

The non-marine molluscs of the Cape Range peninsula, Western Australia

S. M. Slack-Smith

Western Australian Museum, Perth, Western Australia 6000.

Abstract

The extant non-marine molluscan fauna of the Cape Range peninsula, Western Australia, consists of two species of aquatic prosobranch gastropods and 16 species of terrestrial pulmonates. The fauna contains a high proportion of endemic taxa with nine camaenid and one pupillid species being endemic to the Cape Range peninsula (56% of all species). Of these, seven camaenids (39% of all species) are endemic to the plateau and slopes of Cape Range itself. The Cape Range peninsula populations of four of the remaining eight species are at the southern limits of the species' ranges (22% of all species). The only fossil of a non-marine mollusc known from this area is of a species of the bulimulid genus *Bothriembryon*.

Available information on the biology of these and related species from the Cape Range peninsula is discussed with reference to the environment of the area and its amelioration within the limestone caves of the range and its coastal plains. Three widespread non-camaenid species (*Discocharopa aperta*, *Eremopeas interioris* and *Stenopylis coarctata*), which are here at the southern limits of their ranges, have here been found living exclusively in caves although elsewhere they are not generally cavernicolous. This habitat restriction of the disjunct Cape Range populations supports the hypothesis that they are relictual.

Introduction

The non-marine molluscan fauna of the Cape Range peninsula area of Western Australia has not previously been examined as an entity, although some of its species have been described by authors of more widely-ranging works. Cotton (1953) and Solem (1986) described new species from this area, and the latter gave new distributional records for established non-camaenid species or for forms of uncertain relationship to them (Solem 1984, 1986).

At the time of his death in 1990, Dr A. Solem was preparing a manuscript entitled "Camaenid land snails from western and central Australia (Mollusca: Pulmonata: Camaenidae). VII. Taxa from Dampierland through the Nullarbor". It is anticipated that this work will be published once the illustrations have been completed. In preparing that manuscript, Dr Solem used specimens which he had collected as well as material in the collections of the Western Australian Museum. The Museum specimens include material collected between 1984 and 1992 as part of a survey of the cave fauna of Cape Range (Humphreys 1993). This review is based upon Dr Solem's manuscript, on previously published papers and on material, particularly that recently collected, in the collections of the Western Australian Museum. In identifying and evaluating the camaenid material I have adopted the taxonomic limits defined in the Solem manuscript and have used its clear, though not yet illustrated, descriptions of taxa. In anticipation of the publication of that manuscript, new generic and specific names have not here been proposed for undescribed taxa. Localities mentioned in the text are indicated in Figures 1 and 2, and in Appendix 1. Catalogue numbers

are given for those specimens in the collections of the Western Australian Museum (WAM) on which new distributional information is based.

Physical environment of the Cape Range peninsula

The Cape Range peninsula extends in a northerly direction from that part of the mainland coastline between the latitudes of about 23° 30' and 22° 30'S. A series of four almost-parallel ranges of hills occupies much of the peninsula, with the Scrubby and Giralia Ranges situated across its base, and the Rough and Cape Ranges progressively further to the west. Between and around these ranges are sandy plains, with a narrow coastal plain to the west, north and east of Cape Range, which is the main focus of this work.

The area encompassing this peninsula is situated on a climatic boundary. To the north is a region with a tropical dry climate, with high daytime temperatures in summer and with generally very low rainfall (except during occasional summer cyclones). To the south is a region characterised as a transitional zone with no cold season but with low rainfall in winter and virtually none in summer (Bridgewater 1987). At this boundary air temperatures are generally high, with a mean daily temperature of about 27°C. The rainfall is very variable and the relative humidity is low, with the annual amount of evapo-transpiration being about 11 times greater than the rainfall (Vine *et al.* 1988).

The calcareous sandstones and limestones of the Cape Range rise to 311m and are eroded, sparsely vegetated and deeply dissected by steep-sided gorges. Soils are shallow and oligotrophic. Streams draining to the east and the west of Cape Range run briefly only after

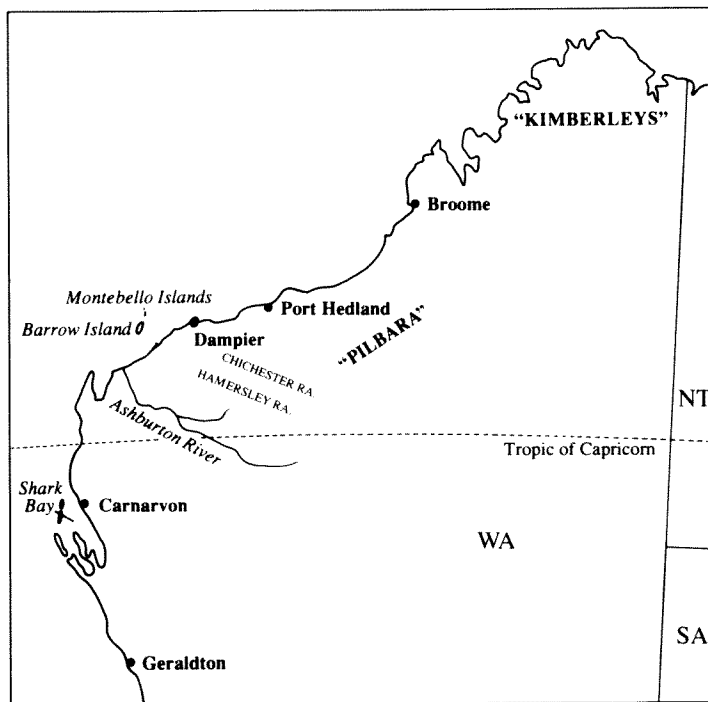


Figure 1. Northern Western Australia, indicating the localities mentioned in the text other than those included in Map 2 or Appendix 1.

heavy rain and the few pools are ephemeral. Only the westerly-flowing Yardie Creek retains water permanently in its lower reaches. Its mouth is dammed by a sand bar which is breached only after very heavy rain and/or high seas.

In places the groundwater of the coastal plain is open to the surface in caves, rockholes and cenotes, and it contains a rich stygofauna (Humphreys and Adams 1991; Poore and Humphreys 1992; Humphreys 1993; Knott 1993).

The extant molluscan fauna

Collections of the non-marine molluscan fauna of the Cape Range peninsula indicate that it consists exclusively of gastropods.

CLASS GASTROPODA, SUB-CLASS PROSOBRANCHIA

Family Iravadiidae

Genus *Iravadia* Blanford, 1867

Iravadia (Iravadia) sp. ? *I. ornata* Blanford, 1867

New record - WA: Cape Range peninsula - Bundera Sinkhole (C-28) (WAM 110.92).

Known range - (of *I. ornata*) South-east Asia north to southern China (Ponder 1984).

Notes - The species *I. ornata* has not previously been recorded from Australia, although this might be due to the lack of careful collecting in suitable habitats in the lower littoral zone of estuarine situations. In the Bundera Sinkhole *Iravadia* sp. is found on algae in brackish water which exhibits tidal movements. The water in this sinkhole was recorded as being much more saline than that of other cave pools in the area which are also inhabited by the blind gudgeon *Milyeringa veritas* Whitley, 1945 (Humphreys and Adams 1991).

Pertinent taxa

Other species of *Iravadia* s.s. have been recorded from estuaries in north-eastern Australia (Ponder 1984).

Family Thiaridae

Genus *Melanoides* Olivier, 1804

Melanoides sp.

New Record - WA: Cape Range - Yardie Creek (WAM 859.71,26.93).

Notes - This population is known only from a pool upstream of the limit of saline water in Yardie Creek. The lineage to which this population appears to belong has been found to occur from the Greenough River S of Geraldton northwards to northern Australia. Nothing is known of the biology of this form, and little is known of that of its congeners.

Pertinent taxa

An apparently-separate lineage of thiarids is generally sympatric with this, although the distributional range of that lineage extends further south to the Perth area in the Swan River and its tributaries (Stoddart 1985).

CLASS GASTROPODA, SUB-CLASS PULMONATA

Family Pupillidae

Sub-family Pupillinae

Genus *Pupoides* Pfeiffer, 1854*Pupoides contrarius* (Smith, 1894)

New records - WA: Cape Range - Caves C-18 (WAM114.92), C-103 (WAM116.92), C-207 (WAM115.92); near Cave C-163 (WAM117.92), near Cave C-312 (WAM118.92); 1.3 km west of Learmonth (WAM113.92).

Known range - Australia: WA - central west coast, from the Houtman Abrolhos off Geraldton north to Cape Latouche Treville S of Broome, including Cape Range peninsula [Goat Cave (C-17), Charles Knife Road, Shothole Canyon, 19 km north of Point Cloates near Ningaloo Homestead, 14.9 km north of Ningaloo]; Barrow Island (Solem 1986, 1991a).

General notes - The distributional range of this sinistrally-coiled species overlaps that of the dextrally-coiled *P. lepidulus* to the south of Cape Range and to the east of Exmouth Gulf

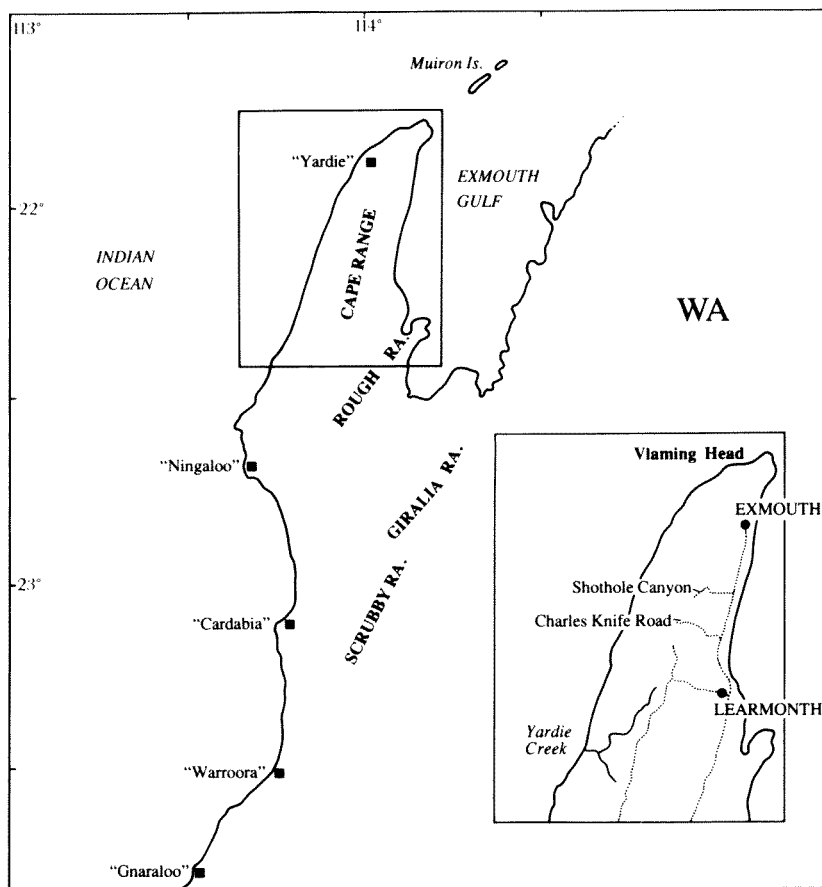


Figure 2. The Cape Range peninsula, indicating localities mentioned in the text other than those for which the co-ordinates are given in Appendix 1, or those included in Map 1.

(Solem 1991a). Like other species of the genus, *P. contrarius* shelters under rocks and in fissures.

Pupoides sp indet.

New records - WA: Cape Range - 1.3 km west of Learmonth (WAM119.92).

Notes - Only one sample has been taken of this dextrally-coiled form which appears to differ in shell morphology from the three following dextrally-coiled species.

P. lepidulus (Adams & Angas, 1864)

Known range - Australia: WA - coastal and inland areas from Cape Latouche Treville (S of Broome) south to the Cape Range peninsula (north of 4 Mile Well on Ningaloo Station; Cy Creek on Cardabia Station) and to the Shark Bay area; Barrow Island; South Muiron Island; Houtman Abrolhos off Geraldton (Solem 1986, 1991a).

Pupoides sp. aff. *P. beltianus* (Tate, 1894)

Known range - Australia: WA (Hamersley Range; Cape Range peninsula [Cy Creek on Cardabia Station] south to the southern Shark Bay area).

General notes - This form, which has a mosaic distribution, is possibly conspecific with the widespread *P. beltianus* which inhabits Central Australia, with its geographic range extending into the southern Northern Territory, northern South Australia and eastern Western Australia (Solem 1986, 1989, 1991a).

Pertinent taxa

Pupoides sp. aff. *P. adelaidae* (Adams & Angas, 1864).

Known range - Australia: WA (Warroora Station south to the Hamelin Pool area at the S end of Shark Bay).

General notes - The shape of the shell of this form differs slightly from that of the more widespread typical form of *P. adelaidae*. The geographic range of the latter form extends from western NSW and Vic. through South Australia to the south-east of WA and north-west to Hines Hill and Morawa, ESE of Geraldton (Solem 1986, 1991a).

Sub-family Gastrocoptinae

Genus Gastrocopta Wollaston, 1875

G. pilbarana Solem, 1986

New records - WA: Cape Range - Caves C-18 (WAM120.92), C-103 (WAM122.92), C-167 (WAM121.92, 123.92), C-207 (WAM124.92).

Known range - Australia: WA - inland Pilbara region south through the Shark Bay area, although, on the Cape Range peninsula, not found north of Cy Creek on Cardabia Station (Solem 1986).

Notes - An unlocalised indication on a distributional map (Solem 1991a) is the only previous record of this species' existence on the Cape Range. To the south and east of Exmouth Gulf its geographic range overlaps that of *G. deserti* Pilsbry, 1917.

G. deserti Pilsbry, 1917

Known range - Australia: WA - Kimberleys south to Point Quobba N of Carnarvon, including the Dampier Archipelago off Dampier, Barrow Island, the Muiron Islands and Cape Range peninsula (Cy Creek on Cardabia Station) ; Qld; SA (Solem 1986).

Notes - Extending from the centre of the continent to near-coastal areas. In the north-west it inhabits dry areas and vine thickets of the Kimberleys (Solem 1986, 1989, 1991).

Family Charopidae**Genus *Discocharopa*** Iredale, 1913

Known range - The Philippines; Indonesia; the South Pacific islands east to the Society Is; Australia.

D. aperta (Moellendorff, 1888)

New records - WA: Cape Range - Caves C-18 (WAM129.92), C-103 (WAM126.92), C-167 (WAM125.92, 127.92), C-207 (WAM128.92).

Known range - Indo-Pacific Region (Java, Indonesia; Philippines; Solomon Islands; the Society and other south Pacific island groups). Australia: WA - Cape Range peninsula (Cardabia Station and Cape Range [C-18, C-21]); Kimberleys including the Napier, Oscar and Ningbing Ranges; NT; Central Australia; south-eastern Qld; northern NSW (Solem 1983, 1984, 1991), Vic. and SA (Smith 1992).

Notes - A protean species or species complex which is widespread but only moderately abundant in the Kimberleys (Solem 1991).

Family Subulinidae**Genus *Eremopeas*** Pilsbry, 1906

Known range - Australia (northern and central areas); Torres Strait islands; possibly introduced into New Caledonia.

Notes The relationship of this genus of two species to non-Australian taxa has not, as yet, been definitely determined.

E. interioris (Tate, 1894)

New records - WA: Cape Range - Caves C-15 (WAM 137.92,131.92), C-18 (WAM 134.92, 141.92), C-103 (WAM 133.92,140.92, 144.92), C-111 (WAM 138.92), C-154 (WAM139.92), C-167 (WAM 135.92, 136.92), C-207 (WAM132.92), C-278 (WAM 142.92).

Known range - Australia: WA from the Kimberley south to the Hamersley Range in the Pilbara and to the Cape Range [Goat Cave (C-17); Monagee Cave (C-21); (C-22); the road from Learmonth to Cape Range]; NT south-west to the northern part of Central Australia (Solem 1991).

Notes - Abundant in drier areas as well as rainforest patches of the Kimberley, where it is widespread and common, and in the Northern Territory. This species secretes a heavily calcified single or multiple epiphragm, sometimes with up to 12 layers in a series. The degree

of development of shell sculpture is very variable, apparently depending on the availability of moisture during growth (Solem 1991).

Pertinent taxa

E. tuckeri (Pfeiffer, 1846)

Known range - Australia: NSW; Qld; NT; Torres Strait islands.

Family Helicodiscidae

Genus *Stenopylis* Fulton, 1914

Known range - Indonesia, the Philippines, New Guinea, Solomon Islands and northern Australia (Solem 1984, 1991).

Notes - A monotypic genus.

S. coarctata (Moellendorff, 1894).

New records - WA: Cape Range - Cave C-103 (WAM130.92); Millstream in the Chichester Range, Pilbara region.

Known range - Philippines; Indonesia; New Guinea; Solomon Islands; Australia: WA (Kimberley, Port Hedland); NT; Qld; SA (Solem 1984, 1991; Smith 1992).

Notes - This species is widespread and very common in the Kimberley, though less so in the north of the Northern Territory. The record from the Cape Range is based upon a single shell apparently collected with a sample of the similar and more commonly-collected charopid species, *Discocharopa aperta*. The specimens from Port Hedland were dead-taken. However a flourishing population of this species has recently been located in the Millstream area (G.W. Kendrick pers. comm. 1992). Further careful collecting is desirable to ascertain the status of this tiny snail in the fauna of the Cape Range area.

S. coarctata aestivates in litter, generally in the deeper layers, and shelters under rocks in hot dry areas. It broods its young within its shell.

Family Camaenidae

Sub-family Sinumeloninae

Genus *Plectorhagada* Iredale, 1933

Known range - Australia: WA - endemic to the area from Shark Bay area north to the Pilbara region (Smith 1992).

Notes Epiphragms formed during aestivation are sometimes multiple. Snails lie loose on the substrate, or seal by the calcified rim of the outermost epiphragm to other shells, sometimes forming chains (Solem ms.).

Plectorhagada sp.#1

New records WA: Cape Range peninsula (southern end of Scrubby Range north to the southern end of Rough Range)(Solem ms.); Cape Range - Caves C-103 (WAM108.92), C-207 (WAM109.92); near the entrance of Cave C-252 (WAM107.92); near Goat Cave (C-17)

(WAM 1541.70); 9 miles S of Central Hill (WAM1143.81); on coastal plain W of Learmonth (WAM106.92).

Notes: Some doubt must exist as to the conspecificity of the Cape Range specimens and Solem's proposed new species of *Plectorhagada*. Some specimens from the Range which Solem had labelled as paratypes of his new species were not listed as such in his manuscript.

Pertinent taxa

P. plectilis (Benson, 1853)

Known range - WA: Shark Bay area but not including Peron Peninsula or the Shark Bay islands (Solem ms.).

P. carcharias (Pfeiffer, 1864)

Known range - WA: Minilya River N of Carnarvon north to Warroora Station, and on Dirk Hartog and Dorre Islands, Shark Bay (Solem ms.).

Plectorhagada sp.#2

Known range - WA: Ashburton River basin in the Pilbara region (Solem ms.).

P. gascoynensis (Smith, 1894)

Known range - WA: loc. ?.

P. rovina Iredale, 1939

Known range - WA: loc. ?.

Sinumelonine genus #1

Known range - WA: endemic to Cape Range .

Notes - A monotypic genus.

Sinumelonine gen.#1 sp.#1

New records - WA - Cape Range extending N/S for about 20 km between Yardie Creek and the track to Cape Range #3 Deep Oil Well, including Goat Cave (C-17) and along the track from Learmonth to Cape Range (Solem ms). Caves C-21 (WAM105.92), C-60 & C-68 (outside cave entrances) (WAM103.92), C-102 (WAM102.92), C-420 (WAM104.92).

Notes - Aestivates sealed by a thin calcified rim to rock faces and to other shells.

Sinumelonine genus #2

Known range - WA: endemic to Cape Range.

Notes - Monotypic genus. Aestivate sealed to a rock face or to another shell by the very narrow, lightly calcified rim of the epiphragm (Solem ms.).

Sinumelonine gen.#2 sp.#1.

New records - WA: Cape Range - from Charles Knife Road southwards, including Goat Cave (C-17), and perhaps throughout the rest of the Cape Range (Solem ms.) Caves C-60 & C-68 (outside cave entrances) (WAM97.92), near C-68 (WAM95.92), C-118 (WAM96.92).

Notes - These camaenids aestivate in rock fissures or between boulders in rubble. Animals achieve their largest size in populations in the centre of the species' geographic range, in the heart of Cape Range. Solem and Christensen (1984) indicated that the size of individual adult camaenids in the Kimberley depended upon the amount of moisture available during their growing period. In the Cape Range area this would be greatly influenced by the very variable rainfall pattern and by the amount of moisture retained in the microhabitats of individual snails.

Sinumelonine genus #3

Known range - WA: endemic to the Cape Range peninsula as far south as Cardabia Station (Solem ms.).

Notes - Commonly inhabit exposed limestone shelves in positions sheltered by foliage. They seal by the heavily calcified mucus rim of the epiphragm to vertical or near-vertical walls or to the undersides of stones (Solem ms.).

Sinumelonine gen.#3 *rugus* (Cotton, 1953).

New records - WA: Cape Range peninsula - area extending N/S for 42 km along the central and eastern parts of the Cape Range (Yardie Creek, Goat Cave [C-17], Trealla Hill, Cape Range #2 Deep Oil Well, along the track to Cape Range #3 Deep Oil Well, along the track from Learmonth to the Cape Range, Charles Knife Road) to the southern part of Rough Range (Solem ms.). Cave C-65 (WAM98.92); near Cave C-312 [juvenile](WAM99.92).

Notes - Placed in the genus *Plectorhagada* by Smith (1992).

Sinumelonine gen.#3 sp.#1.

New records - WA: Cape Range - area extending N/S for 26 km along the eastern side of the Range between Goat Cave [C-17] and Shothole Canyon) (Solem ms.). Caves C-65 (WAM100.95), near C-156 (WAM101.92).

Sinumelonine gen.#3 sp.#2.

New records - WA: Cape Range - area extending N/S for 33km along the western side of the Range from Yardie Creek to the foothills near the Ningaloo Homestead (Solem ms.).

Sinumelonine gen.#3 sp.#3.

New records - WA: Cape Range - Milyering Well (C-24) (Solem ms.).

Sinumelonine gen.#3 sp.#4.

New records - WA: Gnaraloo Station north to Cape Range peninsula near Ningaloo Homestead (on coastal and near-coastal dunes). This species may be extinct as only sub-fossils have been found (Solem ms.).

Sub-family Pleurodontinae

Genus *Rhagada* Albers, 1860

Known range - Australia: WA - central Kimberley region and coastal islands south to Shark Bay and inland from these areas (Solem 1985; Smith 1992).

Notes - This is a genus endemic to Western Australia with 29 species inhabiting the mainland and coastal islands from the Mitchell Plateau in the Kimberley south to Bernier Island, Shark Bay and inland from there. The greatest diversity within this genus occurs in the area between Carnarvon and Dampier Land, N of Broome.

Rhagada species are free-sealers, forming a single calcified epiphragm to seal off the shell aperture. They usually aestivate underground after burrowing into sandy soil, litter or sometimes into rock rubble, under spinifex clumps or shrubs. Adaptations of the genital system similar to those found in the Sinumeloninae occur in this genus. A gradation in the degree of development of these characters occurs through the succession of species from the Kimberley south to Shark Bay (Solem 1991, ms.). A single undescribed species of *Rhagada* is the only representative of this diverse genus occurring on the Cape Range, although *R. convicta* inhabits the plains to the east and west of the Range, and two other species live just to the south.

Rhagada sp.#1.

New records - WA: Cape Range peninsula - Cape Range (from Vlaming Head southwards on the plateau near Central Hill, and on the slopes to the E and W), south to 23° 7'S in the Scrubby Range (Solem ms.). Near Cave C-291 (WAM111.92), near Cape Range #2 Deep Oil Well (WAM27.93); Caves C-106 (WAM436.89), C-96 (WAM435.89), in small cave on plateau to S of Shothole Canyon (WAM28.93).

Notes - The distribution of this species is discontinuous. Although it inhabits the hillsides W and E of Cape Range its distribution does not extend onto the plains area between the ranges. The snails shelter under large spinifex clumps near limestone exposures, or sometimes in rocky rubble on limestone hillsides. Larger animals occur in those populations inhabiting the central parts of the Range (Solem ms.).

R. convicta (Cox, 1870)

New records - WA: Minilya River N of Carnarvon to the Dampier region including the plains on the eastern side of Exmouth Gulf and on the eastern side of Cape Range; the Muiron Islands (Solem ms.).

Range - WA: the Pilbara region including islands of the Dampier Archipelago off Dampier (Smith 1992).

Notes - This species has the most extensive range of the genus. It inhabits open situations and creek and riverbeds, and shelters under rocks (Solem ms.).

Rhagada sp.#2

New records - Cape Range peninsula - from Warroora Station N to Ningaloo Station (Solem ms.).

Pertinent taxa

R. torulus (Ferussac, 1819)

Known range - WA: Bernier Island, Shark Bay to Warroora Station (Solem ms.).

R. plicata Preston, 1914

Known range - WA: ? Barrow Island; Montebello Islands (Solem ms.).

Rhagada sp.#3

Known range - WA: Dampier Archipelago off Dampier (Solem ms.).

Rhagada sp.#4

Known range - WA: Dampier Archipelago off Dampier (Solem ms.).

R. elachystoma (von Martens, 1878)

Known range - WA: Dampier Archipelago off Dampier (Solem ms.).

Rhagada sp.#5

Known range - WA: Dampier Archipelago off Dampier (Solem ms.).

Rhagada sp.#6

Known range - WA: Dampier Archipelago off Dampier (Solem ms.).

R. perprima Iredale, 1939

Known range - WA: Dampier Archipelago off Dampier (Solem ms.).

Rhagada sp.#7

Known range - WA: Python Pool and Mount Herbert, Chichester Range (Solem ms.).

R. radleyi Preston, 1908

Known range - WA: Pilbara region (Fortescue River drainage areas Chichester Range, and Upper Ashburton River drainage areas, Hamersley Range). (Solem ms.).

R. richardsoni (Smith, 1874).

Known range - WA: Depuch Island between Dampier and Port Hedland, east to Cape Keraudren, and the inland Pilbara (Solem ms.).

Genus of unknown sub-familial affinity

Genus *Quistrachia* Iredale, 1939

Known range - Australia: WA (Pilbara and Kimberley regions); Qld (a single report).

Notes - This genus is at its most diverse between Carnarvon and the Pilbara. The geographic ranges of WA species do not overlap one another, and disjunct populations exist within some of the species. The species of this genus do not exhibit a north/south gradation of characters of the genital system as has been observed in the genus *Rhagada* and in the genera of the Sinumeloninae (Solem 1991, ms.).

Quistrachia sp.#1

New records - WA: Cape Range - from E of Norwegian Bay northwards to Vlaming Head including Goat Cave (C-17); Yardie Creek; near Tantabiddy Well (C-26); Cape Range#2 Deep Well; south of Learmonth; Charles Knife Road; Shothole Canyon (Solem ms.). Cave C-103 (identification uncertain, protoconch only) (WAM112.92).

Notes - Snails of this species shelter under spinifex near limestone rubble or in the rubble. The sealed aestivating snails lie free on and in the substrate.

Quistrachia sp.#2

Known range - WA: Cape Range peninsula (Warroora Station; Scrubby Range) (Solem ms.).

Pertinent taxa*Quistrachia* sp.#3

Known range - WA: Barrow Island and associated islets; the Lowendal Islands S of the Montebello Islands (Solem ms.).

Q. montebelloensis (Preston, 1914)

Known range - WA: Montebello Islands.

Quistrachia sp.#4

Known range - WA: Dampier area including the Dampier Archipelago (Solem ms.).

Quistrachia sp.#5

Known range - WA: Lower Fortescue River drainage area and Mt Herbert, Chichester Range (Solem ms.).

Quistrachia sp.#6

Known range - WA: Yule and Turner River basins, Chichester Range (Solem ms.).

Quistrachia sp.#7

Known range - WA: Glen Florrie Station, on a tributary of the Ashburton river (Solem ms.).

Extinct molluscan fauna of the peninsula

General Notes: Only one specimen of a fossil non-marine mollusc is known to have been collected from the Cape Range area.

CLASS GASTROPODA, SUB-CLASS PULMONATA

Family Bulimulidae

Genus *Bothriembryon* Pilsbry, 1894

Known range - The genus *Bothriembryon* is virtually limited to the southern half of Australia and is most abundant and diverse in the southwest of Western Australia. Along the west coast living populations of the genus are known to occur only as far north as Ningaloo Station, the northern limit of the species *B. costulatus* (Lamarck, 1822). Two unnamed species occur as a number of seemingly-disjunct populations in the inland Pilbara in the area of the Hamersley and Chichester Ranges.

Bothriembryon sp.

New records: WA: Cape Range - 8 miles south of Yardie Homestead, in sand dunes lying on the Tantabiddi Terrace, western foothills of the Range.

Notes: The single specimen of *Bothriembryon* is not sufficiently well preserved to indicate, at present, whether it belongs to an undescribed extinct species or is a particularly large specimen of the species *B. costulatus*. More material is needed to clarify its relationships. This specimen was embedded in a calcareous fossil soil which is probably of Pleistocene age (G.W. Kendrick, pers. comm.). Its presence indicates that a contraction of the geographic range of the coastal populations of the genus has occurred since that time.

Discussion

The calcareous nature of the rocks and soil of Cape Range and its surroundings is advantageous for shelled molluscs. However the aridity and the low fertility of the oligotrophic soils are generally not conducive to plant growth or to the development of the bacteria and fungi involved in the decomposition of plant litter. It is this decomposing litter and its associated organisms which seems to form the food for many snail groups. On Cape Range such litter may fall directly into caves or be washed into them after rain (Humphreys 1991). The physical environment in the caves, which is advantageous to the snails, is also suitable for the activity of saprophytic bacteria and fungi.

Terrestrial molluscs have developed adaptations of morphology, physiology and behaviour which enable them to live out of water in a more-or-less desiccating environment (Solem 1974). Such adaptations are particularly important in an area such as the Cape Range peninsula which is situated within a region of generally low and unpredictable rainfall (Humphreys *et al.* 1989). Long periods without rain, in combination with a very high evaporation rate, produce arid conditions which are generally inhospitable to snails. Where snails cannot afford to have a set seasonal regime they must be able to take advantage of favourable conditions whenever they occur, by emerging from aestivation to quickly mate, feed and lay eggs before conditions once more become unfavourable.

Freshwater species, though less well known, must exhibit a similar degree of adaptation to enable them to occupy water bodies of varying salinities.

The gastropod fauna

Iravadiidae

This family is mainly of tropical Indo-West Pacific distribution, inhabiting both marine and brackish waters. A few species have been recorded from tropical and temperate Australian waters (Ponder 1984).

The Cape Range peninsula population of a species of the Indo-West Pacific genus *Iravadia* inhabits the Bundera Sinkhole on the Tantabiddi Terrace on the western side of the Range. This sinkhole contains an anchialine pool in which the water level varies with the tide. The salinity of this water is about half that of seawater, and is thus higher than that in other caves on the coastal plains (Humphreys and Adams 1991). These coastal plain caves are situated in a bed of alluvium and calcarenite formed during the last interglacial period. This apparently-isolated population does not appear to have undergone any morphological differentiation to distinguish it from typical forms of the species occurring on the south-east Asian mainland.

Further searching for populations of this species along the coastal areas of northern Australia, a study of its biology - particularly its reproductive biology - and studies on the degree of its genetic isolation are desirable.

Thiaridae

This family of freshwater snails is widely distributed in the Middle East, Africa, Asia, Central and South America, the islands of the Indo-West Pacific region and Australia. Among its members parthenogenesis seems to commonly occur (Jacob 1957a, b). The young are brooded in a neck pouch of the female up to the veliger larval stage and, in some groups, to an later shelled-juvenile stage. Many species act as hosts to trematode parasites, some of which are of great importance to the health of humans and other animals.

The genus *Melanoides* is widespread in the tropical Indo-Pacific region and in north and east Africa. Some species of this genus have been recorded as feeding upon algae and upon detritus on and in the muddy substrate upon which they crawl. The Yardie Creek population of *Melanoides* is spatially isolated from other such populations in northern Australia, the closest being those in the Gascoyne River to the south near Carnarvon and the Fortescue River to the north-east. Distinctive morphological characteristics of the shells of the Yardie Creek population may indicate a response to a set of environmental factors peculiar to that area. However it could indicate that the population consists of a parthenogenetic clone (Stoddart 1985), or could be the result of a genetic shift in a sexually reproducing population. If the population is of obligate parthenogenotes then reproductive isolation would have been instant and not dependent on time. If not, then such reproductive isolation would be related, in part at least, to the length of time during which the Yardie Creek system has been isolated from other such river systems. However, in considering the latter possibility, caution is necessary in equating the degree of taxonomic distinctiveness of a population with the length of its period of isolation, as Peake (1978) indicated.

Examination of the reproductive strategy of the adults, of the degree of dispersal available to the young and of the degree of genetic difference that has been achieved need to be examined, and related to the environmental characteristics and geological history of Yardie Creek and its surroundings.

Pupillidae

This large family of small elongate terrestrial snails, exhibiting considerable conservatism in shell form (Peake 1978), has a worldwide distribution, with three of the five recognised sub-families occurring in Australia. The family is particularly diverse in northern Australia but is absent from the south-west of the continent. Many taxa are dry country inhabitants, particularly in limestone areas. Small snails such as these are presumed to be distributed by flood, and they aestivate with the shell aperture sealed to an object by a mucoid epiphragm (Solem 1986).

The genus *Pupoides* (subfamily Pupillinae) occurs in all continents except Europe, and is probably an old Australian dry zone resident (Solem 1991a). It occurs mainly in tropical and subtropical arid areas and in dry habitats within humid areas (Pilsbry and Cooke 1918-1920; Solem 1991a), with most Australian species inhabiting rocky areas.

Of the four *Pupoides* species found in the Shark Bay - North West Cape area, only the sinistrally-coiled species, *P. contrarius*, is living on the Cape Range. This would seem to indicate that it possesses physiological and/or behavioural characteristics lacking in *P. lepidulus* (Adams & Angas, 1864), *Pupoides* sp. aff. *P. beltianus* (Tate, 1894), *Pupoides* sp. aff. *P. adelaidae* (Adams & Angas, 1864) and the undetermined *Pupoides* species. Those species are sympatric with *P. contrarius* elsewhere but, apparently, have not been able to colonise the Cape Range or to maintain a presence there.

The genus *Gastrocopta* (subfamily Gastrocoptinae) is found in most tropical and temperate regions except Europe. There are 11 native species, and one introduced and one possibly introduced species in Australia. They inhabit most of mainland Australia except the humid south. The species show no sign of local differentiation (Solem 1986, 1991a). These tiny snails inhabit rocky areas, sheltering under boulders and in rock fissures.

The general sympatry of the two North West Cape-Pilbara species of *Gastrocopta* in areas to the south and the north-east of the Cape Range peninsula is apparently not continued onto

the peninsula itself. It seems that only *G. pilbarana* (Solem, 1986) is living on Cape Range where it has been found only within the shelter of the caves, although elsewhere its habitat is more varied.

Charopidae

This large family of small flattened snails occurs in Australia, New Zealand, the islands of the Philippines, the Indo-Malay Archipelago and the south Pacific. It constitutes one of the two most diverse and abundant families of land snails in Australia. Charopids are usually found sheltering in damp situations (Solem 1991). They probably feed mainly upon decaying plant material and the fungi, bacteria etc. associated with it.

The tiny but widespread species *Discocharopa aperta* is the single representative of this family on the Cape Range peninsula. Although it is an essentially tropical species, the extent of its very wide geographic and environmental range seems to indicate its tolerance of a wide range of physical factors. However such a tolerance might be more apparent than real, as the species might be occupying a much more homogeneous range of micro-habitats which it can occupy because of its small size.

The apparent isolation of this population of *D. aperta* on Cape Range and Ningaloo Station could indicate that it may represent a vestige of what was once a more widespread population. Although it is possible that its very small size might have allowed immigration through passive dispersal by wind etc., this is contra-indicated by the presence on Depuch Island of an endemic species of a mono-typic genus, *Dupucharopa millestriata* (Smith, 1874).

Subulinidae

This is essentially a pantropic family, widespread through most tropical and warm temperate regions. Several of its widespread species have been carried beyond their natural range by man and also, presumably, by birds, wind, drifting plants, etc. (Solem 1974; Peake 1978).

Subulinids have had such a long history of introduction into areas outside their original geographic ranges that they have been termed "tropical tramps" (Peake 1978). However, the distributional range of *Eremopeas interioris* throughout the Cape Range seems to preclude the possibility of its introduction by man, and passive rafting is not indicated because of the altitude of these habitats.

The diversity of habitats in which this tropical species is found to occur, and its relatively large geographic range, indicate a considerable degree of environmental tolerance. Its development of multiple, heavily calcified epiphragms to seal the shell aperture during aestivation (Solem 1991b), and its ability to brood its young until they reach an advanced stage of development probably contribute to its ability to spread and to persist in sometimes-hostile areas.

Helicodiscidae

This small family has a widely disjunct distribution, with two genera living in North America and one monotypic genus, *Stenopylis*, inhabiting Indonesia, the Philippines, New Guinea, the Solomon Islands and northern Australia (Solem 1984, 1991).

Stenopylis coactata is a minute snail, with a diameter of less than 2mm, which is usually found associated with moist habitats. However, in Australia, it is also found in generally dry areas. The single record of this species in the Cape Range could indicate a considerably wider geographic range than had previously been realised. The apparent sparsity of its occurrence

south of the Kimberley might prove to be only a result of inadequate collecting of this tiny snail, although the equally small *Discocharopa aperta* has been more widely collected. As with *D. aperta*, the small size of this species must raise the possibility of passive dispersal by wind, water and/or by man and other animals, although a once-wider geographic range seems likely.

Camaenidae

This is one of the world's major land snail families. It is an essentially tropical group with its main centre of distribution in southern and eastern Asia, and with many species distributed throughout the Indo-Pacific region and in Central and South America. It is believed to have colonised Australia after the Miocene collision of Australia with south-east Asia (Solem 1978). Throughout its range this family exhibits a wide diversity of habitat preference and of form, although a considerable convergence of shell characters has been noted within many groups. Many species are found in northern Australia with habitats ranging from tropical rainforests to deserts. The number of camaenid species generally diminishes from north to south, other than in South Australia (Solem 1992). No camaenid species occur in the south-west of Australia and a single species is found in the temperate forests of Victoria and on King Island in Bass Strait. However, no camaenids occur on mainland Tasmania (Smith 1984).

The Shark Bay - Cape Range peninsula area, situated on the boundary between the areas dominated by the southern and northern weather systems, might miss out on both summer and winter rains in some years. Camaenids living in this unpredictable, dry and drought-prone area must be ready to reproduce whenever it rains. In this, they differ from species inhabiting the Kimberleys, which have a behavioural and reproductive biology adapted to a more predictable monsoon climate (Solem and Christensen 1984).

In Australia, the subfamily Sinumeloninae is centred on Central Australia and the Flinders-Gawler Range area in South Australia. Its geographic range extends to the west and north-west to overlap those of the pleurodontine lineage and of the genus *Quistrachia* (of undetermined sub-familial affinity) in the Shark Bay area.

West coast sinumelonine taxa generally do not undergo a seasonal change in the size of the ovo-testis. They possess a much enlarged albumen gland which acts as an energy store, permitting maximum reproductive effort as soon as environmental conditions become favourable. A general gradation in the degree of development of this and some other characters of the genital system is evident between species and genera distributed from the Nullarbor east to Norseman, northwest to the Geraldton area and then north to North West Cape. However, in part, this gradation is reversed among the Cape Range taxa (Solem ms.).

In Australia, members of the subfamily Pleurodontinae occur along the west coast from the north Kimberley to Shark Bay, and through inland areas of the Pilbara.

The genus *Quistrachia* does not fit well within the defined limits of any of the three camaenid subfamilies represented in the Australian fauna. Its affinities might lie with some taxa in China, the Solomon Island arc and eastern Queensland (Solem ms.).

The camaenids of the Cape Range area fall into three groups:

1. The Cape Range peninsula populations of the diverse genera *Quistrachia* and *Rhagada*, apparently endemic to northern WA, lie near the southern end of their geographic ranges. Each of these genera is represented on Cape Range by single species endemic to the Cape Range peninsula, with the *Quistrachia* species being endemic to the Cape Range itself. A

second *Rhagada* species from the plains to the east of the Range also inhabits the coastal Gascoyne and Pilbara regions and the Muiron Islands. Other species of both genera are endemic to Barrow Island, the Montebello and Lowendal Islands and to the islands of the Dampier Archipelago.

2. The genus *Plectorhagada* is endemic to the area from the Gascoyne to the Pilbara regions and is here recorded from the Cape Range. It is there represented by an undescribed species known previously only from the more southern ranges of the Cape Range peninsula (Solem ms.). This genus is not represented on the islands off the Pilbara coast.

3. Three new genera are endemic to the Cape Range peninsula. Two of these are monotypic and are restricted to the Cape Range. The third has four species living on the Range and on the plains to the east and west of it. A fifth species of this genus from further south is known only from fossil specimens.

Bulimulidae

The family Bulimulidae is distributed through South and Central America, New Zealand and the Pacific Islands, and through the more southern parts of Australia. In the southwest of Australia it forms the dominant group in the land snail fauna (Smith 1992). The fossil *Bothriembryon* specimen from the Cape Range peninsula represents a range extension of the genus well north of the northern limit of the coastal populations, and well to the west of the populations inhabiting the Hamersley and Chichester Ranges.

Table 1. Snail Species of Cape Range, indicating the biogeographic relationships of the Cape Range populations. o = on foothills; p = on coastal plain.

Species	Endemics to:		Non-endemics at:		
	Cape Range	Cape Range peninsula	N limit of range in WA	S limit of range in WA	Mid-range in WA
<i>Iravadia</i> sp.				X(p)	
<i>Melanoides</i> sp.					?X
<i>Pupoides contrarius</i>					X
<i>Pupoides</i> sp.	?X(p)				
<i>Gastrocopta pilbarana</i>					X
<i>Discocharopa aperta</i>				X	
<i>Eremopeas interioris</i>				X	
<i>Stenopylis coarctata</i>				X	
<i>Plectorhagada</i> sp.		X			
Sinumelonine; gen.1, sp.1	X				
Sinumelonine; gen.2, sp.1	X				
Sinumelonine; gen.3 <i>rugus</i>		X			
Sinumelonine; gen.3, sp.1	X				
Sinumelonine; gen.3, sp.2	X				
Sinumelonine; gen.3, sp.3	X(o)				
<i>Rhagada</i> sp.1		X			
<i>Rhagada convicta</i>					X(p)
<i>Quistrachia</i> sp.1	X(p)				
Total	7	3	0	4	4
approx. %	39	17	0	22	22

Biogeographic relations

The extant molluscan fauna of the Cape Range peninsula comprises 18 species of generally tropical affinity:

1. Two aquatic prosobranch species of Indo-West Pacific affinity inhabiting sparse, isolated water bodies of variable and varying salinities.

2. Ten species of the terrestrial pulmonate family Camaenidae which typically shelter in rock crevices, under boulders and spinifex clumps and in plant litter and rubble. On Cape Range some juveniles shelter within the caves. Nine of these ten camaenid species are endemic to the Cape Range peninsula and, of those, six are endemic to the Cape Range itself. Of the six camaenid genera represented, three are endemic to the Cape Range peninsula, with two restricted to the Range itself.

3. Among the other pulmonate families are three species whose habitat, in the Cape Range area, is apparently restricted to the caves. These species are generally of small size and have an extensive distributional range.

A summary of the distributional relationships of the snail populations of the Cape Range peninsula is given in Table 1. It demonstrates that, of the 18 species present on the Cape Range and its slopes, 10 (56%) are endemic to the peninsula. Of these, seven species (39% of the total) are endemic to the Cape Range. Of the eight remaining species, the Cape Range populations of four (22% of the total) lie at the southern limit of the species' ranges, while the geographic ranges of the remainder extend to both the north and the south of these populations.

The caves of the Cape Range are important to at least some of the snail species of the area in providing a habitat which is not only cooler and more humid than the surrounding plateau slopes and plains, but which contains food in the form of plant litter.

The isolated populations of the non-camaenid pulmonate species may represent relicts of formerly more widespread populations. However it is possible that they may be supplemented by occasional passive migration from other areas. Those species, which appear from the collecting data to be limited on Cape Range to a cavernicolous existence, are known to inhabit a greater diversity of habitats in more humid areas. Here they appear to depend on the caves for their continued existence in an area which is otherwise unsuitable for their survival either temporarily or permanently. Even some of the more dry-tolerant pupillid and camaenid species sometimes take advantage of the caves during their juvenile, presumably less stress-tolerant, stages.

Conclusions

The molluscan taxa of the Cape Range area appear to have become increasingly isolated from their ancestral populations by the progressive development of aridity. This is suggested by the degree of endemism and vicariance of the taxa, and by the occurrence of a fossil well outside the present range of its genus. This hypothesis is supported by the adoption of the cave habitat by species not elsewhere cavernicolous.

Acknowledgements

In assembling much of this account of the molluscs of the Cape Range area I have been fortunate in being able to follow the work of the late Dr Alan Solem. I hope that I have done

justice to that part of it contained in his extremely important unpublished manuscript. I have also had much recent and past assistance and encouragement from Mr George Kendrick, for which I am very grateful. His deep, active interest in the evolution of the Cape Range and its fauna has stimulated and facilitated the work of so many. I thank Dr Bill Humphreys, who demonstrated skill, patience and tenacity in organising the Workshop at which this paper was presented and in editing the Proceedings of which this is a part. He provided most of the recently-collected specimens on which this work is based and much of the data pertaining to them. Among those who enthusiastically worked with Dr Humphreys I thank Ms Julianne Waldock, Mr Darren Brooks, Mr Malcolm East, Mr Brian Vine and Mr Ray Wood.

References

- Bishop, M. J. (1981). The biogeography and evolution of Australian land snails. Pp. 925-954 in A. Keast (ed.). *Ecological biogeography in Australia. Volume 2*. Junk, The Hague.
- Bridgewater, P. B. (1987). The present Australian environment — terrestrial and freshwater. Pp. 69-100 in G.R. Dyne and D.W. Walton (eds). *Fauna of Australia. Volume 1A - General Articles*. Australian Government Publishing Service, Canberra:
- Cotton, B.C. (1953). New species and records of Mollusca from South Australia. *Transactions of the Royal Society of South Australia* 76: 21-26.
- Harvey, M.S. (1988). A new troglobitic schizomid from North West Cape, Western Australia (Chelicerata: Schizomida). *Records of the Western Australian Museum* 14: 15-20.
- Heller, J. (1984). Deserts as refugia for relict land snails. Pp. 105-123 in A. Solem and A.C. van Bruggen (eds). *World-wide snails*. Brill/Backhuys, Leiden.
- Humphreys, W.F. (1989). *The status of relict cave fauna of Cape Range, Western Australia, especially the Schizomida*. Unpublished report to the Australian National Parks and Wildlife Service, Canberra.
- Humphreys, W.F. (1990). The biology of a troglobitic schizomid (Chelicerata: Arachnida) from caves in the semi-arid Cape Range, Western Australia. *Acta Zoologica Fennica* 190: 181-186.
- Humphreys, W.F. (1991). Experimental re-establishment of pulse-driven populations in a terrestrial troglobite community. *Journal of Animal Ecology* 60: 609-623.
- Humphreys, W.F. (1993). The significance of the subterranean fauna in biogeographical reconstruction: examples from Cape Range peninsula, Western Australia. *Records of the Western Australian Museum, Supplement* 45: 165-192.
- Humphreys, W.F. and Adams, M. (1991). The subterranean aquatic fauna of the North West Cape peninsula, Western Australia. *Records of the Western Australian Museum* 15: 383-411.
- Humphreys, W.F., Adams, M. and Vine, B. (1989). The biology of *Schizomus vinei* (Chelicerata: Schizomida) in the caves of Cape Range, Western Australia. *Journal of Zoology, London* 217: 177-201.
- Jacob, J. (1957a). Cytological studies of Melaniidae (Mollusca) with special reference to parthenogenesis and polyploidy. I. A study of meiosis in the rare males of the polyploid race of *Melanooides tuberculata*. *Transactions of the Royal Society of Edinburgh* 63: 433-444.
- Jacob, J. (1957b). Cytological studies of Melaniidae (Mollusca) with special reference to parthenogenesis and polyploidy. II. Oogenesis of the parthenogenetic species of *Melanooides*. *Transactions of the Royal Society of Edinburgh* 63: 341-352.
- Knott, B. (1993). The groundwater fauna of North West Cape, Western Australia: present distribution and possible origins. *Records of the Western Australian Museum, Supplement* 45: 109-127.
- Peake, J. (1978). Distribution and ecology of the Stylommatophora. Pp. 429-526 in V. Fretter and J. Peake (eds). *Pulmonates, volume 2A, Systematics, evolution and ecology*. Academic Press, London, New York, San Francisco.
- Pilsbry, H.A. and Cooke, C.M. (1918-1920). *Manual of conchology*. 2nd series, volume 25. Academy of Natural Sciences, Philadelphia.
- Ponder, W.F. (1984). A review of the genera of the Irvadiidae (Gastropoda: Rissoacea) with an assessment of the relationships of the family. *Malacologia* 25: 21-71.
- Poore, G. and Humphreys, W.F. (1992). First record of Thermosbaenacea (Crustacea) from the southern hemisphere: a new species from a cave in tropical Western Australia. *Invertebrate Taxonomy* 6: 719-725.

- Smith, B.J. (1992). Non-marine Mollusca. Pp. 1-405 in W.W.K. Houston (ed.). *Zoological catalogue of Australia, volume 8*. Australian Government Publishing Service, Canberra
- Solem, A. (1974). *The shell makers. Introducing molluscs*. John Wiley and Sons, New York.
- Solem, A. (1978). Cretaceous and early Tertiary camaenid land snails from western North America. *Journal of Paleontology* 52: 581-589.
- Solem, A. (1983). *Endodontoid land snails from Pacific Islands (Mollusca: Pulmonata: Sigmurethra). Part II. Families Punctidae and Charopidae, zoogeography*. Chicago: Field Museum.
- Solem, A. (1984). Small land snails from northern Australia, III: species of Helicodiscidae and Charopidae. *Journal of the Malacological Society of Australia* 6: 155-179.
- Solem, A. (1985). Camaenid land snails from western and central Australia (Mollusca: Pulmonata: Camaenidae). V. Remaining Kimberley genera and addenda to the Kimberley. *Records of the Western Australian Museum, Supplement* 20: 707-981.
- Solem, A. (1986). Pupilloid land snails from the south and mid-west coasts of Australia. *Journal of the Malacological Society of Australia* 7: 95-124.
- Solem, A. (1989). Non-camaenid land snails of the Kimberley and Northern Territory, Australia. 1. Systematics, affinities and ranges. *Invertebrate Taxonomy* 2: 455-604.
- Solem, A. (1991a). Distribution and diversity patterns of Australian pupilloid land snails (Mollusca: Pulmonata: Pupillidae, s.l.). *Veliger* 34: 233-252.
- Solem, A. (1991b). Land snails of Kimberley rainforest patches and biogeography of all Kimberley land snails. Pp. 145-246 in N.L. McKenzie, R.B. Johnston and P.G. Kendrick (eds). *Kimberley rainforests*. Surrey Beatty and Sons Pty Ltd, Chipping Norton, New South Wales.
- Solem, A. (1992). Camaenid land snails from southern and eastern South Australia, excluding Kangaroo Island. *Records of the South Australian Museum, Monograph Series No 2*: 1-425.
- Solem, A. (ms.). Camaenid land snails from western and central Australia (Mollusca: Pulmonata: Camaenidae) VII. Taxa from Dampierland through the Nullarbor.
- Solem, A. and Christensen, C. C. (1984). Camaenid land snail reproductive cycle and growth patterns in semiarid areas of north-western Australia. *Australian Journal of Zoology* 32: 471-491.
- Stoddart, J. A. (1985). Analysis of species lineages of some Australian thiarids (Thiaridae, Prosobranchia, Gastropoda) using the evolutionary species concept. *Journal of the Malacological Society of Australia* 7:7-16.
- Vine, B., Knott, B. and Humphreys, W.F. (1988). Observations on the environment and biology of *Schizomus vinei* (Chelicerata: Schizomida) from Cape Range, Western Australia. *Records of the Western Australian Museum* 14: 21-34.

Appendix: Cape Range collecting localities

Cave	Latitude	Longitude
C-15	22° 13'S	113° 59'E
C-17	22° 15'S	113° 57'E
C-18	22° 05'S	114° 00'E
C-21	22° 14'S	113° 58'E
C-22	22° 14'S	113° 58'E
C-60	22° 06'S	113° 59'E
C-65	22° 06'S	114° 00'E
C-68	22° 06'S	113° 59'E
C-102	22° 08'S	113° 59'E
C-103	22° 07'S	113° 59'E
C-111	21° 55'S	114° 00'E
C-118	22° 09'S	113° 59'E
C-154	22° 09'S	113° 59'E
C-156	22° 07'S	114° 00'E
C-163	22° 09'S	114° 00'E
C-167	21° 59'S	114° 07'E
C-207	22° 12'S	113° 59'E
C-252	22° 03'S	114° 00'E
C-278	22° 04'S	114° 00'E
C-291	22° 16'S	113° 58'E
C-312	22° 03'S	114° 01'E
C-420	22° 09'S	113° 59'E
Other Localities		
C-24, Milyering Well	22° 01'S	113° 56'E
C-26, Tantabiddi Well	21° 56'S	113° 58'E
C-28, Bundera Cenote	22° 25'S	113° 46'E
Cape Range #2 Deep Oil Well	22° 06'S	114° 00'E
Cape Range #3 Deep Oil Well	22° 09'S	114° 00'E
Trealla Hill	22° 13'S	114° 00'E
Central Hill	22° 18'S	113° 57'E