outline, but there is overlap in this character. *C. grossum* Solem, 1981 is much larger and there is very strong radial sculpture on the spire. Anatomically, *C. monodon* **(Figs 252a-c)** has the vagina (V) essentially equal in length to the penis sheath and there are very slender pilasters inside the apex of the penis, whereas *C. bubulum* Solem (1981b: 410, figs 105a-b) has the vagina only half to two-thirds the penis sheath length and there is a tendency for one enlarged pilaster to be located at the apex of the penis.

Holotype

WAM 622.80, Sta. WA-604, ridge 2.7 km south of Ningbing Bore, ca 750 m west of track, south Ningbing Ranges, north of Kununurra, Western Australia (1:100,000 'Carlton' map sheet 4667 – grid reference 651:115). Collected by A. Solem, L. Price, F. and J. Aslin 17 May 1980. Height of shell 8.8 mm, diameter 17.5 mm, H/D ratio 0.503, whorls 5½, umbilical width 2.55 mm, D/U ratio 6.86.

Paratopotypes

WAM 39.84, WAM 40.84, FMNH 204805-6, 12 live, 64 dead adults, 8 dead juveniles from the type locality.

Paratypes

South Ningbing Ranges: Sta. WA-603, ridge 2.7 km south of Ningbing Bore, ca 750 m west of track ('Carlton' 4667 – 650:120) (49 live, 190 dead adults, 5 live, 11 dead juveniles, WAM 41.84-42.84, FMNH 204803-4); Sta. WA-606, isolated small hills just east of WA-605, 3.2 km south of Ningbing Bore, ca 650 m west of track ('Carlton' 4667 – 653:112) (1 live, 20 dead adults, 1 dead juvenile, WAM 43.84, FMNH 204812-3); Sta. WA-605, north end of WA-604 ridge, 3.2 km south of Ningbing Bore, 750 m west of track ('Carlton' 4667 – 652:112) (3 live, 49 dead adults, WAM 44.84-45.84, FMNH 204808-9); Sta. WA-607, ca 250 m east of WA-608, south side of creek, 3.2 km south of Ningbing Bore, ca 850 m off track ('Carlton' 4667 – 652:111) (10 live, 19 dead adults, 2 live, 4 dead juveniles, WAM 46.84-47.84, FMNH 204814-5).

Distributional limits

Cristilabrum monodon has a very limited distribution in the southern Ningbing Ranges, extending between *C. primum* Solem, 1981 at Sta. WA-608 on the south to the dual ranges of *C. simplex* Solem, 1981 and *C. buryillum* Solem, 1981 at Sta. WA-670 on the north, a distance of about 1.1-1.5 km, allowing for the unsampled area between WA-670 and WA-603. The rock mass to the south is occupied by *C. primum* and *C. grossum* Solem, 1981, with *C. bubulum* Solem, 1981 not appearing until Stas WA-237 and WA-633, isolated hills south-west of this cliff complex **(Fig. 241)**.

Diagnosis

Shell of average size, diameter 15.4-19.5 mm (mean 17.45 mm), with $5\frac{1}{8}$– to 6+ (mean $5\frac{1}{2}$–) normally coiled whorls. Apex and spire moderately and evenly elevated **(Fig. 251b)**, height of shell 7.6-10.4 mm (mean 8.93 mm), H/D ratio 0.455-0.582 (mean 0.509). Apical sculpture of prominent pustules. Postapical whorls with vague, irregular growth wrinkles to nearly smooth, base of shell smooth. Shell periphery bluntly rounded or slightly angulated, body whorl descending slightly behind lip **(Fig. 251b)**. Lip strongly expanded, a deep indentation basally behind lip. Basal lip with a somewhat recessed, often transversely oriented, very high knob that usually is sharply defined, greatly narrowing aperture. Columellar lip often with a weak ridge. Parietal callus thin. Umbilicus open, regularly and slightly decoiling **(Fig. 151c)**, width 1.05-3.6 mm (mean 2.60 mm), D/U ratio 4.70-16.6 (mean 6.78). Colour light yellow horn, base lighter in tone, lip white. Based on 418 measured adults.

Genitalia **(Figs 252a-c)** typical of southern Ningbing *Cristilabrum* (Solem, 1981b: 400-410, figs 101-105). Vagina (V) long, equal in length to penis sheath (PS), free oviduct (UV) very short, spermatheca (S) short. Vas deferens (VD) entering base of penis sheath (PS), reflexing apically to enter penis through a simple pore (DP). Penis (P) slender, longer than penis sheath

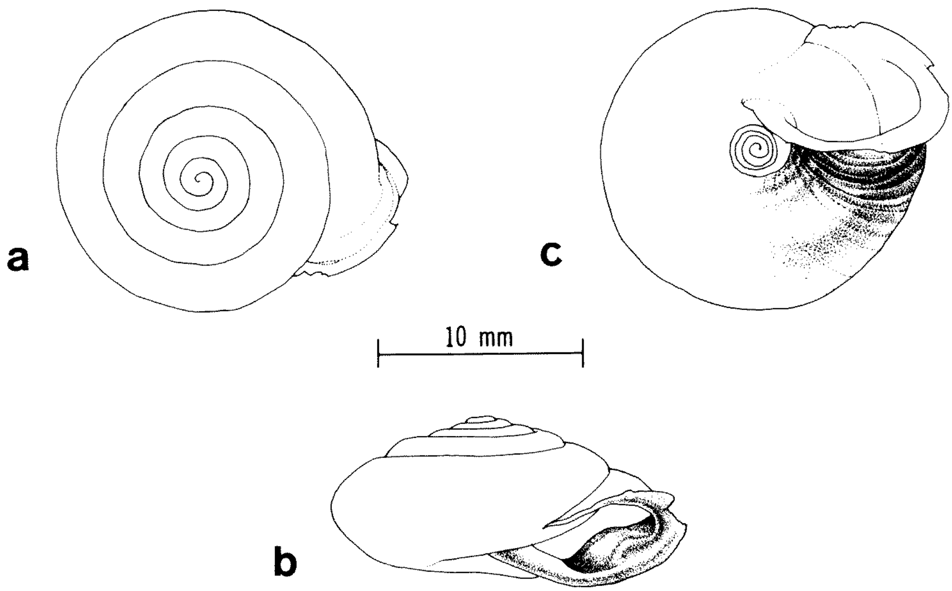

Fig. 251: Shell of *Cristilabrum monodon:* Sta. WA-604, 3.2 km south of Ningbing Bore, south Ningbing Ranges, north of Kununurra, WAM 622.80, holotype. Scale line equals 10 mm. Drawings by Linnea Lahlum.

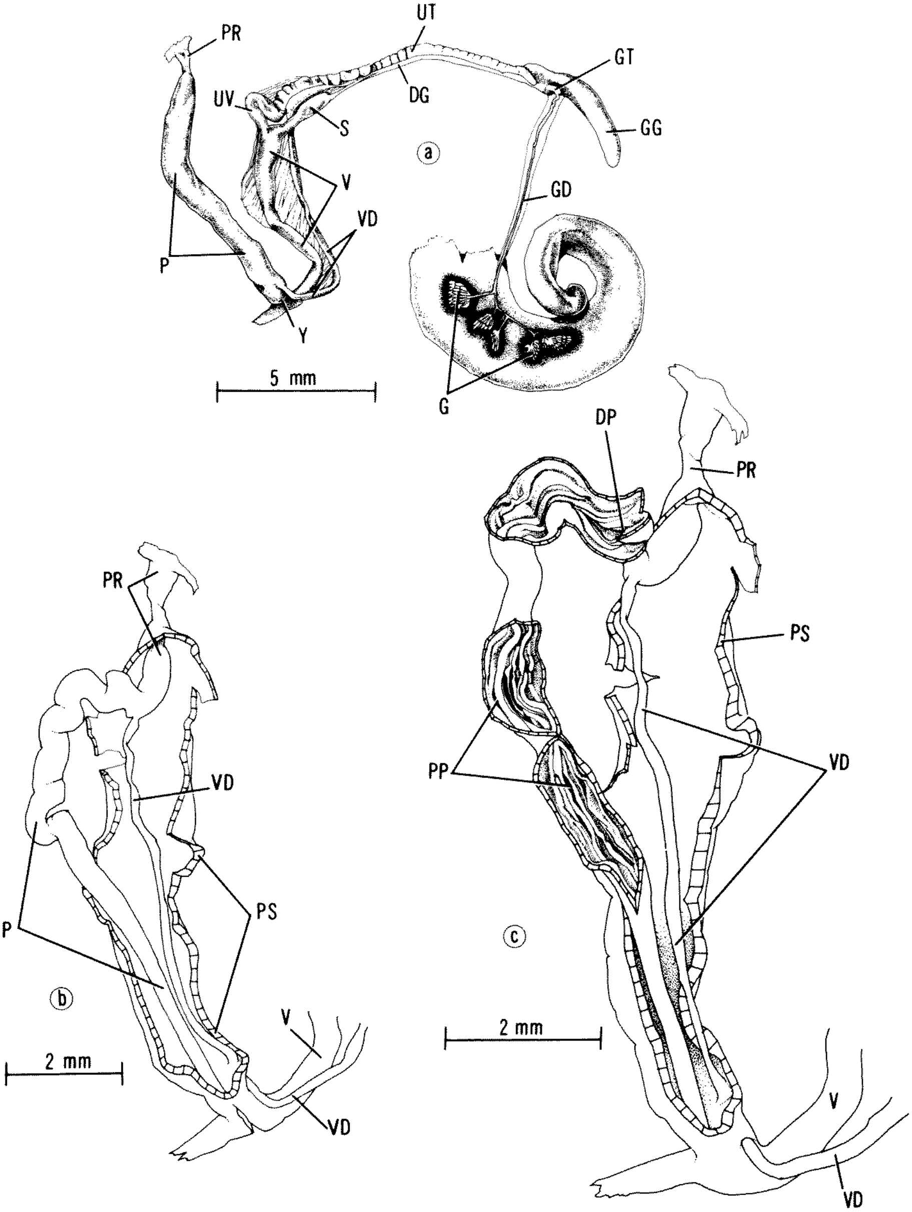

Fig. 252: Genitalia of *Cristilabrum monodon.* Sta. WA-604, 3.2 km south of Ningbing Bore, south Ningbing Ranges, north of Kununurra, 17 May 1980, FMNH 204806, Dissection B: (a) whole genitalia; (b) opened penis sheath; (c) interior of penis. Scale lines as marked. Drawings by Linnea Lahlum.

(PS, **Fig. 252b**), upper portion tightly coiled, internally (**Fig. 252c**) with very fine pilasters and no prominent apical pilasters or other structures. Based on six dissected adults.

Remarks

Cristilabrum monodon is very similar to *C. bubulum* in shell features, but the differences outlined in the Comparative remarks above, combined with the disjunct range, suggest specific separation. A change to subspecific status would not be surprising when adequate collections have been made from the west face of this rather wide limestone mass. *C. primum*'s known range occupies most of the east face, until succeeded by *C. grossum* at Sta. WA-621. In shell size and shape, *C. monodon* (**Table 93**) and *C. bubulum* (Solem 1981b: 384, table 39) are almost identical.

The name *monodon* refers to the very large basal lip knob in the shell aperture.

CRISTILABRUM BILARNIUM SOLEM, 1981

Cristilabrum bilarnium Solem, 1981, Rec. West. Aust. Mus., Suppl. No. **11**: 411-416, pl. 18c, figs 100a-c, 106a-b.

Comparative remarks

Cristilabrum bilarnium is characterised by the lack of radial sculpture on the shell base, distinct node near the basal-columellar margin, generally more rounded spire, and weakly angulated periphery. *C. spectaculum* rarely has a minute node at the basal-columellar margin, generally has strong radial sculpture on the shell base, a larger aperture, and different insertion of the columellar lip onto the parietal wall (**Fig. 253c**). *C. isolatum* (**Figs 253d-f**) has a very small, slightly recessed tubercle on the basal lip, radial ribs reduced in size on shell base, and a weakly expanded lip. Anatomically, *C. bilarnium* (Solem 1981b: 413, figs 106a-b) has no swelling of the vas deferens, fairly high entry of the vas deferens into the penis sheath, a rather short penis (P) that is very slender for the upper two-thirds, expanded basally with two larger pilasters, and with the junction of the vagina-spermatheca-free oviduct enlarged. *C. spectaculum* (**Figs 254a-b, 255a-d**) has the ascending arm of the vas deferens grossly enlarged and with a peculiar invagination, high entry of the vas deferens into a very thin-walled penis sheath, and longitudinal pilasters inside the penis. The free oviduct is very long and the vagina quite short. *C. isolatum* (**Figs 256a-c**) has the free oviduct and spermatheca very short, vagina longer, vas deferens distinctly swollen with near basal entry of the penis sheath, and the penis long and slender with simple internal pilasters.

Remarks

My original description of *C. bilarnium* included two distinct species, which was recognised as a possibility. The examples of *C. spectaculum* from this locality were all long dead and description was withheld. Subsequent collection of samples from the Jeremiah Hills of the undissected form resulted in the description of *C. spectaculum* below.

It is also evident that the cited type locality for *C. bilarnium* is in error. My original field notes state that Sta. WA-435 was 7.4 km by bush track south-east of Limestone Mill and 14.65 km by bush track from the junction with Carlton Hill Road. I could not locate this on the 'Carlton' topographic sheet, and asked staff at the Kimberley Research Station for assistance after I had returned to Chicago. Their estimate was that I had collected at the south end of the Jeremiah Hills, even though my speedometer readings did not check out. I suspect, on the basis of the 1980 field results, that I collected instead from limestone somewhat east of the Jeremiah Hills, using a track that did not exist in 1980. Certainly we found no trace of *C. bilarnium* in the Jeremiah Hills during the 1980 work. The difference in anatomy is striking, and the shell itself is quite different from that of the other two *Cristilabrum* in this region. Thus I cannot give a precise locality for *C. bilarnium,* but instead must say that the cited locality undoubtedly is wrong.

C. bilarnium is only known from the one collection.

CRISTILABRUM SPECTACULUM SP. NOV.
(Figs 253a-c, 254a-b, 255a-d)

Cristilabrum bilarnium Form A, Solem, 1981, Rec. West. Aust. Mus., Suppl. No. **11**: 414 – south-east of Limestone Mill, north-west of Kununurra, Western Australia.

Comparative remarks

Cristilabrum spectaculum (**Figs 253b-c**) differs from *C. bilarnium* (Solem 1981b: 395, figs 100a-c) in generally lacking any trace of a basal lip node (except in more northern populations) and in having the radial ribbing continue to be prominent on the shell base (except reduced in the southernmost known population). *C. bilarnium* averages a little smaller in size (**Table 93**), and has a narrower umbilicus, but overlap is so extensive that size alone cannot be used as a separating criterion. *C. isolatum* has a slightly recessed tubercle on the basal lip, variable sculpture, and the junction of the columellar lip onto the parietal margin is more direct. The only other *Cristilabrum* without any trace of a lip node is *C. simplex* Solem (1981b: 391, figs 97d-f) from just south of Ningbing Bore in the south Ningbing Ranges. It has only traces of radial sculpture on the spire and a smooth shell base.

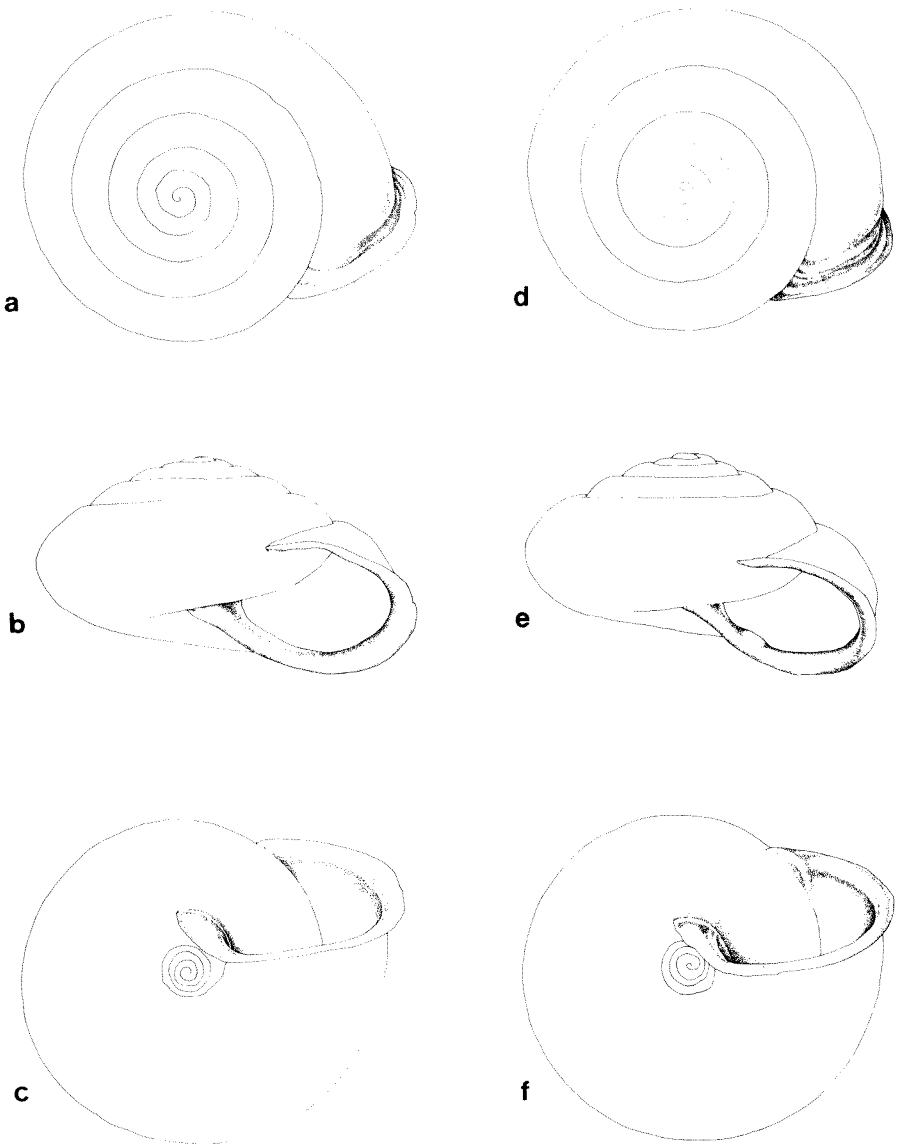

Fig. 253: Shells of *Cristilabrum spectaculum* and *C. isolatum:* (a-c) *C. spectaculum,* Sta. WA-672, south-east edge Jeremiah Hills, north of Kununurra, WAM 12.84, holotype; (d-f) *C. isolatum,* Sta. WA-675, isolated limestone mass north of Jeremiah Hills, north of Kununurra, WAM 68.84, holotype. Scale lines equal 10 mm. Drawings by Linnea Lahlum.

Mesodontrachia fitzroyana from the Northern Territory **(Figs 220a-c)** differs in its fine pustulation, lack of radial ribbing, and very different anatomy **(Figs 221a-c)**. Anatomically, *Cristilabrum spectaculum* is immediately identifiable in having the ascending arm of the vas deferens (VD) enormously swollen and the vas entering the penis sheath about half-way up **(Figs 254a, 255b)**. *C. bilarnium* Solem (1981b: 413, figs 106a-b) lacks the swollen vas deferens, shares the mid-penis sheath entry of the vas deferens, and has a very short main penis with much less complex pilasters. *C. isolatum* **(Figs 256a-c)** differs in having moderate swelling of the *descending* arm of the vas deferens, near basal entry of the penis sheath by the vas deferens, and a long, slender penis that exceeds the penis sheath length and internally has simple pilasters.

Holotype

WAM 12.84, Sta. WA-672, south-east edge of Jeremiah Hills, north of Kununurra, Western Australia (1:100,000 'Carlton' map sheet 4667 – grid reference 721:918). Collected by A. Solem, L. Price, F. and J. Aslin 28 May 1980. Height of shell 11.55 mm, diameter 20.4 mm, H/D ratio 0.566, whorls 5⅞, umbilical width 2.65 mm, D/U ratio 7.70.

Paratopotypes

WAM 48.84-49.84, FMNH 205110-1, 42 live, 167 dead adults, 49 dead and broken juveniles from the type locality.

Paratypes

Jeremiah Hills, north of Kununurra: Sta. WA-674, north-east corner of hills ('Carlton' 4667 – 725:942) (8 live, 51 dead adults, 10 live, 8 dead juveniles, WAM 50.84-51.84, FMNH 205121-2); Sta. WA-673, centre east section of hills ('Carlton' 4667 – 721:930) (13 live, 161 dead adults, 64 live, 4 dead juveniles, WAM 52.84-53.84, FMNH 205118-9); Sta. WA-601, south end of limestone, east of track, 13.7 km south of Limestone Mill ('Carlton' 4667 – 732:890) (12 live, 80 dead adults, 2 live, 7 dead juveniles, WAM 60.84-61.84, FMNH 204791-2); WA-635, isolated limestone hill 7.4 road km south-east of Limestone Mill, 14.65 road km north of Carlton Hill Road, north of Kununurra (30 dead adults, WAM 540.79, FMNH 209068).

Distribution limits

Cristilabrum spectaculum has a known north-south range in the Jeremiah Hills of 5.3 air kilometres, between Sta. WA-674, the northernmost record, and WA-601, the southern limit of limestone. The east-west limits, to include the type locality of *C. bilarnium,* are unknown.

Diagnosis

Shell relatively large, diameter 16.9-24.5 mm (mean 20.80 mm), with 5⅛– to 6⅜+ (mean 5¾+) normally coiled whorls. Apex and spire moderately to strongly elevated, sometimes rounded above **(Fig. 253b)**, height of shell 9.0-14.2 mm (mean 11.49 mm), H/D ratio 0.481-0.641 (mean 0.551). Apical sculpture of prominent pustules. Postapical whorls with fine, rather crowded radial ribs that generally continue across shell base into umbilicus without diminution, reduced in southernmost populations. No distinctive microsculpture. Shell periphery bluntly rounded to weakly angulated, body whorl at most descending slightly behind lip **(Fig. 253b)**. Lip slightly expanded, not thickened, normally without a trace of a node. Parietal callus thin, but covering most of rib contour. Umbilicus open, slightly decoiling **(Fig. 253c)**, width 2.55-4.5 mm (mean 3.36 mm), D/U ratio 5.04-8.79 (mean 6.18). Colour light yellow horn, lip white. Based on 565 measured adults.

Genitalia **(Figs 254a-b, 255a-d)** highly modified. Vagina (V) and spermatheca (S) short, free oviduct (UV) longer and slightly sinuated. Descending arm of vas deferens (VD) simple, after reflexing upwards from peni-oviducal angle becoming enormously expanded with an invagination of the upper vas deferens surrounding the inner vas tube **(Figs 255b-d)**. This invagination extends from just inside the penis sheath to the anterior part of the swollen section. Tube of vas **(Fig. 255d)** narrowing just inside sheath, ascending to be enveloped by penial retractor muscle (PR) for short distance just before entering penis chamber through a simple pore (DP, **Fig. 255a**). Penis sheath (PS) rather thin-walled, penis (P) thick-walled, with ridged longitudinal pilasters, part of penis extended as a caecum laterally above vas entrance **(Figs 255a-b)**. Based on eight dissected adults.

Remarks

Cristilabrum spectaculum is named for its very unusual male genital structures, which are not duplicated elsewhere in the Camaenidae. The peculiar invagination of the *ascending* arm of the vas deferens is a unique structure. In *Turgenitubulus* the *descending* arm of the vas deferens is surrounded by heavy layers of muscle and glandular tissue, but there is no accessory chamber equivalent to the structure in *C. spectaculum.*

As predicted (Solem 1981b: 414-415), Form A of *Cristilabrum bilarnium* proved to be a distinct species (p. 966). These long dead shells from WA-435 match exactly the material collected in 1980 from the Jeremiah Hills.

I was much less fortunate in describing *C. funium* Solem (1981b: 416-417) as a *Cristilabrum.* Collections of live material near Katherine and Mataranka, Northern Territory show that this species is part of a monophyletic radiation derived from *Torresitrachia* and is not even distantly related to *Cristilabrum* (Solem, unpublished). In trying to pack it into an anatomically known genus, I erred.

The geographic relationship of *C. bilarnum* and *C. spectaculum* is discussed above under that species.

Variation among the populations will be treated in detail elsewhere. Here it is necessary to point out that the northern population (WA-674)

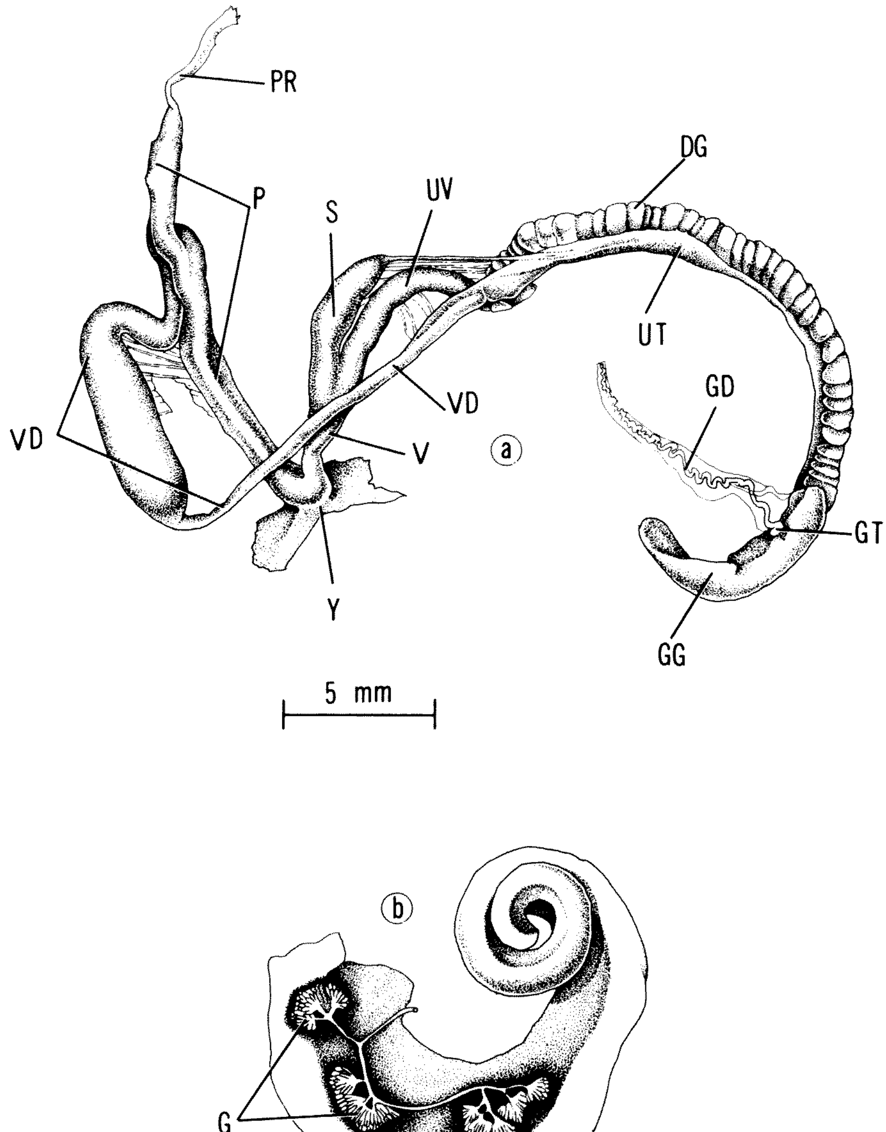

Fig. 254: Genitalia of *Cristilabrum spectaculum*. Sta. WA-672, south-east edge of Jeremiah Hills, north of Kununurra, 28 May 1980, FMNH 205111, Dissection A: (a) whole genitalia; (b) ovotestis. Scale line equals 5 mm. Drawings by Linnea Lahlum.

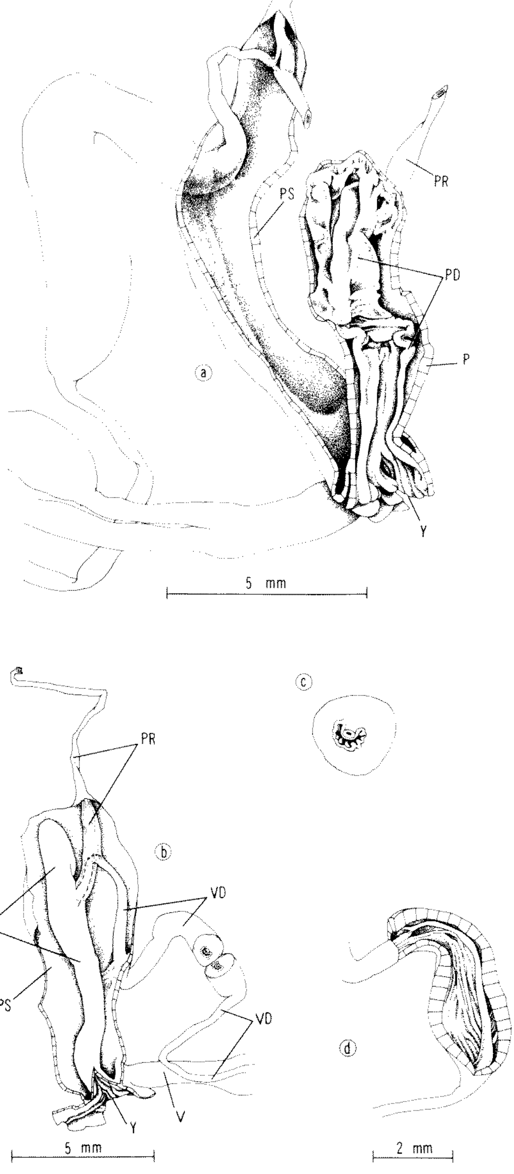

Fig. 255: Male genitalia of *Cristilabrum spectaculum*. Sta. WA-672, southeast edge of Jeremiah Hills, north of Kununurra, 28 May 1980, FMNH 205111: (a) Dissection C, interior of penis; (b) Dissection B, open penis sheath; (c) Dissection B, cross-section of expanded part of vas deferens; (d) Dissection D, longitudinal opening of expanded part of vas deferens. Scale lines as marked. Drawings by Linnea Lahlum.

has a slight trace of a basal-columellar node and prominent radial ribbing continues onto the shell base. None of the other populations show any trace of the lip node. The southernmost population (WA-601) is unusual in that the radial ribbing is greatly reduced on the shell base, and the shells may show some subtle differences in shell contours.

CRISTILABRUM ISOLATUM SP. NOV.
(Figs 253d-f, 256a-c)

Comparative remarks

Cristilabrum isolatum has a slightly recessed, very small tubercle on the basal-columellar lip **(Fig. 253f)**, the ribs reduced to nearly absent on the shell base, and a more direct insertion of the columellar lip onto the parietal wall. *C. bilarnium* Solem (1981b: 395, figs 100a-c) has a rather long, less well defined node on the basal lip, never any radial sculpture on the shell base, and a less capacious aperture. *C. spectaculum* **(Figs 253a-c)** rarely has any trace of a tubercle on the lip, the sculpture on the shell base generally is quite strong, and the aperture is more circular in outline. Anatomically, *C. isolatum* **(Figs 256a-c)** has the descending arm of the vas deferens swollen, near basal entrance of the vas into a long and slender penis with simple longitudinal pilasters inside, and a relatively long vagina. *C. spectaculum* has the ascending arm of the vas deferens enormously swollen and invaginated **(Figs 254a, b)**, near mid-sheath entry of the vas deferens, while *C. bilarnium* Solem (1981b: 413, figs 106a-b) has the penis short, slender apically, with two main pilasters basally, and the terminal female genitalia swollen.

Holotype

WAM 68.84, Sta. WA-675, isolated limestone mass north of Jeremiah Hills, north of Kununurra, Western Australia (1:100,000 'Carlton' map sheet 4667 – grid reference 713:970). Collected by A. Solem, L. Price, F. and J. Aslin 28 May 1980. Height of holotype 11.3 mm, diameter 19.6 mm, H/D ratio 0.577, whorls 5⅝ –, umbilical width 2.35 mm, D/U ratio 8.34.

Paratopotypes

WAM 62.84-63.84, FMNH 205123-4, 16 live, 117 dead adults, 3 live, 7 dead juveniles from the type locality.

Paratypes

Sta. WA-676, Laurie's Bit, an isolated limestone hillock, 3.9 km north-west of Limestone Mill, north of Kununurra ('Carlton' 4667 – 685:015) (4 live, 57 dead adults, 1 live, 10 dead juveniles, WAM 69.84-70.84, FMNH 205126-7).

Distribution limits

Cristilabrum isolatum has been taken from two isolated bits of limestone in the south drainage of Sandy Creek, between the Ningbing Ranges and Jeremiah Hills. They are 5.25 air km apart. Sta. WA-675 is 3.0 km north-north-west of WA-674, the northernmost locality for *C. spectaculum*. The other locality, WA-676, is north-west of WA-675, and about 8.3 km south-south-east of the southern bulge of the Ningbing Range. The intervening areas appear to be limestone-free, open plains.

Diagnosis

Shell relatively large, diameter 15.2-22.5 mm (mean 19.80 mm), with 5 to $6^1/_8$+ (mean $5^5/_8$) normally coiled whorls. Apex and spire moderately elevated, sometimes rounded above **(Fig. 253e)**, height of shell 7.5-13.2 mm (mean 10.75 mm), H/D ratio 0.449-0.601 (mean 0.543). Apical sculpture typical. Postapical whorls with moderately prominent radial ribs that become reduced or lost on shell base. Shell periphery bluntly angulated to rounded, body whorl descending only slightly before aperture **(Fig. 253e)**. Lip reflected, little expanded, a slightly recessed tubercle on basal-columellar lip. Parietal callus thin. Umbilicus open, regularly decoiling **(Fig. 253f)**, width 2.1-4.1 mm (mean 3.33 mm), D/U ratio 5.10-7.44 (mean 5.98). Colour yellow horn, lip white. Based on 195 measured adults.

Genitalia **(Figs 256a-c)** with relatively long vagina (V), short spermatheca (S). Descending arm of vas deferens moderately enlarged, same diameter as vagina, narrowing at peni-oviducal angle, reflexing upward to near basal entry of the thin walled penis sheath (PS, **Fig. 256b**), continuing up to insertion of penial retractor muscle (PR). Latter originating on diaphragm, entering penis sheath after a short distance, extending downward to insert on vas-penis junction. Penis (P) thin, longer than sheath, weak pilasters apically, one somewhat enlarged pilaster near base. Based on partial dissection of two dried specimens.

Remarks

Both known localities for *Cristilabrum isolatum* are from very small and isolated limestone hillocks in the south drainage of Sandy Creek **(Fig. 241)**. Sta. WA-624, another isolated bit of limestone near the Redbank Creek track in the upper drainage of Sandy Creek was visited and found to be without any camaenids. There are a number of isolated limestone fragments to the east of the Jeremiah Hills, and collections should be made from them.

The two populations agree in anatomy, in so far as the dried out material could be rehydrated and studied. They are noticeably different in shell size **(Table 94)**, with the smaller, more isolated limestone mass at Sta. WA-676 having specimens that average 2.5-3.1 mm less in diameter and with the mean whorl count lowered by $^3/_8$ths, compared with specimens from Sta. WA-675.

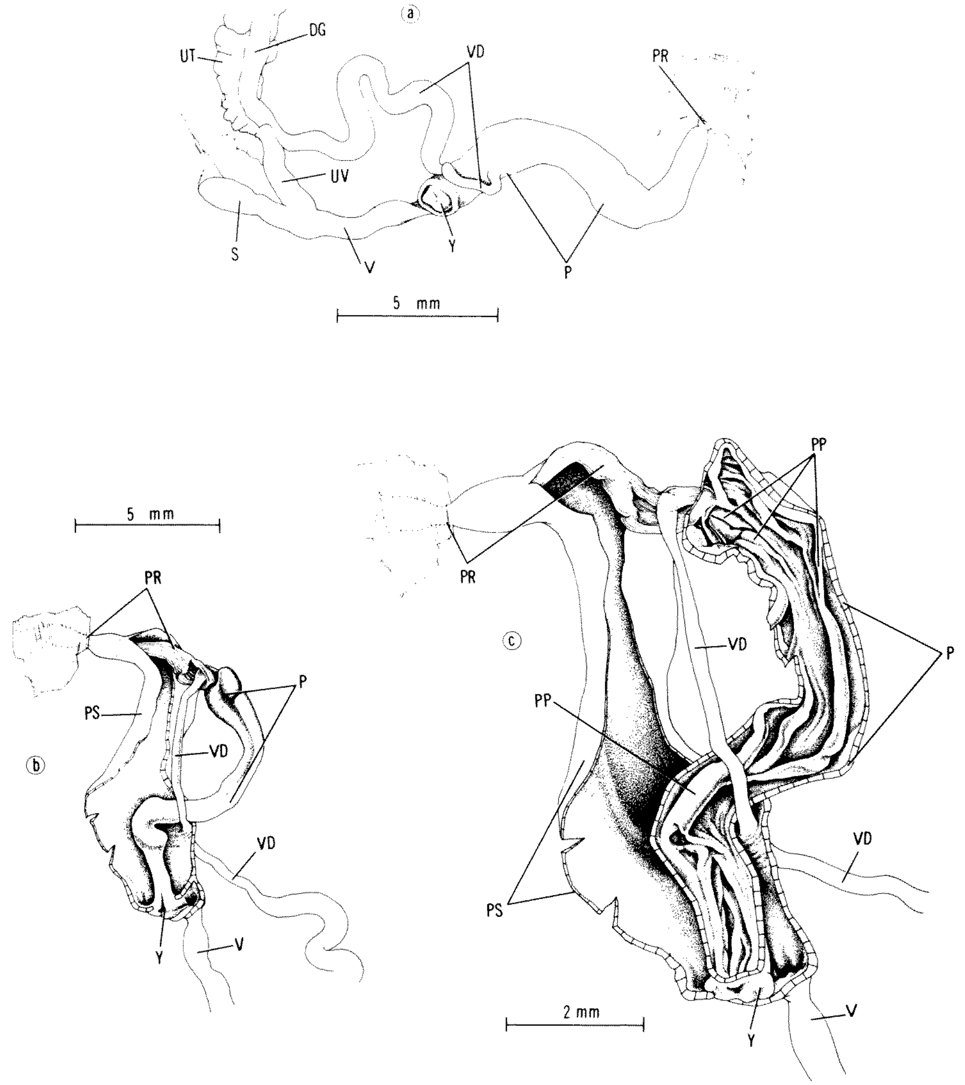

Fig. 256: Genitalia of *Cristilabrum isolatum,* Sta. WA-676, northern outlier from Jeremiah Hills, north of Kununurra, 28 May 1980, FMNH 205127, Dissection A: (a) terminal genitalia; (b) opened penis sheath; (c) interior of penis. Scale lines as marked. Drawings by Linnea Lahlum.

The differences among the three taxa from the Sandy Creek-Jeremiah Hills taxa in respect to anatomy are striking. They also do not conform to the generic patterns shown by the Ningbing radiation. Rather than comment, at this time, on their generic allocation, I prefer to leave them, temporarily, in *Cristilabrum,* with a revision of generic concepts postponed until more material is available from this area. The isolated nature and small size of the exposed limestone areas result in small populations. Founder effects, rare colonisation by catastrophic floods, and opportunities for experimentation exist. *C. bilarnium* Solem, 1981, *C. spectaculum* and *C. isolatum* are clear evidence that such experiments have occurred.

C. bilarnium probably lives in isolated limestone to the east of the Jeremiah Hills; *C. spectaculum* ranges throughout the Jeremiah Hills and then presumably east to the type locality of *C. bilarnium;* while *C. isolatum* lives north of the Jeremiah Hills, on isolated limestone pimples just south of Sandy Creek (**Fig. 241**). It is quite probable that additional species exist on other isolated limestone exposures in this region.

GENUS *PRYMNBRIAREUS* SOLEM, 1981

Prymnbriareus Solem, 1981, Rec. West. Aust. Mus., Suppl. No. **11**: 417-423.

Remarks

The single known species, *Prymnbriareus nimberlinus* Solem, 1981, was originally taken in the Nimberline area of El Questro Homestead. In 1980, the type locality was revisited (Sta. WA-593). An additional 3 dead adults, several recently dead juveniles, and one live subadult were collected (WAM 124.84, FMNH 204752-3). A single dead juvenile was taken at Sta. WA-592, on the flood plain edge of the south bank of the Pentecost River, just west of El Questro Homestead ('Elgee' 4465 – 299:909), providing a range of extension of a few kilometres.

Discussion

Parts I through V of *Camaenid Land Snails from central and Western Australia* record 137 species in 23 genera from the Kimberley or adjacent areas of the Northern Territory. Ninety-eight of the species and 11 of the genera were new; an additional six species are noted as being new, but not described, because of limited material. In Part I, 13 additional taxa from extralimital regions were reviewed in order to establish generic limits and/or species affinities.

Hedley (1916: 68-70) listed 17 Kimberley species, and Iredale (1939: 46-73), in his compilation of all Western Australian land snails, reviewed or described 32 species, plus an additional 9 synonyms. The current reports thus represent a considerable advance in knowledge over the two previous attempts to summarise the Kimberley fauna, but it is probable that at least a doubling of species numbers will occur when other parts of the Kimberley are explored for land snails. This series is a progress report, not a completion of a task.

Of the 23 genera, 12 were described previously: three by Albers or von Martens in 1860; one by Thiele in 1931; and eight by Iredale (plus another three that are reduced to synonymy in this series). Sixteen to 18 genera are restricted endemics. A maximum of seven genera range outside of the Kimberley and adjacent portions of the Northern Territory. *Torresitrachia* Iredale, 1939, *Xanthomelon* von Martens, 1860 and *Hadra* Albers, 1860 range across the top of Australia between Queensland and Western Australia. Quite possibly *Damochlora* Iredale, 1938 and *Setobaudinia* Iredale, 1933 eventually will be found to have Queensland representatives, but at present are treated as if they are as western endemics. The material needed to determine if Queensland taxa should be included in them are not available at this time, and thus their relationships remain uncertain. *Rhagada* Albers, 1860 is most diverse in the area between Carnarvon and Cape Leveque along the west coast of Australia, with the Kimberley its northern limit. *Quistrachia* Iredale, 1939 has one Kimberley species in part of the Napier and Oscar Ranges, several inland taxa in the Pilbara, and then coastal taxa almost south to Carnarvon.

Relationships with taxa from the Red Centre, Pilbara and the south coast of Australia are strong enough that phyletic discussions must wait until these taxa have been monographed. In the meantime, the many Kimberley genera need to be identifiable by the user of these monographs.

A key to species based only on shell characters would be most useful, but this would be nearly impossible to construct. Convergences in shell features are many and dramatic: for example, *Westraltrachia* and *Amplirhagada* in the western Napier Range become so similar in size, shape and shell colour that identification at 50 cm distance is not possible (Solem, in press). The fact that many, perhaps most, areas of the Kimberley have not yet been investigated for land snails, also complicates key construction. I anticipate numerous additional genera will be found and a doubling of the currently known species will occur. I can safely predict that most of them would not 'key out' properly.

A key including anatomical criteria has the defect that most casual collections of snails by non-malacologists consist of long dead, bleached and worn shells picked up from open ground. They have been washed down by rains from the rocky slopes that shelter the living populations, and are indicators 'that snails live(d) up there'. While useful in establishing range limits, they are, by themselves, of limited value in working out species limits or generic placement of taxa. Even if specimens are collected alive, often they will be plunged into formalin (which soon renders them useless for study) or into alcohol (which enables later dissection with some success). Such 'plunging' causes the animal to retract deeply into the shell. Internal organs are grossly distorted and compacted in the process. Or, equally frequently, the snails are allowed to 'dry out' without any attempt at preservation, which makes anatomical information unavailable. Rarely are such casual collections relaxed and preserved properly (drowned overnight in a jar filled with water, to which half a cheap cigarette per litre has been added as a relaxant, then fixed in 95% ethanol or methylated spirits, with long term storage in 70% ethanol).

A key incorporating anatomical features will permit associating a new species to a genus with some certainty. It also will encourage proper preservation by collectors and use of anatomical data.

Thus the following key uses primarily anatomical features, with secondary emphasis on shell characters and distribution to provide choices. There are 24 listings for the 23 genera, since the patterns in the Ningbing endemic genus *Cristilabrum* Solem, 1981 are varied enough for the genus to key out in two places. Actually this probably is a compound genus, but revision of this generic complex has been postponed, pending results of mid-1984 field work. This is an *artificial* key, without any phylogenetic implications: discrimination, not genealogy, is its focus. References to figures are provided as an aid. It is assumed that the user will have all five parts of this series available during identification attempts. Dissection of the terminal and pallial genital organs is required, plus opening the penis to determine its internal patterns of structure.

KEY TO THE KIMBERLEY GENERA OF CAMAENID LAND SNAILS

1. Penis without a sheath (**Figs 195-6**) 2
   Penis with a sheath (**Fig. 252**) 6
2. Epiphallus with a caecum (EC) (**Figs 227, 239**) 3
   No epiphallic caecum present; aperture of shell with very large lip nodes (**Figs 194b, e**) . . . . *Baudinella* Thiele, 1931 (p. 775)
3. Penis with a medium to large verge (PV) (**Figs 230, 233**) 4
   No verge in penis; shell umbilicus with micro-pustules (Solem 1979: 51, pl. 3g) . . . . *Torresitrachia* Iredale, 1939 (Solem 1979: 45)
4. Umbilicus widely open (**Figs 197, 200, 202**) 5
   Umbilicus closed or barely open (**Figs 222c, f, 225c**) . . . . *Rhagada* Albers, 1860 (p. 875)
5. Spermatheca (S) short, not kinked or coiled (**Fig. 203a**) . . . . *Kendrickia* new genus (p. 804)

Spermatheca long, strongly kinked or coiled **(Figs 198, 201)** ....
Retroterra new genus (p. 787)

6. Spermatheca (S) long, reaching or nearly reaching base of albumen gland (GG) 7
Spermatheca short, never extending more than half way up the prostate (DG)—uterus (UT) **(Fig. 243)** 9

7. Shell with prominent microsculpture; diameter under 16 mm 8
Shell surface smooth; diameter over 20 mm ....
Hadra Albers, 1860 (Solem 1979: 133)

8. Shell diameter more than 10 mm; lip without nodes; sculpture of radial microridges (Solem 1979: 94, pl. 8) ....
Damochlora Iredale, 1938 (Solem 1979: 101) (p. 933)
Shell diameter less than 10 mm; lip with prominent nodes **(Figs 182, 184)**; sculpture of periostracal setae **(Plates 64-69)** ....
Setobaudinia Iredale, 1933 (p. 711)

9. Vas deferens (VD) entering base of penis sheath (PS) **(Figs 214a, 249a, 252a)** 10
Vas deferens entering middle to apex of penis sheath 11

10. Penis wall with longitudinal pilasters; Ningbing Ranges ....
Cristilabrum Solem (1981b: 382) (p. 959)
Penis wall with pustules **(Figs 214b-c)** ....
Quistrachia Iredale, 1939 (p. 846)

11. Verge absent 12
Verge (PV) present (Solem 1981a: 243, fig. 54) ....
Amplirhagada Iredale, 1933 (Solem 1981a)

12. Shell not globose in shape; if mean H/D ratio over 0.800, spire evenly elevated 13
Shell globose; mean H/D ratio near 1.00; usually more than 20 mm in diameter ....
Xanthomelon von Martens, 1860 (Solem 1979: 9)

13. Shell surface smooth, or with many crowded ribs **(Plate 85)** 14
Shell with a few very large radial ribs; aperture of shell strongly deflected (Solem 1984: 640, fig. 163) ....
Mouldingia Solem, 1984 (Solem 1984: 635)

14. Epiphallus (E) protruded into a loop within penis sheath (PS), arms normally bound by fibres (Solem 1984: 498, fig. 113) ....
Westraltrachia Iredale, 1933 (Solem 1984: 431)
Epiphallus with at most a remnant of the loop (Solem 1984: 668, fig. 173) 15

15. Penis (P) with remnant of epiphallic loop, plus a heavy muscular-glandular zone on penis (Solem 1984: 658, fig. 168) 16
Penis without epiphallic loop remnant or muscular-glandular zone .. 17

16. Shell with rounded periphery; often spiral red bands or spots ....
Exiligada Iredale, 1939 (Solem 1984: 670)
Shell with angulated to carinated periphery ....
Ordtrachia Solem, 1984 (Solem 1984: 647)

17. West Kimberley or Napier Range 18
East Kimberley or Northern Territory 19

18. Shell periphery carinated (**Fig. 216b**); walls of penis chamber with longitudinal pilasters .... *Carinotrachia* new genus (p. 857)
Shell periphery rounded; walls of penis chamber with complex pustules and a main pilaster (**Fig. 210**) ....
Kimboraga Iredale, 1939 (p. 818)

19. Penis long; no verge present 20
Penis short (**Fig. 244a**); conical verge present (**Fig. 245**); descending arm of vas deferens usually grossly enlarged (**Fig. 244a**) ....
Turgenitubulus Solem, 1981 (Solem 1981b: 358) (p. 947)

20. Penis chamber walls normally with large pilasters having complex sculpture (Solem 1981b: 420, fig. 109) 21
Penis chamber walls normally with simple pilaster or at most widened pilasters at one point 23

21. Northern Territory; spire with variegated colour pattern ....
Prototrachia Solem, 1984 (Solem 1984: 681)
Western Australia; spire with uniform colour 22

22. Shell sculpture of pustulose ridges; vagina long ....
Prymnbriareus Solem, 1981 (Solem 1981b: 417) (p. 975)
Shell sculpture of radial ribs or surface smooth ....
Ningbingia Solem, 1981 (Solem 1981b: 326)

23. Shell sculpture of minute pustules; Northern Territory ....
Mesodontrachia new genus (p. 863)
Shell sculpture of radial ribs; Ningbing Ranges and Jeremiah Hills, Western Australia ....
Cristilabrum Solem, 1981 (Solem 1981b: 382)

Biographical analysis of the Kimberley camaenids will be presented elsewhere. The Kimberley is not a unitary area for land snails, and there is little congruence among the ranges of genera. The Camaenidae reached Australia after the Miocene collision of the Australian and Southeast Asian plates. The limestone ranges of the Kimberley already were exposed in essentially their current configuration. We are concerned with a colonising fauna reaching an area without larger land snails present. Thus the evolutionary history of the Kimberley camaenids involves radiations into essentially virgin territory. Their pattern of linear speciation with short ranges, whether in the Ningbing Ranges or along the limestone south fringe of the Napier and Oscar Ranges, is a product of this comparatively recent colonisation.

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