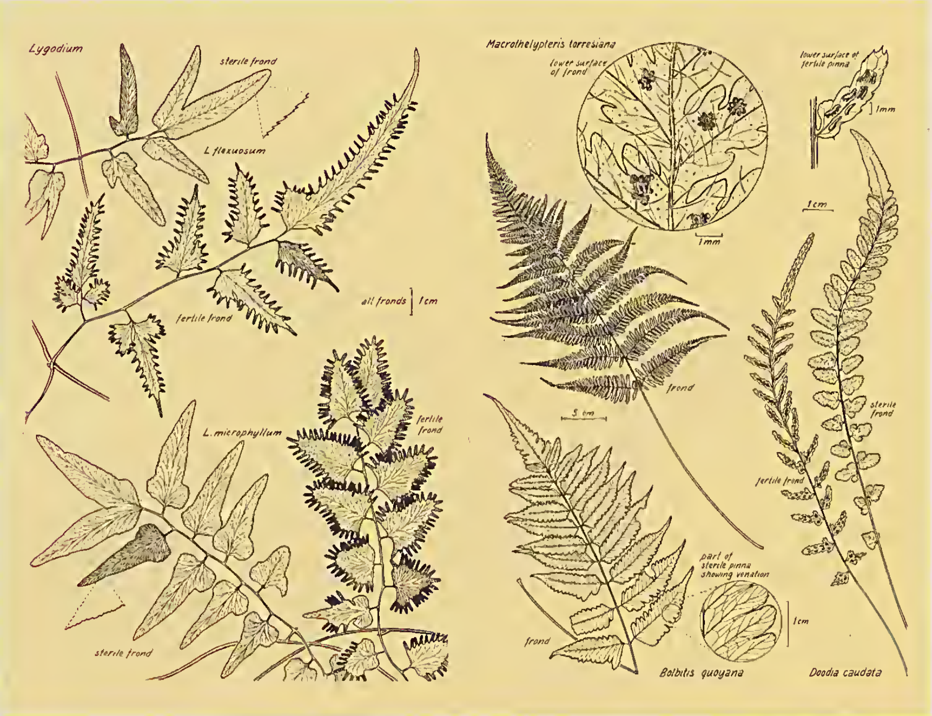
The Beagle

Records of the Museums and Art Galleries
of the Northern Territory

Volume 19 December 2003



The Beagle, Records of the Museums and Art Galleries of the Northern Territory

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Front cover: Composite plate showing the diversity of ferns from the Northern Territory (see Short, Dixon and Osterkamp Madsen, pages 7–80). Illustrations by Monika Osterkamp Madsen.

The Beagle

RECORDS OF THE MUSEUMS AND ART GALLERIES
OF THE NORTHERN TERRITORY

Volume 19, December 2003

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Archaeology of the first recorded petroglyphs for the Darwin region

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ABSTRACT

This paper presents preliminary research into petroglyphs located on Middle Arm Peninsula 16 km south-east of Darwin city. This research was carried out in response to queries on the origin of the petroglyphs in a region not previously known for rock art. Examination of weathering and style characteristics of the rock art and the technique by which it is made, to ascertain possible origins and chronology, found that these petroglyphs are typical of widely distributed Aboriginal 'Panaramitee' pecked geometric and track designs. They are unlikely to be older than nearby middens dated to around 2000 years old, and could have been made within the last century by Aboriginal people coming into the Darwin region, but there is nothing to suggest a non-Aboriginal origin.

Keywords: Petroglyphs, Panaramitee, middens, Darwin, Northern Territory.

INTRODUCTION

Questions have recently arisen, stimulated by Native Title proceedings, over the origin of petroglyphs, or pecked rock markings, at two locations on Middle Arm Peninsula, 16 km south-east of Darwin city. These are the only examples of Aboriginal rock art recorded thus far for the greater Darwin region; a region not previously known for rock art but one that is in proximity to areas that have major rock art traditions, such as Kakadu National Park some 200 km to the east. Middle Arm Peninsula is positioned between the Blackmore and Elizabeth Rivers that feed into Darwin Harbour (Fig. 1). The sites are located at the mouth of the Blackmore River adjacent to a section of Middle Arm known as Haycock Reach. One site (Site 1) was first recorded by one of the authors (Bourke) during an archaeological survey conducted in 1993 as part of her honours thesis research (Burns 1994). Additional features were noted at this site by the authors during field investigations in late 2002. Batchelor Institute of Indigenous Tertiary Education students noticed the second location of rock art (Site 2) in 1999 during a field visit to the area. This paper presents a preliminary recording and analysis of the petroglyphs at these two sites, and addresses some issues as to their possible origin and chronology.

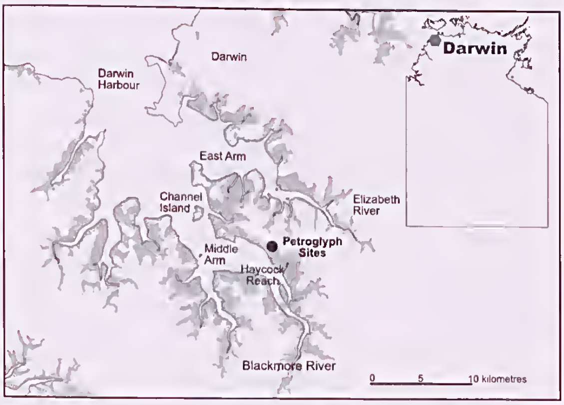

Fig. 1. Location of petroglyph sites on Middle Arm Peninsula, Darwin Harbour.

THE PETROGLYPHS

Unlike the coasts of Arnhem Land and the Kimberleys, which are backed by upland plateaus and ranges of resilient quartzitic sandstones where Aboriginal rock art abounds, the Darwin coastal landscape is one of low relief and soft rocks, and consequently suitable places for rock art are rare. The topography of Middle Arm Peninsula, the largest of many promontories jutting into Darwin Harbour, comprises undulating low ridges and hills 15–40 m high, formed on shales, siltstones and sandstones of the Proterozoic Burrell Creek Formation (Caldwell 1983; Hiscock and Hughes 2001; Pietsch 1986). These low hills and ridges are cut through with ephemeral wet season creeks and covered with tropical savanna eucalypt woodland and patches of monsoon vine forest. The recorded petroglyphs are on low sandstone outcrops at the foot-slopes of the low hills, adjacent to a narrow stretch of saltpan that separates the hinterland from the thick mangrove fringe of the peninsula's southern shoreline.

The petroglyphs first recorded in 1993 are on a near horizontal section (dip 15°) of an undulating panel, on the northern portion of a 9x9 m sandstone outcrop, typical of others in the local area (Fig. 2). The outcrop on which these petroglyphs occur rises a maximum of 2 m and slopes down to the seaward side, 10 m from the extensive mangrove fringe of Haycock Reach. About 250 m to the south-east of this site (Site 1), along the same stretch of shoreline, is the second petroglyph site, designated Site 2. This petroglyph is situated on a vertical surface of the north-western aspect of a weathered panel of rock at the western end of a sandstone hillock (Fig. 3).

Site 1 petroglyphs include a circular ring 155–170 mm in diameter, with a central pit. Two motifs resembling 'emu' tracks with a north-south orientation are situated alongside the circular motif (Fig. 4). The pit inside the ring is approximately 40 mm in diameter and 13 mm deep. It is deeper than the circle ring and track motifs, which are quite shallow and have diffuse, crenellated edges (Fig. 5). The pecked surface of the circle has a scalloping effect that is irregular, of 14–18 mm thickness – narrower than the thickness of the pecked ring outline (28 mm). This effect is more pronounced than in the track motifs, which, although of similar thickness in pecked area (26 and 28 mm) to the ring, appear more smoothed out. The track motifs are each about 90 mm long and 70 mm across the full width of the 'outer toes'.

Fig. 2. Site 1, view looking north-east over sandstone outcrop containing petroglyphs.

Fig. 3. View of Site 2, looking south-east toward sandstone outcrop: the petroglyph is situated on the vertical rock face adjacent to a large tree.

Fig. 4. Site 1, ring and pit and 'emu' track pair petroglyphs on curved and sloping sandstone surface; scale 10 cm.

Fig. 5. Detail of cup and ring motif, Site 1; note the scalloped nature of the pecked surfaces.

During investigations in 2002, one of the authors (Mulvaney) noticed additional rock markings at Site 1, comprising 13 pecked pits (cupules) in a roughly oval pattern (100x200 mm), positioned on the surface of a near vertical sloping lower section of the rock formation on the seaward side (Fig. 6). These cupules, which range from 20 to 40 mm in diameter, may be distinguished from similar natural pitting of the rock surface by their regularity and smoothness at their base and edges.

At Site 2 the petroglyph comprises a single motif resembling an 'emu' track (Fig. 7). This track motif is 200 mm long and 110 mm across the width of the 'outer toes'. This motif is much larger than the track motifs at Site 1, although the thickness of the pecked area is the same (26 mm). The edges of this petroglyph are diffuse and smooth and there is no apparent scalloping.

Fig. 6. Cupule arrangement on near vertical surface of sandstone at Site 1; scale 2 cm.

Fig. 7. Single 'emu' track motif, petroglyph Site 2.

There does appear to be a deeper indentation at the base of the "middle toe" (52 mm thick), however this may simply be a factor influenced by the existence of a narrow quartz vein running through the rock here. The ratio of length of the middle and outer toes is also greater with this single motif than is the case with the track pair at Site 1.

STYLE, TECHNIQUE AND WEATHERING

Researchers generally classify Aboriginal petroglyphs in Australia in terms of characteristics such as form and style, the techniques used to produce the art, and the degree of patination. The Middle Arm Peninsula petroglyphs are reminiscent of a rock art referred to as 'the Panaramitee' style, which is widely, although sparsely, distributed across Australia (Flood 1997). In the Northern Territory this type of Aboriginal rock art occurs more frequently as one moves further inland toward desert regions (Chaloupka 1993; Gunn 2000; Layton 1992; Mulvaney 2001; Rosenfeld and Mumford 1996). 'The Panaramitee' style is characterised by a restricted range of pecked petroglyphs comprising geometric motifs dominated by circles, and includes dots, crescents, spirals and radiate designs, and motif types such as macropod and bird tracks, and to a lesser extent other animal tracks and human footprints (Maynard 1977, 1979). Circles and tracks are often found in numerical proportions to each other (Basedow 1914; Edwards 1966; Clegg 1992). Another feature of 'the Panaramitee' petroglyphs is small relative size (100–200 mm) of the motifs, although infrequently, larger images may occur.

'The Panaramitee' is generally considered to be a stylistic tradition that existed prior to the mid-Holocene, although the antiquity and extent to which it represents a homogenous body of art is debatable (Clegg 1992; Franklin 1993; Rosenfeld 1991). As David *et al.* (1999) point out, similar types of petroglyphs found elsewhere in the Territory (Fig. 8) are now known to have a more recent age, covering the period 7000 BP, dated from deposits at Ingaladdi in Wardaman country (Mulvaney 1975) to the present, as ethnohistoric records show (Flood and David 1994). Sites at Roma Gorge, central Australia, containing similar engraved circles, have been associated with 20th century ceremonial activities (Tacon 1994). This is also the case further north, on the edge of the Barkly Tablelands, although it is evident that the production of some of the art predates the advent of the mythological and ceremonial associations (Mulvaney 2001).

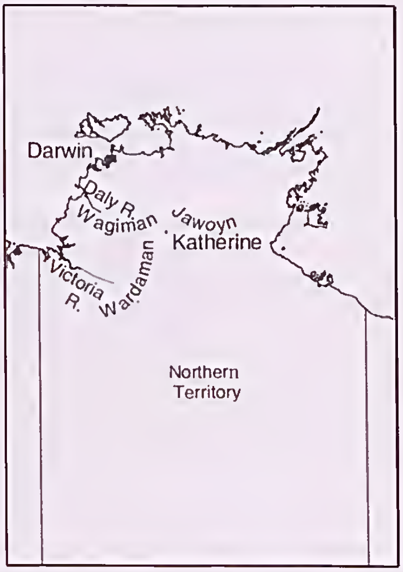

Fig. 8. Nearest occurrence to Darwin of Panaramitee type rock art tradition, in Wardaman, Wagiman and Jawoyn country.

There is a difference between the Middle Arm petroglyphs with their shallow, diffuse-edged form and common examples of 'the Panaramitee', which are finely defined, sharp-edged pitting, either by direct or indirect percussion, pecked into the rock surface with a pointed hammer stone (Maynard 1977). Rather, the Middle Arm petroglyph surfaces suggest they were made by a technique of pounding or bruising the rock surface with a large, blunted hammer. This technique of using a relatively large object to pound the rock, removing at least several millimeters thickness to produce a lower relief area of overlapping marks in the rock, is occasionally referred to as "relief pounding", as occurs in the Laura region of north Queensland (Rosenfeld *et al.* 1981) or as "conjoined punctures" in some Sydney-Hawkesbury sites (McCarthy 1988). Nevertheless, this is a known variant of Aboriginal percussion techniques that falls within Maynard's (1977) definition of pecking as making an indentation in the rock surface (Clegg 1988). Moreover, as Bednarik (1998) suggests, variables such as type of rock, depth of weathering zone, presence of moisture, direction of impact and attributes of the percussion tool may have more to do with the difference between more precise, deep percussion marks and more diffuse, shallow marks than manner of production.

It is possible that the scalloped appearance of the motif surface, particularly evident with the circle image, is a function of weathering and micro-erosion directly attributable to the changed condition of the petroglyph surface. Salt crystals were observed within the motif surface of the petroglyphs when they were first observed in 1993. It is also recorded that petroglyphs associated with the relatively soft sandstone found in Wardaman country to the south-west of Katherine are formed by a combination of pecking and abrasion (David *et al.* 1999). The sandstone of Middle Arm Peninsula appears to be of comparable softness; therefore natural weathering and/or anthropogenic factors may contribute to the particular appearance of these petroglyphs.

All the Middle Arm petroglyphs are patinated (weathered) to the same greyish/pink colour as the soft sandstone, which is an exposed saltwater eroded surface, with the lower levels of rock submerged under sand. Deeply patinated petroglyphs such as this are sometimes interpreted in conjunction with other characteristics such as subject and technique, as indicating greater antiquity than less patinated (showing more contrast with the rock) petroglyphs (eg. Lorblanchet 1992; Forbes 1983). However, the negligible contrast in patination between the rock and art surface is seen as a particular function of the local, coastal environment, not of the antiquity of the respective rock surfaces. In addition, the salt laden environmental conditions and likely erosion rate of this soft sandstone lead us to the conclusion that the petroglyphs are unlikely to be older than nearby middens dated to around 2000 years old (see below), and could be quite recent. Lewis and McCausland (1987) for example, report weathering of historic rock art in the Victoria River district, with loss of contrast to the same extent as nearby pecked Aboriginal art, over a period of less than a century.

DISCUSSION AND CONCLUSION

A number of feasible scenarios exist to explain the unique occurrence and form of these Middle Arm petroglyphs. These petroglyphs are the only known examples in the greater Darwin Region and there exist numerous un-marked sandstone outcrops in the Middle Arm Peninsula. This would seem to preclude any extended local tradition for the creation of petroglyphs. The motif style has its parallels in the arid interior and other parts of Australia, and it is possible that these petroglyphs were made within the last century by Aboriginal people coming into the Darwin region. Bednarik (1998) reported an Indjibandi man (Pilbara region, Western Australia) producing a new petroglyph at a site that was not in his traditional territory. Although there is no direct evidence, the proximity of the now abandoned Channel Island leprosarium (1914–55), some 7 km to the north-west, raises the possibility that Aboriginal people from elsewhere produced the rock markings for some purpose.

There is also the possibility that the art is much older; not produced by visiting persons during the historic period. Thus what we find at Middle Arm may simply be the remnant of a more widespread tradition of rock art production. Petroglyphs may be dated by association with occupation deposits, as Lorblanchet (1992) achieved for engraving sites and middens on the Burrup Peninsula, Western Australia. The Middle Arm cupules, ring and pit, and track pair are situated on a rock outcrop (Site 1) adjacent to a shallow Aboriginal shell midden. Nearby are two mounded middens and a sparse stone artefact scatter of mainly flaked milky quartz, all within a 20 m radius. Radiocarbon dating of one of the mounded middens gave uncalibrated conventional estimates of 1780±60 (Beta–76830) for the surface and 2430±90 (Beta–76831) for the base (Bourke 2000). One question that arises is whether the formation of the shell mound and petroglyphs may be linked in time as well as space. If the petroglyphs were made during this same period, by the shellfish gatherers who built the mounds, they may be up to a couple of thousand years old. Establishing a function of weathering rate for the sandstone would be useful in regard to determining the antiquity of the rock art.

There is no recorded comparable pictograph or petroglyph tradition in the region and certainly not the placement of so few motifs. The nearest occurrence of such features known to the authors is in the Wardaman, Wagiman and Jawoyn country, 200–270 km to the south and south-east (Fig. 8). 'Emu' track and 'cup and ring' motifs are present in Nanggumerri territory south of the Daly River. Pictographs but not petroglyphs have been recorded within the Tabletop Range, approximately 80 km southward of Darwin. This is the closest known art tradition to the Middle Arm petroglyphs. It is possible that the Middle Arm petroglyphs represent an outlier of these more widely spread rock-art traditions. Alternatively, for some unknown reason, a countryman visiting the Darwin region produced the images at Middle Arm.

A non-indigenous creative hand in the production of the Middle Arm petroglyphs is a possibility, but the authors believe this would produce characteristically different art. Aboriginal petroglyphs are usually pecked and occasionally abraded, while non-indigenous rock markings are invariably engraved and incised. If metal tools are used the rock grains and crystals are crushed, bruised and scratched, while stone hammers tend to fracture out the rock particles. It is possible the current appearance of the petroglyph surfaces were formed by natural weathering, producing a resemblance to stone hammer production. However, comparison with photographs taken in 1993 does not reveal any visible change in rock surface character. That no noticeable alteration to the sandstone surfaces has occurred in the intervening ten years, supports the idea that the petroglyphs were produced at a minimum many decades ago.

There is nothing to suggest that the Middle Arm petroglyphs are of non-Aboriginal origin. They are typical of widely distributed recorded Aboriginal pecked petroglyphs. Creation of this art would have required extensive knowledge of Aboriginal art styles and production techniques. There is no indication that metal objects were used in the production of the art, or evident depiction of non-indigenous subjects.

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Note added in press

Since submission of this paper another petroglyph (a track and cupule) has been reported along the same stretch of coastline. To date this has not been investigated by the authors. However, this additional finding would provide more support for the notion that the Middle Arm petroglyphs are remnants of a more widespread tradition of rock art production.

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A review of the ferns and fern allies of the Northern Territory

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ABSTRACT

An account of the 47 genera and 88 formally named species of ferns and fern allies found in the Northern Territory, Australia, is presented. This figure includes records of nine species that were not included in *Flora of Australia* (McCarthy 1998). In addition, the presence of another five entities, whose identity and status is yet to be ascertained, occur in the Northern Territory. Distribution maps and illustrations are provided for most species.

KEYWORDS: Lycopodiophyta, Polypodiophyta, Psilophyta, ferns, fern allies, Northern Territory, Australia.

INTRODUCTION

Robert Brown (1810) was the first to collect ferns from localities now included within the boundaries of the Northern Territory (N.T.), naming and describing several species which are still recognised today. After Brown, knowledge of the ferns of the N.T. slowly increased during the nineteenth century through, for example, the efforts of Melbourne-based botanist Ferdinand Mueller and collectors with whom he was in contact. Mueller himself collected the type material of *Cheilanthes fragillima* from the Fitzmaurice River during the North Australian Expedition (1855–1856), and he described *Paraceterach reynoldsii* from a specimen collected near the Olgas by the explorer W.C. Gosse. Plant specimens collected in the late 1860s and early 1870s by Frederich Schultz in the Darwin region were sent to Kew for examination, with one of them becoming the type specimen of *Cheilanthes contigua*. Despite such activities Ewart and Davies (1917) could list just 36 species of ferns and fern allies for northern Australia.

The establishment of permanent herbaria within the N.T., in Alice Springs in 1954 and Darwin in 1966, with the associated staffing by professional botanists, plus visits by interstate botanists, led to a significant increase in the knowledge of the plants of the N.T. in the latter half of last century. Chippendale (1972) could list 59 species (some unnamed) and, just 15 years later, Dunlop (1987) listed 74 species of ferns and fern allies for the region. In the recent treatment of this group for the *Flora of Australia* series, 87 species were recognised (McCarthy 1998).

Curatorial work since the advent of the *Flora of Australia*, plus the receipt of new collections, has revealed the presence of 13 additional species or possible species in the Northern Territory. They are dispersed among the genera *Actinostachys*, *Adiantum*, *Asplenium*, *Bolbitis*, *Doodia*, *Gleichenia*, *Marsilea*, *Macrothelypteris*, *Microlepia* and *Pteris*. Nine of them are here referred, albeit sometimes tentatively, to known species but non-formal names are used for five others, *i.e. Asplenium* (Litchfield entity), *Asplenium* (Nabarlek entity), *Gleichenia* (Victoria River entity), *Marsilea* (Neutral Junction entity) and *Selaginella* (Mt Gilruth entity). These taxa are not described as new as species circumscription is uncertain, more material is required to establish their status or because names may already exist, the latter being something that cannot be ascertained without the examination of non-Australian specimens.

This review has been written not just to record the presence of new taxa but to emphasise areas requiring further research and to encourage others to observe and collect the ferns and fern allies of the N.T. To that end, some emphasis is placed on providing notes on species and infraspecific taxa that seem to be ill-defined and illustrations of almost all species are provided to assist in identification.

It is difficult if not impossible to make taxonomic changes without looking at variation in taxa throughout their range. Thus, although noting problems with circumscription, most species concepts adopted in this review are those used in various treatments in the *Flora of Australia* (McCarthy 1998). However, there are several areas where some taxonomic changes have been suggested. In both *Marsilea* and *Nephrolepis* broader specific concepts than those used in treatments of the *Flora of Australia* have been adopted and subspecies of *Lindsaea ensifolia* have not been recognised.

With the adoption of the above taxonomy the Northern Territory contains 47 genera of ferns and fern allies and 88 formally named species that are native or believed to be naturalized, plus five informally-named entities of uncertain status. With the taxonomic changes here adopted, comparisons are not exact but Tindale (1998) recorded 456 species and 112 genera for Australia, with north-east Queensland (104 genera, 302 species) having easily the greatest diversity of these plants.

From data provided by Tindale (1998) of the species recognised within Australia, 166 (*ca* 36%) are endemic. However, of the formally named species and infraspecific taxa here recognised for the N.T. only 25 are confined to Australia and only *Isoetes cristata* and *Marsilea latzii* are seemingly confined to the N.T. Most species which occur here are in fact widespread in the Old World tropics and perhaps 13 are pantropical or almost so. The latter group includes the only two weedy ferns within the N.T., *Salvinia molesta* and *Pityrogramma calomelanos*, both being native to the Americas and pantropical by introduction.

MATERIALS AND METHODS

The abbreviation DNA is the accepted abbreviation for the Northern Territory Herbarium. This and other herbarium abbreviations used are summarised in Holmgren *et al.* (1990).

Text abbreviations of the titles of scientific journals follow Lawrence *et al.* (1968) and titles of books are abbreviated following Stafleu and Cowan (1976–1988). Names of authors are abbreviated following Brummitt and Powell (1992).

Many original publications have been consulted but very few type specimens have been examined during the compilation of the review. Thus, in providing details of literature, and particularly of type specimens, considerable reliance has been placed on data gleaned from Chapman (1979) and various treatments, all referenced, in the *Flora of Australia* (McCarthy 1998). Specimens in the Hermann Herbarium have been checked on the Natural History Museum (BM) website.

Family concepts are those used in *Flora of Australia*; full reference to them are given under each family treatment.

For every species and infraspecific taxon the time when fertile plants may be found is indicated. This information is based on data associated with herbarium specimens.

SYSTEMATICS

Key to families of ferns and fern allies

1a. Sporangia in the axils of minute, forked leaves (or leaf-like organs) *or* at the base of small leaves (sporophylls) held in cone-like structures *or* in swollen leaf bases 2

1b. Sporangia on the lamina of leaves (fronds) *or* aggregated into a spike *or* enclosed in a hard, nut-like sporocarp .... 5 (Polypodiophyta)(p.16)

2a. Leaves scale-like and scattered on rigid stems; sporangia fused in groups of 2 or 3 and held in the axis of the leaves .... Psilotophyta (Psilotaceae)(p.11)

2b. Leaves linear and grass-like and sporangia at their bases *or* the leaves small but numerous on weak to erect stems and the sporangia held in cone-like structures .. 3 (Lycopodiophyta)(p.11)

3a. Leaves linear and grass-like .... Isoetaceae (p.11)

3b. Leaves small but numerous on weak to erect stems; sporangia in the axis of sporophylls which are aggregated to form cone-like structures 4

4a. Sporangia of only one kind; leaf bases lacking a ligule .... Lycopodiaceae (p.13)

4b. Sporangia of two size classes; leaf bases with a minute ligule (but often difficult to see in adult plants) .... Selaginellaceae (p.15)

5a. Fronds of 2 pairs of opposite, closely spaced leaflets at the end of a long stipe, the whole having the appearance of a 4-leaved clover .... Marsileaceae (p.24)

5b. Fronds not comprised of apical leaflets 6

6a. Sporangia aggregated in a spike; sterile lamina and fertile spike diverging from a common stalk .... Ophioglossaceae (p.16)

6b. Sporangia not aggregated in a spike; sterile and fertile fronds borne separately or all fronds fertile 7

7a. Free-floating plants, the sterile laminae simple and paired *or* crowded and less than *ca* 2 mm long 8

7b. Terrestrial, lithophytic or epiphytic plants *or* if free-floating the sterile lamina 1–3-pinnate 9

8a. Fronds monomorphic, of many, crowded, bilobed leaves, each less than *c.* 2 mm long .... Azollaceae (p.30)

8b. Fronds dimorphic, with root-like leaves and foliar leaves more than 8 mm long .... Salviniaceae (p.29)

9a. Sori submarginal, each composed of a ring or double row of free sporangia; fern with a short trunk and with fronds to 4 m long, margins of pinnae toothed .... Marattiaceae (p.19)

9b. Sori not submarginal or if so sporangia not in a double row or ring; fern lacking a trunk or if present then margins of pinnae entire 10

10a. Sori on narrow segments arranged like a cock's comb and borne on the apices of fertile fronds *or* on marginal projections of fertile fronds 11

10b. Sori not arranged as above 12

11a. Sori on narrow segments borne on the apices of fertile fronds .... Schizaeaceae (p.30)

11b. Sori borne on marginal segments of fertile fronds .... Lygodiaceae (p.32)

12a. Aquatic or semi-aquatic, usually rooted fern with strongly dimorphic fronds .... Parkeriaceae (p.55)

12b. Terrestrial or epiphytic fern 13

13a. Lamina translucent, the ultimate segments 1-cell thick apart from the veins .... Hymenophyllaceae (p.19)

13b. Lamina not translucent nor 1-cell thick 14

14a. Fronds pseudodichotomously branched, with buds in the axils of the branches .... Gleicheniaceae (p.21)

14b. Fronds unbranched or if branched then not appearing to be dichotomous and buds never present in the axils 15

15a. Fronds dimorphic, the lamina simple or 1-pinnate and the sessile or near-sessile pinnules pouch-like and less than 2.5 mm long .... Platyzomataceae (p.24)

15b. Fronds monomorphic or dimorphic, if dimorphic the pinnules never small and pouch-like 16

16a. Fronds simple, with the lamina linear, 5–50 cm long, 0.25–0.6 cm wide, ultimately pendulous .... Vittariaceae (p.57)

16b. Fronds divided or if simple then not linear and pendulous 17

17a. Sporangia mostly or only borne away from the margins of the pinnae/pinnules or covering all *or* most of the surface; indusium if present never half-cup-shaped 18

17b. Sporangia confined to marginal or submarginal regions and often covered by the reflexed margins of the pinnae/pinnules; indusium absent or present and may be half-cup-shaped 29

18a. Sporangia covering the undersurface of fertile pinna *or* covering all but the narrow margins of the undersurface and the pinnae linear 19

18b. Sporangia not covering the entire surface but in discrete regions 21

19a. Fertile pinnae linear, less than 5 mm wide; sterile pinnae shiny, their veins numerous, close and parallel .... Blechnaceae (p.62)

19b. Fertile pinnae lanceolate or if somewhat linear then 10 mm or more wide; sterile pinnae with reticulate venation 20

20a. Pinnae margins entire .... Pteridaceae (p.39)

20b. Pinnae margins shallowly to deeply lobed .... Lomariopsidaceae (p.66)

21a. Sori circular or subreniform (but in very mature sori the sporangia may link to form an elongate grouping) 22

21b. Sori elongate 25

22a. Fronds simple or 1-pinnatifid or sometimes 1-pinnate, margins of the lobes or pinnae entire or if at all toothed or minutely lobed then irregularly so and lobes or pinnae with entire margins also present on the same or different fronds 23

22b. Fertile fronds 1- or 2-pinnate or 3-pinnatifid, pinnae always regularly toothed or lobed for all or much of their length 24

23a. Sterile fronds 1-pinnate, with 1–3 pairs of pinnae .... Dryopteridaceae (p.66)

23b. Sterile fronds oak-leaf shaped *or* simple or 1-pinnatifid and with (3) 10–30 lobes .... Polypodiaceae (p.69)

24a. Hydathodes prominent on the upper surface of the lamina at the ends of veins .... Davalliaceae (p.67)

24b. Hydathodes absent from the upper surface of the lamina, the veins more or less extending to the lamina margin .... Thelypteridaceae (p.58)

25a. Indusium present 26

25b. Indusium absent 28

26a. Sori formed on either side of, and touching, the costa and sometimes running unbroken for much of its length .... Blechnaceae (p.62)

26b. Sori not as above 27

27a. Fronds monomorphic; lamina with latticed, branching scales .... Aspleniaceae (p.57)

27b. Fronds dimorphic; lamina with uniseriate hairs .... Blechnaceae (p.62)

28a. Lamina glabrous or their lower surface with a white waxy coating .... Adiantaceae (p.42)

28b. Lamina surfaces with a dense indumentum of eglandular and/or glandular hairs .... Aspleniaceae (p.57)

29a. True indusia present (may be poorly developed and if so then pinnules leathery, narrow, with recurved margins and their undersurfaces densely hairy) 30

29b. True indusia absent but margins of lamina may form a false indusium or soral flap (if pinnules leathery, narrow and with recurved margins with membranous, indusium-like margins then their undersurfaces glabrous) 33

30a. Indusia half-cup-shaped .... Dennstaedtiaceae (p.34)

30b. Indusia elongate to continuous 31

31a. Pinnules leathery, their margins recurved and their undersurfaces densely hairy .... Dennstaedtiaceae (p.34)

31b. Pinnules not as above 32

32a. Pinnae jointed to the rachis; ultimate segments with a distinct midvein; fronds 1-pinnate .... Davalliaceae (p.67)

32b. Pinnae not jointed to the rachis; ultimate segments with or without a distinct midvein; fronds 1- or partly 2-pinnate .... Lindsaeaceae (p.36)

33a. Fronds with the lamina thin and glabrous; pinnae sessile, with stipule-like pinnules at the base .... Dennstaedtiaceae (p.34)

33b. Fronds not with the above combination of features 34

34a. Ferns robust, their fronds commonly 1 m or more tall, the pinnae thick, with inrolled margins and glabrous or almost so .... Pteridaceae (p.39)

34b. Ferns mostly weak, their fronds mostly less than 50 cm tall, if pinnae thick then with scales or densely hairy on at least one surface .... Adiantaceae (p.42)

Division Psilotophyta

Cosmopolitan, containing a single family.

Psilotaceae

Two genera, *Psilotum* and *Tmesipteris*, and both in Australia but only the former in the N.T.

Reference: Chinnock (1998a).

Psilotum Sw.

Plants lacking true roots but with a dichotomously branched rhizome bearing rhizoidal hairs. Stems photosynthetic, erect or drooping, dichotomously branched. Leaves scale-like and lacking a vascular nerve, leaves undivided or bifid. Sporangia in trilocular synangia in axils of bifid leaves. Spores numerous, bilateral, monolete.

Ditypic, widespread genus, with both species in Australia but only *P. nudum* in the N.T.

Psilotum nudum (L.) P. Beauv.

(Fig. 1A–C)

Skeleton fork fern

Lycopodium nudum L., Sp. pl. 2: 1100 (1753).

Psilotum nudum (L.) P. Beauv., Prodr. aethéogam. 112 (1805).

Type: 'in Indiis'; syn.: LINN 1257.1.

Plants epiphytic or terrestrial. Rhizome creeping, branched, often clumped. Stems 10–65 cm long; branches subterete, subterete, the largest *ca* 3 mm diam., with 3–7 ribs; stomata restricted to the furrows between the ribs; scale-like leaves 1–2.5 mm long, yellowish, restricted to the ribs. Synangia 1.5–2.5 mm diam., sessile, yellow. Fertile plants: generally throughout the year.

Distribution. Widespread in the tropics and subtropics of the world and sometimes extending to temperate regions and, in areas of permanent water, arid regions (Australia: W.A., N.T., Qld, N.S.W., Vic.) (p.77).

Habitat. Common in monsoonal rainforest, where it may be epiphytic, and in permanent seepage areas in the Top End. Also found in seepage areas, e.g. Twin Gorge (Dulcie Ranges) and waterholes, e.g. Reedy Rockhole (George Gill Range), in southern parts of the N.T.

Division Lycopodiophyta

Cosmopolitan and containing three families, all of which occur in Australia.

Isoetaceae

A family containing perhaps two genera, *Isoetes* and *Stylites*, with only the former in Australia.

References: Andrews (1990), Chinnock (1998b).

Isoetes L.

Quillworts

Perennial or annual, grass-like plants, the corm 2–5-lobed, the roots arising from between the lobes, roots forked towards the tips. Leaves mostly sporophyllous, spirally arranged, erect, filiform or linear but with dilated bases, 1-veined. Sporangia naked or partly or wholly covered by a velum, spores released by decay of sporangial walls. Megasporangia borne on outer leaves; megaspores *ca* 0.3–0.5 mm in diam., white or grey, ornamented. Microsporangia borne on inner leaves; microspores minute.

A widespread genus of *ca* 100 species, with 15 recognised in Australia and three in the N.T.

References: Marsden (1976a, 1976b), Chinnock (1998).

Megasporangia contain almost spherical, nucleate and mostly fertile megaspores and also enucleate, infertile megaspores. The latter are variably flattened and triangular in outline. Dumb-bell shaped megaspores may also occur but are not described in the following descriptions. The distal face is the large, half-spheroid part of the spore: the proximal faces are the three, somewhat triangular faces.

Key to species of *Isoetes*

1a. Fertile megaspores with manifestly different ornamentation on distal and proximal faces .... *I. cristata*
1b. Fertile megaspores with similar type of ornamentation on all faces 2
2a. Fertile megaspore with numerous large tubercles .... *I. coromandelina*
2b. Fertile megaspore with obvious ridges which are often confluent, occasionally with short ridges and small tubercle-like ornamentation ...... *I. muelleri*

Isoetes coromandelina subsp. *macrotuberculata* C.R. Marsden

(Fig. 1D–F)

Isoetes coromandelina L.f., Suppl. pl. 447 (1781) subsp. *macrotuberculata* C.R. Marsden, Contr. Austral. Herb. 24: 2 (1976).

Type: Mt Bundey Station, N.T., 26 Apr. 1974, *C.R. Dunlop 3193*; holo: AD; iso: AD, BM, BRI, CANB, DNA.

Aquatic or amphibious plants. Leaves 10–60 per plant, erect, flexible, 15–70 cm long, 0.5–2 mm diam., bright green, mostly subtriangular in transverse section but basally dilated; base to 20 mm wide, with broad membranous wings. Sporangia orbicular or obovate, 7–12 mm long; velum absent. Fertile megaspores 0.4–0.55 mm diam., white-grey; proximal faces usually with one large tubercle, sometimes a few large and several smaller tubercles present; distal face with numerous large tubercles. Infertile megaspores with the distal face with up to 10 or more tubercles, the proximal faces usually with 1 large tubercle but sometimes 2 or 3 tubercles present. Fertile plants: Feb.–July.

Distribution. Confined to northern Australia (W.A., N.T., Qld) and widespread in the Top End (p.75).

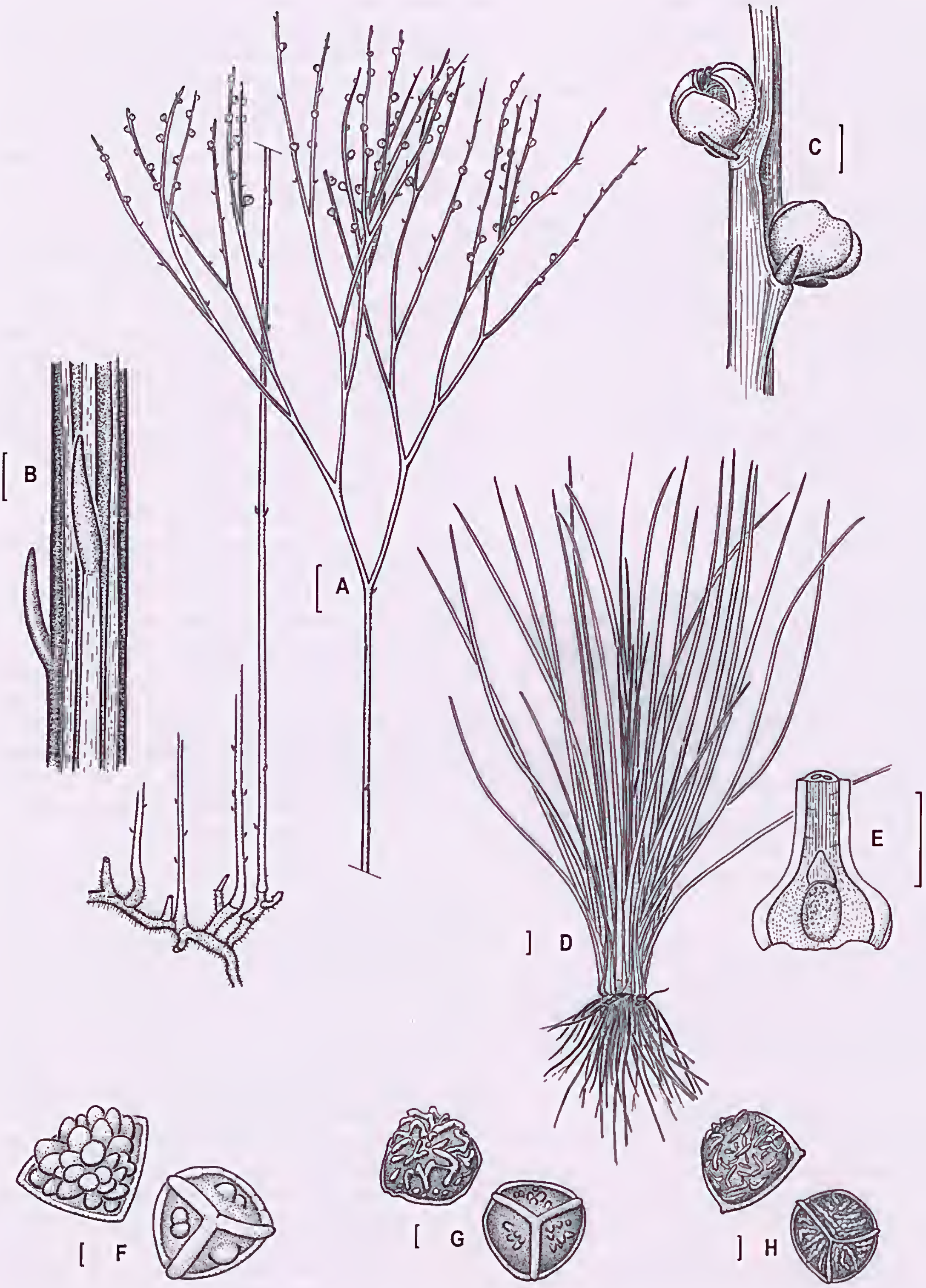

Fig. 1. A-C. *Psilotum nudum*: **A**, habit; **B**, part of stem with unbranched leaves; **C**, bifid leaves with trilobed synangia (**A**, **B**, Dunlop 9911; **C**, Russell-Smith 5260). **D-F**. *Isoetes coromandelina* subsp. *macrotuberculata*: **D**, habit; **E**, base of leaf with sporangia; **F**, megaspores, showing distal and proximal faces (**D-F**, Michell 2526). **G**, *Isoetes cristata*: megaspores, showing distal and proximal faces (Dunlop 4243). **H**. *Isoetes muelleri*: megaspores, showing distal and proximal faces (Latz 7130). Scale bars: **A**, **D**, **E** = 1 cm; **B**, **C** = 1 mm; **F-H** = 0.1 mm.

Habitat. Grows on the margins of seasonal swamps, in seepage areas, in ephemeral streams and, less commonly, on floodplains.

Notes. The only other subspecies, subsp. *coromandelina*, occurs on the Indian subcontinent. It differs in having smaller tubercles on the megaspores.

Isoetes cristata C.R. Marsden and Chinnock

(Fig. 1G)

Isoetes cristata C.R. Marsden and Chinnock, Fl. Australia 48: 704 (1998).

Type: 10 km S of Jimmys Creek, N.T., 13 May 1976, *C.R. Dunlop 4243*; holo: AD; iso: AD, BM, DNA.

Amphibious plants. Leaves to *ca* 65 per plant, erect-patent, flexible, 6–16 cm long, 0.8–1.5 mm diam., bright green; base narrowly winged, translucent. Sporangia elliptic, 2.5–4.5 mm long; velum covering 5–15% of the sporangium. Fertile megaspores 0.3–0.45 mm diam., drying white or grey; distal face with wavy, often confluent ridges; proximal faces with 1–8 tubercles of similar or variable sizes, and usually at least one very prominent. Infertile megaspores with the distal face smooth or with faint to distinct ridge-like ornamentation, the proximal faces with one to several large tubercles plus sometimes several indistinct, small tubercles. Fertile plants: Mar.–May.

Distribution. Confined to, and widely dispersed in, northern N.T. but known only from the type collection plus two specimens from Nitmiluk NP and one each from the Wickham River region and Sturt Plateau (p.75).

Habitat. Recorded from seasonally inundated swamps associated with dominant tree species such as *Asteromyrtus symphyocarpa*, *Corymbia polycarpa*, *Lophostemon lactifluus* and *Melaleuca nervosa*. Also collected from a seepage swamp on sandstone. At two localities it has been recorded as growing with *I. coromandelina*.

Isoetes muelleri A. Braun

(Fig. 1H)

Isoetes muelleri A. Braun, Monatsber. Königl. Preuss. Akad. Wiss. Berlin 541 (1868).

Type: Rockhampton, Qld, 1867, *P.O'Shanesy s.n.*; lecto: B (C.R. Marsden, J. Adelaide Bot. Gard. 1: 50 (1976); isolecto: K.

[*Isoetes humilior auct. non* F. Muell. ex Braun; Chippend., Proc. Linn. Soc. New South Wales 96: 216 (1972).]

Amphibious or aquatic plants. Leaves 5–25 per plant, erect or slightly recurved, 3–12 cm long, *ca* 1.5 mm diam., dark green; base *ca* 4 mm wide, white. Sporangia spheroidal or ellipsoid, 2.5–6 mm long; velum covering the sporangium. Fertile megaspores 0.3–0.5 mm diam., drying grey; all faces similarly ornamented with small ridges which are often confluent, occasionally with short ridges and small tubercle-like ornamentation. Infertile megaspores with numerous small tubercles or very short ridges on the proximal faces. Fertile plants: Jan.–Sept.

Distribution. Australia (all states and mainland territories) (p.75).

Habitat. In keeping with its highly polymorphic nature the taxon is found in a broad range of habitats, including ephemeral pools in arid regions, swamps and seepage areas in the tropics, and alpine tarns. In the N.T. it has been mostly collected from the south, including for example in pools on the top of Uluru (Ayers Rock), but is also found in Top End localities such as Mt Brockman.

Notes. A highly variable species in respect to spore morphology and many populations are known to be apomictic. A collection from Mt Gilruth, *Jones 1539*, has some fertile megaspores that approach those of *I. cristata* but the numerous tubercles on the proximal faces of the infertile megaspores suggests it is best placed with this species.

Lycopodiaceae

Family of four genera, all of which are represented in Australia but only *Lycopodiella* in the N.T.

Reference: Chinnock (1998c).

Lycopodiella Holub

Plants terrestrial, main stems indeterminate, creeping or subterranean and giving rise to determinate branches from the dorsal surface. Roots dichotomously branched. Leaves simple, eligulate, with 1 central vein, arranged in alternating spirals or irregular whorls, equal or unequal in size and shape at any point on a branch. Stroboli (aggregated sporophylls) terminal and nodding on ultimate branchlets or (not N.T.) erect. Sporophylls subpeltate. Sporangia axillary or attached to the base of the sporophyll, unilocular. Spores rugose. Gametophyte on surface of substrate, tuberous, green and hemisaprophytic.

About 40 species in temperate and tropical regions of the world, with five in Australia and one in the N.T. The genus is closely related to, and sometimes included in, *Lycopodium* L.

Lycopodiella cernua (L.) Pic. Serm.

(Fig. 2A–D)

Lycopodium cernuum L., Sp. pl. 2: 1103 (1753).

Lycopodiella cernua (L.) Pic. Serm., Webbia 23: 166 (1968).

Type: details not clear but including Hermann specimens from Sri Lanka; syn: LINN 1257.13, Herb. P. Hermann 1: 30 (BM 621335), Herb. P. Hermann 3: 45 (BM 621967).

Main stem stout, trailing, rooting at intervals. Determinate stems erect or climbing, to 100 cm tall and to 0.4 cm diam, the lower part simple, the upper part much branched. Leaves subwhorled or spirally arranged, somewhat linear or narrowly triangular, 2–5

Fig. 2. A-D. *Lycopodiella cernua*: **A**, habit; **B**, branch with stroboli; **C**, strobilus; **D**, dorsal view of sporophyll (**A-D**, Wightman 645). **E**. *Selaginella ciliaris*: part of branch showing dimorphic leaves (Parker 884). **F-I**. *Selaginella pygmaea*: **F**, habit; **G**, sporophyll with megaspores; **H**, megaspores; **I**, sporophyll with microspores (**F-I**, Henshall 3620). Scale bars: **A** = 4 cm; **B**, **F** = 1 cm; **C**, **D**, **E**, **G**, **I** = 1 mm; **H** = 0.1 mm.

mm long, 0.2–0.5 mm wide, acuminate, yellowish or green. Strobili 3–10 mm long, 2–2.5 mm diam., nodding, on the ends of ultimate branchlets. Sporophylls somewhat ovate, 1.3–2 mm long, 0.5–1 mm wide, imbricate, margins finely toothed. Fertile plants: throughout the year.

Distribution. Pantropical species and widespread in Australia (W.A., N.T., Qld, N.S.W.). In the N.T. it is confined to northern regions, with the most southerly collection from Wollogorang Station (p.76).

Habitat. Permanently wet areas such as swamps, seepage areas and the banks of creeks in rainforest.

Selaginellaceae

A monogeneric family.

Reference: Jermy and Holmes (1998).

Selaginella P. Beauv.

Plants terrestrial or sometimes epiphytic, mostly perennial, heterosporous. Roots produced at the end of rhizophores (leafless branches). Stems creeping to erect, usually dichotomously branched and sometimes appearing pinnate. Leaves simple, monomorphic or dimorphic, decussate or spirally arranged, ligulate, with 1 central vein. Sporophylls terminal on stem and branches and normally aggregated into stroboli. Sporangia solitary in axils of the sporophylls; megasporangia assuming the shape of the 4 large spores developed therein; microsporangia kidney-shaped to globose, with numerous microspores. Megaspores trilete, 200–800 µm diam., often rugose-reticulate. Microspores trilete, 20–60 µm diam., echinate to rugose.

A genus of *ca* 700 species, with 10 or 11 species in Australia.

Key to species of *Selaginella*

1a. Sterile leaves dimorphic .... *S. ciliaris*
1b Sterile leaves monomorphic 2
2a. Stems erect; sporophylls in distinct strobili .... *S. pygmaea*
2b. Stems prostrate; strobili indistinct .... *Selaginella* (Mt Gilruth entity)

Selaginella ciliaris (Retz.) Spring
(Fig. 2E)

Lycopodium ciliare Retz., Obs. 5: 32 (1789).

Selaginella ciliaris (Retz.) Spring, Bull. Acad. Roy. Sci. Bruxelles 10: 233 (1843).

Type: Ceylon, *König*; holo: LD; iso: K.

Plants with the main stem creeping, to 10 cm long and branching and rooting throughout its length; branches leafy, ascending to erect, to *ca* 5 cm long. Leaves dimorphic, with median leaves directed along the axis and manifestly smaller than the lateral leaves which spread at an angle to the axis. Median leaves appressed, ovate to narrowly ovate, 0.9–1.7 mm long, 0.5–0.95 mm wide, base asymmetrical, apex acute to acuminate, margins entire or with minute, widely spaced teeth. Lateral leaves somewhat ovate, asymmetric, 1.5–2.9 mm long, 0.8–1.5 mm wide, bases with or without scattered cilia, the upper margins not or slightly toothed. Strobili 5–15 mm long; sporophylls in the median position symmetrical or almost so, ovate, acute to acuminate, the margins with a few rigid cilia; sporophylls in the lateral position asymmetrical, somewhat ovate, obtuse to acute, the margins with a few minute teeth. Megaspores *ca* 210–280 µm diam., surface faintly reticulate, verrucose. Microspores *ca* 20–40 µm diam., surface granulose to tuberculose. Fertile plants: Feb.–Sept.

Distribution. Occurs from India to Taiwan and the western Pacific (Australia: W.A., N.T., Qld). Widespread in northern N.T., ranging from the Pickerton Ranges east to Gove Peninsula and as far south as Mallapunyah Station (p.78).

Habitat. A plant of moist situations, including rainforest floors, the grass understorey of wet sclerophyll forests, the edges of permanent water in sandstone outcrops, and *Melaleuca*-dominated seasonal swamps.

Notes. Jermy and Holmes (1998) described the species as a perennial but some collectors have recorded it as being an ephemeral or annual.

Selaginella pygmaea (Kaulf.) Alston
(Fig. 2F–I)

Lycopodium pygmaeum Kaulf., Enum. fil. 9 (1824).

Selaginella pygmaea (Kaulf.) Alston, J. Bot. 69: 257 (1931).

Type: in promontorio bonae spei ad radicum montis daiboli [Cape Province, South Africa], *Bergius s.n.*; holo: B.

[*S. uliginosa auct. non* (Labill.) Spring: Chippend., Proc. Linn. Soc. New South Wales 96: 216 (1972); Dunlop (ed.), Checklist Vasc. Pl. Northern Terr. 3 (1987); Jermy and Holmes, *Fl. Australia* 48: 89, fig. 44 (1998), *p.p.* as to *Symon 7841*.]

Plants annual, with a short rhizome; roots many and filamentous; stems tufted and erect, to 35 cm long, much branched. Leaves monomorphic, ovate to lanceolate, 1.1–1.7 mm long, 0.35–0.7 mm wide, apex acute, margins entire. Strobili 6–25 mm long; sporophylls ovate, 1.5–1.9 mm long, 0.7–0.9 mm wide, keeled, tapering to an acute point, margins usually entire, occasionally with one to several small teeth. Megaspores *ca* 250–350 µm diam., surface reticulate. Microspores *ca* 30–45 µm diam., surface with reticulate ridges or rugose. Fertile plants: all months.

Distribution. South Africa (Cape Province) and northern Australia (W.A., N.T., Qld). Within the N.T., it has been located as far south as the Pine Creek area and ranges east from Litchfield NP and the Tiwi Islands to the Mitchell Range and Lake Evella in eastern Arnhem Land (p.78).

Habitat. A plant of moist and often perennially wet situations, such as swamps and stream banks, and usually recorded as growing in sandy soil.

Notes. This name has been applied by Jermy and Holmes (1998) to N.T. material that has been previously included under the name *S. uliginosa*. They recorded "that much of the material seen compares well with that from Africa" and that there is considerable variation in Australian material, noting in particular that some robust specimens from the N.T. "may be genetically distinct or habitat forms" (Jermy and Holmes 1998).

A specimen, *Symon 7841*, from the N.T. was cited by Jermy and Holmes (1998) as belonging to *S. uliginosa*. I concur with the comments of Dr R. J. Chinnock (*in litt.*), who also kindly provided a photocopy of the AD specimen, that it fits within the circumscription of *S. pygmaea*.

Selaginella (Mt Gilruth entity)

Jermy and Holmes (1998) tentatively recognised an additional species for the N.T., referring to it as '*Selaginella* sp. A'. The entity was, and still is, only known from the one collection, *Jones 1543* (D22971), gathered 6 km south of Mt Gilruth (p.78). They suggested that it may be a juvenile form of *S. pygmaea*. It has prostrate stems (and therefore in habit resembles *S. ciliaris*) and indistinct stroboli but otherwise has monomorphic leaves and megaspores and microspores resembling those of *S. pygmaea*.

Division Polypodiophyta

The true ferns, with the Division containing, depending on the authority, somewhere between 40 and 77 families and more than 9000 species.

Ophioglossaceae

Three genera, all in Australia but *Botrychium* not in the N.T.

References: Andrews (1990), Wagener (1990), Chinnock (1998d).

Key to genera of Ophioglossaceae

1a. Sporangia clustered on short lateral branches of a cylindrical sporophore; veins of fronds free ....*Helminthostachys*

1b. Sporangia imbedded in two rows along a spike-like sporophore; veins of fronds anastomosing .... *Ophioglossum*

Helminthostachys Kaulf.

Plants terrestrial, the rhizome creeping, unbranched and with thick, fleshy roots. Fronds mostly solitary, the common stipe with rounded stipules at the base. Sterile lamina palmately divided into 3 parts, each of which is deeply lobed; veins free, dichotomously branched. Sporophore cylindrical and arising at the base of the sterile lamina, consisting of many short, lateral branches crowded together. Sporangia globose, opening by a vertical slit. Spores trilete, granular, yellowish.

Monotypic genus.

Helminthostachys zeylanica (L.) Kaulf.

(Fig. 3A)

Osmunda zeylanica L., Sp. pl. 2: 1063 (1753).

Helminthostachys zeylanica (L.) Kaulf. in Hook., Gen. fil. 7. 47B (1840).

Type: Sri Lanka, *P. Hermann*. Iso: Herb. P. Hermann 5: 272 (BM 621045).

Fronds 1 or sometimes 2. Stipe 10–50 cm long. Sterile lamina 8–23 cm long, tripartite. Pinnae usually 3 or 5 per division, rarely 2 or 6, narrowly elliptic or lanceolate, 6–21 cm long, 1–4 cm wide, margins entire, crenate or toothed, apex acute to obtuse. Sporophore 5–14 cm long on a stalk 6–12 cm long; lateral branches *ca* 0.5 mm long. Sporangia globular, 0.7–0.9 mm diam., brown. Fertile plants: throughout the year.

Distribution. India and Sri Lanka to Japan, Australia (W.A., N.T., Qld), New Guinea and New Caledonia (p.75).

Habitat. A species of shady forests and alluvial soils, including the margins of *Melaleuca* swamps and billabongs.

Ophioglossum L.

Plants terrestrial or epiphytic (not N.T.), the rhizome creeping or shortly erect, with fleshy roots. Fronds 1–several, the common basal stipe erect. Sterile lamina sessile or stalked, simple, venation reticulate. Sporophore a simple spike; sporangia immersed on either side of the axis and either extending to, or not reaching, the apex. Sporangia subglobose. Spores trilete or rarely monolete, globose, reticulate, pitted or warty, yellowish.

An almost cosmopolitan genus (excluding the Antarctic and Arctic) with perhaps 25–30 species. Species delineation is often problematic. Following Chinnock (1998d), seven occur in Australia, with six in the N.T.

Key to species of *Ophioglossum*

1a. Sporophore on a stipe fused to the sterile lamina and together forming a linear frond; sporangia reaching the apex of the sporophore .... *O. intermedium*

1b. Sporophore and lower part of the sterile lamina together forming a terete stipe; sporangia not reaching the apex of the sporophore 2

2a. Sterile lamina linear, at least six times as long as wide, sometimes absent .... *O. gramineum*

2b. Sterile less than six times as long as wide, always present 3

3a. Sterile lamina with a pale band running the length of the lamina and with a conspicuous midrib..... .... *O. costatum*

3b. Sterile lamina lacking a median band and without a conspicuous midrib 4

Fig. 3. A. *Helminostachys zeylanica*: fertile plant (Jones 1727, McKean DNA 35816). **B.** *Ophioglossum costatum*: fertile plant (Jones 1494). **C-D.** *Ophioglossum gramineum*: **C**, fertile plant; **D**, sterile plant (**C**, **D**, Henshall 1739). **E.** *Ophioglossum intermedium*: fertile plant (Leach 1699, Taylor 65A). **F.** *Ophioglossum reticulatum*: fertile plant (Jones 1460, Russell-Smith 8417). Scale bars: **A** = 2 cm, **B-F** = 1 cm.

4a. Old leaf bases persisting; stipe of sporophyll barely to obviously adnate for part of its length to the sterile lamina; roots not obviously fleshy .... *O. polyphyllum*

4b. Old leaf bases not persisting; stipe of sporophyll not adnate to the sterile lamina and arising at or below its base; roots tending to be fleshy 5

5a. Lamina thick and the venation obscure (southern N.T.) .... *O. lusitanicum*

5b. Lamina thin and with obvious venation (northern N.T.) .... *O. reticulatum*

Ophioglossum costatum R. Br.
(Fig. 3B)

Ophioglossum costatum R. Br., Prodr. 163 (1810).

Type: Arnheim Bay, 14 Feb. 1803, *R. Brown Iter Austral. 118*; lecto: BM, *fide* Pic.Serm., Webbia 9: 626 (1954); isolecto: K.

Rhizome erect, globose; roots many, fibrous. Fronds 1–5, erect and somewhat fleshy; old leaf bases not persisting. Common stipe 11–55 mm long. Sterile lamina ovate or somewhat elliptic, 11–65 mm long, 4.5–27 mm wide, with a prominent midrib and a pale median band; venation distinct. Sporophore 10–60 mm long; stipe 45–145 mm long and not or very slightly adnate to the base of the lamina; sporangia obviously not or sometimes almost reaching the apex, the sterile tip to 2 mm long. Fertile plants: Feb.–Mar.

Distribution. Widespread, ranging from Africa and Madagascar to Malesia and Australia (W.A., N.T., Qld). In the N.T. only recorded from the Top End, including Marrawal Plateau in Nitmiluk NP, Holmes Jungle and Bradshaw Station (p.77).

Habitat. Found in an array of moist habitats, including ephemeral creeks dominated by *Lophostemon grandiflora*, in swampy areas dominated by *Melaleuca*, and in jungles.

Ophioglossum gramineum Willd.
(Fig. 3C, D)

Ophioglossum gramineum Willd., Abh. Kurfürstl.-Mainz. Akad. Nützl. Wiss. Erfurt 2: 18 (1802).

Type: near St Thomas, *Dr Friedland s.n.*; holo: B.

[*O. lineare auct. non* Schltr. and Brause: Dunlop (ed.), Checklist Vasc. Pl. Northern Terr. 2 (1987).]

Rhizome erect, ovoid or cylindrical, roots fleshy. Fronds 1–4, erect; leaf bases not persistent. Common stipe 10–50 mm long. Sterile lamina linear-lanceolate or linear-elliptic, 15–65 mm long, 3–6 mm wide but often not developed; venation distinct. Sporophore 5.5–35 mm long, with a sterile tip 1–5 mm long; stipe 20–110 mm long; sporangia not reaching the apex and the sterile tip 1.5–6 mm long. Fertile plants: Feb.–May.

Distribution. A species commonly described as being pantropical but also extending to arid and temperate climes. In Australia found in W.A., N.T. and Qld (p.77).

Habitat. In northern N.T. the species has been found growing on poorly drained clayey sand of the Howard River floodplain and in moist depressions in sandstone regions of Nitmiluk NP and Kakadu NP. Southern collections are from the Davenport Range where plants were growing in damp silt at the edge of a seepage area, and from Gosse River in the Murchison Ranges where they were in a clay depression in grassland.

Ophioglossum intermedium Hook.
(Fig. 3E)

Ophioglossum intermedium Hook., Icon. pl. 10: t. 995 (1854).

Type: Borneo, near Sarawak. *T. Lobb*; holo: K.

Rhizome short, creeping and fleshy. Fronds 1–6, erect, slightly fleshy. Common stipe and the sterile lamina forming a continuous, flattened, entire blade 50–380 mm long, 4–24 mm wide; venation usually distinct. Sporophore 20–45 mm long, 3–3.5 mm wide; stipe 30–80 mm long and distally fused to the face of the sterile lamina; sporangia reaching the apex. Fertile plants: throughout the year.

Distribution. Recorded from Indonesia, the Philippines and Australia (northern N.T. only). Localities include Koolendong Valley, Nitmiluk NP, Groote Eylandt and Melville Island (p.77).

Habitat. Mostly found in rainforest but also recorded in other areas with permanent or semi-permanent water, including a *Melaleuca*-dominated swamp in Nitmiluk NP.

Ophioglossum lusitanicum L.
Adder's tongue

Ophioglossum lusitanicum L., Sp. pl. 2: 1063 (1753).

Type: Lusitania.

[*O. nudicaule auct. non* L.: Dunlop (ed.), Checklist Vasc. Pl. Northern Terr. 2 (1987).]

Rhizome erect and cylindrical; roots few and tending to be fleshy; vegetative buds often resulting in dense colonies. Fronds 1 or 2, erect; old leaf bases not persisting. Common stipe 5–30 mm long. Sterile lamina ovate or elliptic, 10–35 mm long, 3–10 mm wide, thick, apex acute, basally gradually narrowing into the stipe; venation somewhat obscure. Sporophore 5–20 mm long; stipe 5–65 mm long and arising at or below the base of the lamina; sporangia not or sometimes almost reaching the apex, the sterile tip to *ca* 1 mm long. Fertile plants: Feb.–Sept.

Distribution. All continents except Antarctica, and in Australia in all States and Territories. In the N.T. confined to the southern region and collected from localities such as Ayers Rock (Uluru) and Simpsons Gap (p.77).

Habitat. Grows in seasonal depressions and on the edge of waterholes and watercourses.

Notes. The above account is predominantly based on Chinnock (1998d) and specimens (e.g. *Latz 4891*) determined by him as being of this species. As he noted the species is highly variable and at least some specimens here referred to this species may be better placed in *O. polyphyllum*. Field work and the study of additional specimens should help clarify matters.

Ophioglossum polyphyllum A. Braun

Ophioglossum polyphyllum A. Braun in M.A. Seubert, Fl. azor. 17 (1844).

Type: near Djeddam, 2 Jan. 1836, *Schimper?*; iso?: BM, G, P.

Rhizome erect and cylindrical; roots usually many and somewhat fibrous and stiff. Fronds 2 or 3, erect, robust; old leaf bases persisting and forming an obvious sheath. Common stipe 10–60 mm long. Sterile lamina lanceolate or narrowly elliptic, 20–70 mm long, 6–14 mm wide, leathery, apex acute. Sporophore 5–16 mm long; stipe 7–45 mm long, barely to manifestly adnate for part of its length to the sterile lamina; sporangia not or almost reaching the apex and the sterile tip less than *ca* 1 mm long. Fertile plants: Feb.–Nov.

Distribution. Portugal and Africa to India, south-east Asia and Australia (all mainland States and Territories). In the N.T. only known from the southern region, with all specimens collected below 22° S (p.77).

Habitat. Ephemerally wet depressions, including those in mulga woodland, chenopod shrubland and gibber plains.

Ophioglossum reticulatum L.

(Fig. 3F)

Ophioglossum reticulatum L., Sp. pl. 2: 1063 (1753).

Type: Fond de Baudin, near Léogane, Haiti; lecto: plate 164 in C. Plumier, Traité Foug. Amér. (1705), *fide* G.R.Procter, *Ferns Jamaica* 55 (1985).

[*O. nudicaule auct. non* L.: Dunlop (ed.), Checklist Vasc. Pl. Northern Terr. 2 (1987), e.g. as to *Jones 1555* and *1723*.]

Rhizome erect, ovoid; roots often somewhat fleshy; vegetative buds may result in colonies. Fronds 1 or 2, erect. Common stipe 12–150 mm long. Sterile lamina circular to widely elliptic, widely ovate to ovate or obovate, 6–75 mm long, 4–32 mm wide, more or less uniform in colour and lacking a distinct midrib, thin, apex acute to obtuse, basally abruptly narrowing into the stipe; venation usually obvious. Sporophore 4.5–40 mm long; stipe 30–180 mm long and attached at or below the base of the lamina; sporangia obviously not or sometimes almost reaching the apex, the sterile tip to *ca* 1.5 mm long. Fertile plants: Nov.–July.

Distribution. Usually cited as being a pantropical species, although at least in Australia (W.A., N.T., Qld, N.S.W., Vic.) ranging from tropical to temperate regions; in the N.T. restricted to the north (p.77).

Habitat. Commonly collected in rainforest but also found in wet areas in sandstone woodland.

Notes. Chinnock (1998d) commented on the highly polymorphic nature of the species, noting that in northern Australia specimens from forests were very robust compared to small forms from the sandstone.

Marattiaceae

Four genera and about 300 subtropical or tropical species; in Australia just two species, *Angiopteris evecta* and *Marattia oreades*, with only the former in the N.T.

Reference: Camus (1998).

Angiopteris Hoffm.

Plants terrestrial, large, homosporous. Rhizome an erect trunk which is obscured by the persistent frond bases (stipules). Fronds large, clustered. Lamina 1- or 2-pinnate; pinnae with swollen, jointed bases, veins free, simple or 1-forked at the base. Sori lacking an indusium, submarginal along lateral veins, each composed of a ring or double row of sporangia. Spores typically globose and trilete.

A taxonomically unresolved genus of the Old World tropics (excluding Africa) with *ca* 200, mostly poorly defined, species described and only *A. evecta* in Australia.

Angiopteris evecta (G. Forst.) Hoffm.

(Fig. 4A–C)

Polypodium evectum G. Forst., Fl. Ins. Austr. 81 (1786).

Angiopteris evecta (G. Forst.) Hoffm., Commentat. Soc. Regiae Sci. Gott. 12: 29 (1796).

Type: Society Is., *G. Forster s.n.*; ?iso: BM.

Trunk short to *ca* 90 cm tall. Fronds to more than 4 m long. Stipe up to 2/3 the total length of the frond. Lamina 2-pinnate. Pinnae alternate, *ca* 9 pairs, to 150 cm long. Pinnules essentially linear-lanceolate or narrowly oblong but usually with an acuminate apex, 3.5–18.5 cm long, 1–2.5 cm wide, alternate, the apex manifestly toothed, the sides inconspicuously toothed. Sori with 6–10 sporangia. Fertile plants: *ca* Nov.

Distribution. A species of the Old World tropics; in Australia in the N.T., Qld and N.S.W. The only wild-collected specimens from the N.T. are from near Mirrngadja, eastern Arnhem Land (p.73).

Habitat. Spring-fed jungle in sandstone gorges.

Notes. Known to be in cultivation in the Howard Springs region.

Hymenophyllaceae

Family delimitation is problematical; following Iwatsuki it contains eight genera and *ca* 800 species. Only *Cephalomanes obscurum* in the N.T.

References: Iwatsuki (1990), Bostock and Spokes (1998a).

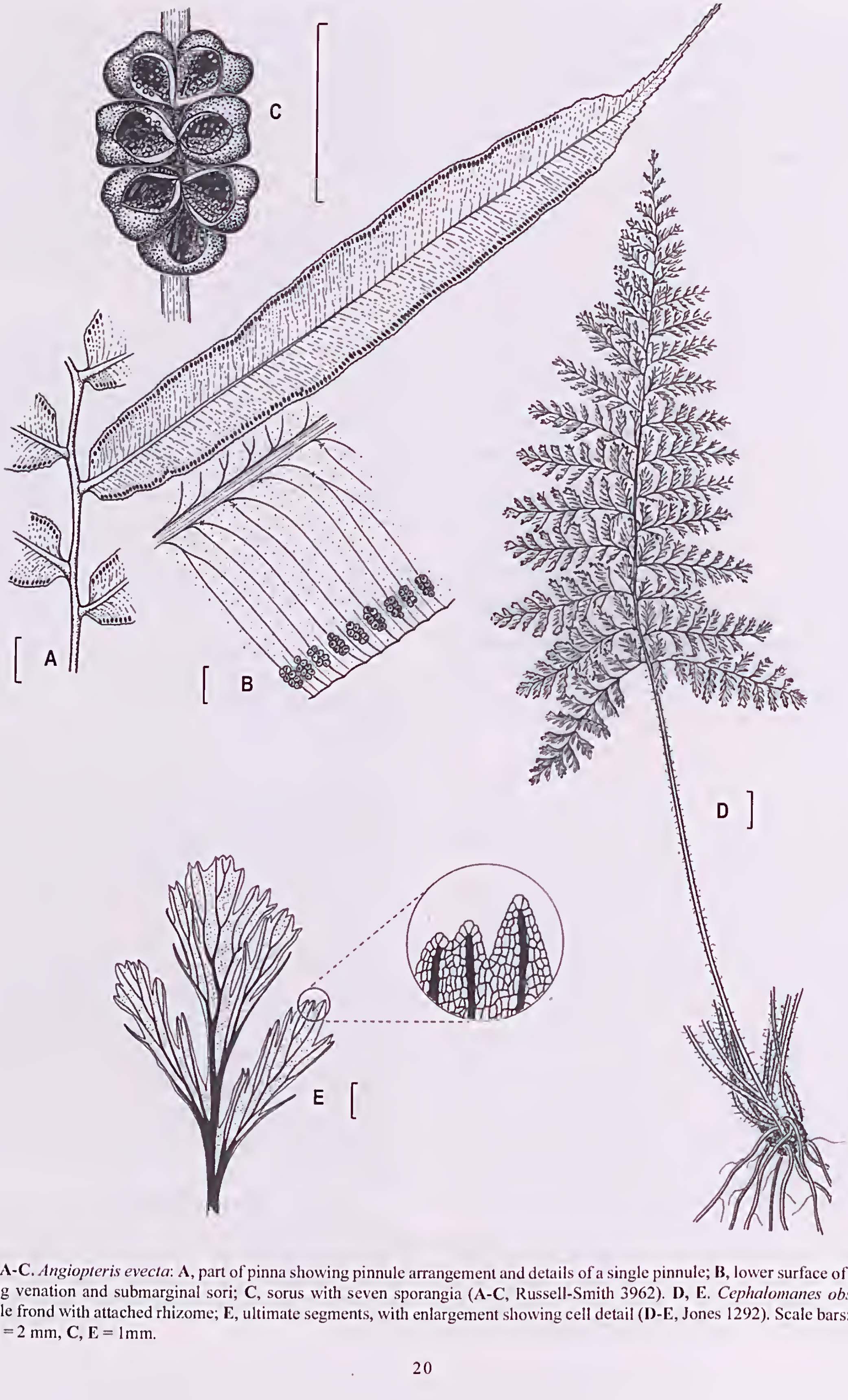

Fig. 4. A-C. *Angiopteris evecta*: **A**, part of pinna showing pinnule arrangement and details of a single pinnule; **B**, lower surface of pinnule showing venation and submarginal sori; **C**, sorus with seven sporangia (**A-C**, Russell-Smith 3962). **D, E.** *Cephalomanes obscurum*: **D**, single frond with attached rhizome; **E**, ultimate segments, with enlargement showing cell detail (**D-E**, Jones 1292). Scale bars: **A, D** = 1cm, **B** = 2 mm, **C, E** = 1mm.

Cephalomanes C. Presl

Plants terrestrial or lithophytic, homosporous. Rhizome creeping or erect, with wiry, often stilt-like roots and shiny, multicellular hairs. Stipes distinct, terete, usually with a narrow wing, bearing stiff hairs at least when young. Lamina variously pinnate; rachis usually winged; ultimate segments 1-cell thick except for the veins. Sori usually at the tips of ultimate segments; indusium (or involucre) cylindrical or cup- or bell-shaped; receptacle usually long and manifestly exserted.

A genus of *ca* 60, mostly Old World, species, with four in Australia but only *C. obscurum* in the N.T.

Cephalomanes obscurum (Blume) K. Iwats.

(Fig. 4D, E)

Trichomanes obscurum Blume, Enum. pl. Javae 227 (1828).

Selenodesmium obscurum (Blume) Copel., Philipp. J. Sci. 67: 81 (1938).

Cephalomanes obscurum (Blume) K. Iwats., J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot. 13: 547 (1985).

Type: Buitenzorg [Bogor, Java], *A. Zippelius s.n.*; lecto: L, *fide* C.V. Morton, Contr. U.S. Natl. Herb. 38: 381 (1974).

Plants terrestrial; rhizome creeping or erect and several cm tall; roots rigid. Fronds clustered, 3–26 cm long. Stipes unwinged, 2–11 cm long, with rigid, uniseriate, septate, reddish hairs which often extend to the rachis. Lamina 3-pinnate or 3-pinnate-pinnatifid, 2–15 cm long, 1–8 cm wide, thin and dark green; ultimate segments flat or curled. Sori on short lobes in the axis of tertiary segments; indusium (or involucre) cylindrical, 1–1.5 mm long, barely winged; receptacle projecting *ca* 0.5–2.5 mm beyond the involucre. Fertile plants: Jan.–Sept.

Distribution. From Sri Lanka and India east to Malesia, Solomon Islands and Australia (N.T., Qld, N.S.W.). In the N.T. only known from the Magela Creek area and from Taracumbie Falls on Melville Island (p.74).

Habitat. Splash zone of permanent waterfalls.

Gleicheniaceae

A family of about 125 species placed, following Kramer, in five genera; 13 species in four genera recognised in Australia.

References: Andrews (1990), Kramer (1990b), Chinnock and Bell (1998).

Key to genera of *Gleicheniaceae*

1a. Rhizome with branched hairs; lateral veins of ultimate segments twice- or more forked; sori mostly with more than 8 sporangia .... *Dicranopteris*

1b. Rhizome with scales; lateral veins of ultimate segments simple or once-forked, sometimes obscure; sori usually with fewer than 8 sporangia 2

2a. Largest ultimate segments less than 5 mm long .... *Gleichenia*

2b. Largest ultimate segments to *ca* 20 mm long .... *Sticherus*

Dicranopteris Bernh.

Plants terrestrial, homosporous. Rhizome creeping, with septate, branched hairs. Fronds complex, the lamina several-times, equally or unequally, pseudodichotomously forked, the primary branches with dormant vegetative buds between them and accessory, divided segments often present at the forks; ultimate branches 1-pinnatifid; venation dichotomous, veins of ultimate segments at least twice-forked. Sori usually single on a secondary vein, exindusiate, each with 5–15 sporangia; paraphyses absent. Spores trilete or monolete.

A mostly pantropical genus of about 12 species, with only *D. linearis* in Australia.

Dicranopteris linearis (Burm.f.) Underw. var. *linearis*

(Fig. 5A–D)

Polypodium lineare Burm.f., Fl. indica 235 (1768).

Dicranopteris linearis (Burm.f.) Underw., Bull. Torrey Bot. Club 34: 250 (1907).

Type: Java.

Rhizome with reddish, septate, branched hairs and some simple hairs. Fronds to 2 m or more long, scrambling or trailing, commonly 2- or 3-times pseudodichotomously branched; rachis with scattered branched hairs but generally appearing glabrous; ultimate branches 10–25 cm long, 1-pinnatifid; ultimate segments linear, to 50 mm long and 6 mm wide, decreasing in size towards the apex of the branch, leathery, upper surface glabrous, undersurface barely to obviously glaucous and often with scattered, minute reddish glandular hairs on minor veins and some branched, reddish hairs at the base of the midrib. Fertile plants: throughout the year.

Distribution. A highly variable species, with Chinnock and Bell (1998) tentatively recognising three varieties in Australia and noting the need for more thorough investigation. Following them the N.T. specimens are referable to var. *linearis*, a taxon they list as extending from Africa and Asia to Australia (W.A., N.T., Qld, N.S.W.) and New Zealand. In the N.T. it is mainly found in the Top End but also occurs in the southern region on permanent springs such as in the Chewings Range (p.75).

Habitat. A common fern in monsoon rainforest, sandstone gorges and other areas with permanent or near-permanent water, including seepage areas behind mangroves.

Fig. 5. **A-E.** *Dicranopteris linearis* var. *linearis*: **A**, part of frond; **B**, rhizome; **C**, ultimate segment showing venation and position of sori; **D**, sorus; **E**, rhizome hair (**A**, **B**, **E**, Callis 22, **C**,**D**, Dunlop 9878). **F**, **G**. *Sticherus flabellatus* var. *compactus*: **F**, ultimate segment showing venation; **G**, rhizome scale (**F**, **G**, Russell-Smith 4816). **H**, **I**. *Platyzoma microphyllum*: **H**, habit; **I**, lower surface of fertile pinnules (**H**, **I**, Egan 2757). Scale bars: **A**, **B**, **H** = 1 cm, **C** = 2 mm, **D-G**, **I** = 1 mm.

Gleichenia Sm.

Plants terrestrial, homosporous. Rhizome long-creeping, wiry, with scales and sometimes hairs; scales entire or with ciliate margins. Fronds variable, glabrous or with stellate hairs and/or ciliate scales, the lamina 1-pinnate-pinnatifid or with 1-pinnate-pinnatifid primary branches or pseudodichotomously branched, with vegetative buds in the forks, the ultimate branches (pinnules) determinate, linear, reducing in size towards the end of the branch and 1-pinnate-pinnatifid; ultimate segments flat, revolute, strongly recurved or with a pouched undersurface; veins of ultimate segments simple or once-forked. Sori single on the ultimate segments, exindusiate, with 1–4 sporangia, paraphyses absent. Spores trilete, tetrahedral.

A genus of *ca* ten species ranging from southern Africa to Australia (six spp.) and New Caledonia. Absent from the New World.

Within the N.T. the genus is only known by a few specimens, gathered from Twin Falls (Kakadu NP) and the Victoria River region. They were not treated in the *Flora of Australia* and their identity is by no means certain although the Twin Falls specimen seems referable to *G. dicarpa*.

Key to species of *Gleichenia*

1a. Largest ultimate segments less than 2 mm long; sporangia 1 or 2 per sorus .... *G. dicarpa*

1b. Largest ultimate segments more than 3 mm long; sporangia up to 4 per sorus .... *Gleichenia* (Victoria River entity)

Gleichenia dicarpa R. Br.

(Fig. 6A–C)

Gleichenia dicarpa R. Br., Prodr. 161 (1810).

Type: Dalrymple, Tas., *R. Brown Iter Austral. 108;* syn: BM, K.

Rhizome with dark red-brown scales with ciliate margins. Fronds with dormant vegetative buds in each fork. Stipe red-brown to yellowish, bearing yellow-brown stellate hairs and long-ciliate scales. Pinnules 1–6 cm long, with *ca* 12–80 ultimate segments, costa yellowish, with pale brown, ciliate scales along its length. Ultimate segments 1–1.8 mm long, 0.8–1 mm wide, almost flat, only old growth with obvious recurved margins and rarely slightly pouched, discolorous, the upper surface green, the lower grey-green. Sori with 1 or 2 sporangia. Fertile plants: Dec.

Distribution. Ranges from Malaysia to Australia (N.T., Qld, N.S.W., Vic., Tas.), New Caledonia and Australia. In the N.T. it is only known from *Brennan 1996* which was collected from a gorge near Twin Falls in 1992 (p.75).

Habitat. The only collection comes from a permanently wet sandstone wall.

Notes. The presence of vegetative buds, 1 or 2 sporangia per sorus and scale morphology are all features that support the placement of *Brennan 1996* in *G. dicarpa*. However, the collection is atypical in that the ultimate segments are usually not manifestly pouched, this feature is only developed – and barely so – in just a few old segments.

Gleichenia (Victoria River entity)

(Fig. 6D, E)

Rhizome with brown scales with coarse-ciliate margins. Fronds with dormant vegetative buds in each fork. Stipe red-brown, with scattered brown or whitish stellate hairs and brown, long-ciliate scales. Pinnules 1–7.5 cm long, with 18–80 ultimate segments, costa yellowish-brown, usually glabrous but sometimes several pale brown, long-ciliate scales near the base. Ultimate segments 1.5–4.5 mm long, 0.7–1.9 mm wide, almost flat, only old growth with obvious recurved margins, slightly discolorous, both surfaces green but the upper surface marginally darker than the lower. Sori with 2–4 sporangia. Fertile plants: Apr.–May.

Distribution. Victoria River district (p.75).

Habitat. All specimens are from apparently permanent seepage areas on sandstone escarpment.

Notes. This entity is only represented in DNA by four separate specimens collected in 2001. On one specimen it is recorded as being locally abundant, on another that it was regenerating after fire.

Although the above-mentioned are the only recently collected specimens, Ferdinand Mueller also gathered the same entity from the upper Victoria River during the 1855-56 North Australian Expedition (P. Bostock, *in litt.*).

In vesture this entity is not dissimilar to the Twin Falls specimen referred above to *G. dicarpa,* but it differs in having larger ultimate segments and in the number of sporangia per sorus. It also lacks manifestly pouched segments. Chinnock and Bell (1998) recognised three other Australian species of *Gleichenia* which have 2–4 sporangia per sorus but none have such large ultimate segments and also differ in one or more other features.

Sticherus C. Presl

Plants terrestrial, homosporous. Rhizome creeping, with peltately attached scales which are at least apically ciliate or fimbriate. Fronds usually scandent, complex, pinnately branched or repeatedly pseudodichotomously branched, primary branches with dormant vegetative buds bewteen them, ultimate branches deeply pinnatifid; accessory branches absent; ultimate segments more or less oblong or linear, with once-forked lateral veins. Sori on distal branches of veins, exindusiate, arranged in a single row on either side of the midrib of the ultimate segments, each with 2–8 sporangia; paraphyses present or absent. Spores monolete, ellipsoidal.

A mainly pantropical genus of *ca* 80–100 species, with three species in Australia and one in the N.T.

Sticherus flabellatus var. *compactus* (C.T. White and Goy) D.A. Sm.

(Fig. 5E, F)

Umbrella fern, shiny fan fern

Sticherus flabellatus (R. Br.) H. St.John var. *compactus* (C.T. White and Goy) D.A. Sm., N. Queensland Naturalist 14: 6 (1946).

Type: Mt Spurgeon, Qld, Sept. 1936, *C.T. White 10556*; holo: BRI.

Rhizome long-creeping, (2–) 3–4.5 (–7) mm diam., tuberculate; scales lanceolate, brown, the margins barely toothed or with short, stiff cilia. Stipe *ca* 10–20 (–70) cm long, with scales at the base. Fronds with the rachis 2- or 3-times forked. Ultimate branches 10–17 cm long. Ultimate segments linear, 5–20 mm long, 1–2.5 mm wide, margins at least apically toothed and commonly so for *ca* ½ their length, glabrous. Sori with 2–5 (8) sporangia. Sporangia (2–) 2.5–3 mm diam. Fertile plants: Feb.

Distribution. Endemic to north-east Qld and the N.T. where it is only known from north-east Arnhem Land (p.78).

Habitat. Sandstone cliffs in riparian vine forest.

Notes. The specimen *Russell-Smith 4816* is the only one of this taxon held at DNA. The segments are glabrous but Chinnock and Bell (1998) noted that the lower segments may have branched hairs and ciliate scales. Extreme measurements given in brackets in the above description are from Chinnock and Bell's account of the species.

Two varieties of *S. flabellatus* have been recognised, the var. *flabellatus* from New Guinea, New Caledonia, New Zealand and the east coast of Australia differing from var. *compactus* by having ultimate segments that are 20–45 mm long and sporangia *ca* 4 mm in diameter.

Platyzomataceae

A monospecific family confined to Australia.

Reference: Chinnock (1998e).

Platyzoma R. Br.

Plants terrestrial, large, heterosporous. Rhizome short, condensed, densely covered in unbranched, uniseriate hairs. Fronds clustered, erect and dimorphic, being simple or pinnate, non-circinnate. Stipe short, glabrescent. Lamina simple or 1-pinnate, the pinnules sessile or shortly stalked, pouch-like due to strongly revolute margins; veins free. Sori absent, the sporangia borne singly at the tips of veins and protected by the revolute margins. Sporangia with the annulus oblique or irregular. Spores dimorphic, each sporangium with spores of one kind, with up to 16 large spores or to 32 small spores per sporangium; globose and trilete and tetrahedral or bilateral and either monolete or trilete.

Platyzoma microphyllum R. Br.

(Fig. 5G, H)

Platyzoma microphyllum R. Br., Prodr. 160 (1810).

Type: Facing Island, Qld, *R. Brown Iter Austral. 102*; lecto: BM; isolecto: K.

Tussock-forming fern with clumps up to several metres across. Rhizomes creeping, clothed in simple, uniseriate, often orange-brown hairs. Simple fronds linear or filiform, 40–100 mm long, 0.2–0.5 mm wide. Pinnately-divided fronds 150–700 mm long, 2.5–4.5 mm wide; stipes reddish or dark brown, *ca* ¼ or less than the total length of the frond, hairy, the hairs uniseriate, septate, eglandular, whitish and somewhat transparent; pinnules ovate or somewhat circular, 0.7–2.3 mm long, 0.65–1.8 mm wide, glabrous except for short, glandular hairs along the recurved margins, the lower surface usually with yellowish deposits. Sporangia *ca* 4–6 per pinnule. Fertile plants: throughout the year.

Distribution. Confined to northern Australia (W.A., N.T., Qld, N.S.W.), with all specimens in the N.T. collected above 17° S (p.77).

Habitat. A common fern in low-lying, seasonally inundated woodland and tending to favour sandy soil.

Ethnobotany. In some areas Aboriginal people are known to use fronds to make children's necklaces (Wightman and Smith 1999).

Marsileaceae

A family containing three genera (two in Australia) and about 70 species. Only *Marsilea* in the N.T.

References: Andrews (1990), Jones (1998a), Short (2000).

Marsilea L.

Nardoo

Rhizome long-creeping. Fronds scattered along rhizome, the lamina of 2 pairs of opposite, closely spaced leaflets at the end of a long stipe, the whole having the appearance of a 4-leaved clover; leaflets glabrous or hairy, margins entire or crenate, veins radiating from the base. Sporocarps (or conceptacles) thick-walled, 2-valved, stalked, solitary or clustered at the base of or along the stipes, smooth or ribbed, glabrous or hairy, usually with 1 or 2 basal teeth which may be associated with the apex of the stalk. Sori exuded in a gelatinous mucilage.

A cosmopolitan genus of about 70 species. Species delimitation is generally problematic within *Marsilea*. Jones (1998a) noted that *M. drummondii* is highly polymorphic but it is evident that species are generally poorly delimited, with supposed differences in features of the sporocarp being highly subjective. Jones recognised eight species for Australia, recording all for the N.T., but *M. exarata* is not recognised here and attention is drawn to a peculiar entity collected from Neutral Junction Station.

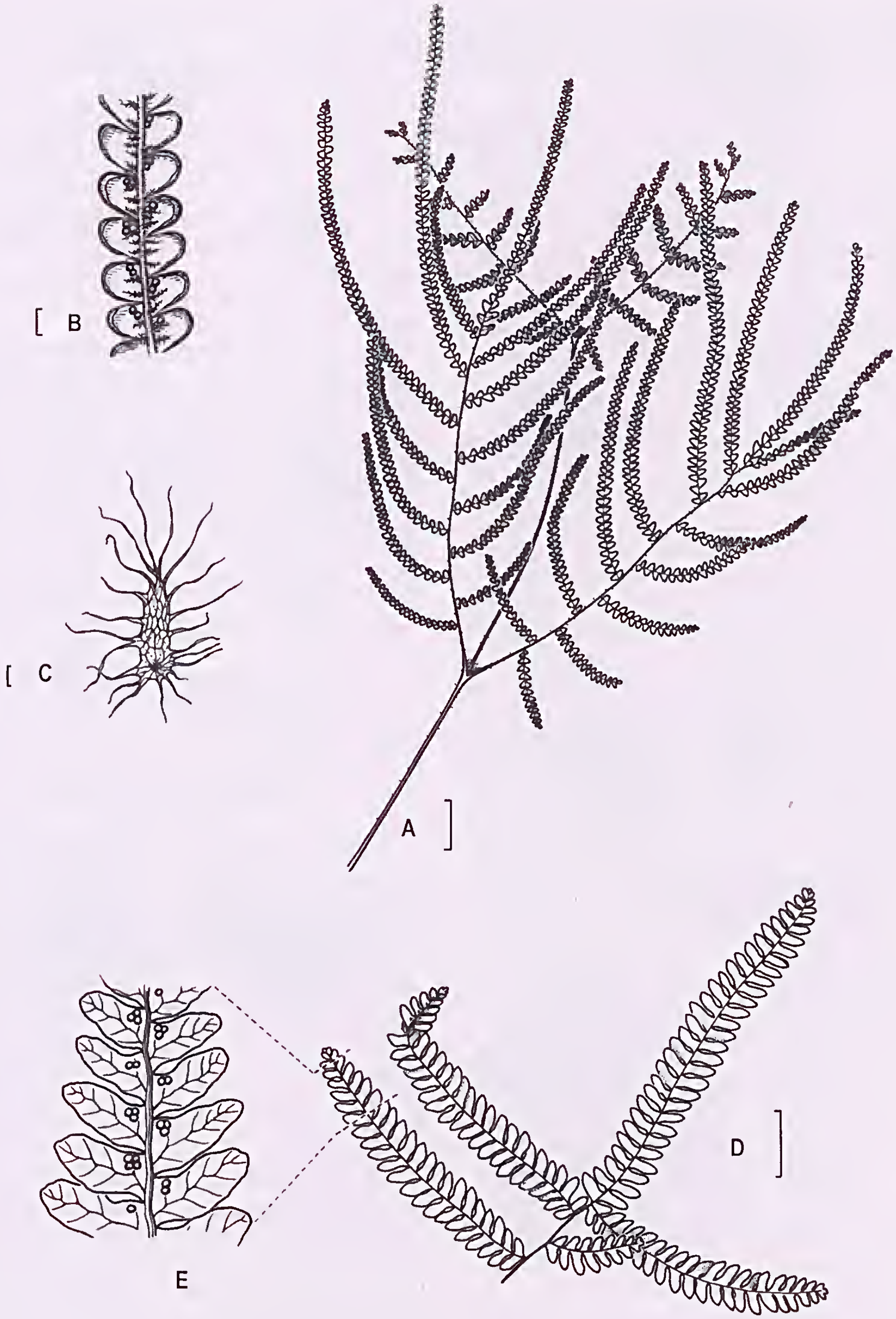

Fig. 6. A-C. *Gleichenia dicarpa*: **A**, part of frond; **B**, lower surface of pinnule showing sporangia and scales on ultimate segments; **C**, scale from stipe (**A-C**, Brennan 1996). **D, E.** *Gleichenia* (Victoria River entity): **D**, part of frond; **E**, lower surface of pinnule showing sporangia on ultimate segments (**D, E**, Cowie 9193). Scale bars: **A, D** = 1 cm, **B** = 1 mm, **C** = 0.1 mm.

In *Marsilea*, the hairs on the leaflets, stalks and sporocarps are not basally attached but are bifid. They have a very short arm and a much longer arm, so much so that they may appear to be simple, particularly when the long arm is spreading rather than appressed.

Key to species of *Marsilea*

1a. Sporocarps in clusters and enveloped in long, woolly hairs obscuring their presence at the base of fronds ...... *Marsilea* (Neutral Junction entity)

1b Sporocarps glabrous or with hairs but the hairs neither woolly nor obscuring the presence of the sporocarps 2

2a. Sporocarps lacking basal teeth; fresh leaflets with obvious colour band .... *M. mutica*

2b. Sporocarps with 1 or 2 basal teeth; fresh leaflets lacking a colour band 3

3a. Sporocarp with 1 tooth; leaflets mostly more than 3-times as long as wide .... *M. angustifolia*

3b. Sporocarp with 2 teeth; leaflets less than 3-times as long as wide 4

4a. Sporocarps 5.5–13 mm long, with the basal tooth obtuse and longer and broader than the upper, somewhat pointed, tooth; stalks usually 2-times or more the length of the sporocarp, rarely the length of the sporocarp .... *M. drummondii*

4b. Sporocarps 2.5–7 mm long, with teeth about equal in length *or* the upper one longer and narrow than the lower *or* the lower one narrower and longer than the upper; stalks mostly less than the length of the sporocarp but sometimes to about twice its length 5

5a. Sporocarps unribbed, commonly red-punctate beneath the hairs, the upper tooth narrow, longer and more pointed than the lower .... *M. crenata*

5b. Sporocarps ribbed or unribbed, the teeth not as above 6

6a. Sporocarps longer than their stalks ...... *M. latzii*

6b. Sporocarps shorter than their stalks 7

7a. Sporocarps 2.5–3 mm long, obviously ribbed ... . *M. costulifera*

7b. Sporocarps mostly more than 3 mm long (if less then not ribbed), smooth or slightly to obviously .... *M. hirsuta*

Marsilea angustifolia R. Br.
(Fig. 7A)

Marsilea angustifolia R. Br., Prodr. 167 (1810).

Type: tropical coast of Australia, *R. Brown*; holo: BM.

Rhizome glabrous except for prominent tufts of orange-brown hairs on growing tips. Stipes 4–22 cm long, slender, glabrous or sparsely hairy. Leaflets mostly narrowly elliptic or oblanceolate, 8–34 mm long, 2–9 mm wide, entire or with apices with irregular small teeth, glabrous or sparsely hairy. Sporocarp 6–7 mm long, densely hairy, basally with a single blunt tooth; stalk about the length or to *ca* 1.5-times the length of the sporocarp, rarely the apex somewhat tooth-like. Fertile plants: Apr.

Distribution. Endemic to Australia (W.A., N.T.) and widespread in the N.T (p.76).

Habitat. Grows in clay and sandy soils on the margins of seasonal swamps and streams.

Notes. Rarely collected with sporocarps.

Marsilea costulifera D.L. Jones

Marsilea costulifera D.L. Jones, Muelleria 8: 65, fig. 1 (1993).

Type: Gilgunnia, N.S.W., 31 Dec. 1903, *W. Baeuerlen* 3175; holo: NSW.

Rhizome much-branched, glabrous except for growing tips. Stipes 0.5–6 cm long, glabrous or hairy. Leaflets obovate to narrowly oblanceolate or cuneate, 2–5.5 mm long, 1–3 mm wide, margins entire, very sparsely to densely hairy. Sporocarp 2.5–3 mm long, hairy, with distinct ribs, basally with 2 teeth, the upper one large and blunt, the lower tooth comparatively small and blunt; stalk 1–2 mm long, unbranched. Fertile plants: May–Sept.

Distribution. Australia (N.T., S.A., Qld, N.S.W., Vic.). In the N.T. restricted to the southern region (p.76).

Habitat. Claypans and swamps often dominated by *Muehlenbeckia* (e.g. *Albrecht 9684*).

Notes. Approaches forms which are otherwise here placed in *M. hirsuta*.

Marsilea crenata C. Presl
(Fig. 7B–D)

Marsilea crenata C. Presl, Reliq. haenk. 1: 84 (1825).

Type: Philippine Islands, *T. Haenke*; holo: ?PRC.

Rhizome long-creeping, mostly glabrous or sparsely hairy but usually densely hairy at base of peduncles and stipes. Stipes 2–15 cm long, glabrous or sparsely hairy. Leaflets widely obovate to widely depressed obovate, 4–20 mm long, 4–19 mm wide, at least the largest leaflets glabrous or with scattered, slightly spreading hairs, margins entire or apically crenate. Sporocarp 2.5–3.5 mm long, mostly hairy but some of the surface often glabrous, with hairs removed appearing uniformly dark reddish brown or black and commonly red-punctate, unribbed, with 2 basal teeth, the upper tooth somewhat larger and pointed, the lower tooth smaller and apically rounded; stalks 2.5–6 mm long, shorter to nearly 2-times the length of the sporocarps. Fertile plants: Feb.–Sept.

Distribution. South-east Asia (including the Philippines), New Guinea and Australia (W.A., N.T., Qld). Widespread in the N.T., from northern localities such as Fogg Dam, Melacca Swamp and floodplains of the Adelaide and Daly Rivers, to as far south as the Alice Springs district (p.76).

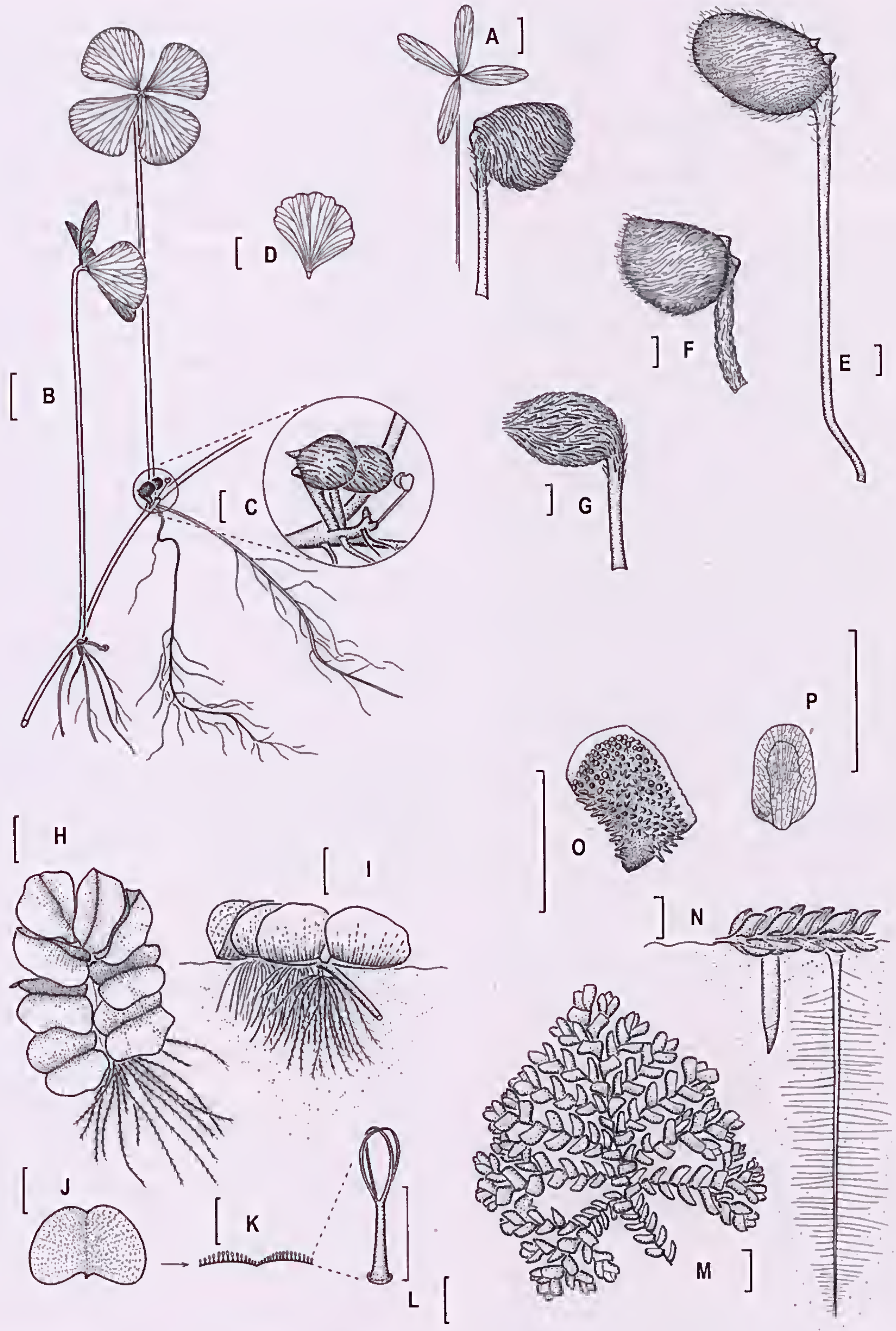

Fig. 7. A. *Marsilea angustifolia*: sporocarp and small leaf (Rankin 2315). **B-D.** *Marsilea crenata*: **B**, habit; **C**, sporocarps; **D**, leaflet showing crenate margin (**B-D**, Cowie 7051). **E.** *Marsilea drummondii*: sporocarp (Cowie 2116). **F.** *Marsilea hirsuta*: sporocarp (Albrecht 5800). **G.** *Marsilea mutica*: **G**, sporocarp (Thomson 1882). **H-L.** *Salvinia molesta*: **H**, plan view of a plant floating on water; **I**, side view of a plant floating on water; **J**, floating frond; **K**, transverse section of floating frond showing distribution of hairs; **L**, hair from the upper surface of a floating frond (**H-L**, from unvouchered specimen). **M-P.** *Azolla pinnata*: **M**, plan view of a plant floating on water; **N**, side view of a plant floating on water; **O**, upper lobe of a leaf; **P**, submerged lobe of leaf (**M-P**, Wilson DNA 127104). Scale bars: **B**, **H**, **I** = 1 cm, **A**, **C-G**, **M**, **N** = 2 mm, **L**, **O**, **P** = 1 mm.

Habitat. Usually grows in heavy clay on the floodplains, around lagoons and in *Melaleuca* forest.

Notes. Unlike many taxa the sporocarp morphology is generally distinctive.

Marsilea drummondii A. Braun

(Fig. 7E)

Marsilea drummondii A. Braun, Linnaea 25: 721 (1853).

Type: Swan River, W.A., *J. Drummond*; holo: ?B.

Rhizome long-creeping, more or less glabrous to conspicuously hairy, densely hairy at bases of stipes. Stipes 1.5–30 cm long, more or less glabrous or sparsely to densely hairy (at least in part). Leaflets widely obovate to widely depressed obovate, 4–260 mm long, 4–27 mm wide, sparsely to densely hairy, hairs appressed or spreading, margins entire or apically somewhat crenate. Sporocarp 5.5–7 mm long, more or less densely hairy, with hairs removed appearing uniformly dark reddish brown, smooth to ribbed, with 2 teeth, the basal one tending to be longer and broader than the upper and apically rounded, the upper tooth apically somewhat pointed; stalks c.10–100 mm long, commonly 2-times or more the length of the sporocarp but sometimes about the length of the sporocarp. Fertile plants: throughout the year.

Distribution. All mainland states of Australia and particularly widespread in inland areas (p.76).

Habitat. Seasonally wet areas, including northern floodplains and ephemeral swamps and clay pans in the southern regions.

Notes. A highly polymorphic species in regards such features as the degree of hairiness, the length of the fronds, length of the stalk of the sporocarp and the morphology of the sporocarp.

In contrast to some other parts of Australia, there are no records for the N.T. of the sporocarps of this species being used as food by Aboriginal people.

Marsilea hirsuta R. Br.

(Fig. 7F)

Marsilea hirsuta R. Br., Prodr. 167 (1810).

Type: Port Jackson Colony and the tropical coast of Australia, *R. Brown*; holo: BM.

M. exarata A. Braun, Monatsber. Deutsch. Akad. Wiss. Berlin 732 (1870). Type: Brisbane R., Qld, 1855, *F. Mueller*; holo: ?K.

Rhizomes long-creeping, mostly glabrous or sparsely hairy. Stipes 1–28 cm long, glabrous or sparsely hairy. Leaflets widely obovate to widely depressed-obovate or widely cuneate, 1–17 mm long, 2–15 mm wide, more or less glabrous to conspicuously hirsute; hairs appressed or spreading; upper margins entire or apically crenate. Sporocarp 4–6 mm long, mostly manifestly hairy, smooth or faintly to obviously ribbed, with 2 teeth, the basal usually obviously associated with the apex of the stalk; teeth of more or less equal size and shape or the upper one comparatively broad and apically rounded (but sometimes with an apical mucro) and the lower one narrower, sometimes slightly longer, and often somewhat recurved; stalk shorter than the sporocarps. Fertile plants: Mar.–Dec.

Distribution. Australia, all mainland states and territories, widespread in the N.T (p.76).

Habitat. Ephemeral depressions, swamps and floodplains and the edge of waterholes and mainly on clay soil.

Notes. One cannot differentiate the two taxa, *M. hirsuta* and *M. exarata*, which are commonly recognised as occurring in the N.T. The range of variation in morphology, particularly of the sporocarp, suggests to us that it is best to consider that the N.T. specimens belong to one polymorphic taxon, and one that is not always readily distinguished from some specimens referred to *M. drummondii*.

No specimens from elsewhere in Australia, nor type specimens of both names, have been examined, leaving the problem as to which name should apply to the N.T. material should they indeed be "good" species, only one of which occurs in the N.T. However, the morphological variation we have observed, plus the fact that distributional data provided in various references show *M. hirsuta* and *M. exarata* to have similar distributions, strongly suggest that throughout Australia, a broader, single-species concept should be used. Thus, the earlier name *M. hirsuta* is adopted here.

Marsilea latzii D.L. Jones

Marsilea latzii D.L. Jones, Fl. Australia 48: 707, fig. 56 E, F. (1998).

Type: 9 km E of Rabbit Flat, N.T., 7 July 1980, *P.K. Latz 8466*; holo: DNA; iso: AD, CANB, MEL, SP.

Rhizome much-branched, glabrous except for growing points. Stipes to *ca* 1 cm long, glabrous or hairy. Leaflets cuneate to widely cuneate, 1–6 mm long, 1–4 mm wide, glabrous or hairy, upper margins entire or irregular. Sporocarp 3–4 mm long, hairy and distinctly ribbed, with an upper prominent tooth and a lower tooth clearly associated with the stalk; stalks 4–6 mm long, unbranched, thin, glabrous. Fertile plants: July.

Distribution. Only known from the Tanami Desert, N.T (p.76).

Habitat. Grows in sand on the margins of brackish lakes.

Notes. The above description is based on the original description by Jones (1998). It is a diminutive species and in this regard it is like many which are apparently referable to *M. costulifera*. Unlike that species, it is not recorded from clay soils.

Marsilea mutica Mett.

(Fig. 7G)

Marsilea mutica Mett., Ann. Sci. Nat. Bot., sér. 4, 15: 88 (1861).

Type: Lieux inonde a Kanala, New Caledonia, 1855–1860, *Vieillard 1698*; holo: P.

Rhizome long-creeping, mostly glabrous or sparsely hairy but growing points and base of stipes may be densely hairy. Stipes 2.5–30 cm long, glabrous. Leaflets mostly widely obovate to widely depressed obovate but small ones may be obovate, 6–40 mm long, 3–45 mm wide, the distal green part of the leaflet separated from the lower yellowish part by a brownish band, mature leaflets glabrous except for a few hairs at the base of the leaflets, margins entire or apically somewhat crenate. Sporocarp 4.5–6.5 mm long, densely hairy, unribbed, lacking basal teeth; stalks 3–6 mm long, *ca* the length or shorter than the sporocarp. Fertile plants: May–June.

Distribution. New Caledonia and Australia (W.A., N.T., Qld, N.S.W. and seemingly introduced to both Vic. and Tas.) (p.76).

Habitat. Common around lagoons, swamps and billabongs.

Notes. The banding on the leaflets is diagnostic for the species but the feature is only readily apparent in fresh plants growing in water.

Marsilea (Neutral Junction entity)

Rhizome long-creeping, mostly glabrous or sparsely hairy but growing points and base of stipes densely woolly. Stipes to *ca* 15 cm long, glabrous to manifestly hairy. Leaflets cuneate, 10–35 mm long, 10–35 mm wide, the rounded upper margins strongly toothed, immature leaflets densely hairy on undersurface, comparatively sparsely hairy on the upper, mature leaflets glabrous on both surfaces. Sporocarp 2–2.5 mm long, densely woolly, ribbed, lacking basal teeth or with a very slight protuberance above the apex of the stalk; stalks shorter than the sporocarp. Fertile plants: *ca* July.

Distribution. Known only from a single collection, *Albrecht 9192*, gathered 7 km WNW of Claypan Bore, Neutral Junction Station, N.T (p.76).

Habitat. Recorded as forming monospecific swards in shallow water on a stony claypan.

Notes. The seemingly unique, woolly nature of the indumentum plus the sporocarp morphology suggest that this will prove to be a new taxon.

Salviniaceae

A monogeneric family.

Reference: Andrews (1990).

Salvinia Séguier

Plants aquatic, free-floating, heterosporous. Rhizomes hairy, lacking true roots. Fronds simple, in whorls of 3, with 2 of each whorl green and floating and 1 submerged and divided into root-like segments. Sporocarps borne on the submerged leaf, containing either megasporangia or microsporangia or, in some species, both. Spores trilete, chlorophyll absent; microspores minutely rugulose; megaspores perforate.

A genus containing about ten species and widely distributed throughout subtropical and tropical regions of both the Old and New Worlds. Only one species, introduced, in Australia.

Salvinia molesta D.S. Mitch.

(Fig 7H–L)

Salvinia

Salvinia molesta D.S. Mitch., Brit. Fern. Gaz. 10: 251 (1972).

Type: Ruziruhuru River inlet, Lake Kariba, Rhodesia, *D.S. Mitchell 1330*; holo: ?SRGH.

[*S. auriculata auct. non* Aubl.: H.I. Aston, Aquat. Pl. Australia 43–45 (1973).]

Rhizomes branching. Floating fronds shortly stalked, circular or ovate, 0.8–3.5 cm long, 0.5–3.5 cm wide, cordate, apically rounded or emarginate, with a prominent midrib; upper surface covered with stiff, erect hairs, the hairs usually terminating in 4 upwardly curved arms united at their extremities; lower surface with brownish, appressed septate hairs. Submerged frond shortly stalked, much dissected, to *ca* 30 cm long. Sporocarps sterile; microsporocarps many, arranged in 2 rows on segments of the lower frond; megasporocarps several at the base of segments.

Distribution. Apparently native to South America but now widespread in warmer regions of Africa, southern Asia and Australia (W.A., N.T., Qld, N.S.W.) (p.78).

Habitat. Aquatic fern growing on still or slow-flowing water.

Notes. *Salvinia molesta*, a declared noxious weed in the N.T., commonly reproduces by vegetative fragmentation and can rapidly spread to blanket waterways and catchments. Plants do produce sporocarps, and this has been recorded from November to March on herbarium specimens, but spores are sterile and usually visibly deformed.

The species was first recorded in the N.T. in August 1976 when it was found in a pool in a Darwin plant nursery. The following month it was found near Nhulunbuy and more field infestations have been subsequently recorded from localities such as Adelaide River, East Alligator River floodplain, Howard Springs, Girraween Lagoon, Leichhardt Billabong, Magela Creek and Mission Hole (Elizabeth Downs). Some infestations have been eradicated and others are controlled, with variable degrees of success, by chemical, physical and biological methods. Biological control is with the microscopic weevil *Cyrtobagous salviniae*. Adult weevils feed externally upon leaf buds and larvae feed internally on rhizomes. The larvae of three natives species of pyralid moth also feed on the leaves. A summary of the methods of management of *Salvinia* in the N.T. is provided by Miller and Wilson (1989).

Azollaceae

A monogeneric family.

Reference: Andrews (1990).

Azolla Lam.

Aquatic, free-floating ferns; rhizome flexuose, rooting at nodes. Leaves numerous, 2-lobed; upper lobe thick and photosynthetic and containing blue-green algae in a central cavity; lower lobe submerged and thin and bearing megasporocarps and microsporocarps. Megasporocarps smaller than microsporocarps, each containing a single megaspore. Microsporocarps with usually many microsporangia, each microsporangium containing 4 or more groups (massulae) of microspores; massulae with or without barbed processes.

Azolla contains about six species and the genus is widely distributed throughout tropical to temperate regions of the world. Two species occur in Australia but only *A. pinnata* is in the N.T.

Azolla pinnata R. Br.

(Fig. 7M–P)

Azolla pinnata R. Br., Prod. 167 (1810).

Type: Richmond and Hawkesbury Rivers, *R. Brown Iter Austral. 134*; syn: BM, K, U, MEL; Patterson River, Oct. 1804, *R. Brown Iter Austral. 135*; syn. BM.

Free-floating, regularly branched plants somewhat triangular in outline, to *ca* 3 cm long; roots of mature plants feathery. Leaves with lobes *ca* 1 mm long; upper lobe green or reddish, upper surfaces papillate except for the somewhat membranous margins; lower lobe brownish and scale-like. Massulae more or less conical and basally with 1–6 unbarbed processes. Fertile plants: not seen.

Distribution. Asia, New Caledonia, New Guinea, New Zealand and Australia (SA, N.T., Qld, N.S.W., Vic.). In the N.T. confined to the Top End (p.73).

Habitat. A common species in still and slow-moving waters, e.g. at Fogg Dam and floodplains of the Mary and Finniss rivers.

Notes. Plants are usually red or red-brown when growing on open water and greenish in shaded places. They commonly multiply by fragmentation.

Schizaeaceae

A family consisting of two genera with *ca* 41 species; seven in Australia, three in the N.T.

Reference: Chinnock (1998f).

Key to genera of Schizaeceae

1a. Fertile segments digitately arranged; lamina unbranched .... *Actinostachys*

1b. Fertile segments pinnately arranged; lamina dichotomously branched .... *Schizaea*

Actinostachys Wall.

Terrestrial. Rhizome short creeping, clothed with simple or multicellular hairs, roots wiry. Fronds simple, dimorphic, flattened or terete. Stipe grading into lamia, indistinct. Sterile lamina undivided; fertile lamina similar to sterile but with apical sporogenous segments. Sporogenous lobes with constriction at point of attachment. Sporangia in 2 or 4 rows, on either side of the vein. Spores ellipsoidal, smooth or with tubercles.

A genus of *ca* 13 species, two of which are found in Australia, including the N.T.

Key to species of *Actinostachys*

1a. Sporangia in four rows, not interspersed with hairs; lamina constricted below sporogenous lobes .... *A. digitata*

1b. Sporangia in two rows, interspersed with brown hairs; lamina not constricted below sporogenous lobes .... *A. wagneri*

Actinostachys digitata (L.) Wall.

(Fig. 8A, B)

Acrostichum digitatum L., Sp. pl. 2: 1068 (1753).

Schizaea digitata (L.) Sw., Syn. fil. 150, 380, t. 4, fig. 1 (1806).

Actinostachys digitata (L.) Wall., Numer. List, No. 1 (1829).

Type: Sri Lanka, *P. Hermann s.n.*; holo: Herb. P. Hermann 2: 73 (BM 621756).

Rhizome short creeping or suberect, clothed with long stiff glossy pale brown hairs. Fronds clustered, linear-flattened, erect to sinuously erect, grass-like, 8.5–41 cm long, 1.6–4 mm wide; surface smooth, dull to slightly shiny, constricted below sporogenous lobes; midrib prominently raised on one side, margins flat to recurved. Sporogenous lobes 3–18, linear, tufted at apex, 8–54 mm long, to 0.5 mm wide, occasionally with some branches forked distally. Sporangia in four rows. Fertile plants: all year.

Distribution. From Sri Lanka to south-east Asia, northern Australia (W.A., N.T., Qld). In the N.T. it occurs in the Top End north of latitude 15° S and on adjacent offshore islands (p.73).

Habitat. Common in perennial wet rainforests.

Actinostachys wagneri (Selling) C.F. Reed

(Fig. 8C)

Schizaea wagneri Selling, Svensk. Bot. Tidskr. 40: 278 (1946).

Actinostachys wagneri (Selling) C.F. Reed, Bol. Soc. Brot., ser. 2, 21: 131 (1948).

Type: Mt Tjajiak, Manus Is., Admiralty Islands, D.F. *Grether and W.H. Wagner 4177*; ?holo: S-PA; iso K.

Rhizome short creeping or suberect, clothed with long stiff brown hairs. Fronds clustered, few, weak, linear and channelled when dry, 6–20 cm long, to 0.5 mm diameter, not constricted below sporogenous lobes.

Fig. 8. A, B. *Actinostachys digitata*: **A**, habit (Michell 1503); **B**, tip of sporogenous lobe (Dunlop 7540). **C.** *Actinostachys wagneri*: sporogenous lobes with enlargement showing the tip of a lobe (Russell-Smith 2056). **D-H.** *Schizaea dichotoma*: **D**, sterile frond; **E**, fertile frond; **F**, sporogenous heads; **G**, ventral view of the tip of a fertile segment; **H**, side view of the tip of a fertile segment (**D-H**, Michell 1559). Scale bars: **A, D, E** = 1cm, **B, C, F–H** = 1 mm.

Sporogenous lobes 2–5, linear, tufted at apex, 7–15 mm long, to 0.5 mm wide. Sporangia in two rows, interspersed with long pale brown hairs. Fertile plants: March.

Distribution. Known from only one collection, 12 km N of Paru on Melville Island (p.75). Also in Qld, Malay Peninsula, Indonesia, Papua New Guinea and the Admiralty Islands (p.73).

Habitat. Raised humic soil mounds in perennial spring rainforest.

Notes. The specimen at DNA (*Russell-Smith 2056*) was annotated by David Jones as *Actinostachys wagneri* but is not recorded in the *Flora of Australia* (1998) as occurring in the N.T. It is possible that this species is more common and that its small size and grass-like habit hinder detection in the field.

Schizaea Sm.

Terrestrial. Rhizome short- or long-creeping and clothed with simple or multicellular hairs, roots wiry. Fronds clustered, dimorphic. Stipe grading into lamia, indistinct. Sterile lamina undivided or dichotomously branched once to many times; segments narrow, linear; veins free; fertile lamina similar to sterile but with sporogenous segments borne pinnately or digitately at the apex of lamina axes which are undivided or dichotomously branched, separate or rarely joined by intercostal lamina tissue. Sporangia in two rows, on either side of the vein, fringed by teeth or hairs. Spores ellipsoidal, smooth to variously ornamented.

A genus of *ca* 28 species, with a predominantly tropical distribution. Five species in Australia, one in the N.T.

Schizaea dichotoma (L.) Sm.

(Fig. 8D–H)

Branched comb fern

Acrostichum dichotomum L., Sp. pl. 2: 1068 (1753).

Schizaea dichotoma (L.) Sm., Mém. Acad. Roy. Sci. (Turin) 5: 422 (1793).

Type: China, Herb. Sloan; ?holo: BM.

Schizaea forsteri Spreng., Anleit. 3: 57 (1804); *S. dichotoma* var. *forsteri* (Spreng.) Domin, Biblioth. Bot. 20(85): 207 (1913). Type: not located.

Rhizome short-creeping, densely clothed with glossy dark brown hairs. Fronds clustered, or spaced along rhizome, erect, 3.9–61 cm long, scabrid; unbranched portion 1–2 mm wide, subterete, flattened on one side, brown near base, clothed with long brown hairs, green above, hairs scattered; sterile frond shorter than sporogenous frond, dividing above middle into repeated dichotomous branchlets; sporogenous frond similar, but branches more open; sporogenous heads 3–11 mm long, 1–3 times longer than broad; segments 1.5–5 mm long, scabrid. Sporangia mixed with hairs. Fertile plants: all year.

Distribution. Ranges from the Mascarenes to Sri Lanka, south-east Asia, Australia (W.A., N.T., Qld, N.S.W.), New Zealand and islands of the Pacific. In the N.T. it occurs in the Top End, north of latitude 15° S, and extends to adjacent offshore islands (p.78).

Habitat. A common fern mostly associated with margins of perennially wet rainforest, but occasionally found within rainforest. Soils are rich in organic matter.

Lygodiaceae

A monogeneric family consisting of 30 species widespread in the tropics and subtropics. Four species occur in Australia, two in the Darwin region.

References: Andrews (1990), Chinnock (1998g).

Lygodium Sw.

Terrestrial climbing ferns. Rhizome subterranean, short- or long-creeping, dichotomously branched, clothed with septate or multicellular hairs, roots fibrous. Fronds circinnate, exstipulate, clustered along rhizome, dimorphic to trimorphic. Juvenile fronds of definite growth, once-forked into two palmately branched leaflets; climbing fronds with a wiry rachis of indefinite growth formed by unequal dichotomies; the shorter primary rachis branches, alternate, and terminating with a hairy dormant apex, each bearing a pair of pinnate, bipinnate or tripinnate leaves; fertile and sterile leaflets similar or dissimilar; leaflets distinctly stalked or palmatilobate or pinnatilobate, sometimes jointed at base of laminal portion. Sporangia borne separately in two rows on marginal lobes of the fertile leaflets, each near a vein ending and covered with an indusium. Spores tetrahedral-globose.

A widespread tropical and subtropical genus of *ca* 30 species, with four occurring in Australia and two or perhaps three in the N.T.

Key to species of *Lygodium*

1a. Pinnule stalks of similar length ....*L. microphyllum*

1b. Pinnule stalks decreasing in length distally 2

2a. Fertile fronds with basal pinnules bipinnate .... *L. flexuosum*

2b. Fertile fronds with basal pinnules tripinnate .... *L. japonicum*

Chinnock (1998) reported *L. japonicum* from the general Darwin area. Records of this species at DNA indicate that it was collected from the coastal vine forest adjacent to Lameroo Beach, Darwin. It is believed to be a garden escape and is not treated further.

Lygodium flexuosum (L.) Sw.

(Fig. 9A, B)

Ophioglossum flexuosum L., Sp. pl. 2: 1063 (1753).

Lygodium flexuosum (L.) Sw. J. Bot. (Schrader) 1800(2): 106 (1801).

Type: [India]; BM, status not determined.

Fig. 9. A, B. *Lygodium flexuosum*: **A,** sterile frond, with an enlargement showing the margin (Tindale 10056); **B**, fertile frond (van Oertzen DNA 145121). **C, D.** *Lygodium microphyllum*: **C**, sterile frond, with an enlargement showing the margin; **D**, fertile frond (**C, D**, Must 1641). Scale bar: **A-D** = 1 cm.

Ophioglossum scandens L., Sp. pl. 2: 1063 (1753).

Type: [India]; BM, LINN, status not determined.

Lygodium semibipinnatum R. Br., Prodr. 162 (1810).

Type: New Holland, 1803, *R. Brown;* syn: BM; north coast, [Australia], *R. Brown;* syn: K.

Rhizome short-creeping. Juvenile fronds once-forked. Climbing rachis wiry, subterete, flattened on one side with ridged edges, glabrous or sparsely pubescent. Primary rachis branches 0.5–4 mm long. Secondary rachis flattened and winged along upper side; sterile frond pinnate, fertile frond bipinnate at base; petiolules of leaflets decreasing in length distally, with distal leaflets appearing sessile. Basal leaflets of sterile frond palmate with up to seven lobes, lateral leaflets (obscurely) 3-lobed, terminal leaflet (irregularly) palmately lobed. Sterile leaflets 12.5–64 mm long, 4.5–10.5 mm wide, chartaceous; (obliquely) ovate-lanceolate to triangular; base truncate to cuneate; margins serrulate; veins free. Fertile leaflets 8–78 mm long, 9–12 mm wide. Sporogenous lobes 0.5–7.5 mm long. Fertile plants: all year.

Distribution. India, Sri Lanka, Malesia and Australia (W.A., N.T., Qld). In the N.T. common in the Top End north of latitude 16° S (p.76).

Habitat. Associated with monsoon forests on scree slopes close to water.

Lygodium microphyllum (Cav.) R. Br.

(Fig. 9C, D)

Climbing maidenhair

Ugena microphylla Cav., Icon. 6: 76 (1801).

Lygodium microphyllum (Cav.) R. Br. Prodr. 162 (1810).

Type: Luzon, [Philippines], *L. Née*; holo: MA.

Rhizome long-creeping. Juvenile fronds once-forked. Climbing rachis wiry subterete, flattened on one side occasionally with ridged edges, glabrous or sparsely pubescent. Primary rachis branches 1–10 mm long. Secondary rachis flattened and winged along upper side; sterile frond pinnate, fertile frond pinnate, rarely bipinnate at base; petiolules of leaflets of similar length. Basal leaflet of sterile frond 3- or 4-lobed, lateral leaflets (obscurely) 3-lobed, terminal leaflet (irregularly) palmately lobed. Sterile leaflets 9–63 mm long, 4–22 mm wide, membranous to chartaceous; laminal portions deciduous, (obliquely) ovate-lanceolate to triangular; base cordate, truncate to cuneate; margins finely or often obscurely crenulate; veins free. Fertile leaflets 9–55 mm long, 4–22.5 mm wide. Sporogenous lobes 0.5–17.5 mm long. Fertile plants: all year.

Distribution. Tropical Africa, south-east Asia, Malesia and Australia (W.A., N.T., Qld, N.S.W.). In the N.T. it is found north of latitude *ca* 19° S (p.76).

Habitat. A commonly collected fern associated with wetlands or monsoon vine thickets fringing springs, creeks or rivers.

Notes. Some individuals are dormant over the dry season, persisting by their subterranean rhizomes.

Dennstaedtiaceae

A family with 11 or 12 genera and 190, mostly tropical, species. In Australia 5 genera and 14 species.

References: Andrews (1990), Kramer (1990a), Brownsey (1998).

Key to genera of Dennstaedtiaceae

1a. Sporangia in discrete, round or ovate, submarginal sori .... *Microlepia*
1b. Sporangia elongate and more or less continuous along the margins of the lamina 2
2a. Fronds leathery, undersurface hairy .... *Pteridium*
2b. Fronds thin, glabrous .... *Histiopteris*

Histiopteris (J. Agardh) J. Sm.

Plants terrestrial, homosporous. Rhizomes long-creeping, scaly. Fronds monomorphic, 2–4-pinnate, thin, glabrous. Stipe with basal scales. Pinnae sessile, with stipule-like pinnules at the base; veins anastomosing and with a marginal connecting vein. Sori continuous, or almost so, along the marginal connecting vein, paraphyses present; indusium absent, the sori partially covered by the reflexed, membranous margins of the lamina. Spores monolete, tuberculate.

Primarily a pantropical genus but with one species, *H. incisa*, extending to subantarctic islands. With perhaps six to eight species in total but delimitation of taxa is problematic.

Histiopteris incisa (Thunb.) J. Sm.

(Fig. 10A, B)

Bat's wing fern

Pteris incisa Thunb., Prodr. pl. cap. 171 (1800).

Histiopteris incisa (Thunb.) J. Sm., Hist. fil. 295 (1875).

Type: Cape of Good Hope, South Africa, *C.P. Thunberg*; holo: UPS (Herb. Thunberg).

Rhizome creeping and branched, with scales. Fronds erect to arching, to at least 1.5 m long. Stipe and rachis reddish brown in the lower parts, yellowish brown in the upper, glabrous except for a few basal, narrowly triangular scales. Lamina mostly 2-pinnate, may be 3- or 4-pinnate at base, usually discolorous, the upper surface green, the lower glaucous, thin. Pinnae opposite. Pinnules to 65 mm long and 25 mm wide, adnate to midribs, margins entire to lobed, the apices obtuse. Fertile plants: June, Oct.–Dec.

Distribution. Pantropical species extending to southern temperate regions and subantarctic islands (Australia: W.A., N.T., S.A., Qld, N.S.W., Vic., Tas). In the N.T. most records are from the southern region (e.g. Giles Spring, Kings Canyon, Serpentine Gorge, Talipata Gorge), with the only Top End specimens from the vicinity of Twin Falls, Kakadu NP. Not noted as occurring in W.A.

Fig. 10. A, B. *Histiopteris incisa*: **A**, primary pinna with stipule-like pinnules at the base (Russell-Smith 703); **B**, part of pinnule showing sori and anastomosing veins (Russell-Smith 5582). **C-E.** *Microlepia speluncae*: **C**, primary pinna; **D**, pinnule showing submarginal sori at end of veins; **E**, a ½-cup-shaped sorus with sporangia just visible (**C-E**, Russell-Smith 5583). **F, G.** *Pteridium revolutum*: **F**, primary pinna; **G**, part of secondary pinna showing venation, hairs and reflexed margin (**F, G**, Russell-Smith 725). Scale bars: **A–D**, **F** = 1 cm, **G** = 1 mm, **E** = 0.5 mm.

in the *Flora of Australia* but specimens are held at PERTH (R. Chinnock, *in litt.*) (p.75).

Habitat. Perennially damp gorges and waterholes.

Microlepia C. Presl

Plants terrestrial, homosporous. Rhizomes short- to long-creeping, the young parts with short, uniseriate hairs. Fronds monomorphic, 1–4-pinnate, usually hairy, scales absent; veins free. Sori discrete, ovate or round, submarginal, borne at the vein endings, paraphyses sometimes present; indusium present, ½ cup-shaped, being attached by the base and sides to the lamina. Spores trilete, smooth or echinate.

A genus of *ca* 45 species occurring mainly in warm temperate to tropical regions of the Old World and with most species in Asia. One species native to Australia.

Microlepia speluncae (L.) T. Moore

(Fig. 10C–E)

Polypodium speluncae L., Sp. pl. 2: 1093 (1753).

Microlepia speluncae (L.) T. Moore, Index fil. 93 (1857.

Type: Ceylon.

Rhizome short-creeping. Fronds to at least 1m long. Stipe yellowish brown, grooved, mostly glabrous. Rachis with an indumentum of uniseriate, septate hairs. Lamina 3-pinnate, both surfaces hairy. Primary pinnae to *ca* 20 cm long. Secondary pinnae to 5.5 cm long. Pinnules ovate, to 12 mm long, 8 mm wide, margins shallowly lobed, obtuse, decurrent, the lowest pinna markedly larger that the one opposite. Sori several on each ultimate segment, borne near the sinuses but distant from the margin, paraphyses present. Fertile plants: *ca* June.

Distribution. Widespread in tropical regions of the world (including the Neotropics where it may be introduced) and in Australia (W.A., N.T., Qld). In the N.T. known only from the Twin Falls region, Kakadu NP (p.76).

Habitat. The only specimen held at DNA was collected from perennial seepage at the base of a rock face.

Pteridium Gled. ex Scop.

Plants terrestrial, homosporous. Rhizomes long-creeping, branched, subterranean, hairy; hairs simple. Fronds monomorphic, 2–4-pinnate, hair present, scales absent; veins forked, free except for a marginal connection; nectaries present at base of pinnae. Sori continuous, or almost so, along the marginal connecting vein, paraphyses absent, the sori partially covered by the reflexed, usually membranous margins of the lamina and sometimes by an inner membranous indusium. Spores trilete, irregularly granulose, lacking a perispore.

Sometimes considered to contain a single, highly variable species, *P. aquilinum*, or several closely related species. Following Andrews (1990) and Brownsey (1998), three species are recognised as occurring in Australia, with just *P. revolutum* in the N.T.

Pteridium revolutum (Blume)

(Fig. 10F, G)

Hairy bracken

Pteris revoluta Blume, Enum. pl. Javae 214 (1828).

Pteridium revolutum (Blume) Nakai, Bot. Mag. (Tokyo) 39: 109 (1925).

Type: Java.

Stipe and rachis yellow-brown or partly pale chestnut brown, glabrous or with scattered hairs. Fronds to at least 2 m long, stipe usually shorter than the lamina. Lamina 2- or 3-pinnate, lower surface densely hairy, the upper surface glabrous or with scattered hairs. Primary pinnae triangular, to 40 cm long, the midrib prominent and hairy on the undersurface and on the upper surface showing as a distinct groove; hairs of the midrib often reddish brown and coarser than the whitish, almost transparent hairs on the lamina. Secondary pinnae 2.5–15 cm long. Pinnules entire, the membranous reflexed margins with long hairs. Sori linear, submarginal. Indusium membranous, *ca* 0.1–0.2 mm wide, fimbriate. Fertile plants: Nov.

Distribution. India to southern China, New Guinea and Australia (N.T., Qld). In the N.T. it is common in the Top End (p.77).

Habitat. Favouring sandy soils, this plant is commonly found on the edge of rainforests and swamps and in sandstone gorges with a permanent or near-permanent supply of water.

Notes. Fertile plants are rare in this species, Brownsey (1998) not having seen any in Australian material. Only one of the 25 specimens from the N.T. and housed in DNA is fertile.

Lindsaeaceae

Family of perhaps six genera with only *Lindsaea* in Australia.

References: Kramer (1971), Kramer and Tindale (1976), Kramer and McCarthy (1998a).

Lindsaea Dryand. ex Sm.

Ferns terrestrial or epiphytic. Rhizome short- or long-creeping, with coarse, narrow scales. Fronds monomorphic or dimorphic. Lamina 1- or 2-, sometimes 3-pinnate; veins not extending to margins, free or anastomosing. Sori indusiate, terminal on the veins. Indusia short to linear and opening towards the margins, margins entire or irregular.

A genus of *ca* 180–200 species, with most in the Old World tropics and 15 in Australia. Species delimitation is problematic; with the exception of *L. walkerae* the N.T. species seem ill-defined.

Key to species of *Lindsaea*

1a. Lamina 2-pinnate for much of its length, ultimate segments always lacking a distinct midvein .... *L. media*

1b. Lamina 1-pinnate or partly 2-pinnate, if partly 2-pinnate then at least some non-terminal segments with distinct midveins 2

2a. Veins anastomosing (at least in segments with a distinct midvein)............................... *L. ensifolia*

2b. Veins free 3

3a. Pinnae linear-elliptic or linear lanceolate .... *L. walkerae*

3b. Pinnae fan-shaped or obovate in outline and symmetric to strongly asymmetric..................... ....*L. brachypoda*

Lindsaea brachypoda (Baker) Salomon

(Fig. 11A, B)

Davallia brachypoda Baker, Syn. fil. 2nd ed., 468 (1874).

Lindsaea brachypoda (Baker) Salomon, Nomencl. Gefässkrypt. 212 (1883).

Type: Gilbert River, Qld, *Daintree*; holo: K.

Rhizomes short-creeping, scales reddish-brown. Fronds *ca* 3–30 cm long, more or less monomorphic. Stipe yellowish or pale brown. Lamina 1-pinnate; pinnules strongly asymmetrical and fan-shaped to symmetrical and ovate or obovate, 3–15 mm long, 2–9 mm wide, terminal pinna much smaller to larger than the lateral pinnae, the margins entire or shallowly incised; veins free, simple or 1- or 2-forked, no lateral pinnae with a prominent midvein. Sori continuous or interrupted. Spores smooth. Fertile plants: Aug.–May.

Distribution. Australian endemic (N.T., Qld, N.S.W.), within the N.T. all specimens have been collected in the northern region, the most southerly record being from Jasper Gorge (p.75).

Habitat. Commonly found in sandstone rock crevices with a permanent or near-permanent supply of water, be it from seepage or from the splash received from waterfalls.

Notes. As illustrated in Kramer and McCarthy (1998a: fig. 99I), the size of the terminal pinna in relation to the lateral pinnae may vary in fronds from the one plant; they may have a very small terminal pinna, with there being a gradual decrease in the size of pinna from the base of the frond to the apex, or the terminal pinna may be at least as large as any of the lateral pinnae, with the lowest pinnae being the smallest of any of the laterals. In several other specimens (e.g. *Russell-Smith 2280*), which are here included under *L. brachypoda*, the terminal pinna may be larger than the lateral pinnae.

Kramer and McCarthy (1998) suggested that a depauperate specimen which they cited (seemingly erroneously) as *Latz 23493*, from the Wessel Islands may be *L. orbiculata*. No N.T. specimens match the illustration of *L. orbiculata* provided by Kramer (1971: fig. 15). *Latz 3493B*, also a depauperate specimen from the Wessel Islands, and which is presumed to be a duplicate of that cited by Kramer and McCarthy, has some individual fronds which closely match those of *Byrnes D1307* from Katherine Gorge. These, in turn, seem to link with other forms which are here referred to as *L. brachypoda*.

The species was described by Kramer and Tindale (1976) as having occasional 2-pinnate fronds but no such material from the N.T. is held at DNA.

Lindsaea ensifolia Sw.

(Fig. 11C–F)

Lindsaea ensifolia Sw., J. Bot. (Schrader) 1800 (2): 77 (1801).

Type: Mauritius, *Anon.*; holo: S.

Rhizomes short- to long-creeping; scales narrowly triangular, to *ca* 2 mm long, reddish brown. Fronds monomorphic. Stipe 10–35 cm long, usually shorter than the lamina, yellowish to reddish brown. Lamina 15–50 cm long, 1-pinnate or with at least the basal ½ of the frond 2-pinnate; pinnae widely depressed ovate to linear-lanceolate, 7–230 mm long, 7–23 mm wide, barely to markedly reduced in size from the base to the apex of the lamina, margins entire or toothed; midvein prominent in at least some pinnae and the lateral veins anastomosing; often the lower and sometimes most pinnae and pinnules lacking a midvein and with 3 or 4 veins of equal size at the base and these forking and often anastomosing before reaching the apex. Sori continuous but not always extending around the apices of the pinnae; indusium entire, 0.5–1 mm wide, reaching or almost reaching the margin. Fertile plants: throughout the year.

Distribution. Widespread in the Old World tropics, ranging from West Africa to Australia (W.A., N.T., Qld), Hawaii and southern Japan. In the N.T. extremely common in the Top End but also found in the south (p.75).

Habitat. A common fern of rainforest and woodland, growing along stream margins, the edge of springs, seepage areas and in rocky crevices exposed to the spray from waterfalls.

Notes. Two subspecies, *i.e.* subsp. *agatii* (Brackenr.) Kramer and *L.* subsp. *ensifolia* Sw., have been recognised as occurring in Australia and both have been recorded for the N.T. Those plants in which the pinnae are mostly or totally undivided and are barely reduced in size from the base to the apex of the frond, and in which the terminal pinna is large, are referable to *L.* subsp. *ensifolia*. Specimens in which pinnae markedly reduce in size from the base to the apex, have a small terminal pinna, and in which the lamina are basally 2-pinnate are referable to *L.* subsp. *agatii*.

Fig. 11. A, B. *Lindsaea brachypoda*: **A**, frond; **B**, pinna showing veins and sori (**A, B**, Russell-Smith 3932). **C-F**. *Lindsaea ensifolia*: fronds from three variants plus a pinna from one morph showing anastomosing venation, **C** (Henshall 3819), **D, E** (Latz 2903), **F** (Brennan 2687). **G, H**. *Lindsaea media*: **G**, frond; **H**, pinnules showing continual sori (**G, H**, Russell-Smith 3007). **I, J**. *Lindsaea walkerae*: **I**, frond; **J**, pinna showing free, forking venation (**I, J**, Russell-Smith 5759). Scale bars: **A, C, D, F, G, I** = 1 cm, **E, J** = 2 mm, **B, H** = 1 mm.

However, intermediate specimens (e.g. *Cowie 2055*) are common and the maintenance of infraspecific taxa seems untenable in this highly variable taxon.

Ethnobotany. Some Aboriginal people are believed to eat the rhizome and possibly other parts of the plant (Wightman and Smith 1999).

Lindsaea media R. Br.

(Fig. 11G, H)

Lindsaea media R. Br., Prodr. 156 (1810).

Type: Island G2, north coast of Australia, 18–24 Feb. 1803, *R. Brown Iter Austral. 82*; holo: BM; iso: E, K, ?P, ?U.

Rhizome creeping; scales *ca* 1 mm long, yellow. Fronds monomorphic, to *ca* 60 cm long. Stipes yellowish or pale brown. Lamina 2-pinnate for usually at least ½ of its length, to *ca* 30 cm long; pinnae reducing in size towards the apex of the frond, the largest to 2 – 8 cm long; pinnules subsessile, fan-shaped or subrhombic, 5–16 mm long, 3–11 mm wide, entire or toothed; prominent midvein absent, veins free and 1–3-forked or irregularly anastomosing. Sori continuous except at marginal incisions; indusium reaching to or slightly exceeding the margin, variably incised. Fertile plants: July–Feb.

Distribution. New Guinea and Australia (N.T., Qld). In the N.T. all specimens are from NE Arnhem Land (p.75).

Habitat. A species of riparian forest and sandstone areas with permanent seepage.

Lindsaea walkerae Hook.

(Fig. 11I, J)

Lindsaea walkerae Hook., Sp. fil. 1: 219, pl. 69A (1846).

Type: Ceylon, *Mrs Walker*; holo K; iso: B.

Rhizome short- to long-creeping; scales narrow, to 1.5 mm long, reddish brown. Fronds monomorphic. Stipes dark reddish brown to almost black. Lamina 1-pinnate, to 80 cm long, with 6–19 lateral, opposite or alternate pinnae; pinnae sessile or very shortly stalked, linear-lanceolate or linear-elliptic, margins entire and slightly revolute, 15–110 mm long, 4–10 mm wide, firm; prominent midvein present, lateral veins free, closely spaced, 1–3-forked. Sori usually continuous along the margins and mostly extending around the apices of the pinnae; indusium 0.4–0.6 mm wide, entire. Fertile plants: May, June, Oct.

Distribution. Sri Lanka east to New Guinea, Micronesia and northern Australia (N.T., Qld). In the N.T. only known from Bathurst and Melville islands and from near Lake Evella in eastern Arnhem Land (p.75).

Habitat. Mostly collected from the margins of spring jungle but also recorded from a peaty swamp on Bathurst Island.

Pteridaceae

A cosmopolitan family with five genera and *ca* 300 species. In Australia 12 species and two genera, *Acrostichum* and *Pteris*. Sometimes given a much broader circumscription to encompass, for example, the members of Adiantaceae.

Reference: Kramer and McCarthy (1998b).

Key to genera of Pteridaceae

1a. Sporangia covering the undersurface of fertile pinnae .... *Acrostichum*

1b. Sporangia in elongate, submarginal sori which are protected by a recurved pinna margin ...... *Pteris*

Acrostichum L.

Plants terrestrial. Rhizome creeping or erect, thick, with fleshy prop roots. Fronds to *ca* 3 m tall; stipe shorter than the lamina, with basal scales; lamina 1-pinnate (but juvenile fronds simple), leathery, the pinnae mostly stalked but the upper ones may be sessile, the upper pinnae fertile and generally smaller than the lower sterile ones, veins reticulate. Sori absent, the sporangia covering the undersurface of the fertile pinnae. Spores tetrahedral.

A pantropical genus with three species, two of which occur in Australia.

Key to species of *Acrostichum*

1a. Sterile pinnae with truncate, rounded, or sometimes slightly bilobed apices and usually with a short abrupt point .... *A. aureum*

1b. Sterile pinnae with at least some acute to acuminate apices .... *A. speciosum*

Acrostichum aureum L.

Acrostichum aureum L., Sp. pl. 2: 1069 (1753).

Type: Jamaica and Dominica; LINN.

Fronds to ca. 2 m tall, in clumps; juvenile fronds not seen. Sterile pinnae linear or linear-lanceolate, 18–45 cm long, 3.5–7.5 cm wide, more or less abruptly rounded, truncate or rarely bilobed at the apex but with a small point. Fertile pinnae with the lamina somewhat linear, 15–22 cm long, 1.5–3 cm wide, basally asymmetric, apically truncate but with a short point. Fertile fronds: *ca* Nov.

Distribution. Generally regarded as a pantropical species which in Australia is found in the N.T. and Qld. In the N.T. it is only known from a few sites in the north (p.73).

Habitat. The only specimens that seem to be of this taxon are from freshwater (e.g. rainforest on the edge of a black soil floodplain at Kemp Airstrip and freshwater seepage at the Adelaide River crossing on the Arnhem Highway) and brackish water such as on the edge of the Habgood River.

Notes. Almost all specimens of this genus held at DNA are seemingly *A. speciosum*. Very few, following Holttum (1954) and Kramer and McCarthy (1998) and as often determined by Kramer, are referable to *A. aureum* by virtue of their sterile pinnae with truncate to bilobed apices with a short central point. Apart from this character there is no absolute feature on DNA specimens that seems to distinguish the two taxa. Rhizome scales, said to be to 40 mm long in *A. aureum* and less than 10 mm long in *A. speciosum*, are lacking from almost all specimens.

Although using the shape of the apices to distinguish taxa it must also be said that there is a gradation from obtuse to acuminate between specimens and to some extent within single plants; e.g. *Dunlop 9236* has pinnae with obtuse and acute apices and *Russell-Smith 5873* has pinnae with acute apices and truncate apices. Thus several specimens with truncate apices here referred to *A. aureum* can be viewed as nothing more than extremes in that variation. Specimens referred to *A. aureum* always have some pinnae more than 4 cm wide but so do some which are otherwise seemingly best placed in *A. speciosum*.

Kramer and McCarthy (1998) noted that it is not clear whether intermediates that "occur sparingly" between the two species "are of hybrid origin or extreme atypical plants of one or the other". The question must be asked whether two "good" species are actually involved. Disconcertingly, Holttum (1954) recorded that juvenile fronds of *A. aureum* are strap-shaped but Andrews (1990) recorded that in Queensland material they are the same shape, lanceolate, as in *A. speciosum*. The lamina of the juveniles is always ovate to lanceolate in outline in the few specimens of *Acrostichum* held at DNA. Clearly, species circumscription and the application of names in *Acrostichum* requires further investigation.

A common name of "golden mangrove fern" is sometimes applied to this species (e.g. Kramer and McCarthy 1998) but given that the N.T. specimens are not associated with mangrove communities, this seems a particularly inapt name.

Acrostichum speciosum Willd.

(Fig. 12A, B)

Mangrove fern

Acrostichum speciosum Willd., Sp. pl. 5: 117 (1810).

Type: India Orientali; holo: B (herb. Willdenow).

Fronds to *ca* 1.5 m tall, in clumps. Sterile pinnae elliptic to narrowly elliptic or ovate to lanceolate, 5–40 cm long, 1.8–5.5 cm wide, gradually to somewhat abruptly tapering to an acute to acuminate apex. Fertile pinnae with the lamina lanceolate, 7–16 cm long, 1–2.5 cm wide, apex acute to acuminate. Fertile fronds: throughout the year.

Distribution. Tropical Asia and Australia (W.A., N.T., Qld, N.S.W.) (p.73).

Habitat. A mostly coastal species associated with mangroves and areas regularly inundated by saltwater, occasionally on inland springs.

Ethnobotany. Some Aboriginal people eat parts of the plant for sustenance (Wightman and Smith 1999).

Pteris L.

Plants terrestrial. Rhizome creeping or erect, commonly stout, prop roots usually absent. Fronds monomorphic or dimorphic, to *ca* 1 m or more tall; stipe straw-coloured, reddish-brown or brown, with basal scales few to many; lamina 1–4-pinnate-pinnatifid, somewhat thin or leathery, glabrous or with some uniseriate hairs, the pinnae not or barely stalked, veins free or anastomosing. Sporangia in elongate, submarginal, mostly continual sori which are protected by a recurved pinna margin; paraphyses absent or present. Spores bilateral or tetrahedral, surfaces smooth or sculptured.

A genus of more than 240 species in temperate and tropical regions of the world. In Australia ten species are recognised, two of which are introduced. In the N.T. there are perhaps three species, *P. tremula*, *P. vittata* and *P. tripartita*.

Key to species of *Pteris*

1a. Fronds 1-pinnate .... *P. vittata*
1b. Fronds 2- or 3-divided 2
2a. Veins near costae anastomosing; lamina dark green .... *P. comans*
2b. Veins free, simple or once- or twice-forked; lamina pale green .... *P. tremula*

Pteris comans G. Forst.

(Fig. 12C, D)

Netted brake

Pteris comans G. Forst., Fl. ins. austr. 79 (1786).

Type: New Zealand.

Terrestrial fern with the upper part of the lamina with sessile pinnae, the individual pinnae deeply pinnatifid. Rachis grooved, yellowish, with scattered uniseriate, eglandular hairs. Ultimate segments somewhat oblong and falcate, 12–30 mm long, 4–5 mm wide, the lower margins entire, the upper margins crenate, sometimes with lobes in the lower half; lower side of upper pinnae decurrent on the rachis; terminal segment of pinnae gradually extending to a point; veins anastomosing near the midrib.

Distribution. Australia (N.T., Qld, N.S.W., Vic., Tas.), New Zealand and islands of the south Pacific. In the N.T. it is known by a single collection from Aquarium Springs Gorge, Woologorang Station (p.77).

Habitat. The only known specimen was growing in a seepage area at the base of a cliff.

Notes. The single specimen, *Trainor 156*, of this species which is held at DNA is sterile, but nonetheless seems referable to this species rather than *P. tripartita*, being in accord with the illustration and description included in Andrews (1990: 300, fig. 30.2B). Due to the paucity of material the above description is necessarily brief.

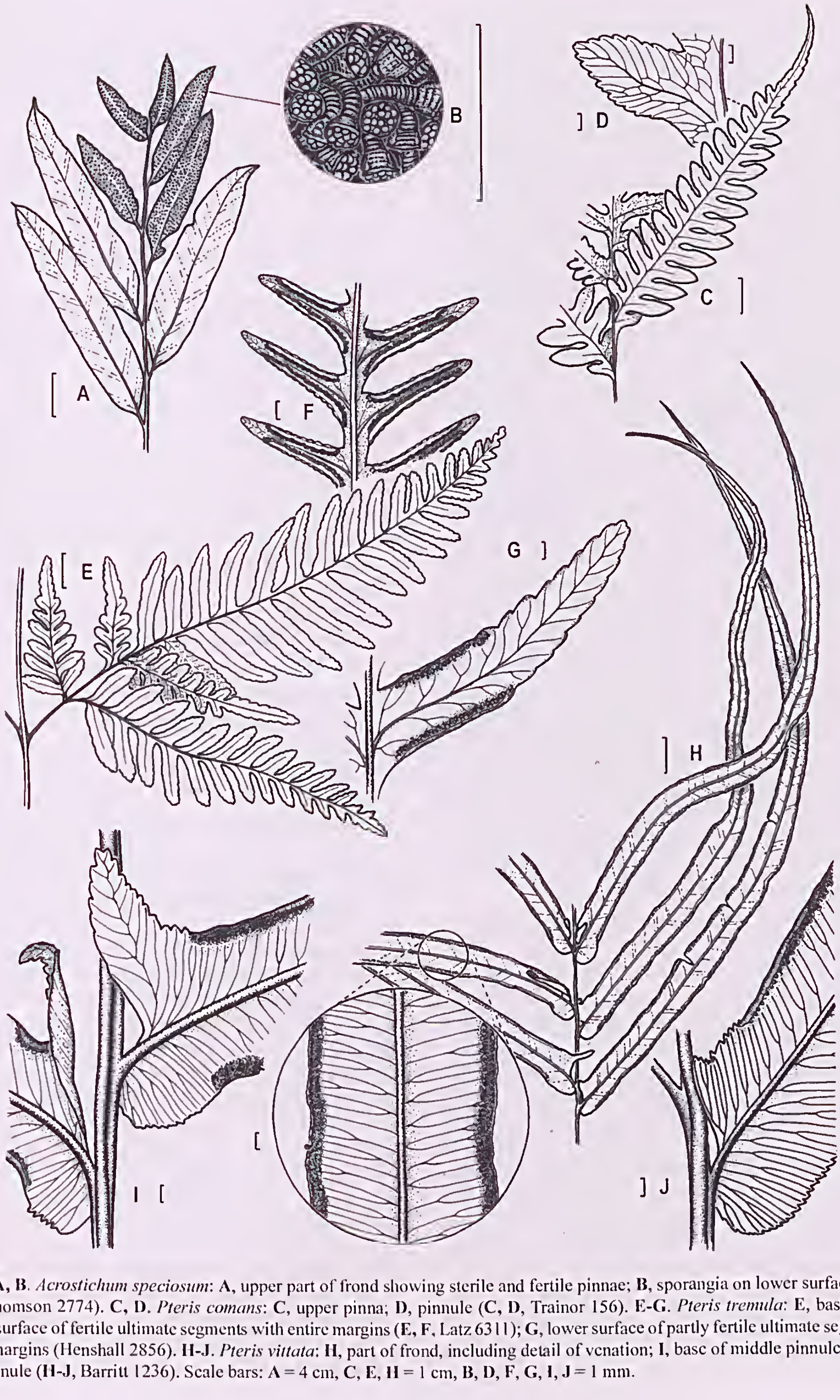

Fig. 12. A, B. *Acrostichum speciosum*: **A**, upper part of frond showing sterile and fertile pinnae; **B**, sporangia on lower surface of pinna (**A, B**, Thomson 2774). **C, D.** *Pteris comans*: **C**, upper pinna; **D**, pinnule (**C, D**, Trainor 156). **E-G.** *Pteris tremula*: **E**, base of frond; **F**, lower surface of fertile ultimate segments with entire margins (**E, F**, Latz 6311); **G**, lower surface of partly fertile ultimate segment with toothed margins (Henshall 2856). **H-J.** *Pteris vittata*: **H**, part of frond, including detail of venation; **I**, base of middle pinnule; **J**, base of upper pinnule (**H-J**, Barritt 1236). Scale bars: **A** = 4 cm, **C, E, H** = 1 cm, **B, D, F, G, I, J** = 1 mm.

Pteris tremula R. Br.

(Fig. 12E–G)

Tender brakefern

Pteris tremula R. Br., Prodr. 154 (1810).

Type: Port Jackson, *R. Brown*.

Rhizome short, creeping, with numerous pale brown scales. Fronds dimorphic, tufted, to *ca* 120 cm or more long. Stipe to *ca* 60 cm or more long, reddish brown, grooved, with or without a few basal scales; scales narrowly triangular, *ca* 2 mm long, pale brown. Lamina 3-pinnate for most of its length, to *ca* 60 cm or more long and perhaps *ca* 40 cm wide. Rachis glabrous. Pinnae decreasing in size from the base to the apex, the largest pinnae *ca* 30 cm long, 9 cm wide, costae often conspicuously grooved on the upper surface; ultimate segments to *ca* 3 cm long, *ca* 0.5 cm wide and with toothed margins and infertile or fertile or the segments to *ca* 1.5 cm long, 0.2 cm wide and with entire margins and always fertile; veins at *ca* 45° to the costa, free, not or once- or twice-forked. Sori continual from the base to or almost to the apex of the ultimate segments or disrupted at the sinuses in those with toothed margins; paraphyses absent. Fertile: May–Dec.

Distribution. Australia (N.T., S.A., Qld, N.S.W., A.C.T., Vic., Tas.) to New Zealand, Kermadec Islands, Lord Howe Island, Norfolk Island and Fiji. In the N.T. restricted to the southern region, e.g. Standley Chasm, Mt Giles and Kings Canyon (p.77).

Habitat. On the margins of springs and in permanently wet seepage areas in sheltered gorges.

Note. A variable species, often said to have dimorphic fronds, implying that fertile and sterile fronds are morphologically different but in some specimens it is evident that fronds with broad ultimate segments may produce sori, not just those with narrow segments.

Pteris vittata L.

(Fig. 12H–J)

Ladder brake, Chinese brake

Pteris vittata L., Sp. pl. 2: 1074 (1753).

Type: China, *P. Osbeck*; lecto: LINN 1246.3, *fide* R.Tryon, Contr. Gray Herb. 194: 191 (1964).

Rhizome short, creeping, with numerous scales. Fronds monomorphic, arching, to *ca* 1.5 m long. Stipe to *ca* 25 cm or more long, pale brown, grooved, with a dense cover of scales at the base; scales narrowly triangular, 4–12 mm long, yellowish-brown or brown. Lamina 1-pinnate, to *ca* 80 cm or more long and perhaps *ca* 40 cm wide. Rachis with scattered hairs. Pinnae decreasing in length from the upper part of the lamina to the base of the lamina although the uppermost pinnae also shorter than the mid-pinnae and the terminal pinna also very long, the largest pinnae *ca* 25 cm long, 1 cm wide and tapering to the apex, the lowest basal pinna *ca* 3.5 cm long, *ca* 0.7 cm wide, all pinnae with the margins serrate in sterile zones; bases of pinnae often asymmetrical and often slightly overlying the rachis, the mid-pinnae sometimes with a basal acroscopic lobe to 15 mm long; veins nearly at right-angles to the costa, free, once-forked. Sori linear, continual from near the base and for most of the length of the pinna; paraphyses abundant. Fertile: May.

Distribution. Temperate to tropical regions of the Old World (Australia: W.A., N.T., Qld, N.S.W., Vic.). In the N.T. known only from the Fitzmaurice River gorge and Matt Wilson Creek (p.78).

Habitat. Sheltered areas in sandstone country with permanent water.

Notes. Except for the acroscopic lobes on the mid-pinnae of *Barritt 1236,* the specimens seem to fit within the circumscription of *P. vittata* as illustrated and described by Kramer and McCarthy (1998).

Adiantaceae

The Adiantaceae are sometimes treated as a monogeneric family and have also been treated as part of the Pteridaceae. Following Bostock in *Flora of Australia,* the Adiantaceae are treated here as a cosmopolitan family with 28 genera and *ca* 600 species, of which eight genera and about 36 species occur in Australia.

References: Andrews (1990), Tryon (1990), Bostock (1998a).

Key to genera of Adiantaceae

1a. Rhizomes with bristles only .... *Taenitis*
1b. Rhizomes with scales and sometimes also with hairs 2
2a. Sori borne on reflexed flap of lamina .... *Adiantum*
2b. Sori not borne on a marginal flap (but may be covered by lamina margin)................................ 3
3a. Sporangia away from the margins and borne along the length of the veins; undersurface of frond white .... *Pityrogramma*
3b. Sporangia in marginal or nearly marginal sori; undersurface of fronds never white................. 4
4a. Sori concealed by toothed scales . *Paracetarach*
4b. Sori not concealed by scales 5
5a. Primary frond division palmate; minor veins obscure .... *Doryopteris*
5b. Primary frond division pinnate; minor veins visible .... *Cheilanthes*

Adiantum L.

Maidenhair ferns

Ferns terrestrial. Rhizome prostrate and creeping or erect, commonly branched, with basally attached scales. Fronds monomorphic or almost so. Stipes shiny, brown or black, with basal scales as on rhizome. Lamina 1–5-pinnate, pinnately decompound or helicoid, membranous to leathery, glabrous or hairy, sometimes glaucous. Pinnules commonly fan- or somewhat diamond-shaped; veins usually free or sometimes anastomosing, ending at or near the margins. Sori on the lower surface of the reflexed lamina margins which form a false indusium or soral flap. Sporangia borne along the terminal part of the veins; paraphyses present or absent. Spores trilete, tetrahedral to globose, with 32 or 64 per sporangium.

Cosmopolitan genus with *ca* 150 species, with eight in Australia and five in the N.T.

Reference: Bostock (1998a).

Key to species of *Adiantum*

1a. Lamina 1-pinnate 2
1b. Lamina 2–5-pinnate 3
2a. Pinnules glabrous .... *A. philippense*
2b. Pinnules beset with single-celled, dark hairs .... *A. diaphanum*
3a. Pinnules mostly asymmetrical at base and subtrapeziform .... *A. hispidulum*
3b. Pinnules mostly symmetrical at base, shallowly obdeltate to obtriangular or widely depressed obovate to obovate 4
4a. Outer margins of pinnules shallowly lobed; soral flaps notched at the junction with the pinnule margin .... *A. atroviride*
4b. Outer margins of pinnules manifestly cleft; soral flaps not indented into the pinnule margin .... *A. capillus-veneris*

Adiantum atroviride Bostock

(Fig. 13A, B)

Adiantum atroviride Bostock, Fl. Australia 48: 707, fig. 104, B–D (1998).

Type: Manning River, 22.5 km NNW of Gloucester, N.S.W., *R. Coveny 6401, P. Hind and P. Phillips*; holo: NSW; iso: BRI.

Rhizome erect or shortly creeping; scales numerous, narrowly triangular, 1.5–3 mm long, brown, the margins shortly ciliate. Fronds to *ca* 55 cm; stipe dark reddish or purplish brown, shiny, glabrous or with a few scales at the base. Lamina 2–4-pinnate, pale green. Pinnules very widely obovate to obovate, symmetric or somewhat asymmetric at the base, 5–14 mm long, 3–14 mm wide, glabrous, distally with 2–6 shallow lobes; veins conspicuous, free, mostly 2- or 3-forked; stalks reddish-brown except for whitish base, 1–8 mm long. Sori 2–7 on distal margins of each pinna; soral flaps reniform, 0.9–1.3 mm across longest axis, occurring at the base of a sinus on the margin of the pinnule, glabrous. Fertile plants: *ca* Aug.–Nov.

Distribution. Australia (N.T., Qld, N.S.W.) and Lord Howe Island. In the N.T. only known from near Mirringatja and Ramingining in north-central Arnhem Land (p.73).

Habitat. Recorded as a ground fern of semi-deciduous vine forest and from spring jungle in a sandstone gorge.

Notes. Bostock (1998a) noted that the N.T. and north Qld specimens included in this species belong to a distinct taxon which "almost certainly warrants separation at least at a varietal or subspecific level".

Adiantum capillus-veneris L.

(Fig. 13C, D)

Adiantum capillus-veneris L., Sp. pl. 2: 1096 (1753).

Type: locality unknown, *Magnol s.n.*; lecto: LINN No. 1252.9, *fide* Pic.Serm., Webbia 12: 678 (1957).

Rhizome creeping; scales dense, elongate, yellow-brown, margins entire. Fronds to *ca* 30 cm; stipe slender, dark reddish brown, shiny, glabrous except for a few scales near the base. Lamina usually 2- or 3-pinnate, pale green, glabrous. Pinnules shallowly obdeltate to obtriangular or widely depressed obovate to obovate, 5–22 mm long, 6–25 mm wide, distally deeply lobed and at least in sterile specimens coarsely denticulate; veins reddish-brown at base but otherwise conspicuous but pale; stalks reddish-brown, 1–7 mm long, not basally articulated. Sori *ca* 3–11 on distal margins of each pinna; soral flaps somewhat oblong and 0.8–1.2 mm long, not or barely indented on the lamina margin, glabrous. Fertile plants: Mar.–May.

Distribution. A widely distributed species in warm to tropical parts of the world. In Australia it is known from all States and Territories except Tasmania. Within the N.T. it is only known from three localities, *i.e.* Hugh Gorge in the south and Jasper Gorge and Matt Wilson Creek in the Victoria River district (p.73).

Habitat. Seepage areas on cliff faces and along water courses in sheltered rocky gorges.

Notes. The specimen from Jasper Gorge is depauperate and some fronds consist of the equivalent of a single pinnule in larger specimens.

Adiantum diaphanum Blume

Adiantum diaphanum Blume, Enum. pl. Javae 215 (1828).

Type: Linga Jattie, Java, *C.L. Blume 649*; holo: L.

Rhizome erect; scales narrowly- to linear-triangular, brown, to *ca* 1.5 mm long, margins entire. Fronds to *ca* 12 cm or more long; stipe and rachis reddish-brown, glabrous or with occasional stiff, reddish-brown hairs. Lamina 1-pinnate, not proliferous. Pinnules asymmetric, somewhat rectangular or trapeziform, 4–12 mm long, 2–5 mm wide, distally shallowly lobed or denticulate, with dark, reddish-brown, stiff, pointed hairs scattered over the surface; veins conspicuous, free, mostly 2- or 3-forked; stalks to 2 mm long, barely articulated to rachis. Sori *ca* 2–5 per pinna; soral flaps reniform, 0.7–11 mm across longest axis, occurring at the base of a sinus on the margin of the pinnule, setose. Fertile plants: *ca* Oct.

Distribution. Taiwan and Japan to Malesia, Australia (N.T., Qld, N.S.W., Vic.), New Zealand and

Fig. 13. A, B. *Adiantum atroviride*: **A**, frond and rhizome; **B**, fertile pinna (**A, B**, Searlett 233). **C, D.** *Adiantum capillus-veneris*: **C**, frond; **D**, fertile pinna (**C, D**, Cowie 9178). **E, F.** *Adiantum hispidulum* var. *hispidulum*: **E**, frond; **F**, fertile pinna (**E, F**, Russell-Smith 5080). **G, H.** *Adiantum philippense*: **G**, frond and rhizome; **H**, fertile pinna (**G, H**, Russell-Smith 3187). Scale bars: **A, C, E, G** = 1 cm, **B, D, F, H** = 1 mm.

Pacific Islands, as far east as Fiji. In the N.T. only known from a single collection (*Harwood 531*) collected south of Wollogorang homestead (p.73).

Habitat. The only specimen was obtained from around a rock pool at the base of a cliff face.

Notes. Bostock (1998a) recorded that fronds may sometimes be 2- or 3-pinnate at the base.

Adiantum hispidulum Sw. var. *hispidulum*

(Fig. 13E, F)

Adiantum hispidulum Sw., J. Bot. (Schrader) 1800(2): 82 (1801) var. *hispidulum*.

Type: Australia; holo: S.

[*A. pubescens auct. non* Schkuhr: Dunlop (ed.), Checklist Vasc. Pl. Northern Terr. 1 (1987).]

Rhizome shortly creeping, stoloniferous; scales brown, margins entire. Fronds to *ca* 55 cm; stipe and rachis dark reddish or purplish brown, glabrous or more commonly with an obvious indumentum of antrorse reddish brown hairs, the rachis often with some basal scales. Lamina 2- or 3-pinnate. Pinnules symmetric and tending to be obovate or obtriangular at the base of the lamina but most manifestly asymmetric at their base and the whole subtrapeziform, 8–15 (27) mm long, 3–8 mm wide, distally dentate or shallowly lobed, glabrous or more commonly with an indumentum of scattered, often erect hairs; veins conspicuous, mostly 2- or 3-forked; stalks to *ca* 1 mm long. Sori to *ca* 14 on distal margins of each pinna; soral flaps subcircular, 0.8–1.1 mm across longest axis, occurring at the base of a sinus on the margin of the pinnule, with erect, brown setae. Fertile plants: throughout the year.

Distribution. Africa, Asia, all states and territories of mainland Australia, New Zealand and east to Polynesia. Widespread in the N.T (p.73).

Habitat. Occurs in a wide range of habitats, from rock faces permanently damp from seepage to riparian, evergreen vine forest.

Notes. In recognising four varieties of the species within Australia, Bostock (1998a) noted that they represent "extremes of a myriad of mutations and intergrades".

Adiantum philippense L.

(Fig. 13G, H)

Adiantum philippense L., Sp. pl. 2: 1094 (1753).

Type: illustration, Petiver, Gazophyll. Nat. t. 4, fig. 4 (1702).

Rhizome short-creeping, suberect to erect; scales narrowly- to linear-triangular, reddish brown, 1–2.5 mm long, margins entire or barely toothed. Fronds to *ca* 45 cm long; stipe and rachis reddish-brown, glabrous. Lamina 1-pinnate, sometimes with proliferous buds. Pinnules asymmetric, mostly somewhat rectangular or trapeziform but smallest ones may be almost obovate, 4.5–30 mm long, 3–13 mm wide, distally shallowly lobed, glabrous; veins conspicuous, free, mostly 1–3-forked; stalks 2–12 mm long, articulated to rachis. Sori 2–8 per pinna; soral flaps oblong, 2–9 mm long, occupying the entire outer margin of the lobe, glabrous. Fertile plants: throughout the year.

Distribution. Tropical regions from Africa to Polynesia, in Australia in W.A., N.T. and Qld (p.73).

Habitat. A common species in perennially wet, shaded areas of monsoon forest and often in sandstone areas but also, for example, found at the shaded entrances of limestone caves and potholes.

Cheilanthes Sw.

Rock ferns

Terrestrial ferns. Rhizome short-creeping, with scales. Fronds monomorphic or sometimes dimorphic, erect or spreading. Stipes tufted, shiny, brown or black. Lamina 1–4-pinnate at base, glabrous or hairy or with scales; pinnae up to 14 pairs. Pinnules short-stalked or sessile, glabrous or with hairs or scales; veins usually free. Sori discrete or continuous, marginal and often protected by the inrolled margins of the lamina. Spores tetrahedral to globose, ornamented, with 16 or 32 per sporangium.

Holttum (1954) recorded of the genus that it "is a large and difficult one". This is reflected in the account of Chambers and Farrant (1998a) and the previous attempts by them and others to circumscribe taxa. A lack of good qualitative characters by which they can be defined and the all too common occurrence of intermediate specimens suggests it would be better – and more practical – to treat some of them as a single, polymorphic species, *C. tenuifolia*. However, they are here maintained, albeit with reservation.

Description of the spores included below are taken from Chambers and Farrant (1998a).

Quirk *et al.* (1983) recorded that some species are apomictic or are likely to be apomictic and it is also known that some species are triploids (Tindale and Roy 2002). The mix of sexual and apomictic reproduction presumably explains some of the perplexing variation in this genus.

References: Quirk *et al.* (1983), Jones (1988), Chambers and Farrant (1991, 1998a), Tindale and Roy (2002).

Key to species of *Cheilanthes*

1a. Pinnules with long, curling, weak hairs and often their surfaces manifestly woolly 2
1b. Pinnules glabrous or hairy, but if hairy never with long, weak, curling hairs and the pinnule surface never obscured by the indumentum 4
2a. Stipe and rachis with abundant scales; hairs and scale bases branched .... *C. lasiophylla*
2b. Stipe and rachis with few scales; hairs and scale bases unbranched 3

3a. Pinnule margins incised and tending to be inrolled and partly covering the sori .... *C. sieberi*

3b. Pinnule margins entire, or almost so, and fairly flat and not covering sori .... *C. brownii*

4a. Pinnules (at least the terminal and near terminal pinnules in a pinna) narrowly oblong to linear in outline and more than 5 times longer than wide 5

4b. Pinnules never linear and less than 5 times longer than wide 6

5a. Pinnules always or mostly at least 10 times longer than wide; lamina 2-pinnate at base or sometimes trifoliolate pinnules at base .... *C. nitida*

5b. Pinnules less than 10 times as long as wide; lamina 3-pinnate or 4-pinnatifid at base .... *C. caudata*

6a. Pinnules membranous and the minor veins conspicuous; lamina 1–3-pinnate at base .... *C. pumilio*

6b. Pinnules thick and minor veins generally indistinct; lamina 2–4-pinnate at base 7

7a. Lamina ovate or triangular, 2-pinnate or 3-pinnatifid at base; pinnule surfaces discolorous; midribs of primary pinnae dark for part of their length .... *C. praetermissa*

7b. Lamina linear, ovate or triangular, 2–5-pinnate or 5-pinnatifid, if ovate or triangular then 3- or 4-pinnate or 5-pinnatifid at base; lower pinnules usually concolorous; midribs of primary pinnae usually not dark 8

8a. Pinnules with the upper surface completely glabrous, the lower glabrous or almost so .... *C. sieberi*

8b. Pinnules with the upper surface and/or the margins sparsely to moderately hairy, the lower sparsely to densely hairy 9

9a. Pinnae with straight, stiff, pointed hairs .... *C. fragillima*

9b. Pinnae hairs not as above 10

10a. Lamina 2- or rarely 3-pinnate at base; longest hairs on upper surface of pinnae *ca* 0.5–0.6 mm long .... *C. nudiuscula*

10b. Lamina 3- or 4-pinnate at the base; longest hairs on upper surface of pinnae *ca* 0.3 mm long....... 11

11a. Hairs on the rachises, rachillas and midribs on the lower surface of the pinnules moderately dense; pinnules usually not well separated from each other and their apices tending to be obtuse .... *C. contigua*

11b. Hairs on the rachises, rachillas and the midribs on the lower surface of the pinnules sparse; pinnae usually well separated from each other and their apices tending to be acute .... *C. tenuifolia*

Cheilanthes brownii (Kuhn) Domin
(Fig. 14A)

Gymnogramma brownii Kuhn, Bot. Zeitung (Berlin) 27: 458 (1869), as *Gymnogramme*.

Cheilanthes brownii (Kuhn) Domin, Biblioth. Bot. 20(85): 133 (1913).

Type: Arnhem South Bay, Point U [Mt Caledon, N.T.], 6 Feb. 1803, *R. Brown Iter Austral. 5*; holo: BM.

Fronds to 30 cm long, stipe and rachis dark reddish brown, with a scattered to dense indumentum of unbranched, uniseriate, multi-septate, apically acute, whitish or pale brown hairs to *ca* 4 mm long and some long, brownish, scale-like hairs on the rachis. Lamina ovate to lanceolate or narrowly elliptic, 3.5–18 cm long, 2.5–7 cm wide, 1- to 3- pinnate at base, but 2-pinnate for most of its length. Largest pinnae ovate to lanceolate, to 2.5 cm long; pinnules apically obtuse, the upper surface usually with a well-developed indumentum of whitish, tangled hairs, the lower surface obscured by long, brownish hairs. Spores spherical, smooth or variously ornamented, either ridged and 16 per sporangium or trilete and 32 per sporangium. Fertile plants: Dec.–Apr.

Distribution. Australian native (W.A., N.T., Qld) found throughout much of the N.T (p.74).

Habitat. Crevices and shaded areas in rocky outcrops in a range of communities.

Cheilanthes caudata R. Br.
(Fig. 14B, C)

Cheilanthes caudata R. Br., Prodr. 156 (1810).

Type: Port II [Port Clinton, Qld], *R. Brown*; holo: BM.

Cheilanthes pinnatifida D.L. Jones, Austrobaileya 2: 472 (1988).

Type: Lightning Dreaming, Arnhem Land, N.T., *D.L. Jones 1478*; holo: DNA; iso: BRI, CANB, MEL.

Fronds to 55 cm long, stipe and rachis reddish brown or sometimes blackish, glabrous or sparsely hairy, the hairs eglandular. Lamina ovate to oblanceolate or triangular to narrowly triangular, 6–22 cm long, 3.5–14 cm wide, 3-pinnate or 4-pinnatifid at base but 2-pinnate for most of its length. Largest pinnae to 8 cm long; largest pinnules narrowly oblong or somewhat lanceolate, 10–37 mm long, 1.5–5 mm wide, their margins entire to pinnatifid, the upper and lower surfaces glabrous or with a few very short eglandular hairs. Spores variously spiny, either spherical and 16 per sporangium or tetrahedral, trilete and 32 per sporangium. Fertile plants: Jan.–May.

Distribution. Northern Australia (W.A., N.T., Qld) and perhaps New Caledonia (p.74).

Habitat. Commonly growing between rocks and in crevices in rainforest and vine thickets and in shaded situations in woodland. Also recorded from the edge

Fig. 14. A. *Cheilanthes brownii*: fertile mid-pinna (Dunlop 6757). **B, C.** *Cheilanthes caudata*: **B**, frond; **C**, fertile lower surface of a mid-pinna (**B, C**, Jones 1462). **D-F.** *Cheilanthes contigua*: **D**, frond; **E**, mid-pinna, lower surface; **F**, basal pinnule, upper surface (**D-F**, Russell-Smith 5289). **G-H.** *Cheilanthes fragillima*: **G**, mid-pinna, lower surface; **H**, pinna, upper surface displaying the typical stiff, pointed hairs (**G, H**, Russell-Smith 5359). **I-L.** *Cheilanthes lasiophylla*: **I**, frond; **J**, scale from rachis; **K**, lower surface of fertile pinna; **L**, branching hair from rachis (**I-L**, Chippendale A2606). **M, N.** *Cheilanthes nitida*: **M**, frond (Brennan 840); **N**, basal pinna, lower surface (Russell-Smith 7170). Scale bars: **D** = 3 cm, **M** = 2 cm, **B, C, E, G, I, N** = 1 cm, **A, F, H, J, K** = 1mm, **L** = 0.1 mm.

of streams and in marshy ground dominated by Restionaceae.

Cheilanthes contigua Baker

(Fig. 14D–F)

Cheilanthes contigua Baker in Hook. and Baker, Syn. fil. 2nd ed., 476 (1874).

Type: Port Darwin, *Schultz 35*; holo: K.

Fronds to 65 cm long, stipe dark reddish brown, glabrous or with a sparse to dense indumentum of short hairs and some narrow scales, the rachis with a mix of short eglandular hairs and long hairs and narrow scales. Lamina ovate to ovate-lanceolate or triangular to narrowly triangular, 6–30 cm long 5–20 cm wide, 3- or 4-pinnate at base, but 2-pinnate for most of its length. Largest pinnae somewhat ovate, elliptic or triangular, to 18 cm long but usually less than 10 cm; pinnules close together, their surfaces with a sparse to conspicuous indumentum of short eglandular hairs which tend to be longer on the lower surface. Spores rounded-tetrahedral, granulose and trilete, with variable reticulate-echinate ornamentation, 32 per sporangium. Fertile plants: Dec.–July.

Distribution. Southern India east to New Guinea and northern Australia (W.A., N.T., Qld) and common in the Top End (p.74).

Habitat. Recorded from an array of habitats, including monsoon forest, vine thickets, the sandy banks of creeks, laterite mounds in *Melaleuca* swamps and open forest and woodland.

Notes. Details of the type specimen of *C. contigua* were originally given as "Port Darwin, N. Australia, R. Schomburgh (1869), No. 35". Quirk (1983) and Chambers and Farrant (1991, 1998a) have since given the date of collection as October 1869. However, the specimen should be attributed to Frederick Schultz, whose specimens were forwarded overseas by Schomburgh. This is clear from unpublished lists at Kew of specimens collected by Schultz from the Darwin region. Indeed the annotation "comm[unicated]: R. Schomburgh x/69" makes it clear that the date of October 1869 is also not the date of collection. In the list specimen 35 was recorded as "Cheilanthes tenuifolia Sw. var. (or a closely allied n. sp.)".

There is little to distinguish this taxon from *C. tenuifolia*, differences in pinnule shape, arrangement and hair distribution being tendencies rather than absolute, diagnostic differences, but in keeping with recent treatments it is here maintained as a distinct species. For further comments see under *C. tenuifolia*.

Cheilanthes fragillima F. Muell.

(Fig. 14G, H)

Notholaena fragilis Hook., Sp. fil. 5: 114 (1864), *non Cheilanthes fragilis* Hook.

Cheilanthes fragillima F. Muell., Fragm. 5: 123 (1866).

Type: Fitzmaurice River, Oct. 1855, *F. Mueller*; holo: MEL 503529.

Fronds to 50 cm long, stipe dark brown, commonly glabrous or almost so but some hairs and scales usually at the base and sometimes uniseriate, multiseptate, brownish hairs along the length of the stipe, the rachis dark reddish brown and with white, straight, pointed hairs. Lamina shallowly deltate to triangular or widely depressed ovate to ovate, 5–28 cm long 5–20 cm wide, 3- or 4-pinnate at base and grading to 1-pinnate at the apex. Largest pinnae shallowly deltate to triangular, to 8 cm long; pinnules with margins and both surfaces with an indumentum of white, straight, rigid, pointed hairs. Spores rounded-tetrahedral, granulose and trilete, with variable reticulate-echinate ornamentation, 32 per sporangium. Fertile plants: Nov.–July.

Distribution. Endemic to northern Australia (N.T., W.A.) and widespread in northern N.T (p.74).

Habitat. Mostly recorded from eucalypt forest and *Allosyncarpia* forest in sandstone country.

Notes. Following Chambers and Farrant (1991), specimens such as *Bowman 363* and *Jones 1685* from Melville Island and others from Bathurst Island and parts of the mainland which "morphologically … appear to be uncommon intermediates between" *C. contigua* and *C. fragillima* are here referred to *C. fragillima* by virtue of their possession of rigid, straight white hairs on the pinnae. They somewhat resemble *C. contigua* in that the pinnae also have short hairs on the upper surface. Although not consistently so, they also tend to have broader pinnules than other specimens referred to *C. fragillima*.

Cheilanthes lasiophylla Pic. Serm.

(Fig. 14I–L)

Notholaena canescens Kunze, Ind. sem. hort. Lips. 3 (1845), *nom. illeg.*, *non Cheilanthes canescens* Kunze, Linnaea 13: 143 (1839).

Cheilanthes lasiophylla Pic. Serm., Webbia 8: 209 (1951).

Type: Jardin de Leipzig (raised by chance from spores brought from Australia to the garden by L. Preiss), 1846, *G. Kunze*; lecto: K (Pic. Serm. *l.c.*, p. 207).

Notholaena lasiopteris F. Muell., J. Bot. (Hooker) 5: 105 (1853), *nom. nud.*

Fronds to *ca* 40 cm long, stipe and rachis dark reddish brown, with a prominent indumentum of branched hairs and scales. Lamina narrowly elliptic, lanceolate or linear, 7.5–33 cm long, 2.5–4.5 cm wide, 2-pinnate at base and for most of its length. Largest pinnae triangular or ovate, to 2.5 cm long; pinnules with the upper surface with a sparse to moderately dense indumentum of slender, branched hairs, the lower surface with a dense indumentum of hairs and some scales. Spores spherical, granulose and ridged, surface variably reticulate, 16 per sporangium. Fertile plants: throughout the year.

Distribution. Australia (all mainland states). In the N.T. restricted to the southern region (p.74).

Habitat. In crevices and shaded areas of rocky outcrops.

Cheilanthes nitida (R. Br.)

(Fig. 14M, N)

Pteris nitida R.Br., Prodr. 155 (1810).

Cheilanthes nitida (R. Br.) P.S. Green, Kew Bull. 43: 653 (1988).

Type: tropical Australia, *R. Brown*; holo: not traced; Port Darwin, *Schultz 796*; neo: K (see P.S. Green 1988).

Acrostichum pteroides R. Br., Prod. 145 (1810).

Neurosoria pteroides (R. Br.) Mett., Bot. Zeitung (Berlin) 27: 438 (1869), *non Cheilanthes pteroides* Sw.

Type: North Coast Island, *R. Brown Iter Austral. 3*; holo: BM.

Fronds to *ca* 40 cm long, stipe and rachis dark reddish brown, mostly glabrous except for scales and hairs near the base. Lamina oblong or ovate, 4–18 cm long 4–8 cm wide, usually 2-pinnate, rarely 3-pinnate at the base and 1- or 2-pinnate for most of its length. Largest pinnae to 7 cm long; pinnules linear and mostly ten times longer than wide, margins entire or sometimes shallowly lobed, upper surface glabrous, lower surface glabrous or with the midrib sparsely hairy. Spores tetrahedral, granulose and trilete, with variable echinate ornamentation, 32 per sporangium. Fertile plants: Dec.–June.

Distribution. Northern Australia (N.T., Qld) (p.74).

Habitat. Recorded from *Allosyncarpia* forest and vine thickets in sandstone country and also from seasonally wet areas in woodland with dominants such as *Callitris intratropica*, *Livistona humilis* and *Eucalyptus miniata*.

Cheilanthes nudiuscula (R. Br.)

(Fig. 15A–C)

Pteris nudiuscula R. Br., Prodr. 155 (1810).

Cheilanthes nudiuscula (R. Br.) T. Moore, Index. Fil. 249 (1860).

Type: tropical coast of Australia, *R. Brown Iter Austral. 60*; holo: BM.

Pteris hirsuta Poir. *in* Poir. and Lama., Encycl. 5: 719 (1804).

Cheilanthes hirsuta (Poir.) Mett., Farngatt. 3: 69 (1859), *nom. illeg.*, *non* Link (1833).

Type: locality and date unknown, *P. Sonnerat*; holo: P.

Fronds to *ca* 30 cm long, stipe dark reddish brown, with a conspicuous indumentum of hairs and scales; rachis with some scales and prominently hairy, the longest hairs *ca* 1 mm long, septate, glandular. Lamina elliptic to lanceolate or somewhat linear, 3–20 cm long, 2–5 cm wide, 2- or 3-pinnate at base, but 2-pinnate for most of its length. Largest pinnae to 3 cm long; pinnules oblong or triangular, margins entire or lobed, upper surface glabrous or with a sparsely hairy, lower surface with a sparse to dense indumentum of hairs about the same length as those on the upper surface. Spores spherical, granulose and ridged, with variable amounts of echinate ornamentation, 16 per sporangium. Fertile plants: Jan.–July.

Distribution. Hong Kong south to the Philippines, New Caledonia, Fiji, Timor and Australia (W.A., N.T., Qld) (p.74).

Habitat. Recorded from a range of moist habitats, including woodland, lancewood thickets, rocky vine thickets and under rocks on a coastal cliff.

Notes. Chambers and Farrant (1991, 1998a) recorded that the hairs on the lower surface of the pinnules are longer than those on the upper surface, but in some specimens determined by them, the hairs are about the same length on both surfaces.

This species, as much as any, highlights the difficulty in delimiting taxa in *Cheilanthes*. Seven specimens housed in DNA were determined by Farrant and Chambers as being of *C. nudiuscula*, another seven were deemed to be "unusual forms" or "atypical" *C. nudiuscula*. All have been used to compile the description and are included in the distribution map.

Cheilanthes praetermissa D.L. Jones

(Fig. 15D)

Cheilanthes praetermissa D.L. Jones, Austrobaileya 2: 472, fig. 2 e, d. (1988).

Type: near Mt Howship, East Alligator River area, 19 Feb. 1984, *D.L. Jones 1443*; holo: DNA; iso: BRI, CANB, MEL.

Fronds to *ca* 40 cm long, stipe and rachis dark reddish brown, glabrous or with a sparse indumentum of hairs and scales. Lamina somewhat triangular or ovate, 4–17 cm long 2.5–13 cm wide, 2-pinnate or 3-pinnatifid at base, but 2-pinnate for most of its length, leathery. Largest pinnae somewhat triangular, to 7 cm long; basal pinnae unequally basiscopically divided; all pinnae and some pinnules with the undersurface with a dark midvein extending part of their length but other venation generally obscure, their surfaces tending to be obviously discolorous, the upper darker than the lower, both surfaces usually glabrous or almost so. Spores rounded-tetrahedral, granulose and trilete, with sparse reticulate-echinate ornamentation, 32 per sporangium. Fertile plants: Dec.–June.

Distribution. Endemic to the Top End of N.T. or possibly also extending (*Fl. Australia* vol. 48: map 256) into the Kimberley Region of W.A (p.74).

Habitat. Recorded from crevices of both granite and sandstone rock. Recorded from *Allosyncarpia* forest but mostly gathered from eucalypt woodland.

Notes. On pinnae and pinnule shape probably most likely to be confused with *C. pumilo* but the comparatively thick pinnae and obscure minor venation

Fig. 15. A-C. *Cheilanthes nudiuscula*: **A**, frond; **B**, lower surface of pinna; **C**, hair from pinna (**A-C**, Latz 10530). **D.** *Cheilanthes praetermissa*: frond, lower surface (Jones 1435). **E, F.** *Cheilanthes pumilio*: **E**, frond, lower surface; **F**, fertile pinna (**E, F**, Byrnes 676). **G.** *Cheilanthes sieberi* subsp. *sieberi*: frond, lower surface (Henshall 1977). **H.** *Cheilanthes sieberi* subsp. *pseudovellea*: frond, lower surface (Henshall 174). **I, J.** *Cheilanthes tenuifolia*: **I**, frond; **J**, pinnule, lower surface (**I, J**, Dunlop 6877). Scale bars: **I** = 2 cm, **A, D, E** = 1 cm, **G** = 2 mm, **B, F, H, J** = 1 mm, **C** = 0.1 mm.

distinguish it from that species. The specimen *Jones 1428* has pinnae and pinules of similar shape to this species but instead of being glabrous, pinnules have a prominent indumentum of short hairs. According to a determinavit slip added by Farrant it has close affinities with *C. contigua*.

Cheilanthes pumilio (R. Br.) F. Muell.

(Fig. 15E, F)

Notholaena pumilio R. Br., Prod. 146 (1810).

Pteris pumilio Banks and Sol., *ined.*

Cheilanthes pumilio (R. Br.) F. Muell., Syst. census Austral. pl. 138 (1882).

Type: Endeavour River, Qld, *J. Banks* and *D. Solander*; holo: BM; iso: NSW.

Notholaena paucijuga Baker in Hook. and Baker, Syn. fil. 2nd ed, 515 (1874).

Type: Port Darwin, communicated by R. Schomburgh; holo: K.

Cheilanthes cavernicola D.L. Jones, Austrobaileya 2: 469, fig. 1 (1988).

Type: Oenpelli area, Arnhem Land, N.T., 12 June 1978, *T.S. Henshall 1951*; holo: DNA; iso: AD, BRI.

Cheilanthes dunlopii D.L. Jones, Austrobaileya 2: 470, fig. 2 a, b. (1988).

Type: Keep River NP, 3 Mar. 1981, *C.R. Dunlop 5838*; holo: DNA.

Fronds to 50 cm long, stipe and rachis dark reddish brown, glabrous or with a sparse to conspicuous indumentum of scales and eglandular hairs. Lamina triangular or ovate, 3.5–22 cm long, 3–12 cm wide, 1–3-pinnate at base, but 1-pinnate or 2-pinnatifid for most of its length, thin and somewhat membranous. Largest pinnae ovate to lanceolate or triangular, to 8 cm long; lowest pinnae often unequally basicopically divided; all pinnae and pinnules with conspicuous venation, hydathodes usually present, surfaces concolorous or almost so, glabrous or sparsely to densely hairy, the hairs short to long, with cottony hairs absent, sparsely distributed or sometimes in large numbers. Spores granulose and echinate, either spherical and 16 per sporangium or rounded-tetrahedral and trilete and 32 per sporangium. Fertile plants: throughout the year.

Distribution. Northern Australia (W.A., N.T., Qld) (p.74).

Habitat. Often in sandstone country, including vine forest thickets and *Allosyncarpia* forest but also recorded from forest on laterite, along stream banks and from amongst mudstone boulders near the sea.

Notes. As with the type specimen of *C. contigua* (see note under that species), the type of *C. paucijuga* was presumably collected by Schultz.

A polymorphic taxon characterised by the membranous texture of the pinnae and the clearly evident venation. The vestiture is extremely variable with specimens, such as the one illustrated, with a prominent cover of cottony hairs once being referred to *C. cavernicola*.

Cheilanthes sieberi Kunze

Cheilanthes sieberi Kunze in Lehm., Pl. Preiss. 2: 112 (1847).

Cheilanthes tenuifolia var. *sieberi* (Kunze) Hook.f., Handb. N. Zeal. fl. 362 (1867).

C. tenuifolia subsp. *sieberi* (Kunze) Domin, Biblioth. Bot. 85: 140 (1915).

Type: York, *Preiss 1304*; lecto: BM; isolecto: P, *fide* Quirk *et al.*, Austral. J. Bot. 31: 517, 520 (1983).

Fronds to 55 cm long, stipe and rachis dark brown or reddish brown, glabrous or with scales and a sparse to moderately dense indumentum of hairs which may be twisted and glandular. Lamina ovate to linear lanceolate, 4.5–25 cm long, 2–5.5 cm wide, 3-pinnate at base and grading to 1-pinnate at the apex, often 2-pinnate for much of its length. Largest pinnae ovate or triangular, to *ca* 3 cm long; pinnules incised and their margins inrolled and partly covering the sori, surfaces glabrous or with twisted hairs. Spores spherical, with wart-like outgrowths, either black and 16 per sporangium or brown and 32 per sporangium. Fertile plants: throughout the year.

Key to subspecies of *C. sieberi*

1a. Surfaces of pinnules glabrous and lacking twisted hairs .... subsp. *sieberi*

1b. Surfaces of pinnules with an indumentum of twisted hairs .... subsp. *pseudovellea*

Cheilanthes sieberi subsp. *sieberi*

(Fig. 15G)

Rachis and rachillas glabrous or with a sparse to conspicuous indumentum of scales and hairs. Pinnules with the upper surface glabrous, the lower surface glabrous or with few hairs.

Distribution. Australia (all states and mainland territories plus Lord Howe Island), New Caledonia and New Zealand (p.74).

Habitat. Common in sheltered areas on rocky outcrops and in shrubland, e.g. in the shade of mulga shrubs and under tussocks of *Triodia*.

Cheilanthes sieberi subsp. *pseudovellea* Quirk and Chambers

(Fig. 15H)

Cheilanthes pseudovellea (H.M.Quirk and T.C. Chambers) D.L. Jones, Austrobaileya 2: 479 (1988).

Cheilanthes sieberi subsp. *pseudovellea* H.M.Quirk and T.C.Chambers, Austral. J. Bot. 31: 522 (1983).

Type: 20 km N of Mt Isa Waterhole, Qld, Feb. 1977, *T. Farrell*; holo: MEL 829830.

Rachis and rachillas with a moderate to dense indumentum of twisted hairs. Pinnules with both surfaces with twisted hairs, mostly denser on the under surface.

Distribution. Central Australia (?W.A., N.T., S.A., Qld, N.S.W.) (p.74).

Habitat. Essentially as with subsp. *sieberi* although Jones (1988) noted that, although they may grow together, subsp. *pseudovellea* is often in drier situations than that taxon.

Cheilanthes tenuifolia (Burm.f.) Sw.

(Fig. 15I, J)

Trichomanes tenuifolia Burm.f., Fl. Ind. 237 (1768).

Cheilanthes tenuifolia (Burm.f.) Sw., Syn. fil. 129, 332 (1806).

Type: Sri Lanka, *N.L. Burman*; holo: G 1416.

Fronds to *ca* 70 cm long, stipe and rachis dark reddish brown, glabrous or with a sparse indumentum of hairs and narrow scales. Lamina somewhat triangular, pentagonal or ovate 9–35 cm long 8–20 cm wide, 3- or 4-pinnate at base, but 2- or 3-pinnate for most of its length. Largest pinnae somewhat triangular, to 15 cm long; pinnules usually well-spaced and their surfaces glabrous or with a few, scattered short, eglandular hairs. Spores tetrahedral or rounded-tetrahedral, granulose and trilete, with variable reticulate-echinate ornamentation, 32 per sporangium. Fertile plants: Nov.–May.

Distribution. Ranges from India, Sri Lanka and Nepal east to southeast Asia, Australia (?W.A., N.T., Qld) and various Pacific islands. In the N.T. confined to the northern region (p.74).

Habitat. Occurs in a variety of habitats, including coastal and inland monsoon forest and vine thickets, woodland, and the edge of paperbark swamps.

Notes. This species and *C. contigua* have identical spore morphologies and it can be difficult to distinguish between the two. Indeed, at DNA there are specimens determined by Farrant as being *C. contigua* "but close to *C. tenuifolia*" (and vice versa). The two names, *C. tenuifolia* and *C. contigua* are here maintained.

Doryopteris J. Sm.

Ferns terrestrial or lithophytic. Rhizome short- to long-creeping, with bicolorous scales. Fronds monomorphic or sometimes dimorphic, the fertile ones with narrower segments and often a more complex lamina. Stipes shiny, brown or black, with basal scales. Lamina simple or pinnatifid and appearing palmate, leathery, glabrous; veins free or anastomosing but only the major blackish veins visible. Sori marginal or nearly so and more or less continuous, protected by the reflexed, membranous margins of the lamina. Spores trilete, tetrahedral-globose, plain or ornamented.

Pantropical genus with perhaps 25 species, most of which occur in Brazil. Two species in Australia, but only *D. concolor* in the N.T.

Doryopteris concolor (Langsd. and Fisch.) Kuhn

(Fig. 16A)

Pteris concolor Langsd. and Fisch., Icon. fil. 19, t. 21 (1810).

Doryopteris concolor (Langsd. and Fisch.) Kuhn in Decken, Reisen. Ost. Afr., Bot. 3(3): 19 (1879).

Type: Nuku Hiva, Marquesas Archipelago, *G.H. von Langsdorff*; holo: ?LE; iso: B (herb. Willdenow 1996–1), *fide* R.M. Tryon and R.G. Stolze, Fieldiana Bot., n.s. 22: 31 (1989).

Rhizome short-creeping; scales narrowly triangular, 1.5–2.5 mm long, discolorous, with brown axes and pale margins, the margins entire or inconspicuously toothed. Fronds monomorphic or almost so, 6–25 cm long, somewhat crowded. Stipes 3.5–20 cm long, dark reddish-brown, with two very narrow wings for much of its length. Lamina broadly triangular in outline, 2.5–10 cm long, 2–8.5 cm wide, tripartite and appearing palmate, each part 1- to 3-pinnatifid; rachis with scattered scales; veins except for the central vein of the largest segments invisible. Sori marginal and more or less continuous. Fertile plants: Nov.–July.

Distribution. A pantropical species (Australia: W.A., N.T., Qld) which in the N.T. is only known from the Top End (p.75).

Habitat. A fern of monsoonal forests, with all collections from sandstone country and often from *Allosyncarpia* forest.

Paraceterach (F. Muell.) Copel.

Ferns terrestrial or lithophytic. Rhizome short-creeping or suberect, with bicolorous scales. Fronds nearly monomorphic. Stipes shiny, brown or black, with concolorous scales. Lamina 1-pinnate (in Australia), with a dense indumentum of toothed scales; veins free, forking. Sori exindusiate, linear along veins, often concealed by the indumentum, forming a marginal band 1.5–3 mm wide. Spores trilete.

Ranging from the Canary Islands and southern Europe to Asia and Australia, this is a genus of seven species, two of which are confined to Australia and occur in the N.T.

The name *Notholaena* has been accepted as one that applies to a number of ferns inhabiting arid and seasonally dry habitats in many parts of the world and the genus was originally lectotypified with the Antillean *Pteris trichomanoides* L. Yatskievych and Smith (2003) noted that there have been attempts to overturn this lectotypification, with *Acrostichum marantae* L. proposed as the new lectotype, and that acceptance of this would mean that *Paraceterach* would become a synonym of *Notholaena* and the appropriate combination would be unavailable for *P. muelleri*. As argued by the authors, for the sake of nomenclatural stability the lectotypification should not be overturned.

Key to species of *Paraceterach*

1a. Pinna scales partly with long-ciliate margins .... *P. muelleri*

1b. Pinna scales with smooth or minutely denticulate margins .... *P. reynoldsii*

Paraceterach muelleri (Hook.) Copel.

(Fig. 16B, C)

Gymnogramma muelleri Hook., Spec. fil. 5: 143, t. 295 (1864), as *Gymnogramme.*

Paraceterach muelleri (Hook.) Copel., Gen. fil. 75 (1947).

Type: Fort Cooper, Qld, *E. Bowman 229*; iso: MEL.

Rhizome short-creeping; scales narrowly triangular, the middle thick and black, the narrow edges brown and membranous. Fronds 10–40 cm long, close together on the rhizome. Stipes brown to blackish, with a mostly dense indumentum of uniseriate hairs and narrowly triangular, whitish to pale brown scales with toothed to shortly ciliate margins. Lamina 1-pinnate, the three uppermost pinnae often but not always separated from each other; lateral pinnae widely ovate to lanceolate, 10–32 mm long, 7–17 mm wide, margins entire; scales of the lamina somewhat ovate to lanceolate, 1.2–2.5 mm long, 0.3–0.45 mm wide, usually broadest above the base, margins long-ciliate, the scales on the upper surface comparatively sparse and whitish and the green surface of the lamina clearly visible, those on the lower surface dense and pale brown and obscuring the surface of the lamina. Fertile plants: Jan.–Oct.

Distribution. Occurs in W.A., N.T. and Qld. In the N.T. most specimens are from the Victoria River district, with others from near Beswick and Wollogorang Station (p.77).

Habitat. Sheltered sandstone gorges and rock crevices, often in vine forest.

Paraceterach reynoldsii (F. Muell.) Tindale

(Fig. 16D)

Notholaena reynoldsii F. Muell., Fragm. 8: 175 (1874).

Paraceterach reynoldsii (F. Muell.) Tindale in J.M. Black, Fl. S. Austral. 3rd ed., 53 (1978).

Type: near the Olgas, central Australia, *W.C. Gosse*; ?holo: K (*fide* P. Bostock, *in litt.*).

Rhizome long-creeping; scales narrowly triangular, the middle thick and black, the edges brown and membranous. Fronds 6–30 cm long, close together on the rhizome. Stipes brown to blackish, with a sparse to dense indumentum of numerous uniseriate hairs and narrowly triangular to linear triangular, pale brown scales with entire or inconspicuously toothed margins. Lamina 1-pinnate, the two or three uppermost pinnae often not separated from each other; lateral pinnae widely ovate to ovate elliptic, 10–23 mm long, 4.5–13 mm wide, margins entire; scales of the lamina narrowly triangular to linear triangular, 0.8–1.7 mm long, 0.2–0.4 mm wide, margins entire or minutely denticulate, the scales on the upper surface whitish or pale brown and the lamina surface clearly visible, those on the lower surface pale brown and usually denser than those on the upper surface and sometimes obscuring the surface of the lamina. Fertile plants: Feb.–Oct.

Distribution. A species of arid Australia (W.A., N.T., S.A.), with all N.T. specimens from the southern region, e.g. at Mt Zeil, and Ellery, Joker and Ormiston gorges (p.77).

Habitat. Found in the shelter of rock shelves and crevices.

Pityrogramma Link

Ferns terrestrial or lithophytic. Rhizome erect or (not in Australia) creeping, with narrow, thin, concolorous scales with entire margins. Fronds monomorphic or almost so, the fertile being more erect. Stipes tufted, with basal scales. Lamina 2–4-pinnate, membranous or somewhat leathery, upper surface glabrous, lower surface whitish or yellowish and with short glandular hairs; veins free. Sori exindusiate, borne away from the margins along the length of the veins; paraphyses absent. Spores trilete, tetrahedral-globose, ornamented.

A genus of *ca* 16 species, with most native to tropical America and with several in Africa. One species, *P. calomelanos,* is naturalised in Australia.

Pityrogramma calomelanos (L.) Link var. *calomelanos*

(Fig. 16E)

Silver fern

Acrostichum calomelanos L., Sp. pl. 2: 1072 (1753).

Pityrogramma calomelanos (L.) Link, Handbuch 3: 20 (1833).

Type: South America; holo: LINN 1245.19, *fide* R.M.Tryon, Contr. Gray Herb. 189: 60 (1962).

Rhizome erect; scales linear, attenuate, brown. Fronds suberect to erect, to *ca* 90 cm tall, tufted. Stipe to *ca* 50 cm long, the few scales similar to those of the rhizome. Lamina to *ca* 40 cm long, 2-pinnate, the longest primary pinna *ca* 15 cm long; lower surface with a white waxy coating; veins obscure. Sporangia spreading over most of the lower surface at maturity. Fertile plants: June.

Distribution. Native to America, this species is now widely naturalised in many tropical regions with the var. *calomelanos* recorded from the N.T. and Qld. In the N.T. it is sometimes noted as a weed in plant nurseries although it was collected in 1977 from a cliff face at Lameroo Beach, Darwin, and is also known from near the Tomkinson River, south of Maningrida (p.77).

Habitat. Rainforest.

Fig. 16. A. *Doryopteris concolor*: frond with attached rhizome (Dunlop 8472). **B, C**. *Paraceterach muelleri*: **B**, frond; **C**, scale from pinna (**B, C**, Leach 2468). **D**. *Paraceterach reynoldsii*: scale from pinna (Orchard 820). **E**. *Pityrogramma calomelanos* var. *calomelanos*: part of frond (Henshall 1358). **F, G**. *Taenitis blechnoides*: **F**, frond with attached rhizome (Menkhorst 996); **G**, fertile pinna with continuous bands of sori (Russell-Smith 2061). **H, I**. *Taenitis pinnata*: **H**, frond with attached rhizome; **I**, fertile pinna showing sori along individual veins (**H, I**, Brennan 1570). Scale bars: **B, F, H** = 2 cm, **A, E, G, I** = 1cm, **C-D** = 0.2 mm.

Taenitis Willd. ex Schkuhr.

Ferns terrestrial. Rhizome creeping, with rigid bristles. Fronds monomorphic or dimorphic, fertile fronds often with narrower pinnae than the sterile fronds. Stipes dark, glossy, the upper side grooved, at least near the apex. Lamina generally simple when young and 1-pinnate when mature but sometimes simple lamina fertile, glabrous; pinnae entire, shortly stalked except for uppermost 1 or 2 pairs; veins anastomosing and forming oblique areolae without included veinlets. Sori exindusiate, spreading and discontinuous along individual veins or in almost continuous bands between the costa and margin of the pinna; indusium absent; paraphyses abundant, multicellular. Spores trilete, tetrahedral-globose, ornamented.

A taxonomically difficult genus with perhaps 15 species, distributed from India to southern China, Malesia, northern Australia (two species) and Fiji.

References: Holttum (1968), Bostock (1998a).

Key to species of *Taenitis*

1a. Sori in a single, almost continuous band between the margins and midrib .... *T. blechnoides*

1b. Sori discontinuous along individual veins .... *T. pinnata*

Taenitis blechnoides (Willd.) Sw.

(Fig. 16F, G)

Pteris blechnoides Willd., Phytographia 13, t. 9, fig. 3 (1794).

Taenitis blechnoides (Willd.) Sw., Syn. fil. 24: 220 (1806).

Type: South India, *D. Klein*; iso: B (herb. Willdenow), *fide* Holttum, Blumea 16: 90 (1968).

Rhizome with rigid, reddish brown, shiny bristles. Fronds 30–90 cm long, simple when young but otherwise 1-pinnate. Pinnae 4–15, linear-lanceolate or linear, 7–24 cm long, 1–3 cm wide, margins entire but sometimes somewhat undulate, occasionally one or more pinnae with up to 6 irregular lobes; fertile pinnae commonly manifestly narrower than the sterile ones. Sori in a single, almost continuous band which tends to be closer to the margin than to the costa. Fertile plants: throughout the year.

Distribution. Sri Lanka and southern India, east to Malesia, Australia (N.T., Qld), Fiji and Caroline Islands (p.78).

Habitat. A rainforest species often growing in swampy conditions, along creeklines and around springs.

Taenitis pinnata (J. Sm.) Holttum

(Fig. 16H, I)

Syngramma pinnata J. Sm., London J. Bot. 4: 168, t. 7, 8. (1845).

Taenitis pinnata (J. Sm.) Holttum, Kew Bull. 13: 453 (1959).

Type: Island of Jobia [= Japen], West New Guinea, *Barclay*; holo: K, *fide* Holttum, *l.c.*

Rhizome with rigid, reddish brown, shiny bristles. Fronds to 80 cm long, simple or 1-pinnate, simple lamina sometimes fertile. Pinnae 2–15, lanceolate to linear-lanceolate, 5–20 cm long, 1–3 cm wide; fertile pinnae the same width or only slightly narrower than the sterile ones. Sori scattered in irregular, oblique lines along the veins. Fertile plants: Oct.

Distribution. Northern Australia (W.A., N.T., Qld), New Guinea, Solomon Islands, Vanuatu, and Fiji. The only record from the N.T. is *Brennan 1570* from the upper regions of Magela Creek (p.78).

Habitat. The only specimen was collected from fissures in a sandstone rock face near a spring.

Notes. Holttum (1968) recognised three varieties and if his treatment is followed the N.T. specimens are referable to var. *pinnata*.

Measurements were based on the description provided by Bostock (1998a) and Brennan's collection consisting of fronds with only 2 or 3 lobes and simple fronds, one of which is fertile.

Parkeriaceae

A monogeneric family.

Reference: Lloyd (1994).

Ceratopteris Brongn.

Aquatic or subaquatic, may be free-floating; rhizome short, spongy and with translucent scales on the apex. Fronds in a rosette, dimorphic; stipes green, fleshy. Sterile fronds simple to 3-pinnate and with broad lobes. Fertile fronds up to 5-pinnate, more deeply dissected and with narrow lobes, with revolute margins covering the sporangia. Sporangia solitary, in 1–4 rows on the lower surface of the frond, large and shortly stalked, thin-walled. Spores trilete (tetrahedral), ridged.

Species delimitation in *Ceratopteris* is problematic, with one variable species to as many as 12 species having been recognised.

Ceratopteris thalictroides (L.) Brongn.

(Fig. 17A, B)

Acrostichum thalictroides L., Sp. pl. 2: 1070 (1753).

Ceratopteris thalictroides (L.) Brongn., Bull. Soc. Philom. Paris, ser. 3, 8: 186 (1822).

Type: Sri Lanka, *P. Hermann s.n.*; lecto: Herb. P. Hermann 3: 42 (BM 621957), *fide* Pich. Serm., Webbia 12: 651 (1957).

Plants amphibious, rooted. Fronds succulent. Sterile fronds 1–3 pinnate, 8–40 cm long, lobes broad. Fertile fronds erect, 2–4 pinnate, usually exceeding the sterile ones, 25–60 cm long, lobes linear. Plantlets sometimes developing on fronds. Fertile plants: throughout the year.

Distribution. A pantropical, highly polymorphic species (Australia: W.A., N.T., Qld, N.S.W.). In the N.T. it is widespread in the Top End and Gulf region.

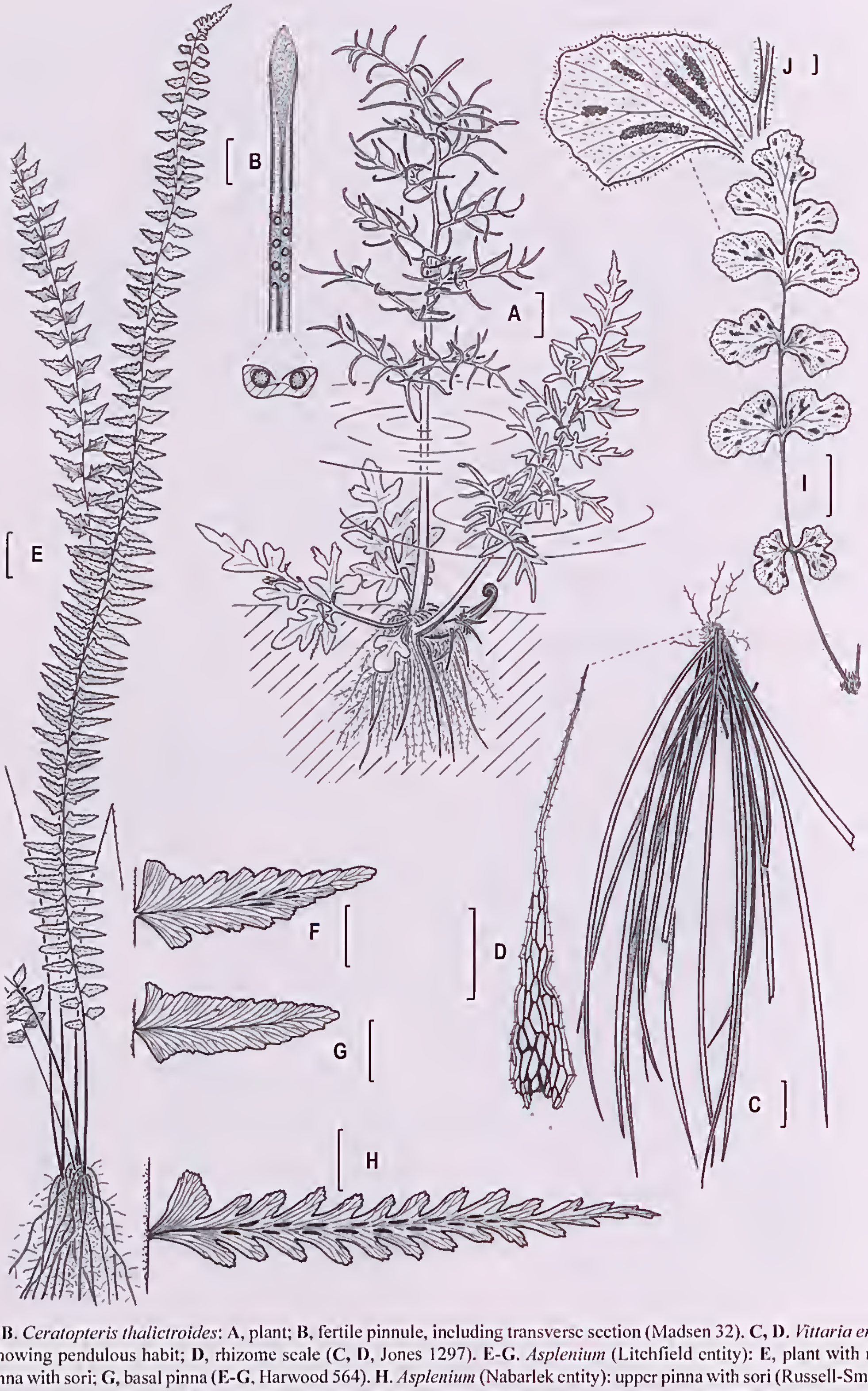

Fig. 17. A, B. *Ceratopteris thalictroides*: **A**, plant; **B**, fertile pinnule, including transverse section (Madsen 32). **C, D.** *Vittaria ensiformis*: **C**, plant, showing pendulous habit; **D**, rhizome scale (**C, D**, Jones 1297). **E-G.** *Asplenium* (Litchfield entity): **E**, plant with rhizomes; **F**, upper pinna with sori; **G**, basal pinna (**E-G**, Harwood 564). **H.** *Asplenium* (Nabarlek entity): upper pinna with sori (Russell-Smith 3875). **I, J.** *Pleurosorus subglandulosus*: **I**, frond, lower surface; **J**, pinna with exindusiate sori (**I, J**, Leach 2027). Scale bars: **E** = 4 cm, **A, C** = 3 cm, **F-I** = 1cm, **B** = 2 mm, **D, J** = 1 mm.

Localities include Bitter Springs (Mataranka), Cato River, Holmes Jungle, coastal plains near the mouth of Goromuru River, North Goulburn Island and floodplains of the Howard River (p.74).

Habitat. Grows on the margins of floodplains, swamps, billabongs and slow-flowing streams. In clay, sand or peaty substrate.

Notes. Lloyd (1974) recognised four species of *Ceratopteris* and indicated that some specimens "with an affinity to *C. cornuta*" have been collected from Australia. All Top End specimens examined appear to be referable to the one taxon, *C. thalictroides*.

Vittariaceae

Six to nine genera and *ca* 100 species worldwide. Three genera and nine species in Australia, but only one species in the N.T.

References: Andrews (1990), Kramer (1990c), Jones (1998b).

Vittaria Sm.

Plants epiphytic or lithophytic. Rhizome creeping and immersed in a mat of roots; scales narrow and attenuate. Fronds simple, entire, crowded or scattered. Stipe very short and barely defined from the lamina. Lamina narrowly elliptic, oblanceolate or linear, erect, curved or pendulous, leathery; veins indistinct. Sori exindusiate, linear along the submarginal vein, more or less in grooves; paraphyses common, unbranched or branched and usually with prominent terminal cells.

A genus of 50–80 species found in tropical and warm-temperate regions of the world. Many species are ill-defined. Two species in Australia, with only *V. ensiformis* in the N.T.

Vittaria ensiformis Sw.

(Fig. 17C, D)

Vittaria ensiformis Sw., Ges. Naturf. Freunde Berlin Neue Schriften 2: 134, t. 7, fig. 1 (1799).

Type: Mauritius, *P. Sonnerat*; holo: ?P.

Rhizome short, branched; roots covered in ginger hairs; scales narrowly triangular to linear triangular, 2.5–6 mm long, latticed, the central veins of the scales thick and blackish, the outer veins comparatively thinner and brown, the scale margins minutely toothed. Fronds crowded. Lamina linear, 5–50 cm long, 0.25–0.6 cm wide, erect when short but becoming pendulous, dark green, leathery, glabrous. Sori linear; sporangia mixed with branching paraphyses with club-shaped terminal cells. Fertile plants: Jan., May, Oct.

Distribution. In tropical and subtropical regions from southern Africa and Asia to Australia (N.T., Qld) and New Guinea. Confined to the Top End of the N.T., with most collections from the Tiwi Islands but also from Channel Island and Nabarlek (p.78).

Habitat. A rainforest species mostly collected as an epiphyte but also in sheltered rock crevices.

Aspleniaceae

A cosmopolitan family with all *ca* 700 species placed in *Asplenium*, or mostly in *Asplenium*, and a number of small, segregate genera. Following Brownsey (1998a) two genera, *Asplenium* and *Pleurosorus*, are recognised in Australia.

Reference: Brownsey (1998a).

Key to genera of Aspleniaceae

1a. Fronds lacking hairs or sometimes with scattered short hairs; sori indusiate .... *Asplenium*

1b. Fronds manifestly hairy; sori lacking an indusium .... *Pleurosorus*

Asplenium L.

Plants terrestrial or epiphytic (not N.T.). Rhizome erect or creeping. Fronds monomorphic or dimorphic (not N.T.). Clathrate (latticed) scales present on rhizomes and fronds. Lamina simple to 5-pinnate; veins free or sometimes anastomosing. Sori elongate along veins and distant from margins of the lamina, indusiate; indusia elongate and attached to veins. Spores monolete, the surface often echinate or reticulate.

A cosmopolitan genus of about 650 species, with Brownsey (1998a) recognising 30 as occurring in Australia. Since his treatment, two taxa have been collected in the N.T., neither of which seem to belong to other species so far recognised as occurring in Australia. Peter Bostock (*in litt.*) has indicated that both are unlikely to prove to be new species but new records for Australia. He has also suggested which names may apply (see below) to the entities but studies of type specimens and thorough revision of the complexes to which they belong is required before names can be applied with certainty.

Key to species of *Asplenium*

1a. Pinnae mostly doubly serrate rather than pinnatifid, the largest *ca* 55 mm long; sori *ca* 0.3 mm wide .... *Asplenium* (Litchfield entity)

1b. Pinnae mostly pinnatifid, the largest *ca* 90 mm long; sori *ca* 1 mm wide..................................... .... *Asplenium* (Nabarlek entity)

Asplenium (Litchfield entity)

(Fig. 17E–G)

Ferns with erect to pendent fronds, the largest *ca* 1 m long. Stipe and rachis pale brown to dark reddish brown, with scattered reddish-brown scales; stipe to *ca* 2 mm diam. Lamina linear, 1-pinnate, to *ca* 80 cm long and 9 cm wide, dark green above, pale green below. Proliferous buds present. Pinnae to *ca* 120 per frond, ovate to lanceolate, 14–55 mm long, 8–15 mm wide, largest pinnae about the middle of the frond, all pinnae sessile or barely stalked, basally with equal to somewhat unequal lobes, margins mostly doubly serrate, the lowest tending to be once-serrate, and apically subobtuse to acuminate, glabrous or with scattered scales. Sori 2–5.5 mm long, *ca* 0.3 mm wide. Fertile plants: Mar., Nov.

Distribution. Wangi Falls, Litchfield NP, N.T.(p.73).

Habitat. Rock faces of waterfall.

Notes. Peter Bostock (*in litt.*, 2002) has suggested that this entity may prove to be *A. longissimum* Bl., a fern otherwise known from south-east Asia (Holttum 1954). He also noted that the entity is in cultivation around Australia, particularly in Queensland.

Asplenium (Nabarlek entity)

(Fig. 17H)

Ferns with erect to pendent fronds, the largest *ca* 70 cm long. Stipe and rachis dark brown, scales scattered to obvious, especially on the rachis; stipe to *ca* 3 mm diam. Lamina linear, 1- or 2-pinnate, to *ca* 60 cm long and 17 cm wide. Proliferous buds not seen. Pinnae with the basal ones somewhat doubly serrate but most pinnatifid, ovate to lanceolate, 30–90 mm long, 12–15 mm wide, discolorous, the upper surface drying a darker brown than the undersurface, largest pinnae probably about the middle of the frond, all pinnae sessile and with scattered, branching scales; ultimate segments with the basal ones mostly manifestly unequal, apically serrate. Sori 1.5–5 mm long, *ca* 1 mm wide. Fertile plants: Oct.

Distribution. Near Nabarlek, N.T. (p.73).

Habitat. Rock crevices in a sandstone gorge.

Notes. Peter Bostock (*in litt.*, 2002) has suggested that this entity may prove to be *A. caudatum* G. Forst., a species otherwise known from south-east Asia and Polynesia (Holttum 1954).

Pleurosorus Fée

Plants lithophytic or terrestrial, with clathrate scales. Rhizome erect. Fronds monomorphic. Lamina 1- or 2-pinnate; veins free. Sori elongate along veins and distant from margins of the lamina, indusium absent. Spores monolete, ridged with a smooth surface.

Brownsey (1998a) referred three or four species to this genus, noting that there are major problems with both generic and species delimitation and that the distinction between the two taxa recognised here is likely to be artificial. Differences in spore size suggest that there may be two cytotypes within the complex but this seems not to correlate with the differences in hair type currently used to distinguish the taxa. As Brownsey noted, resolution of the problem requires study of the plants across their geographic range. I follow him and retain the current taxonomic treatment.

Key to species of *Pleurosorus*

1a. Indumentum of mostly or only eglandular hairs .... *P. rutifolius*

1b. Indumentum of stalked glandular hairs .... *P. subglandulosus*

Pleurosorus rutifolius (R. Br.) Fée

Blanket fern

Grammitis rutaefolia R. Br., Prodr. 146 (1810).

Pleurosorus rutifolius (R. Br.) Fée, Gen. fil. 180 (1852).

Type: Derwent, Risdon, Tas., *R. Brown Iter Austral. 7*; syn: BM, K.

Rhizome erect, with narrowly triangular scales. Fronds semi-erect, 5–13 cm long. Stipe and rachis with a dense indumentum of eglandular hairs, *ca* 0.5–1 mm long, occasionally a few stalked glandular hairs also present. Lamina 1- or 2-pinnate, mostly elliptic to narrowly elliptic, 4–8 cm long, 1.5–4 cm wide. Primary pinnae 7–15, ovate to widely ovate or sometimes elliptic or obovate, 7–20 mm long, 4–12 mm wide, basally equally or unequally cuneate, shortly stalked; margins entire or coarsely dentate, largest pinnae near the middle of the frond. Secondary pinnae 3–5 mm long. Sori 1–3.5 mm long. Fertile plants: Mar.–Nov.

Distribution. New Zealand and Australia (all states and territories), with localities in the N.T. including Palm Valley, Mt Gillen, and Emily, Jessie and Simpsons gaps (p.77).

Habitat. Rocky slopes.

Pleurosorus subglandulosus (Hook. and Grev.)

(Fig. 17I, J)

Blanket fern

Gymnogramma subglandulosa Hook. and Grev., *Icon. fil.* 1: pl. 91 (1828).

Pleurosorus subglandulosus (Hook. and Grev.) Tindale, Victorian Naturalist 73: 169 (1957).

Type: New Holland, *Fraser*; holo: K.

Rhizome erect, with narrowly triangular scales. Fronds semi-erect, 5–13 cm long. Stipe and rachis with a dense indumentum of stalked, glandular hairs, the largest *ca* 0.2 mm long. Lamina 1- or 2-pinnate, mostly elliptic to narrowly elliptic, 3–9 cm long, 1.5–3.5 cm wide. Primary pinnae 7–18, ovate to widely ovate or sometimes elliptic or obovate, 5–15 mm long, 2–13 mm wide, basally commonly unequally cuneate, shortly stalked; margins entire or coarsely dentate, largest pinnae near the middle of the frond. Secondary pinnae 3–5 mm long. Sori 1–6 mm long. Fertile plants: May–Nov.

Distribution. Australian endemic (W.A., N.T., S.A.). Localities in the N.T. include Giles Spring, Mt Winter, and Hugh and Ormiston gorges (p.77).

Habitat. Sheltered rocky areas, particularly areas with seepage.

Thelypteridaceae

A mainly tropical family with perhaps 30 genera and 1000 species (Australia ten genera and *ca* 22 species). *Ampelopteris*, *Sphaerostephanos* and *Christella* are sometimes included in *Cyclosorus* but, at least partly to maintain consistency with the *Flora of Australia*, they are retained here.

A sterile specimen of a species of this family has been collected from Humpty Doo (*Wightman 1777*). It has sessile orange glands and papery scales and as such will key to *Cyclosorus* in the following key but is clearly not of *C. interruptus*. The highly divided pinnae suggest that it is a species of *Thelypteris*. Attempts to relocate the taxon have failed, and as it may not be native it is not treated further.

References: Holttum (1981), Smith (1990), Bostock (1998b).

Key to genera of Thelypteridaceae

1a. Lamina 3-pinnatifid and with long, uniseriate, septate hairs on the lower surface .... *Macrothelypteris*
1b. Lamina 1-pinnate or 1-pinnatifid; long, uniseriate, septate hairs absent 2
2a. Sori lacking indusia .... *Ampelopteris*
2b. Sori with indusia 3
3a. Lower surface of pinnae lacking sessile, spherical glands .... *Christella*
3b. Lower surface of pinnae with sessile, spherical yellow, brown or orange glands 4
4a. Lower surface of costae with broad, papery scales .... *Cyclosorus*
4b. Lower surface of costae lacking broad, papery scales .... *Sphaerostephanos*

Ampelopteris Kunze

Rhizome creeping, scaly. Fronds 1-pinnate, of two types, those with terminal pinnae and those with indefinite apical growth and bearing axillary buds which develop into new fronds. Rachis with forked, unicellular hairs. Pinnae shallowly lobed; veins mostly anastomosing. Sori circular or oblong; indusium absent. Sporangia stalks bearing hairs which terminate in a globular gland.

Monotypic genus found in tropical regions from West Africa to New Caledonia.

Ampelopteris prolifera (Retz.) Copel.

(Fig. 18A)

Hemionitis prolifera Retz., Observ. bot. 6: 38 (1791).

Ampelopteris prolifera (Retz.) Copel., Gen. fil. 144 (1947).

Type: southern India, J.G. König; holo: GOET.

Rhizome short-creeping, *ca* 1 cm diam., densely scaly when young; scales ovate, brown, 1–2 mm long, 0.5–0.8 mm wide. Stipe and rachis with scattered scales and few to numerous and minute forked hairs. Lamina of fronds of indeterminate growth up to several metres long and with linear pinnae (not seen). Lamina of determinate growth with shortly stalked pinnae; pinnae lanceolate, 2–8 cm long, 0.5–1.8 cm wide, margins shallowly lobed, mostly glabrous except for scattered uniseriate hairs on the veins and margins and occasionally with scattered, brown, scales; basally truncate or broadly cuneate and the basal lobes symmetrical or asymmetrical; margins shallowly lobed. Sori somewhat circular or oblong along the veins. Fertile plants: Sept., Oct.

Distribution. Tropical regions of West Africa east to Australia (W.A., N.T., Qld.) and New Caledonia. In the N.T. scattered throughout the northern half and occurring as far south as Siegal Creek (Calvert Hills Stn) (p.73).

Habitat. Riparian rainforest, springs, the edges of lagoons, and rainforest bordering on floodplains.

Christella H. Lév.

Rhizome creeping or erect; scales usually narrow and bearing superficial hairs. Fronds 1-pinnate, not bearing axillary buds. Pinnae lobed, commonly the 1–5 lower pairs of pinnae gradually decreasing in size towards the base of the frond, an acroscopic basal lobe often present; aerophores at base of pinnae not swollen; erect eglandular hairs and sometimes glandular hairs present on the lower surface but sessile spherical glands absent; usually at least the basal veins anastomosing. Sori subcircular or subreniform, indusiate. Sporangia stalks with unicellular, elongate, glandular hairs but distal regions lacking hairs. Spores tuberculate or ridged.

Genus of *ca* 50 species with all but one in the warmer parts of the Old World. Five species in Australia but only one in the N.T.

Christella dentata (Forssk.) Brownsey and Jermy

(Fig. 18B, C)

Polypodium dentatum Forssk., Fl. aegypt.-arab. 185 (1775).

Christella dentata (Forssk.) Brownsey and Jermy, Brit. Fern. Gaz. 10: 338 (1973).

Type: Arabia, *P. Forsskål*; holo: C.

Rhizome short-creeping; scales triangular to narrowly triangular, reddish-brown. Fronds 20–90 cm long, pilose. Stipe 5–50 cm long, glabrous to hairy. Rachis hairy, hairs *ca* 0.2–0.6 mm long. Lamina *ca* 50 cm or more long, 1-pinnate, with 15–25 pairs of sessile pinnae. Pinnae narrowly triangular or lanceolate in outline, 2–10 cm long, 0.7–2.5 cm wide, mostly obtusely lobed about ½ to 2/3 the way towards the costa, the uppermost not lobed; basal pinnae progressively reduced towards the base of the frond and more widely spaced along the rachis than the upper pinnae, often with a prominent acroscopic basal lobes. Sori subreniform, mostly medial, 1–12 per pinna-lobe, each covered by a prominently hairy, thin indusium. Fertile plants: throughout the year.

Distribution. Widespread in subtropical and tropical regions of the Old World and in Australia in all mainland States; introduced in the New World. Most N.T.

Fig. 18. A. *Ampelopteris prolifera*: upper part of frond, with enlargements showing venation and position of sori (Latz 10369). **B, C.** *Christella dentata*: **B**, basal part of frond with enlargement showing sori on the lower surface; **C**, stalked glandular hair from lower surface of pinna (**B, C**, Thomson 3542). **D, E.** *Cyclosorus interruptus*: **D**, frond and rhizome; **E**, enlargement of lower surface of pinna showing sori, scales and spherical glands (**D, E**, *Menkhorst 852*). **F.** *Sphaerostephanos heterocarpus*: lower surface of pinna with an enlargement showing spherical glands and a sorus with the indusium almost obscured by the sporangia (Barritt 1235). **G.** *Sphaerostephanos unitus* var. *unitus*: pinna, with enlargements showing venation, position and shape of sori, and spherical glands (Russell-Smith 6151). Scale bars: **D** = 3 cm, **A, B, G** = 2 cm, **F** = 1mm, **C** = 0.05 mm.

collections are from the northern region, with a single collection coming from Chewings Range in the south (p.74).

Habitat. Perennial seepage areas on rock faces and the edge of watercourses.

Cyclosorus Link

Rhizome long-creeping. Fronds with lowest pinnae not markedly reduced, all pinnae lobed and with basal veins uniting and running to a sinus; under-surface with broad flat scales and orange to red spherical glands. Sori subreniform, indusiate. Sporangia devoid of hairs and glands on body but long hairs with terminal glands on sporangium-stalks. Spores closely and irregularly spinulose.

A pantropical genus with perhaps three species, with one in Australia.

Cyclosorus interruptus (Willd.) H. Itô

(Fig. 18D, E)

Pteris interrupta Willd., Phytographia 13, t. 10, fig. 1 (1794).

Cyclosorus interruptus (Willd.) H. Itô, Bot. Mag. (Tokyo) 51: 714 (1937).

Type: southern India, *Klein*; holo: B (herb. Willdenow 19770).

Rhizome long-creeping, sparsely covered with scales. Fronds with lamina commonly 30–50 cm long, pinnae 15–25 pairs, the largest pinnae 9–13 cm long, 0.9–1.5cm wide, under surface with orange glands, scattered scales and a sparse to dense indumentum of white eglandular hairs. Sori initially circular but often coalescing into rows. Indusia small and often inconspicuous, bearing hairs. Fertile plants: Apr.–Aug.

Distribution. Tropical and subtropical regions of Africa, Asia and Australia (W.A., N.T., Qld, N.S.W.). In the N.T. widespread in the Top End and also occurring in the southern region. Localities include Holmes Jungle, Mallapunyah Spring, North and Vanderlin Islands (Sir Edward Pellew Group) and the Daly River floodplain in the north and Kathleen Spring and Reedy Rockhole (George Gill Range) in the south (p.75).

Habitat. Commonly grows at permanent springs and in *Melaleuca* forest, but sometimes in swamps and on floating mats. Commonly in sandy or organic substrates.

Macrothelypteris (H. Itô) Ching

Rhizome short and creeping, with narrow scales. Stipe with scales at the base. Fronds 2-pinnate to 3-pinnatifid. Rachis and costa with slender, multicellular, eglandular hairs and short capitate hairs. Pinna rachis not grooved on the upper surface. Pinnules mostly adnate to the rachis of the pinna; with slender, uniseriate, septate hairs and some short, glandular hairs; veins free and forking but not reaching the margins of the segments. Sori circular and not terminal on the veins; indusium present. Sporangia with a few shortly stalked glandular hairs. Spores with a fine surface reticulum and slightly winged.

A genus of *ca* 10 species, with two in Australia but just *M. torresiana* in the N.T.

Macrothelypteris torresiana (Gaudich.) Ching

(Fig. 19A, B)

Polystichum torresianum Gaudich. *in* Freyc., Voy. Uranie 8: 333 (1828).

Macrothelypteris torresiana (Gaudich.) Ching, Acta Phytotax. Sin. 8: 310 (1963).

Type: Marianas Island, *G. Gaudichaud-Beaupré*; holo: P, iso: G.

Rhizome to *ca* 1 cm diam. Fronds to 120 cm, pale green. Stipe to 50 cm long, its base persistent and covered with narrow, brown scales but otherwise smooth. Lamina deeply 3-pinnatifid, to 70 cm long and 50 cm wide; subbasal pinnae the longest, to 20 cm long; ultimate segments to 20 mm long and 5 mm wide; the aciculate, white hairs 0.5–1.2 mm long. Sori *ca* 1 mm diam, each with *ca* 15–20 sporangia; indusium small and often obscured by mature sporangia. Fertile plants: Sept.

Distribution. From the Mascarene Islands east to Australia (W.A., N.T., Qld, N.S.W.) and islands in the Pacific. In the N.T. only known from a single specimen, *Trainor 184*, collected at Camel Creek, on Wollogorang Station (p.76).

Habitat. The only collection was obtained from around a small spring and cliffline seepage along Camel Creek gorge.

Note. As the single specimen consists only of part of a fertile frond this description is partly based on that presented by Holttum (1977).

Sphaerostephanos J. Sm.

Rhizome creeping or erect; scales bearing acicular hairs. Fronds 1-pinnate, not bearing axillary buds. Pinnae lobed, the lower pairs of pinnae abruptly decreasing in size towards the base of the frond; lower surface usually with antrorse acicular hairs and also with sessile, orange or yellow, spherical glands; usually at least 1 pair of basal veins anastomosing. Sori subreniform, indusiate, confined to lobes of pinna, in slight depressions. Sporangia often with yellow glands distally, sometimes with bristles, often the stalk with gland-tipped hairs. Spores usually with small wings.

A genus of *ca* 180 species which extends from east Africa through Asia to the Pacific, with one species reaching Tahiti. Two species in Australia.

Key to species of *Sphaerostephanos*

1a. Rhizome erect, plants growing in forests .... *S. heterocarpus*

1b Rhizome long-creeping, plants growing in swampy places .... *S. unitus*

Sphaerostephanos heterocarpus (Blume) Holttum
(Fig. 18F)

Aspidium heterocarpum Blume, Enum. pl. Javae 155 (1828).

Sphaerostephanos heterocarpus (Blume) Holttum in M.P. Nayar and S. Kaur, Comp. Beddome's Handb. Ferns Brit. India 209 (1974).

Type: foot of Mt Boerangrang, Java, *C.L. Blume*; holo: L.

Rhizome erect, to 20 cm tall, sometimes branching from the base. Fronds to 60 cm long. Stipe to 30 cm long, with a dense indumentum of minute, stiffly erect hairs. Lamina somewhat triangular in outline, to *ca* 30 cm long, the basal pinnae much reduced and less than *ca* 10 mm long, the mid-pinnae to *ca* 9 cm long, 1.5 cm wide. Largest pinnae 7–9 cm long, 1–1.5 cm wide, lobed to *ca* ¾ of the way to the costa; lower surface between the veins with numerous sessile, spherical yellow glands plus short erect hairs. Sori with the indusium with stiffly erect hairs and spherical glands. Fertile plants: May.

Distribution. Thailand to Hong Kong, Solomon Islands, Vanuatu, Samoa, Australia (N.T., Qld) and Fiji. In the N.T. only known from the Fitzmaurice River (p.78).

Habitat. Sandstone gorges.

Notes. Due to a paucity of specimens this description is partly based on Bostock (1998b).

Sphaerostephanos unitus (L.) Holttum var. *unitus*
(Fig. 18G)

Polypodium unitum L., Syst. nat. 10th ed., 2: 1326 (1759).

Sphaerostephanos unitus (L.) Holttum, J. S. African Bot. 40: 165 (1974).

Type: locality unknown; holo: LINN.

Rhizome long-creeping, *ca* 5 mm diam. Fronds to *ca* 100 cm long. Stipe 30–60 cm long, brown, glossy. Lamina somewhat ovate in outline, 20–60 cm long, the lower pairs abruptly decreased to auricles. Largest pinnae 10–21 cm long, 0.8–1.8 cm wide, lobed to *ca* 1/3 of the way to the costa; lower surface with sessile, spherical brown or orange glands and erect, whitish, uniseriate hairs. Sori with the indusium glabrous or with stiffly erect hairs and spherical glands. Fertile plants: Oct.

Distribution. East Africa to India, Malesia, Australia (N.T., Qld), Philippines and Guam. In the N.T. only known from Green Ant Springs (p.78).

Habitat. Spring jungle.

Notes. Due to a paucity of specimens this description is partly based on Bostock (1998b).

Blechnaceae

Cosmopolitan family with eight genera; four genera and 29 species in Australia.

References: Andrews (1990), Kramer *et al.* (1990), Chambers and Farrant (1998b).

Key to genera of Blechnaceae

1a. Small ferns with weakly erect fronds and non-leathery pinnae; indusium present .... *Doodia*
1b Robust ferns with leathery pinnae; indusium absent or present 2
2a. Erect, non-climbing fern; fertile and sterile lamina similar .... *Blechnum*
2b. Scrambling or climbing fern; fertile and sterile lamina markedly dissimilar .... *Stenochleana*

Blechnum L.

Rhizome creeping, climbing or erect and sometimes forming a small trunk, scaly, with the scales basally attached and often very dark. Fronds similar or dimorphic (not N.T.). Lamina commonly pinnate or pinnatifid but sometimes simple or lobed, somewhat leathery. Sori in linear rows on each side of the costa and sometimes (not N.T.) covering the surface of the pinnae. Indusium present. Spores with surface ornamentation, a perispore absent or present.

A mostly Southern Hemisphere genus with *ca* 150–200 species; 18 species in Australia.

Key to species of *Blechnum*

1a. Basal pinnae not reduced to auricles; margins of pinnae serrate .... *B. indicum*
1b. Lowermost pinnae abruptly reduced to auricles; margins of pinnae entire .... *B. orientale*

Blechnum indicum Burm.f.
(Fig. 20A, B)

Swamp water fern

Blechnum indicum Burm.f., Fl. indica 231 (1768).

Type: Evans Head, N.S.W., *R.G. Coveny 4712*; neo: NSW, *fide* T.C. Chambers and P.A. Farrant, *Fl. Australia* 48: 710 (1998); isoneo: A, AD, BM, BRI, G, K, L, LE, TNS, UC.

Rhizome creeping, branched; scales lanceolate, to *ca* 5 mm long, dark reddish brown throughout or the margins paler. Fronds to 1 m or more long, fertile and sterile fronds similar. Stipes glabrous except for basal scales. Lamina 1-pinnate, with *ca* 30–80 pinnae, glabrous except for reddish brown costal scales; pinnae sessile, lanceolate or linear-lanceolate or smaller ones somewhat ovate, 1.5–16 cm long, 0.4–1.8 cm wide, margins finely serrate, the basal pinnae similar or slightly shorter than the upper ones. Indusium linear. Fertile plants: probably throughout the year.

Distribution. From south-east Asia to Australia (W.A., N.T., Qld, N.S.W.) and Polynesia. In the N.T. extending as far south as Vanderlin Island (p.73).

Habitat. Common in freshwater swamps and spring jungle and recorded from freshwater seepage areas behind mangroves.

Ethnobotany. Aboriginals eat the rhizome after it has been cooked and hammered (Wightman and Smith 1999).

Fig. 19. A, B. *Macrothelypteris torresiana*: **A**, frond; **B**, lower surface of frond (**A, B**, Trainor 184). **C-E.** *Doodia caudata*: **C**, sterile frond; **D**, fertile frond; **E**, fertile pinna showing sori (**C-E**, Latz 6622). **F, G**. *Bolbitis quoyana*: **F**, upper part of sterile frond; **G**, part of sterile pinna showing venation (**F, G**, Brennan 1157). Scale bars: **A, F** = 5 cm, **C, D, G** = 1 cm. **B, E** = 1 mm.

Blechnum orientale L.

(Fig. 20C, D)

Blechnum orientale L., Sp. pl. 2: 1077 (1753), as *B. occidentale* L. in error; corrected in 2nd ed., 2: 1535 (1763).

Type: China, *P. Osbeck*; holo: LINN.

Rhizome forming a short, erect trunk with a densely scaly apex; scales subulate, brown or reddish brown, shiny, *ca* 15–20 mm long, margins entire or toothed. Fronds 30–200 cm long, fertile and sterile fronds similar. Stipes glabrous except for basal scales. Lamina 1-pinnate, with *ca* 30–70 pinnae, glabrous or with some scales and irregular hairs on the rachis and costae; pinnae sessile and the upper ones adnate to the rachis, most pinnae linear-lanceolate, 5–30 cm long, 0.5–2.3 cm wide but the lowermost abruptly reduced to rounded auricles, margins entire. Indusium linear. Fertile plants: throughout the year.

Distribution. Nepal to Japan, Indonesia, northern Australia (W.A., N.T., Qld) and Pacific islands (p.73).

Habitat. Common fern along creeklines and on the edges of springs and waterholes and in rock crevices with permanent seepage.

Ethnobotany. Aboriginals eat the rhizome after it has been cooked and hammered (Wightman and Smith 1999).

Doodia R. Br.

Rhizome erect or creeping, with dark brown or black scales. Fronds monomorphic (not N.T.) or dimorphic. Sterile lamina 1-pinnate, the pinna closely spaced; pinna margins sharply toothed. Fertile lamina 1-pinnate, the pinnae widely spaced; veins forked. Sori borne on anastomoses and in one or more, discrete or subcontinuous rows parallel to the midvein of the pinna. Indusium present. Spores smooth.

A genus ranging east from Sri Lanka to Australia, New Guinea, New Zealand, Pitcairn and Easter Islands; with *ca* 30 taxa. Artificial hybrids are easily obtained and the considerable morphological variation and possible natural hybridisation makes species delimitation difficult. Following Parris (1998) there are eight species in Australia, with one in the N.T. which seems to be referrable to *D. caudata*.

Reference: Parris (1998).

Doodia caudata (Cav.) R. Br.

(Fig. 19C–E)

Small rasp fern

Woodwardia caudata Cav., Descr. pl. 264 (1801).

Doodia caudata (Cav.) R. Br., Prodr. 151 (1810).

Type: Nova Hollandia, *L. Née*; holo: MA.

Rhizome erect. Fronds 5–20 cm long, stipes and rachises with an indumentum of numerous uniseriate, eglandular hairs 0.2–0.4 mm long; pinnae not or very rarely lobed to their midveins. Sterile fronds with the lateral pinnae shortly stalked to sessile, very widely ovate to ovate or elliptic, 3–16 mm long, 2.5–7 mm wide, weakly or obviously 2-lobed in the basal half but rarely incised to more than ¼ of the way to the costa, with scattered hairs, margins sharply and coarsely toothed. Fertile fronds with the pinnae often oblong or lanceolate and narrower than those in sterile fronds but the lower pinnae often similar and sometimes all similar in shape to those of the sterile fronds. Sori *ca* 3–9 per pinna, 0.8–1.7 mm long, the indusium hairy, at maturity the sori distinct or confluent along and across the costa. Fertile plants: June, July.

Distribution. Australian endemic (N.T., S.A., Qld, N.S.W., Vic., Tas.). Found in southern N.T., e.g. at Giles Spring (p.75).

Habitat. Damp sheltered areas in rocky gullies and crevices on the edge of permanent springs.

Notes. A highly variable taxon in which fronds are not strictly dimorphic and in which sori may or may not be confluent. According to Parris (1998), specimens with distinct sori are from shaded areas.

Stenochlaena J. Sm.

Rhizome scrambling or climbing, scaly when young. Fronds dimorphic. Sterile lamina 1-pinnate, pinnae usually alternate, sessile or almost so, all except the terminal pinna articulated at the rachis, margins serrate; veins numerous, close, parallel. Fertile lamina 1- or (not in Australia) 2-pinnate, linear, articulate. Sori continuous on each side of the costa, except for a narrow marginal band the undersurface of the pinnae covered by the sporangia. Indusium absent. Spores with surface ornamentation, perispore absent.

An Old World genus of six species, with one in Australia.

Stenochlaena palustris (Burm.f.) Bedd.

(Fig. 20E–G)

Polypodium palustre Burm.f., Fl. indica 234 (1768).

Stenochlaena palustris (Burm.f.) Bedd., Suppl. ferns S. India 26 (1876).

Type: 'habitat in Indiis'.

Rhizome long, climbing or scrambling, to *ca* 7 mm diam.; scales round, peltately attached. Fronds dimorphic, *ca* 25–150 cm long , smooth, shiny. Stipes *ca* 10–80 cm long, glabrous or with some peltate scales when young;. Sterile pinnae to 35 or more per frond, ovate to lanceolate, 7–18 cm long, 1.5–4.5 cm wide, shortly stalked, serrate. Fertile pinnae to *ca* 19 or more per frond, linear, 6–22 cm long, *ca* 0.3 cm wide. Fertile plants: throughout the year.

Distribution. India to northern Australia (W.A., N.T., Qld) and Polynesia (p.78).

Habitat. A species of permanently wet monsoon forest, scrambling over rockfaces or climbing up trees. Also commonly gathered from the edge of *Melaleuca* swamps.

Fig. 20. A, B. *Blechnum indicum*: **A**, frond (Michell 1577); **B**, lower surface of fertile pinna (Dunlop 6561). **C, D**. *Blechnum orientale*: **C**, lower part of frond showing pinnae reduced to auricles; **D**, lower surface of fertile pinna (**C, D**, Latz 10885). **E-G**. *Stenochlaena palustris*: **E**, sterile frond; **F**, fertile frond; **G**, pinna from sterile frond showing venation (**E-G**, Jones 1393). **H**. *Tectaria siifolia*: plant (Dunlop 7274). Scale bars: **E, F** = 5 cm, **H** = 3 cm, **A-D**, **G** = 1 cm.

Dryopteridaceae

Cosmopolitan family of *ca* 29 genera and more than 1000 species. In Australia nine genera (one introduced) and 30 species. Aspidiaceae, an earlier but illegitimate family name, is used in some literature.

Within the N.T. the family is only definitely represented by the genus *Tectaria*. There is a specimen of *Polysticum proliferum* (R. Br.) C. Presl held at DNA which is labelled as coming from Reedy Creek in the George Gill Range. However, I here consider this to be an incorrectly labelled specimen. Not only has it been collected just once, which seems unlikely for such a distinctive fern, the species is otherwise known only from montane forests of south-eastern Australia.

References: Andrews (1990, as Aspidiaceae), Jones (1998c), Bostock (1998c).

Tectaria Cav.

Rhizome creeping or erect, with rigid, opaque, usually thin and entire scales. Fronds monomorphic or dimorphic. Lamina commonly at least 1-pinnate and often with basal pinnae with basiscopic lobes or pinnules; veins free or anastomosing to form areoles; reddish articulated hairs usually present. Costae and costules usually ridged on the upper surface and covered with reddish, articulated hairs, sometimes glabrous. Sori usually with reniform or peltate indusia. Spores usually cristate.

Pantropical genus with *ca* 150 species; four species in Australia but just *T. siifolia* in the N.T.

References: Andrews (1990), Bostock (1998c).

Tectaria siifolia (Willd.) Copel.

(Fig. 20H)

Polypodium siifolium Willd., Sp. pl. 5(1): 196 (1810).

Tectaria siifolia (Willd.) Copel., Philipp. J. Sci., C 2: 414 (1907).

Type: Java, *L. Ventenant*; holo: B (Herb. Wildenow 19689).

Rhizome creeping, short; scales narrowly triangular, 3–5 mm long, margins pale and initially fringed with hairs. Fronds dimorphic. Stipes of sterile fronds 20–30 cm long, longer in fertile fronds, all fronds with basal scales. Lamina of sterile fronds 1-pinnate, with 1–3 pairs of pinnae, the entire lamina *ca* 15–23 cm long, as wide or wider than long, papery, with a few hairs on the rachis, the basiscopic lobe of the basal pinnae to 15 cm long and 3.5 cm wide; fertile lamina smaller in all parts and veins forming fewer areoles. Sori circular, in several rows on each side of the costa. Indusium small, only on immature sori. Fertile plants: not seen.

Distribution. Christmas Island, Malesia and Australia (N.T., Qld). In the N.T. only known from the Arafura Swamp region (p.78).

Habitat. Dense, spring-fed rainforest.

Notes. This description is largely based on Bostock (1998c), the single specimen in DNA lacking fertile fronds.

Lomariopsidaceae

A pantropical family with eight genera; four genera and six species in Australia.

Reference: Jones (1998d).

Bolbitis Schott

Ferns terrestrial. Rhizome short to long-creeping, densely scaly; scales peltately attached or attached at with cordate bases and attached at the base, dark. Fronds dimorphic. Stipes in 2–6 longitudinal rows and decurrent on the rhizome. Lamina 1-pinnate, that of the fertile fronds usually smaller than the sterile fronds and with a longer stipe and narrower pinnae. Pinnae with the veins anastomosing on either side of the midrib. Sporangia borne over most of the lower surface of fertile pinnae; sori naked.

A pantropical genus with more than 40 species, with two (one endemic) recorded for Australia.

Bolbitis quoyana (Gaudich.) Ching

(Fig. 19F, G)

Acrostichum quoyanum Gaudich. in Freyc., Voy. Uranie 8: 306 (1828).

Bolbitis quoyana (Gaudich.) Ching in C. Christ., Index filic. suppl. 3, 49 (1934).

Type: Mollucas, *C.L. Blume*.

Sterile fronds to *ca* 60 cm long. Stipe, rachis and base of costa with scattered, latticed, brown or reddish brown scales. Lamina 1-pinnate except for pinnatifid apex, 18.5–32 cm long, 12.5–18.5 cm wide. Pinnae longest towards the base of the lamina, mostly on stalks to 4 mm long but the uppermost 1 or 2 pairs with decurrent bases, basally symmetrical or asymmetricaly lobed, apically rounded or somewhat tapering to the apex, margins shallowly to deeply lobed for much of their length, glabrous throughout; veins tending to form 2 or more rows on either side of the midrib, when ending in a sinus often forming a small bristle. Fertile plants: not seen.

Distribution. Malesia to Australia (N.T., Qld) and Fiji. In the N.T. known only from sterile collections (*Brennan 1157*, *Russell-Smith 8903*) from Dinner Creek, Kakadu NP (p.74).

Habitat. Shaded rock faces and overhangs along perennially wet creek.

Notes. The above description is necessarily brief due to the absence of fertile material.

Kym Brennan (pers. comm.) recorded in August 2003 that the single population consists of *ca* 200 individual plants and that plants are sometimes lost from scouring of the rocks by flood waters.

Davalliaceae

Circumscription of the family has varied widely. Following Bell (1998) it contains nine genera and *ca* 200 species of which four genera and 15 species are native to Australia. Only *Nephrolepis* definitely occurs in the N.T. There is also a questionable record of *Davallia solida* (G. Forst.) Sw. occurring on Groote Eylandt. No specimen of the latter is housed in DNA and as the record is dubious, being based on a cultivated specimen said to have been sourced from that locality, it is not treated further.

References: Andrews (1990), Bell (1998).

Nephrolepis Schott

Ferns epiphytic or terrestrial. Rhizome short, decumbent to erect, densely scaly and bearing stolons; stolons wiry, with both scales and hair-like processes. Fronds in tufts, simply pinnate, monomorphic or dimorphic. Stipes much shorter than lamina, not articulated to rhizome, grooved on the upper surface. Pinnae articulated to rachis, margins entire, crenate or shortly lobed, often with a single large lobe at the base and on the upper side; veins on upper surface of pinnae with prominent hydathodes. Sori superficial (non-marginal) or marginal. Indusia usually reniform or circular, sometimes elongate. Spores tuberculate or rugose.

A genus of perhaps 25–30 species; pantropical and with greatest diversity in south-east Asia but also in temperate areas.

Delimitation of species is often difficult and Bell, with reservation, accepted six species for Australia and five for N.T. Not all are accepted here. Variation in pinna shape and the position of sori is such that specimens variously treated in Australian floras under the names *N. arida*, *N. biserrata*, *N. obliterata* and *N. hirsutula* are here considered to belong to the one variable species, *N. hirsutula*. Identification is also made difficult by the fact that immature and mature fronds may differ in size, shape of the pinnae and the indumentum of the rachises, e.g. as in *Jones 1344*, a form of *N. hirsutula*.

References: Verdcourt (1996), Bell (1998).

Key to species of *Nephrolepis*

1a. Sori marginal; indusium elongate; margins of pinnae entire .... *N. acutifolia*

1b. Sori non-marginal; indusium reniform; margins of pinnae at least partly toothed .... *N. hirsutula*

Nephrolepis acutifolia (Desv.) H. Christ.
(Fig. 21A)

Lindsaea acutifolia Desv., Mém. Soc. Linn. Paris 6(3): 312 (1827).

Nephrolepis acutifolia (Desv.) H. Christ, Verh. Naturf. Ges. Basel 11: 243 (1896).

Type: not designated.

Stolons and stipes with linear-triangular, red-brown scales with entire or sparsely toothed margins. Fronds to *ca* 2m long, pendent, with very narrow scales with basal processes. Pinnae closely spaced, margins entire or very slightly undulate, basally truncate and with somewhat rounded corners, sometimes with a basal, acroscopic lobe, with scattered septate eglandular and glandular hairs and scales but at least the latter lost with age. Sterile pinnae ovate to lanceolate, 10–55 mm long, 4–15 mm wide, apex rounded to somewhat acute. Fertile pinnae ovate to lanceolate, 15–38 mm long, 4–11 mm wide, apex usually acute. Sori marginal and elongate. Fertile plants: probably throughout the year.

Distribution. Tropical Africa through Asia to Polynesia. Uncommon in Australia (N.T., Qld). In the N.T. it occurs from central Arnhem Land to Groote Eylandt (p.76).

Habitat. Sandstone country, with plants growing in crevices of rock faces and amongst boulders in rainforest, the latter often dominated by *Allosyncarpia ternata*.

Nephrolepis hirsutula (G. Forst.) C. Presl
(Fig. 21B–I)

Polypodium hirsutulum G. Forst., Fl. ins. austr. 81 (1786).

Nephrolepis hirsutula (G. Forst.) C. Presl, Tent. pterid. 79 (1836).

Type: not designated.

Nephrodium obliteratum R. Br. Prodr. 148 (1810).

*Nephrolepis obliterata (*R. Br.) J. Sm., in J. Bot. (Hooker) 4: 197 (1841).

Type: "(T.) B.", i.e. tropical coast of Australia by Brown and earlier by Banks.

Aspidium biserratum Sw., J. Bot. (Schrader) 1800 (2): 32 (1801).

Nephrolepis biserrata (Sw.) Schott, Gen. fil. 1: t. 3 (1834).

Type: Mauritius, *C.F. Grondahl*; holo: S.

Nephrolepis arida D.L. Jones, Austrobaileya 2: 474, fig. 3d–f (1988), syn. nov.

Type: Talliputta Gorge, 17 July 1984, *D.L. Jones 1598*; holo: DNA; iso: AD, BRI, CANB, K, MEL, NSW.

[*Nephrolepis cordifolia auct. non* (L.) C. Presl: Chippend., Proc. Linn. Soc. New South Wales 96: 217 (1972); Dunlop (ed.), Checklist Vasc. Pl. Northern Terr. 2 (1987).]

Stolons and basal part of stipes with scales; scales lanceolate, brown or red-brown, the margins usually pale and with few to many cilia. Fronds *ca* 25–250 cm long, arching to erect, rachis glabrous or with scales or scale-like hairs with basal processes and/or uniseriate, septate hairs. Pinnae closely spaced, ovate to linear-lanceolate or somewhat oblong, mature pinnae 1–17 cm long, 0.4–2.8 mm wide, margins toothed for at least part of their length, basally truncate and with somewhat rounded corners, with or without 1 or 2

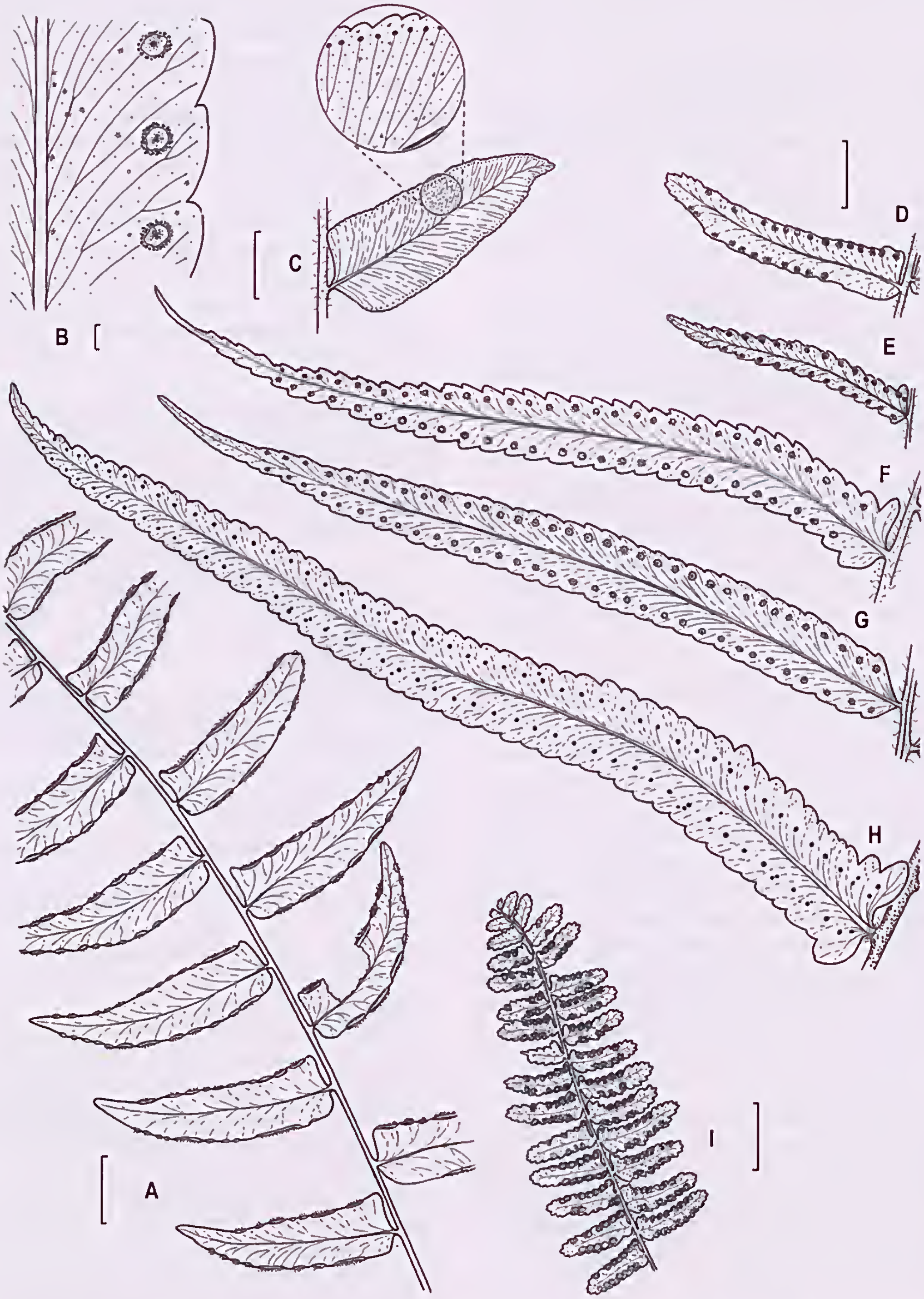

Fig. 21. A. *Nephrolepis acutifolia*: undersurface of part of fertile frond showing marginal sori (Jones 1420). **B-I.** *Nephrolepis hirsutula*: **B**, part of pinna showing typical venation pattern and position of sori at the end of veins (Jones 1699); **C**, lower sterile pinna with enlargement showing hydathodes on vein endings (Brennan 1571); **D-H**, fertile pinnae showing variation in their size and shape and the placement of sori, **D** (Thomson 3034), **E**, **F** (both from a single plant of Jones 1453), **G** (Jones 1699), **H** (Barritt 1230); **I**, fertile pinna of extreme form previously attributed to *N. arida* (Carr 2921). Scale bars: **A**, **C-I**= 1 cm; **B** = 1 mm.

barely formed to conspicuous auricles, apex obtuse to acute, with an indumentum of septate hairs and scattered scales. Sori submarginal to *ca* midway between the margin and the midrib. Fertile plants: throughout the year.

Distribution. Apparently pantropical (Australia: W.A., N.T., Qld) (p.76).

Habitat. In rainforest and on rocky sandstone slopes with permanent or near-permanent water.

Notes. Bell (1998), obviously with some reservation, recognised *N. biserrata*, *N. hirsutula* and *N. obliterata* as distinct species. On the assumption that all three entities are indeed represented in the N.T., their maintenance as distinct species is untenable. Key features used to distinguish taxa – the shape of pinnae and the placement of sori – are extremely variable, even sometimes on the one plant (e.g. *Jones 1453*, fig. 21, E-F). The range of variation in specimens attributed by Jones to *N. arida* is such that it too is best placed in synonymy under *N. hirsutula*. Some specimens from the type locality and from Jasper Gorge (e.g. *Carr 2921*, fig. 21 I), by virtue of their generally smaller mature pinnae, are distinctive but nonetheless seem to merge with others forms.

Ethnobotany. Aboriginal people are known to eat both raw and cooked rhizomes (Wightman and Smith 1999).

Polypodiaceae

As treated by Bostock and Spokes (1998b), this is a family of 20–50 genera and *ca* 1000 species, with 11 genera and 28 or 29 species in Australia. Only two species are found in the N.T.

References: Andrews (1990), Hennipman *et al.* (1990), Bostock and Spokes (1998b).

Key to genera of Polypodiaceae

1a. Sterile, shallowly-lobed nest fronds present at the base of plants; fertile fronds 1-pinnatifid and much longer than nest fronds .... *Drynaria*

1b. Sterile nest fronds absent; fertile fronds 1-pinnatifid or simple .... *Microsorum*

Drynaria (Bory) J. Sm.

Plants epiphytic, lithophytic or terrestrial. Rhizome long-creeping, branched, densely scaly; scales usually peltately attached at the base, margins toothed or ciliate. Fronds dimorphic, with sterile, humus-collecting, nest fronds at the base and longer, pinnate or pinnatifid foliage fronds. Nest fronds shallowly-lobed, becoming papery and commonly bearing scales or stellate hairs. Foliage fronds with pinnae articulated to the rachis or the entire lamina articulated down each side of the rachis; veins mostly prominent, anastomosing, forming areoles; nectaries present. Sori circular or oblong to linear, in one row on either side of the primary vein or in one or two rows on each side of secondary veins. Spores smooth or tuberculate.

About 15 or more species ranging from Africa to Asia, Australia and Polynesia. Especially diversified in China. Four species in Australia but only *D. quercifolia* in the N.T.

Drynaria quercifolia (L.) J. Smith
(Fig. 22A–C)
Oakleaf fern

Polypodium quercifolium L. Sp. pl. 2: 1087 (1753).

Drynaria quercifolia (L.) J. Smith, J. Bot. (Hooker) 3: 398 (1841).

Type: locality and collector unknown; holo: LINN 1251.12.

Rhizome appearing woolly, the ginger or brown, soft, long-tapering scales 3–25 mm long and with ciliate margins. Nest fronds ovate, 6.5–30 cm long, 4.5–22 cm wide, shallowly to deeply lobed; lobes with round apices; venation prominent. Foliage fronds 30–100 cm long; stipes shorter than the lamina; lamina pinnatifid, pinnae lanceolate to linear-lanceolate, 6–24 cm long, 1–3.5 cm wide; veins reticulate between the main veins. Sori circular, scattered over the entire surface and tending to be in two rows between the lateral veins extending from the costa. Fertile plants: throughout the year.

Distribution. Sri Lanka east to northern Australia (W.A., N.T., Qld) and New Britain (p.75).

Notes. Commonly growing on rocks in shady gullies and on tree trunks in rainforest.

Ethnobotany. Aboriginal people eat roasted rhizomes (Wightman and Smith 1999).

Microsorum Link

Plants epiphytic, lithophytic or terrestrial. Rhizome creeping, scaly; scales latticed, peltate or pseudopeltate. Fronds monomorphic or more rarely dimorphic (but lacking humus-collecting, nest fronds). Stipes articulated to short stalks which occur at intervals along the rhizome. Lamina simple, regularly or irregularly lobed or pinnatifid; veins anastomosing, forming areoles and with veinlets ending in hydathodes. Sori conspicuous, usually circular or elongated, in regular or irregular rows or sometimes scattered. Spores hyaline or yellowish, smooth or tuberculate.

A genus centred in Asia and containing perhaps 50 or more species; eight species in Australia but only *M. grossum* in the N.T.

Microsorum grossum (Langsd. and Fisch.)
(Fig. 22D–H)

Polypodium grossum Langsd. and Fisch., Icon. fil. 9, t. 8 (1810).

Microsorum grossum (Langsd. and Fisch.) S.B. Andrews, Ferns Queensland 280 (1990).

Type: Marquesas Island; holo: LE, *fide* E. Schelpe, Contr. Bolus Herb. 1: 100 (1969).

[*Microsorum scolopendria auct. non* (Burm.f.) Copel.: Chippend., Proc. Linn. Soc. New South Wales 96: 217 (1972).]

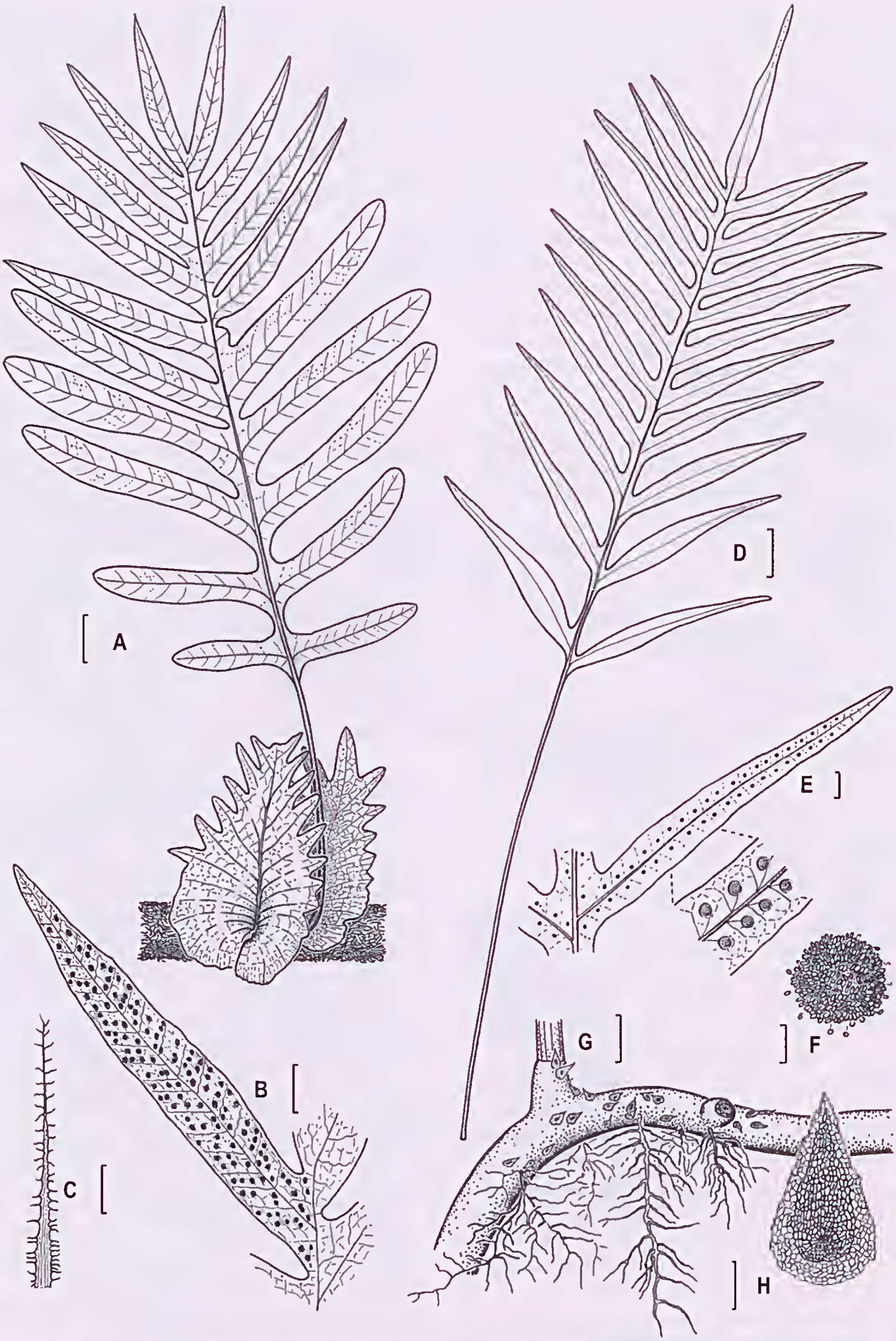

Fig. 22. A-C. *Drynaria quercifolia*: **A**, plant with foliage fronds and basal nest fronds (Dunlop 3316, Jones 1498); **B**, pinna with sori (Scarlett 314); **C**, rhizome scale (Dunlop 3316). **D-H.** *Microsorum grossum*: **D**, frond; **E**, fertile pinna with sori; **F**, sorus (**D-F**, Dunlop 5909); **G**, rhizome; **H**, rhizome scale (**G**, **H**, Russell-Smith 3472). Scale bars: **D** = 6 cm, **A** = 3 cm, **B**, **E**, **G** = 1 cm, **C**, **F**, **H** = 1 mm.

Plants terrestrial or sometimes lithophytic. Rhizome long-creeping, scaly when young; scales 2–4 mm long, brown, peltately attached, margins toothed, apex acute to acuminate. Fronds usually uniform and 1-pinnatifid but sometimes simple, *ca* 20–200 cm long. Stipes glabrous or with some basal scales, *ca* the length or shorter than the lamina. Lamina if 1-pinnatifid with (3) 10–30 lobes, pale green, glabrous or with scattered scales on the rachis and costae; lateral lobes lanceolate or narrowly triangular, 4–27 cm long, 1.5–5.5 cm wide, margins entire or undulate; terminal lobe commonly more elongate than lateral lobes; costae prominent but venation otherwise faint. Sori circular or elliptic, in 1 or sometimes 2 rows on each side of the costa. Fertile plants: throughout the year.

Distribution. Following Bostock and Spokes (1998b), this species occurs in Australia (W.A., N.T., Qld) and New Guinea and extends east to New Caledonia, Fiji and Pitcairn Island and may also extend westward to southern Asia and Africa (p.76).

Habitat. Commonly a species of the rainforest but also recorded as a component of a floating mat on the Daly River floodplain.

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Any guide produced with the aim of enabling others to readily identify plants requires high quality, accurate illustrations. It is with pleasure that the authors thank Monika Osterkamp Madsen for providing them.

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Accepted 7 November 2003

Acrostichum aureum

Acrostichum speciosum

Actinostachys digitata

Actinostachys wagneri

Adiantum atroviridae

Adiantum capillus-veneris

Adiantum diaphanum

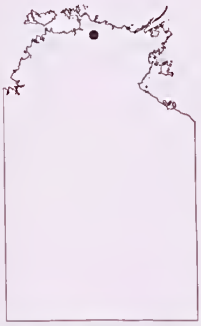
Adiantum hispidulum
var. *hispidulum*

Adiantum philippense

Ampelopteris prolifera

Angiopteris evecta

Asplenium (Litchfield entity)

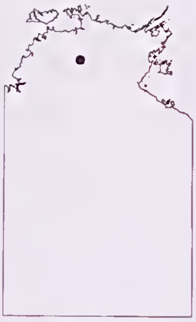


Asplenium (Nabarlek entity)

Azolla pinnata

Blechnum indicum

Blechnum orientale

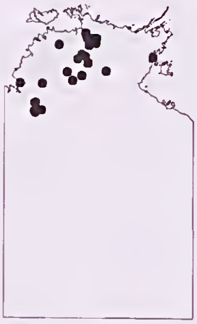


Bolbitis quoyana

Cephalomanes obscurum

Ceratopteris thalictroides

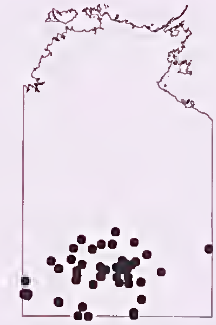
Cheilanthes brownii



Cheilanthes caudata

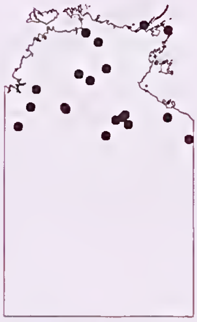
Cheilanthes contigua

Cheilanthes fragillima



Cheilanthes lasiophylla

Cheilanthes nitida

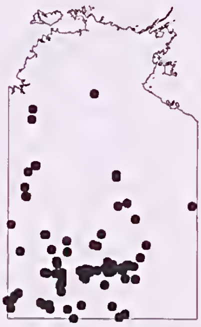


Cheilanthes nudiuscula

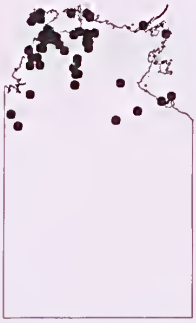
Cheilanthes praetermissa

Cheilanthes pumilio

Cheilanthes sieberi
subsp. *pseudovellea*



Cheilanthes sieberi
subsp. *sieberi*



Cheilanthes tenuifolia

Christella dentata

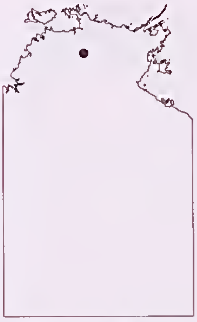
Cyclosorus interruptus

Dicranopteris linearis var. *linearis*

Doodia caudata

Doryopteris concolor

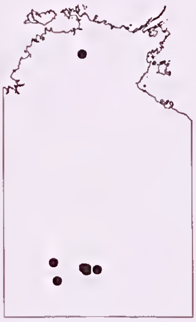
Drynaria quercifolia



Gleichenia dicarpa

Gleichenia
(Victoria River entity)

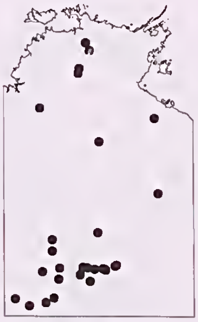
Helminthostachys zeylanica



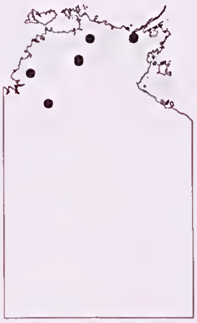
Histiopteris incisa

Isoetes coromandelina subsp. *macrotuberculata*

Isoetes cristata



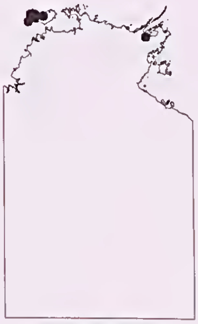
Isoetes muelleri



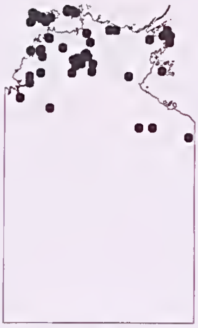
Lindsaea brachypoda

Lindsaea ensifolia

Lindsaea media



Lindsaea walkeri



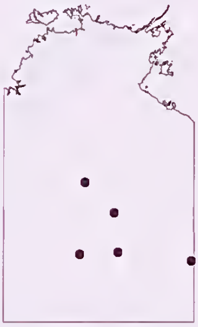
Lycopodiella cernua

Lygodium flexuosum

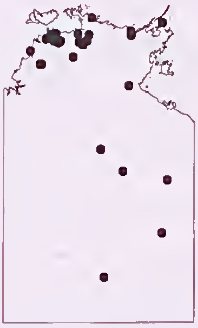
Lygodium microphyllum

Macrothelypteris torresiana

Marsilea angustifolia



Marsilea costulifera



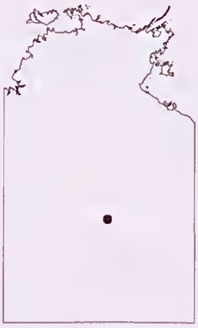
Marsilea crenata

Marsilea drummondii

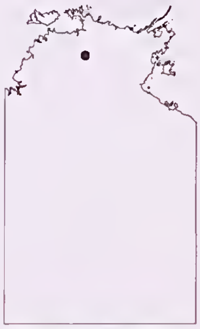
Marsilea hirsuta

Marsilea latzii

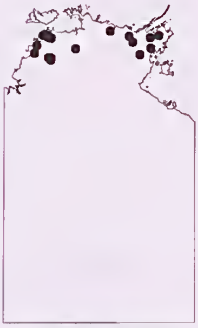
Marsilea mutica



Marsilea (Neutral Junction entity)



Microlepia speluncae



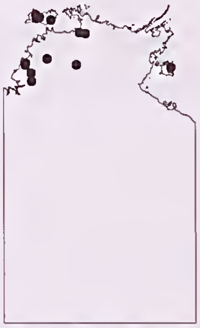
Microsorum grossum

Nephrolepis acutifolia

Nephrolepis hirsutula

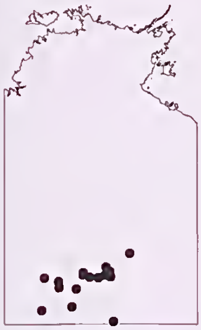
Ophioglossum costatum

Ophioglossum gramineum



Ophioglossum intermedium

Ophioglossum lusitanicum



Ophioglossum polyphyllum

Ophioglossum reticulatum

Paraceterach muelleri

Paraceterach reynoldsii

Pityrogramma calomelanos var. *calomelanos*

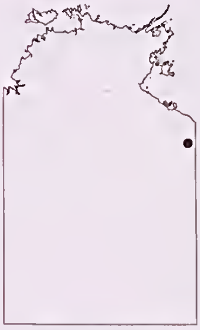
Platyzoma microphylla

Pleurosorus rutifolius

Pleurosorus subglandulosus

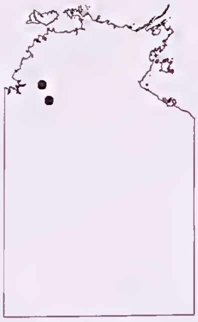
Psilotum nudum

Pteridium revolutum

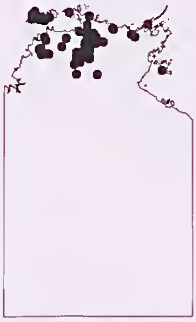


Pteris comans

Pteris tremula

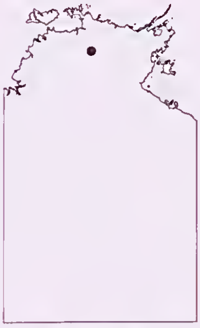

Pteris vittata

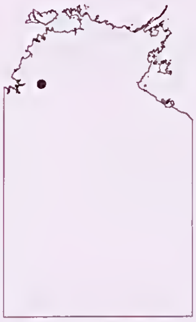

Salvinia molesta


Schizaea dichotoma


Selaginella ciliaris


Selaginella pygmaea

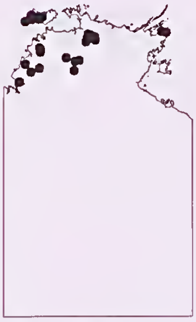

Selaginella
(Mt Gilruth entity)


Sphaerostephanos
heterocarpus


Sphaerostephanos unitus
var. *unitus*


Stenochlaena palustris


Sticherus flabellatus
var. *compactus*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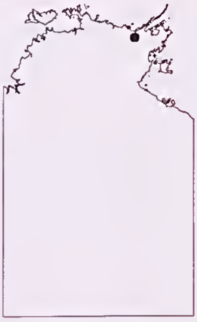
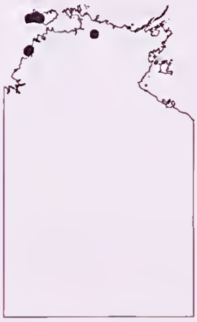
Taenitis pinnata


Tectaria siifolia


Vittaria ensiformis

TAXONOMIC INDEX

Names in Roman are accepted names, those in italics are synonyms, misapplied and rejected names.

The Beagle, Records of the Museums and Art Galleries of the Northern Territory, 2003 **19**: 81–86

Ptychosperma macarthurii or *P. bleeseri*? The taxonomic status of *P. bleeseri* reconsidered

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ABSTRACT

The name *Ptychosperma macarthurii* (syn. nov. *Ptychosperma bleeseri*) is formally adopted by the research staff of the Northern Territory Herbarium as applying to Northern Territory populations of this widespread northern Australian and Papua New Guinean species. This decision was reached after careful appraisal of the published literature before and since the rediscovery of *P. bleeseri* in the Northern Territory in 1982. This decision takes into consideration results from previously published works including: comments made by the original author of the species, assessment of taxonomic decisions made in the world-wide revision of *Ptychosperma*, taxonomic assessment of the species complex containing *P. macarthurii*, isozyme analysis of the NT and some Queensland populations, and biogeographical evidence of other monsoon rainforest species.

KEYWORDS: Arecaceae, *Ptychosperma bleeseri*, *Ptychosperma macarthurii*, taxonomy, nomenclature.

INTRODUCTION

Specimens of the palm *Ptychosperma* Labill., from the Northern Territory (NT) were first collected in 1925 by F.A.K. Bleeser from Bankers Jungle, near Koolpinyah, east of Darwin, and described by Burret (1928) as *Ptychosperma bleeseri* Burret. The distinctiveness of *P. bleeseri*, according to Burret (1928), was based on the narrower leaflets including the terminal pair. Essig (1978), in his revision of *Ptychosperma*, equated the description of *P. bleeseri* with that of *Carpentaria acuminata* Becc. In the absence of type material, Essig (1978) drew this conclusion after personal communication with H.E. Moore who indicated that there were no *Ptychosperma* species present at the type locality. Specimens of *P. macarthurii* (syn. *P. bleeseri*) have since been rediscovered at Banker's Jungle (Anon. 1998). The original collection of *P. bleeseri*, Bleeser 430, was accessioned at the Berlin Herbarium (B) which was destroyed during WWII. In 1982 *P. bleeseri* was rediscovered growing at Howard River and has subsequently been listed by Dunlop (1987), Dunlop *et al.*, (1996) and Cousins (1989) in checklists of NT vascular plants. However, prior to his retirement in December 2000, Dunlop (unpublished) altered the Northern Territory Herbarium (DNA) checklist, relegating the name *P. bleeseri* to synonymy under *P. macarthurii*. In 1991 the late Robert Tucker, former curator of the Townsville Palmetum, was the first person to raise doubts about the taxonomic distinctiveness of *P. bleeseri* (Glenn Wightman pers. comm.). The taxonomic distinctiveness of *P. bleeseri* is also not recognised by the current research staff of DNA and all NT checklists generated since 2000 have appeared with the name *P. macarthurii*. The purpose of this report is to present the evidence supporting the view of the DNA research staff regarding the acceptance of *P. macarthurii* as opposed to *P. bleeseri*.

There has been much written about the conservation of the NT rare palm, *P. bleeseri*. Duff *et al.* (1992), Liddle *et al.* (1992), Barrow *et al.* (1993), Bishop (1993), Liddle *et al.* (1996), and Anon (1998) all have produced documents outlining the threats, population changes, recovery plan, and management of this palm. However, a consistent omission underlying these documents is the fact that they have not addressed the taxonomic uncertainty associated with the species. As *P. bleeseri* has been the focus of major conservation efforts and is listed as endangered by Commonwealth (www.ea.gov.au/epbc/) and NT (Territory Parks and Wildlife Conservation Act, 2001) legislation, the lack of documented evidence supporting the decision to recognise *P. macarthurii* over *P. bleeseri* must be addressed.

ASSESSMENT OF MORPHOLOGICAL CHARACTERS

Ptychosperma has been arranged by Essig (1978) into four subgenera, one of which, *Ptychosperma* subg. *Actinophloeus* (Becc.) Becc. consists of the section

Caespitosa Essig and contains the complex of species that are closely related to *P. bleeseri* (Dowe 1993a). In an effort to establish the taxonomic distinctiveness of *P. bleeseri*, Dowe (1993a) undertook a taxonomic study of cultivated specimens grown at the Townsville Palmetum. Included in his study were five specimens of *P. bleeseri* from Bankers Jungle, NT, three specimens of *P. macarthurii* from Iron Range, Queensland (Qld), and non-provenanced living material of *Ptychosperma microcarpum* (Burret) Burret. However, without authenticated provenanced material the possibility of hybrid plants cannot be excluded, as Essig (1977) pointed out that cultivated plants hybridise freely. No material of *Ptychosperma propinquum* (Becc.) Becc. ex Martelli was examined, instead data was extracted from the species description. This combination of species was chosen presumably because of their close relationship to each other (see Essig 1978).

Characters of taxonomic significance in *Ptychosperma* were discussed by Essig (1978). They included habit, indumentum, leaves, inflorescence, flowers, fruit, and seeds. The five vegetative characters and five reproductive characters used by Dowe (1993a) in his assessment of the four taxa are presented in Table 1.

Habit. The four species in the '*P. macarthurii*' complex are all clumping palms and Essig (1978) has used this character to erect the section *Caespitosa* (Figs 1, 2). The remaining *Ptychosperma* species are all solitary. Some attention has focused on the decumbent or leaning habit as a character allowing recognition of *P. bleeseri* (Jones 1984; Brock 1988; Wightman and Andrews 1989). Although this habit is common in the NT populations, Dowe (1993b) indicated that populations of *P. macarthurii* in Qld also exhibit this character. Dowe (1993b) hypothesised that the leaning habit of some NT individuals could be a response to the seasonally dry climate (hard environment) and could possibly be the reason why the decumbent or leaning habit is also exhibited by populations of *P. macarthurii* occurring in similar habitats on western Cape York, Qld. The decumbent habit is not exhibited by cultivated plants (Dowe 1993a; I. Cowie, unpublished data, D. Dixon pers. obs).

Indumentum. The shape, size, colour, number and distribution of large conspicuous ramenta on the abaxial leaf surface is often of diagnostic value according to Essig (1978). Dowe (1993a) does not discuss shape, size or colour of the ramenta, but does indicate that in *P. bleeseri* various organs can be glabrous or sparingly ramentaceous as opposed to moderately to densely ramentaceous in the other three species (Table 1).

Leaves. Considerable taxonomic weight has been placed on the width of the terminal leaflets as a means of separating *P. bleeseri* from *P. macarthurii*. In distinguishing *P. macarthurii* from *P. bleeseri*, Burret (1928) drew attention to the broader terminal leaflets in *P. macarthurii*, a feature which Dowe (1993a) stated has proved to be of relevant diagnostic value. Essig (1978) however, mentioned that at the specific level

Table 1. A comparison of the species and characters treated by Dowe (1993a) in assessing the taxonomic position of *Ptychosperma bleeseri*.

Character	*P. bleeseri*	*P. macarthurii*	*P. microcarpum*	*P. propinquum*
Ligule	Very often dry and deciduous	More often green and persistent	More often green and persistent	More often green and persistent
Tomentum	Petiole, crownshaft apex and ligule glabrous or sparingly ramentaceous	Often moderately or extremely densely ramentaceous and somewhat persistent	Often moderately or extremely densely ramentaceous and somewhat persistent	Often moderately or extremely densely ramentaceous and somewhat persistent
Pinnae arrangement	Evenly distributed or irregularly clustered	Evenly distributed or irregularly clustered	Clustered	Clustered
Terminal pinnae	Narrow	Usually broad	Narrow	Not known
Leaves in crown	4–6	Usually twice the number in *P. bleeseri*	Usually twice the number in *P. bleeseri*	Not known
Rameal bracts	Small/moderate	Large/prominent	Large/prominent	Large/prominent
Inflorescence axes	Yellow/green, with moderately dense light coloured pubescence	Yellow/green, with moderately dense punctate scales, glabrescent	Yellow/green, with moderately dense punctate scales, glabrescent	Colour unknown, pubescence dense and dark coloured
Pistillode	Slightly longer than *P. macarthurii* and *P. microcarpum*	Slightly shorter than *P. bleeseri*	Slightly shorter than *P. bleeseri*	Not known
Stamen number	28–34	26–40	18–30	33–50
Fruit	No discernible differences between each species			

only the shape of the central pinnae of a leaf was of diagnostic value in *Ptychosperma*. Of two *P. macarthurii* specimens growing in the palm house of the Berlin Botanic Gardens, Burret (1928) could not distinguish one from *P. bleeseri*, providing further evidence of the variability of *P. macarthurii*. Plants with narrow leaflets also occur on Cape York Peninsula. Tucker (1988) indicated that populations of *P. macarthurii* from around Bamaga, Qld, can consist of plants that are very small and finely pinnate.

Fig. 1. Habit of *Ptychosperma macarthurii* from Crocodile Creek, NT. Photo: A. Gibbons, Northern Territory Herbarium photo database.

Fig. 2. Habit of *Ptychosperma macarthurii* from Claudie River, Iron Range, Queensland. Photo courtesy of Queensland Herbarium.

Inflorescence, flowers, fruit, and seed. Essig (1978) listed stamen number, shape of the pistillode, and external colour of the flowers as characters of some diagnostic value. Dowe (1993a) found some slight differences in pistillode length and stamen number but given the small number of individuals examined, these characters should be used with caution. Essig (1978) warned that stamen number should be used with caution when characterising species. No discernible differences in fruit of the four species could be found by Dowe (1993a). Similarly, only differences in indumentum density on the inflorescence were found between *P. bleeseri*, *P. macarthurii*, and *P. microcarpum* (Table 1).

Dowe (1993a) concluded with the statement that "morphological comparison of *P. bleeseri*, *P. macarthurii*, *P. microcarpum*, and *P. propinquum* indicates that they are closely related integrants of a species' complex which lack well defined boundaries". Dowe (1993a) stated further that if Essig's specific circumscriptions are maintained for species within the section, then *P. bleeseri* is sufficiently distinct to maintain its separation. However, Essig (1978) has placed *Ptychosperma hospitum* (Burret) Burret and *Ptychosperma julianettii* Becc. ex Martelli into synonymy under *P. macarthurii* stating that "the features used to distinguish them are rather trivial, *P. hospitum* having narrower pinnae and generally more delicate proportions, and *P. julianettii* somewhat more robust and having a more fastigate inflorescence". An indication of the narrow species concepts employed by Burret in his evaluation of *Ptychosperma* and allied taxa can be gained from further examination of Essig's *Ptychosperma* treatment. Essig (1978) placed 13 of Burret's taxa, including eight *Ptychosperma* species, three *Strongylocaryum* Burret species and one *Ponapea* Becc., species in synonymy under other *Ptychosperma* species. Essig (1978) has also stated that "some of the currently recognised species may ultimately be found to represent only geographic subsets of larger species, for data on range and variability for many species are as yet insufficient for secure definition of their limits".

ASSESSMENT OF ISOZYME ANALYSIS

As a result of the conservation measures undertaken to protect *P. bleeseri*, Shapcott (1998) assessed populations of *P. bleeseri*, *P. macarthurii*, *Ptychosperma elegans* (R. Br.) Blume and *C. acuminata* for isozyme variation. Three hundred and thirty-nine *Ptychosperma* specimens which included 223 wild collected *P. bleeseri*, seven cultivated *P. elegans* and three cultivated *P. macarthurii* of known provenance were assessed. Although the data obtained by Shapcott (1998) are valuable in assessing the genetic variability in the NT populations, they are of little use taxonomically for a number of reasons. Shapcott (1998) stated that *P. bleeseri, P. elegans* and *P. macarthurii* were distinct species as they showed clear and consistent differences at several loci. However, Gottlieb (1977) in a paper dealing with the use of electrophoretic data in plant systematics recommended that the temptation to compare electrophorectic data by direct inspection, i.e. counting the number of bands with similar or dissimilar mobilities, in preference to genetic analysis, should be rejected. Shapcott (1998) stated that no statistical analysis was carried out on the data. Her conclusion about the taxonomic distinctiveness of *P. macarthurii* and *P. bleeseri* is based on three specimens of *P. macarthurii* which were arguably from the same population at Iron Range. However, Gottlieb (1977) advocated that in order to have a 95% confidence, that at least one copy of each allele is included in an analysis, at least 60 individuals should be sampled. Furthermore, not all congeneric taxa believed to be closely related to *P. bleeseri* were analysed for comparison. Finally, it should also be noted that Shapcott (1998) was not trying to answer a taxonomic question, but rather assess the genetic integrity of *P. bleeseri* in order to enhance management strategies.

BIOGEOGRAPHICAL EVIDENCE

Ptychosperma has its centre of distribution in Papua New Guinea (PNG) with 29 species recognised by Essig (1978, 1987). Two species, *P. elegans* and *P. macarthurii*, occur in Qld with disjunct populations of *P. macarthurii* (syn. *P. bleeseri*) occurring in the NT, and PNG. In the NT, *P. macarthurii* (syn. *P. bleeseri*) is known to occur in eight patches of lowland monsoon vine forest in a 40 hectare area adjacent to the Adelaide River floodplain and the Howard River system east of Darwin (Anon. 1998). Shapcott (1998) hypothesised that *P. bleeseri* probably originated from a common genetically depauperate source and that its populations have either been so severely restricted and have since expanded from a refugial population, or that the populations have arisen from a founder event. The restricted distribution and low genetic variability of the NT populations compared with the known distributions of the other taxa in the species complex, i.e. *P. macarthurii* in Qld and PNG, *P. microcarpum* in PNG, and *P. propinquum* in Indonesia is consistent with possible dispersal pathways that could lead to a founder event. Given the fact that *P. bleeseri* does not occupy all available suitable habitats, on either a regional scale or within individual rainforest patches (Barrow *et al.* 1993), is further evidence that a long distance dispersal (founder) event has occurred.

If consideration is given to the fact that *P. bleeseri* is an outlying population of the widespread *P. macarthurii*, then this is consistent with the broader pattern of biogeography of the local lowland monsoon vine forest flora. A large proportion of this flora are vagile species often occurring over a wide geographic range on relatively recent land forms such as stabilised beach dunes and riverine floodplains (Russell-Smith and Dunlop 1987). Thus a high proportion of NT rainforest taxa are shared with Qld (78%), New Guinea-Solomon Islands (57%), Western Australia (51%), SE Asia (38%) and even the Indian subcontinent (32%) (Liddle *et al.* 1994). As might be expected, the proportion of NT endemic species in this flora is low at just 6% (Liddle *et al.* 1994). Whilst some rainforest taxa are common and widespread in the NT, others are disjunct and of restricted distribution, with concentrations of the latter on the Tiwi Islands and in sandstone habitats of western Arnhem Land-Kakadu. Amongst the species with NT-New Guinea or NT-eastern Indonesia disjunctions are *Elaeocarpus meigi* Weibe, *Croton argyratus* Blume, *Schoutenia ovata* Korth., *Pittosporum moluccanum* (Lam.) Miq., *Tropidia curculigoides* Lindl., and *Helicteres hirsuta* Lour., (Hartono 1965; Liddle *et al.* 1994). Other than the NT, these six species do not occur elsewhere in Australia.

In addition, a high proportion (91%) of the lowland rainforest flora of the Alligator Rivers Region of the northern NT have fleshy fruits or other types of bird-attractive propagules, probably also providing dispersal opportunities for the plant species involved (Taylor and Dunlop 1985). In addition, possible dispersal pathways across land bridges between northern Australia and New Guinea have been a regular feature of the recent geological past. The waters forming the Arafura Sea and Torres Strait probably first came into existence in the Pleistocene (2.5 mya). This land bridge has disappeared and reformed at least seven times in the intervening period in response to climatically driven rising and falling sea levels (Barlow 1981). The climate of the exposed land bridges may well have been at least as arid as the Carpentaria region is today (Barlow 1981). However, permanent springs supporting rainforest vegetation were presumably a feature of the landscape then as they are today in much of northern Australia and provided islands of suitable habitat along which rainforest species could disperse.

CONCLUSION

It appears that following the rediscovery of *P. bleeseri*, the taxonomic assessment of the species was based on evidence extracted from too few sources. Only five cultivated provenanced collections of *P. macarthurii*, three cultivated provenanced specimens of *P. bleeseri*, non-provenanced cultivated material of *P. microcarpum*, and the species description of *P. propinquum* were used by Dowe (1993a) in his assessment of the species. Similarly, Shapcott (1998) based her comparisons of the species on only three cultivated provenanced collections of *P. macarthurii*, all of which originated from a similar locality. Using information from a number of sources that adequately described the variation found in populations of *P. macarthurii*, and taking into consideration the reasons why Essig (1978) synonymised two species under *P. macarthurii*, the decision to adopt the name *P. macarthurii* for the NT populations is justifiable. This decision to recognise *P. macarthurii* over *P. bleeseri* is also supported by the biogeographical evidence relating to other monsoon vine forest species and the overall distribution of congers in the *P. macarthurii* complex. The evidence presented in this paper indicates that *P. bleeseri* is taxonomically indistinguishable from *P. macarthurii* and may indeed be indistinguishable from *P. propinquum*. Further, the evidence presented strongly supports the hypothesis that the NT populations are the result of a founder event. The characters used by Dowe (1993a) clearly overlap and are based on too few specimens, they do not take into consideration the possibility of a founder event and do not agree with distributional trends of other monsoon vine forest taxa. The authors, having seen the two species growing, can find no evidence to separate the NT populations from *P. macarthurii*, therefore, the name *P. macarthurii* is accepted as applying to the NT populations of this widespread taxon.

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A new species of *Syzygium* (Myrtaceae) from the Arnhem Land Plateau, Northern Territory, Australia

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ABSTRACT

A new species of *Syzygium, S. arenitense* sp. nov., is described from the Northern Territory of Australia. The new species is compared with the superficially similar, rheophytic race of *S. eucalyptoides* (F. Muell.) B. Hyland. Identification keys are provided for the species of *Syzygium* occurring naturally in the Northern Territory.

KEYWORDS: Myrtaceae, *Syzygium*, *S. arenitense*, *S. eucalyptoides*, rheophyte, new species, Northern Territory, Australia.

INTRODUCTION

The Australian species of *Syzygium* Gaertner were revised by Hyland who recognised 52 species of the genus in the region (Hyland 1983). Most of the species occur in the rainforests of north-eastern Queensland but several occur in the woodlands and gallery forests of the monsoonal region in northern Australia with one, *S. nervosum* DC., occurring there in spring forests. During work on an account of the genus for *Flora of Australia* (Craven and Matarczyk in press), several anomalous collections were noted from the western edge of the extensive sandstone plateau of Arnhem Land, Northern Territory. These collections appeared to be related to the rheophytic race of *S. eucalyptoides* (F. Muell.) B. Hyland, *S. eucalyptoides* subsp. *eucalyptoides*, and were set aside for further study as they differed from this taxon in certain details.

The anomalous collections were mostly in vegetative condition only and it was not until an adequate collection was made on my behalf by Kym Brennan, then of Jabiru, that the taxonomic status of the entity (for convenience referred to as the "sandstone entity" below) could be properly assessed.

In dried specimens, *S. eucalyptoides* subsp. *eucalyptoides* leaves are concolorous, greyish and the veins are not particularly distinct, whereas in the sandstone entity the leaves are discolorous, brownish, and the veins are very distinct (Fig. 1). The hypanthium of *S. eucalyptoides* subsp. *eucalyptoides* is most often funnel-shaped (usually narrowly so), or may be narrowly stipitate-campanulate or goblet-shaped. In the sandstone entity the hypanthium is usually goblet-shaped, to obconic or stipitate-obconic. Other floral differences noted are as follows: *S. eucalyptoides* subsp. *eucalyptoides*: petals clawed, anthers 0.9–1.0 mm long and style 7–16 mm long; sandstone entity: petals not clawed, anthers 0.5–0.7 mm long, style 4–6 mm long. The ripe fruit of *S. eucalyptoides* subsp. *eucalyptoides* has been noted by collectors as being red, pink, cream and pink, or cream while the sandstone entity has been noted to have white fruit at maturity. The leaf differences, in particular, are considered by me to be taxonomically significant. Indeed the leaf morphology is unique among the Northern Territory species of the genus. Undoubtedly, recognition of the sandstone entity as a distinct species is warranted and the novel description of the species is effected below.

The herbarium codes are as given in *Index Herbariorum* (Holmgren *et al.* 1990+) and the author abbreviations follow Brummitt and Powell (1992).

SYSTEMATICS

Syzygium arenitense Craven, sp. nov.
(Fig. 1 Aa, Ab)

A *S. eucalyptoides* (F. Muell.) B. Hyland subsp. *eucalyptoides* foliis discoloribus, brunneolis, venis distinctis differt.

TYPUS: Australia, Northern Territory, Twin Falls, about 0.5 km below falls, 26 October 1997, *Brennan 3532* (holotype: CANB; isotypes: A, BO, DNA, L, MEL).

Other specimens examined. (selection only, 13 collections seen). AUSTRALIA. Northern Territory: upper East Alligator River, 29 October 1987, *Russell-Smith and Lucas 3861* (DNA); upper East Alligator River, 7 September 1991, *Russell-Smith and Brock 8506* (DNA, QRS); tributary of Deaf Adder Creek, 29 May 1980, *Craven 6092* (CANB); Mt. Gilruth, Deaf Adder Gorge, 22 February 1977, *Dunlop 4428* (CANB, DNA, QRS); 10 km N of Jim Jim Falls, 29 May 1980, *Craven 6078* (CANB); top of Jim Jim Falls, 30 January 1981, *Dunlop*

5662, 5684 (DNA); Mann River at Gamarrgawan Outstation, c. 100 km S of Maningrida, *Brennan 3551* (DNA *n.v.*).

Description. Tree or shrub to 12 m tall. Bark pale grey or greyish white, smooth. Branchlets glabrous, compressed or terete, rounded or angled, 0.5–1.5 mm in diameter; branchlet bark dull, slightly striate, cracked or smooth, not glandular-verrucose, flaking in relatively large pieces. Bud scales present. Leaves glabrous. Lamina discolorous, brownish, 3.6–8.2 cm long, 0.7–2.5 cm wide, 2.3–9.1 times as long as wide, narrowly elliptic, narrowly obovate, obovate or elliptic; base attenuate or narrowly cuneate; apex rounded, truncate, acute or emarginate (sometimes shortly acuminate); margin flat, entire or subentire; primary venation distinct with 11–22 veins on each side of the mid-rib, in the median part of the lamina at a divergence angle of 30–45 degrees and 1–5 mm apart; marginal vein absent; intramarginal vein present, 0.4–1.4 mm from leaf margin; secondary intramarginal vein present or absent; oil dots visible with ×10 hand lens in transmitted light (rarely visible to the unaided eye), equally visible on both surfaces or more visible on the abaxial surface, small, sparse or moderately dense. Petiole 2.5–10 mm long, 0.4–0.9 mm wide. Inflorescence among the leaves, terminal, two to many-flowered, paniculate or racemose. Flowers white, with both calyx and petals, not calyptrate. Hypanthium dull, stipitate or not; goblet-shaped, obconic or stipitate-obconic; 4–7 mm long, 3.8–5.0 mm wide; stipe 1.5–2.2 mm long; 2.0–5.6 times as long as the sepals. Sepals 4, the inner pair larger than the outer (0.9–1.5 versus 1.5–2.2 mm long respectively). Petals five to eight (when five or six, all petals are fully developed; when seven or eight petals are present, one or two may not be fully developed), not coherent, not clawed, circular, subcircular or semielliptic, 3–5 mm long, 3.5–5.2 mm wide, visibly gland-dotted (30–100 or more per petal); margin lacerate (often very distinctly so). Staminal disc ascending slightly. Outermost stamens 7–8 mm long; filaments free, inflexed in bud; anther sacs parallel, elliptic or ovate, dehiscing by longitudinal slits, the anthers 0.5–0.7 mm long, 0.3–0.5 mm wide, the connective glands small, solitary. Style 4–6 mm long, the stigma punctiform. Ovary with axile-median placentation, the placenta obovoid or oblong-ellipsoid in plane shape, either divergently or appressedly lobed; ovules 8–15 per locule, ascending, arranged irregularly. Mature fruit white, spherical or ellipsoid, 19–20 mm long, 17–20 mm wide, with the calyx rim not appreciably expanding in fruit; seed uniembryonic; embryo with the cotyledons readily separable and interlocking funicular tissue not present.

Fig. 1. Leaves of *Syzygium* species. *S. arenitense*: **Aa**, adaxial surface; **Ab**, abaxial surface. *S. eucalyptoides* subsp. *eucalyptoides*: **Ba**, adaxial surface; **Bb**, abaxial surface. A from *Brennan 3532* (CANB), B from *Dunlop 3099* (CANB). Scale bar = 1cm.

Distribution and ecology. *Syzygium arenitense* has been recorded as occurring in the East Alligator River (south-east of Oenpelli), Jim Jim Falls area, and the Mann River area, Northern Territory. It commonly is a rheophyte in the beds of the seasonal streams on the western edge of the sandstone plateau of Arnhem Land and this is the only habitat in which the author has observed the species. Herbarium label data indicate that it might also occur away from stream lines in low woodlands and fringing forest but these data may refer to the landscape in a locally general sense and be nonspecific with respect to *S. arenitense*.

Flowering materials have been collected in September and October, and fruits have been collected in January.

Remarks. *Syzygium eucalyptoides* subsp. *eucalyptoides* is commonly found as a rheophyte along stream lines in the lowland country in northern Australia but can also occur along stream lines on the sandstone plateau of Arnhem Land in sympatry with *S. arenitense* (Brennan, pers. comm.). *Syzygium arenitense* and *S. eucalyptoides* subsp. *eucalyptoides* can readily be distinguished on the foliar differences given in the Introduction.

It may be that the rheophytic habit is an obligate feature of the species. Certainly the species can be added to van Steenis' (1981) world census of rheophytes.

Etymology. The specific epithet is derived from the geological name for sandstone, arenite, and refers to the colloquial name used for the sandstone plateau country of northern Australia, i.e. "the sandstone".

Keys to the Northern Territory species of *Syzygium*

The following keys are based upon those given in Dunlop *et al.* (1995).

Key based on fruit characters.

1a. Fruit white 2
1b. Fruit variously coloured, not pure white 5
2a. Fruit c. 25 mm long ..... *S. forte*
2b. Fruit <25 mm long 3
3a. Fruit surface smooth, unwrinkled, the pericarp with numerous peg-like intrusions into the seed ..... *S. armstrongii*
3b. Fruit surface wrinkled, the pericarp without peg-like intrusions into the seed 4
4a. Sepals with one pair larger than the other; seeds 15 mm in diameter ..... *S. arenitense*
4b. Sepals uniform in size or nearly so; seeds 7-8 mm in diameter ..... *S. minutuliflorum*
5a. Fruit >30 mm long ..... *S. suborbiculare*
5b. Fruit <30 mm long 6
6a. Fruit purple to black or white with a purple blush 7
6b. Fruit red, bright pink or white with a red blush 8
7a. Sepals persisting on fruit ..... *S. angophoroides*
7b. Sepals not persisting on fruit ..... *S. nervosum*
8a. Fruit bright pink with narrow triangular sepals ..... *S. fibrosum*
8b. Fruit red or white with a red blush ..... *S. eucalyptoides*

Key based on flower characters.

1a. Young branchlets 4-angled; sepals 5 ..... *S. angophoroides*
1b. Young branchlets + terete; sepals 4 2
2a. Buds >27 mm long; sepals >6.5 mm long ..... *S. suborbiculare*
2b. Buds <20 mm long; sepals <6.5 mm long or calyx calyptrate 3
3a. Calyx calyptrate ..... *S. nervosum*
3b. Calyx not calyptrate 4
4a. Stamens c. 15 mm long; sepals narrowly triangular ..... *S. fibrosum*
4b. Stamens <15 mm long; sepals not triangular, usually semicircular (if triangular then very depressedly so) 5
5a. Buds >9 mm long; sepals >2 mm long ..... *S. eucalyptoides*
5b. Buds <9 mm long; sepals generally <2 mm long 6
6a. Petals coherent (falling as a cap at anthesis) 7
6b. Petals distinct and not coherent 8
7a. Sepals 1–3 mm long; stamens 7–14 mm long ..... *S. forte*
7b. Sepals 0.2–0.4 mm long; stamens 1–4 mm long ..... *S. minutuliflorum*
8a. Petals 5–8, not clawed; sepals transversely semielliptic to transversely semicircular ..... *S. arenitense*
8b. Petals 4, clawed; sepals very depressedly-triangular ..... *S. armstrongii*

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Description of a new species of *Polyodontes* Renieri in Blainville, 1828 (Polychaeta: Acoetidae) from Papua New Guinea

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ABSTRACT

A new species, *Polyodontes vanderloosi* sp. nov., from off Lawadi village, Papua New Guinea, is described and illustrated by figures and unique underwater photographs of the animal while still alive. A comparison with the similar species *P. atromarginatus* Horst, 1917 and *P. tidemani* Pflugfelder, 1932 showed that the main distinguishing characters of *P. vanderloosi* sp. nov. are: (1) palps with rows of small papillae and with very long, digitiform papillae, often with bifid or multifid tips, distributed in the middle to subdistal part of the palps; and (2) five anterior pairs of elytra covering the dorsum completely.

KEYWORDS: Polychaeta, Acoetidae, *Polyodontes*, new species, systematics, Papua New Guinea.

INTRODUCTION

Recently, during a dive in the vicinity of Lawadi village, Papua New Guinea, one of us (R.S.) observed several scale worms belonging to the family Acoetidae Kinberg, 1858 protruding from their tubes. Although he had spent many hundred diving hours at this locality over many years and at different seasons he had never seen these acoetids before. After numerous hours observing and photographing the animals, finally one of them was speared in its tube and subsequently extracted from it. A close examination of the specimen and comparison with similar species described previously (Pflugfelder 1932; Pettibone 1989) showed that it belonged to a new species of the genus *Polyodontes* Renieri in Blainville, 1828. Below, this new species, *Polyodontes vanderloosi* sp. nov., is described, figured, and compared to similar species. Additionally, unique underwater photographs corresponding to the described specimen protruding from its tube are provided. The holotype is deposited in the collection of the Museum and Art Gallery of the Northern Territory, Darwin, Australia (NTM).

SYSTEMATICS

Family Acoetidae Kinberg, 1858
Genus *Polyodontes* Renieri in Blainville, 1828
Polyodontes vanderloosi sp. nov.

(Figs 1–3)

Type material. HOLOTYPE – complete specimen, NTM W18652, Lawadi village, approximately 10°15' S 150°40' E, D'Entrecasteaux Islands, Milne Bay Province, Papua New Guinea, 30 March 2003, speared in its tube at night, 7 m, coll. R. Steene.

Description. Holotype 520 mm long, 24 mm wide for about 210 segments (complete specimen). Body long, vermiform, more or less colourless in alcohol, light orange to brownish in life. Elytra present on segments 2, 4, 5, 7, 9, ... to end of body. Anterior six pairs of elytra large, rounded; in alcohol, surface with small orange spots, more densely pigmented mainly near anterior and outer lateral margins (Fig. 1B); in life, complete surface bright orange with white spots (Fig. 3B–D); of the anterior six pairs of larger elytra, only first five pairs covering dorsum completely (in alcohol). Following elytra oval, not covering dorsum, with brownish pigment in alcohol near margins (Fig. 1C), greyish with white spots in life (Fig. 3D).

Anterior end (Figs 1A, 3B–F): prostomium bilobed, with bulbous ommatophores with distal lenses and long necks (slightly contracted due to fixation). Ceratophore of median antenna inserted in middle of prostomium, with few lateral papillae; style of median antenna about as long as ommatophores, abruptly tapering subdistally; posterior pair of sessile eyes lateral to ceratophore. Lateral antennae inserted ventrally below ommatophores, tips visible dorsally, abruptly tapering subdistally. Palps tapering, about three times length of median antenna, with rows of small papillae and with very long, digitiform ones, often with bifid or multifid tips, distributed in middle to subdistal part of palps. Pharynx not everted, not investigated. All prostomial appendages with scattered brownish pigment.

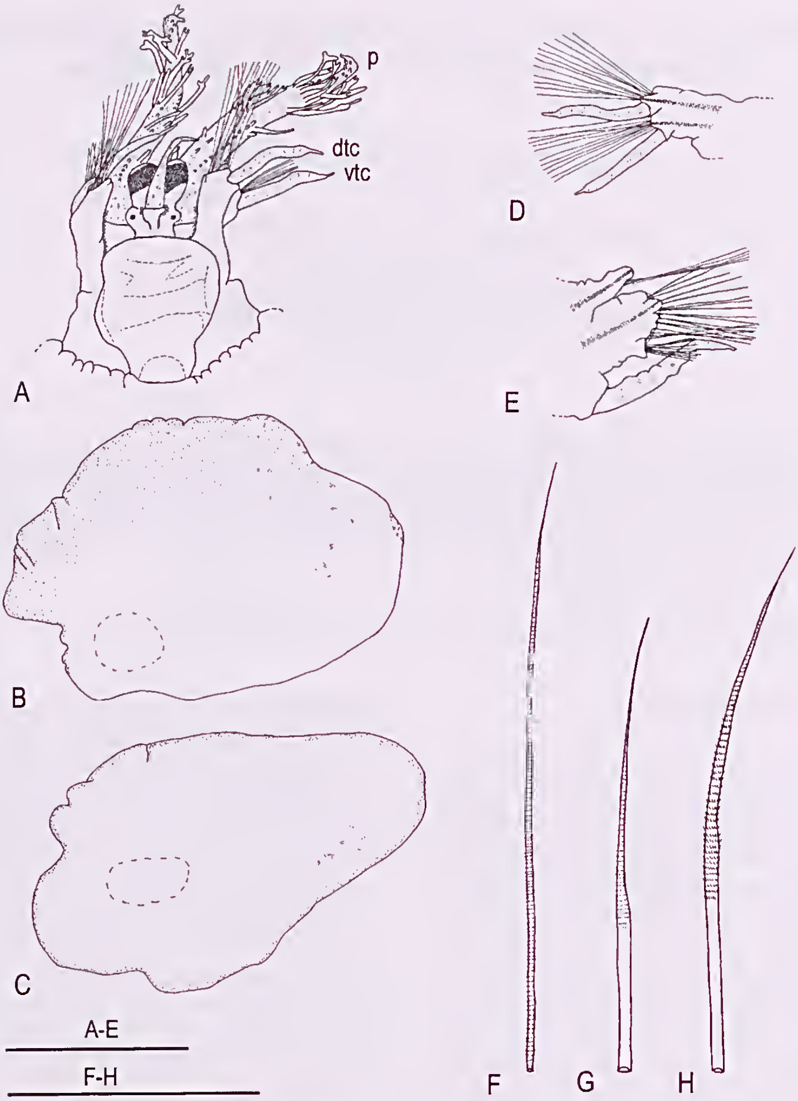

Fig. 1. *Polyodontes vanderloosi* sp. nov., holotype NTM W18652: **A**, anterior end with ommatophores and palps slightly contracted due to fixation, and left lateral antenna and ventral tentacular cirrus bent downwards; **B**, left second elytron from segment 4; **C**, left tenth elytron from segment 19; **D**, left tentaculophore, lateral view; **E**, left elytragerous parapodium of segment 2, anterior view; **F**, capillary notochaeta of same; **G**, upper neurochaeta of same; **H**, lower neurochaeta of same. Abbreviations: **p**, palp; **dtc**, dorsal tentacular cirrus; **vtc**, ventral tentacular cirrus. Scales: upper scale: 4 mm, lower scale: 1 mm.

Tentacular segment distinct dorsally; tentaculophores lateral to prostomium, each with a row of small papillae on inner dorsal side, a pair of acicula and rounded projecting acicular lobes, two bundles of capillary chaetae, and dorsal and ventral tentacular cirri similar to style of median antenna (Fig. 1A,D). Second segment with first pair of elytra, long ventral buccal cirri, and biramous parapodia; notopodia with acicular lobe projecting, rounded, on anterodorsal side of larger neuropodia, and with bundle of long spinous capillary notochaetae; neuropodia wide, subconical with anteroventral bract; neurochaetae slightly enlarged basally, tapering to capillary tip, with numerous rows of spines, shorter in upper and longer in lower neurochaetae (Fig. 1E–H). Third segment with first pair of dorsal cirri, with short cirrophore and tip of tapering style extending beyond neurochaetae; shape of parapodia and chaetae as in segment 2, except for appearance of middle stout acicular neurochaetae (Fig. 2A). In segments 4 to 8, notopodia becoming smaller and notochaetae shorter.

Beginning with segment 9, notopodia wide, rounded, flattened, on anterodorsal side of neuropodia, with spinning glands and row of short spinous capillary notochaetae (Fig. 2B,C). Neuropodia with prechaetal acicular lobe rounded and postchaetal lobe truncate with more or less well developed anteroventral bract (Fig. 2B,C); neurochaetae occurring in three groups: (1) upper group emanating from anterodorsal bract, not hidden by notopodium, of two types (as defined by Pettibone (1989)): (a) long, slender, slightly enlarged basally, tapering to capillary tip, and with numerous rows of short spines (Fig. 2D); (b) shorter, tapering to sharp tip, bipinnate, with widely spaced spines (Fig. 2E); (2) middle group of stout acicular neurochaetae, with tip slightly hooked, not aristate and without subdistal spines (Fig. 2G); and (3) lower group emanating from anteroventral bract numerous, slender, curved, enlarged basally, tapering to capillary tip, with numerous rows of longer spines (Fig. 2F).

Dorsal cirri tapering, with scattered brownish pigment; style longest on segment 3, becoming gradually shorter subsequently and cirrophore becoming wider (Fig. 2A–C). Ventral cirri tapering, with scattered brownish pigment; buccal cirri (on segment 2) reaching about to tips of neurochaetae (Fig. 1E); on segment 3 ventral cirri much shorter, reaching about to distal margin of neuropodia only, becoming even shorter more posteriorly (Fig. 2A–C). Parapodial branchiae present on anterior part of body, difficult to discern more posteriorly, occurring in two groups: (a) dorsally close to cirrophores or clytrophores, more or less globular, starting on segment 8; (b) medially to ventral cirri, globular to digitiform, starting on segment 11 (Fig. 2B,C).

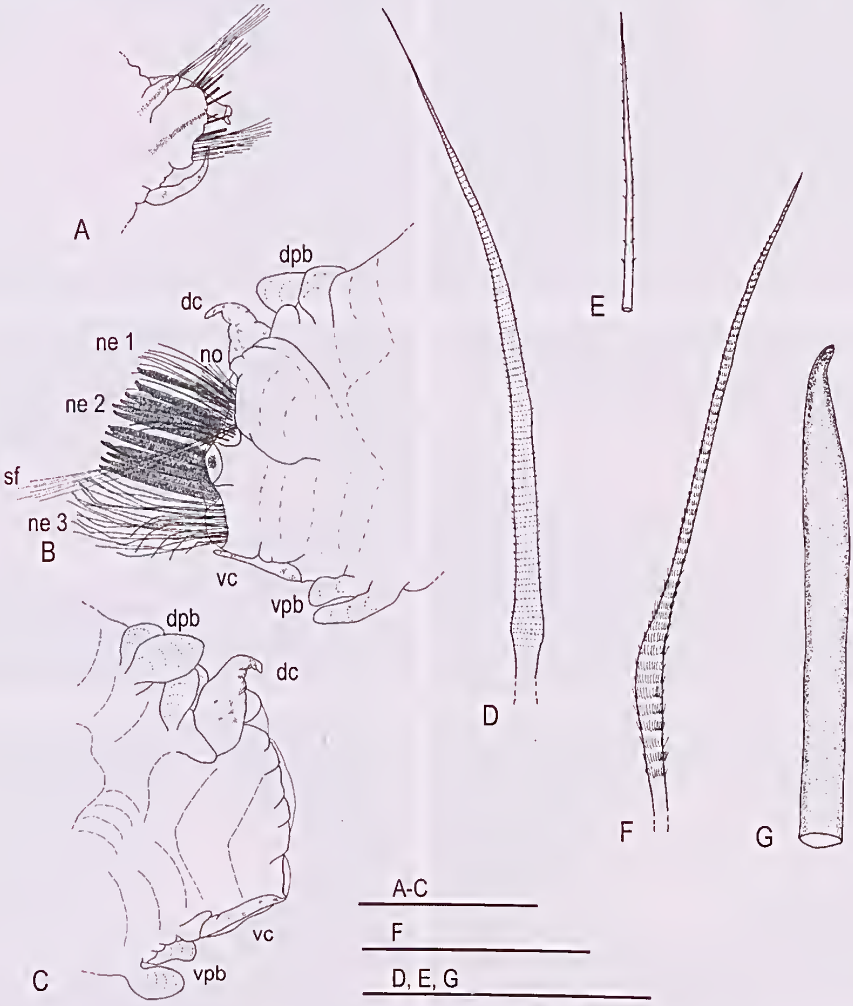

Fig. 2. *Polyodontes vanderloosi* sp. nov., holotype NTM W18652: **A**, left cirrigerous parapodium of segment 3, anterior view; **B**, right cirrigerous parapodium of segment 36, anterior view; **C**, the same, without chaetae, posterior view; **D**, upper neurochaeta of type 'a' of the same, distal part; **E**, upper neurochaeta of type 'b' of same; **F**, lower neurochaeta of the same, distal part; **G**, middle acicular neurochaeta of same. Abbreviations: **dc**, dorsal cirrus; **dpb**, dorsal parapodial branchia; **ne 1–3**, neurochaetae of upper (1), middle (2), lower (3) group; **no**, notochaetae; **sf**, spinning fibres; **vc**, ventral cirrus; **vpb**, ventral parapodial branchia; **vtc**, ventral tentacular cirrus. Scales: upper scale: 4 mm, middle scale: 1 mm, lower scale: 0.5 mm.

Pygidium with dorsal anus and one pair of slender, tapering anal cirri, not longer than dorsal cirri of previous segments.

Tube. Leathery, protruding about 100 mm from substrate, overgrown by algae on top; distal end of tube soft, flap-like (flaps cut off for photos, repaired by worm within 24 hours) (Fig. 3A). Outside width of tube: with algae about 100 mm; tube only 60 mm; tube wall in layers, could be peeled away down to about 40 mm width.

Etymology. The species is named in honour of Rob Vanderloos, the boat skipper, who took one of us (R.S.) not only numerous times to the diving locality, but assisted and helped in many other ways.

Remarks. Among the *Polyodontes* species with long palpal papillae, i.e. *P. atromarginatus* Horst, 1917 and *P. tidemani* Pflugfelder, 1932 (see Pettibone 1989), *P. vanderloosi* is unique due to the following characters: (1) palps with rows of small papillae and with very long, digitiform ones, often with bifid or multifid tips, distributed in middle to subdistal part of palps; and (2) five pairs of anterior elytra covering the dorsum completely (Figs 1A–C, 3B–F).

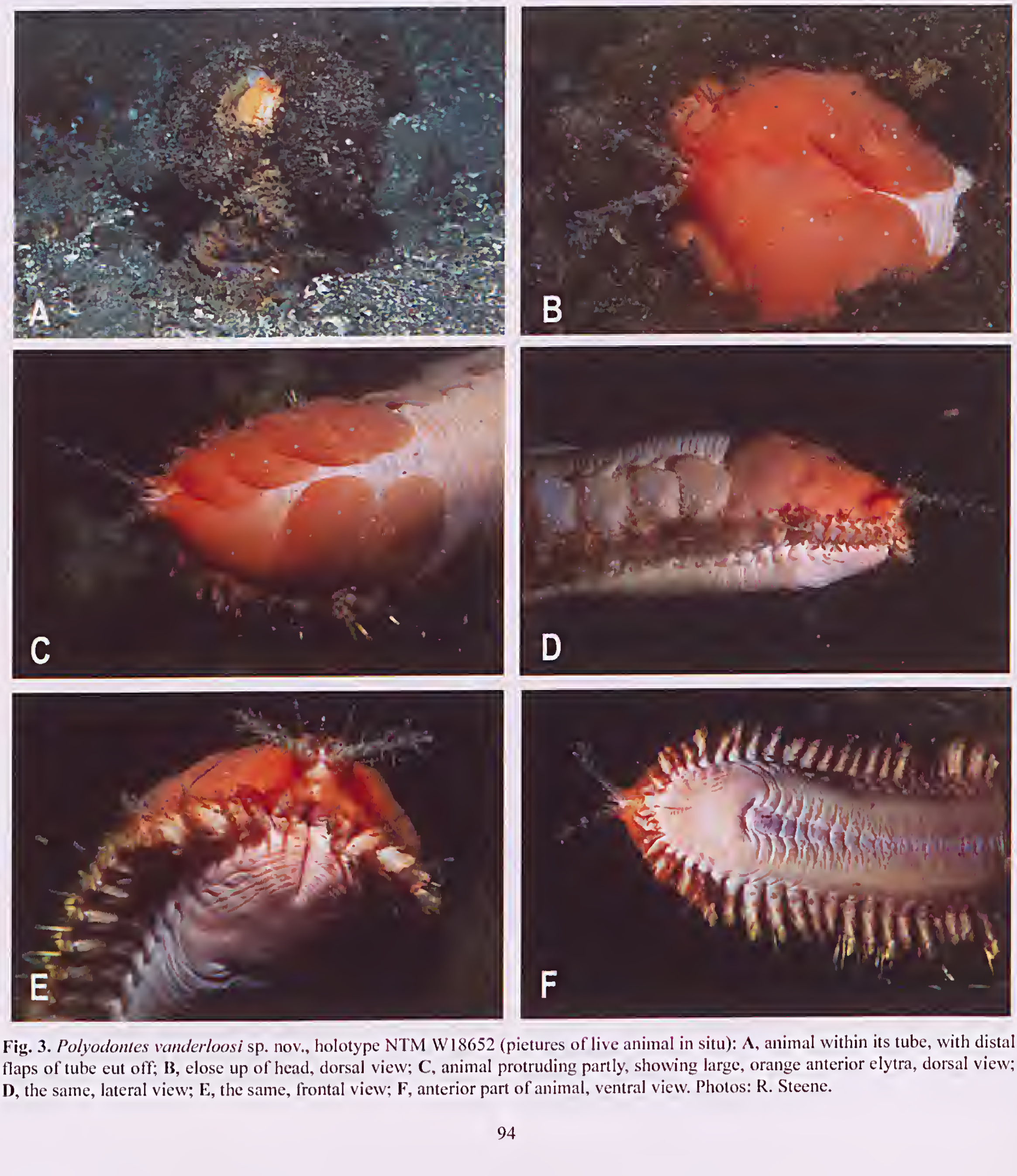

Fig. 3. *Polyodontes vanderloosi* sp. nov., holotype NTM W18652 (pictures of live animal in situ): **A**, animal within its tube, with distal flaps of tube cut off; **B**, close up of head, dorsal view; **C**, animal protruding partly, showing large, orange anterior elytra, dorsal view; **D**, the same, lateral view; **E**, the same, frontal view; **F**, anterior part of animal, ventral view. Photos: R. Steene.

In *P. atromarginatus* in contrast, the long palpal papillae have exclusively entire tips and the dorsum is covered by the three anteriormost pairs of elytra only. Furthermore, *P. atromarginatus* differs from our new species by having posterior eyespots situated anterolaterally to the ceratophore of the median antenna, parapodial branchiae absent, acicular neurochaetae aristate at tip and some with subdistal spines, and neurochaetae of type 'a' with numerous long spines along one side only. In *P. vanderloosi* on the other hand, posterior eyespots occur laterally to the ceratophore (Fig. 1A), parapodial branchiae are present (Fig. 2B,C), acicular neurochaetae are not aristate and never have subdistal spines (Fig. 2G), and neurochaetae of type 'a' have numerous rows of short spines (Fig. 2D).

In comparison to *P. vanderloosi*, the major distinguishing characters of *P. tidemani* are: only long palpal papillae with entire tips; and only the first pair of elytra covering the dorsum (see also Pflugfelder 1932). Additionally, in *P. tidemani* the acicular lobes of the tentaculophores are distinctly pointed and some acicular neurochaetae show subdistal spines, while *P. vanderloosi* has rounded acicular lobes of tentaculophores (Fig. 1D) and the acicular neurochaetae never show subdistal spines (Fig. 1G).

Regarding its size, the holotype of *P. vanderloosi* is up to now not only the largest of all specimens considered herein (see Table 1), but also one of the few acoetids of this size being intact and complete after collection.

Differences in pigmentation of anterior elytra and dorsum, as given in Table 1, are only visible in well preserved material and should only be used in combination with other characters for identification. For a summary of the characters and species considered herein, see Table 1.

Table 1. Main distinguishing characters of *Polyodontes vanderloosi* sp. nov., *P. atromarginatus* and *P. tidemani* (* only width comparable since, except for *P. vanderloosi*, the largest specimens known are anterior fragments).

	***P. vanderloosi* sp. nov.**	***P. atromarginatus* Horst, 1917**	***P. tidemani* Pflugfelder, 1932**
Pairs of anterior elytra covering dorsum completely	five	three	first only
Palps	with rows of small papillae and with very long, digitiform ones, often with bifid or multifid tips, distributed in middle to subdistal part of palps	with small papillae and longitudinal rows of extra long curved ones, tips entire	with four or five longitudinal rows of long papillae, tips entire
Posterior eyespots	lateral to ceratophore of median antenna	anterolateral to ceratophore of median antenna	lateral to ceratophore of median antenna
Acicular lobes of tentaculophores	rounded	rounded	pointed
Parapodial branchiae	present from segment 8	absent	present from segment 10
Tips of acicular neurochaetae	slightly hooked, not aristate and without subdistal spines	slightly hooked, aristate, in middle parapodia some with subdistal spines	slightly hooked, not aristate, in middle parapodia some with subdistal spines
Neurochaetae of type 'a'	with numerous rows of short spines	with numerous long spines along one side	with numerous rows of short spines
Size (*) of largest specimen	width: 24 mm	width: 13 mm	width: 13 mm
Pigmentation of anterior elytra (in alcohol)	with small orange spots, more densely pigmented mainly near anterior and outer lateral margins	with scattered black spots and darker band on posterior and medial borders	absent
Pigmentation of dorsum (in alcohol)	absent	with brown transverse bands	absent
Distribution	Papua New Guinea (Milne Bay Province, off Lawadi village)	Indonesia, Philippines, Gulf of Tonkin, Solomon Islands, Australia (Queensland)	Indonesia (Moluccas)
Reference	this work	Pettibone (1989)	Pflugfelder (1932); Pettibone (1989)

Distribution. Indo-Pacific, Coral Sea: Papua New Guinea, Milne Bay Province, off Lawadi village (D'Entrecasteaux Islands).

Habitat and biology. The holotype was found together with four other individuals in an area of 1 square metre, with tubes protruding from a sandy substrate, in 7 m depth. It was observed at this locality and depth for the first time, although numerous years and diving hours were spent at this locality by one of us (R.S.). Palps were seen to be protruding from tube mostly at night, occasionally also in daytime; the pharynx was everted to swallow small pieces of fish fed to the worm. The large, orange elytra were observed to flap often around the "head".

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We would like to thank Hannelore Paxton, Department of Biological Sciences, Macquarie University, Sydney, Australia, for establishing the contact between the authors and for her advice; Dieter Fiege, Senckenberg Museum, Frankfurt, Germany, for discussing the results presented herein; and Rob Vanderloos, boat captain in Papua New Guinea, for his help in collecting the specimen.

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Short communication

Occurrence of the polychaete *Namalycastis hawaiiensis* Johnson, 1903 (Nereididae: Namanereidinae) in *Pandanus* leaf axils on Palau, West Pacific

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Namalycastis hawaiiensis Johnson, 1903 is a widespread, tropical Indo-Pacific namanereid polychaete occurring from the Hawaiian Islands in the east to Sumatra in the west, and Amami-Oshima, Ryukyu Islands in the north to Milne Bay, Papua New Guinea in the south. The species is known from Palau on the basis of a single record from Arakataoch Stream, a freshwater river about 1.5 km south-east of Ngarekeai village (Glasby 1999), but details of the habitat there are unknown. Typically, *N. hawaiiensis* is associated with various coastal riparian habitats including streams, swamps, aquaculture ponds (for *Macrobrachium* species) and, in the Hawaiian Islands, slightly saline anchialine pools and aquaculture ponds.

This note records the occurrence of *N. hawaiiensis* in a new habitat – phytotelmata, or plant container habitats – better known as refuges for insects. Phytotelmata, derived from the Greek words for plant, *phyton*, and for standing water or pool, *telma*, are small water bodies that accumulate in the depressions and crevices of plants, including tree holes and leaf axils (see Kitching 2000). Often phytotelmata contain small amounts of detritus in addition to the water. The only previously published record of a polychaete species associated with phytotelmata is the tropical Indo-Pacific namanereid *Namanereis catarractarum* Feuerborn, 1931 (Glasby *et al.* 1990; Glasby 1999: 128). Freshwater is a very unusual habitat for polychaetes in general especially when, as in phytotelmata, there is no direct connection to the sea.

Namalycastis hawaiiensis Johnson, 1903

(Figs 1–3)

Material examined. One specimen (NTM W18656), complete, 2.0 mm wide (including parapodia), about 20 mm in length, with 120 chaetigerous segments.

Remarks. The specimen resembles closely the description of the neotype of *Namalycastis hawaiiensis* and other material from Hawaii (Glasby 1999: 49). The only difference is the size and form of the two pairs of eyes, which in the Palau specimen are slightly larger, with the anterior eyes of each pair coalesced with the posterior ones (Fig. 1). This difference may be an artefact because the appearance of the eyes can be affected to some degree by preservation; for example, the eyes may coalesce because of distortion of the prostomium either during fixation or preservation. Importantly, no lenses were observed in this specimen, which distinguishes it from the lens-eyed *N. indica* (Southern, 1921), its freshwater congener in coastal regions of the Indian subcontinent. The two species can further be distinguished from each other in the form and relative number of falcigerous chaetae in the parapodia. *Namalycastis indica* has been reported from similar habitats in coastal areas of India (Bay of Bengal) and Thailand (Andaman Sea) (Glasby 1999: 55), but not as yet from phytotelmata.

Habitat and biology. The specimen was collected in coastal lowlands vegetated with grasses and *Pandanus* (species not identified) about 1 km from the shore and about 13 km from Ngarekeai village (Fig. 2). The worm was found in the water-filled leaf axils of a *Pandanus*, together with mosquitoes (Fig. 3). The mosquitoes were identified as *Ochlerotatus* (subgenus *Finlaya*) sp. and *Culex* (subgenus *Lophoceraomyia*) sp. At the time of collection the trunks of the *Pandanus* were dry, which presumably created a barrier for the dispersal of the worm to the ground.

Observations made on specimen in a shallow, water-filled plastic container indicate that it will expose part of its body to air although it never completely left the container. The worm may be confined to the phytotelmata during dry periods, but could possibly move around the plant more freely – including down

Fig. 1. Preserved specimen of *Namalycastis hawaiiensis*, anterior end, dorsal view. Photo: C. Glasby.

Fig. 2. Habitat of *Namalycastis hawaiiensis* on coastal lowlands near Ngarekeai village, Palau. Photo: M. Mogi.

the trunk – during wet periods. It did not appear to catch live mosquito larvae, but it did show interest in dead mosquito larvae – by stopping and touching them a few times – although it did not consume them.

DISCUSSION

Feuerborn (1931) found that southern Sumatran populations of *N. hawaiiensis* (which he referred to by its junior synonym, *Lycastis ranauensis* Feuerborn, 1931) are hermaphrodites, with both eggs and immature sperm found in the same individual. Eggs, 125-135 µm in diameter, are thought to be fertilised outside the body and deposited in a jelly mass. After four days, the larvae hatch into 3-chaetiger juveniles, and leave the jelly mass. The jelly mass probably affords some protection against desiccation and/or osmotic stress that would normally affect an embryo lacking nephridia. Feuerborn (1931) described a similar reproductive strategy for the other phytotelmatic namanereid, *Namanereis catarractarum*. This suggests that this particular reproductive strategy permits life in phytotelmata, as well as the other freshwater environments inhabited by these species.

Although *N. hawaiiensis* normally lives in fresh or slightly saline waters, it can tolerate full-strength seawater if the salinity is increased gradually – over a period of eight days according to Feuerborn (1931). However, it is not known how long the worms can survive in full strength seawater because although all of his experimental worms died after four weeks in seawater; they may have died of starvation rather than osmotic stress. Therefore, the species may have the ability to disperse away from freshwater container habitats, especially during the wet season, and potentially reach the coast. How they have ended up with such a wide Indo-Pacific distribution is, however, quite a mystery. A vicariant explanation has been suggested – uplifting of continental margins and/or sea level change could explain simultaneous speciation of a marine ancestor in tectonically active areas, and could be a general mechanism for speciation in the subfamily (Glasby 1999: 142). But human-assisted translocation of populations (e.g. via the freshwater aquarium trade, aquaculture activities, and/or the trade or exchange of particular plant specimens) is also a possibility because of this species' preference for riparian detritus and plant-associated habitats. The record of *N. hawaiiensis* in freshwater ponds at the Botanical Gardens, Bogor, Java, Indonesia (Horst 1909), may be an example of such an introduction. Hermaphroditism (especially self-fertilisation) would clearly increase the probability of colonization success by anthropogenic means.

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Fig. 3. Close-up of the *Pandanus* leaf axils from where the specimen was collected. Photo: M. Mogi.

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New records of *Salmoneus* Holthuis, 1955 (Crustacea: Decapoda: Alpheidae) from northern Australia, with description of one new species and remarks on *S. serratidigitus* (Coutière, 1896)

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ABSTRACT

Salmoneus seticheles sp. nov. is described from the mangroves of Darwin, Northern Territory, Australia. The most characteristic feature of the new species is the presence of long, flexible setae on the upper and lower margins of the major chela. Two individuals possess, instead of a normal minor cheliped, a so-called "subminor" cheliped, which is only slightly smaller than the major cheliped. This type of chelar dimorphism is unique among species of *Salmoneus*. *Salmoneus cristatus* (Coutière, 1897) is reported for the first time from Queensland offshore reefs, representing a further new record for the Australian alpheid fauna. A single, incomplete specimen from Queensland was assigned to the taxonomically problematic *S. serratidigitus* (Coutière, 1896) species complex. At least two species from this species complex are present in northern Australian waters. *Salmoneus latirostris* (Coutière, 1896) and *S. sibogae* (De Man, 1910), prematurely placed in the synonymy of *S. serratidigitus* by Banner and Banner (1981), are considered to be distinct species. A key to world species of *Salmoneus* is provided.

Keywords: Alpheidae, *Salmoneus*, mangroves, coral reef, Northern Territory, Queensland, cheliped dimorphism, species complex, synonymy.

INTRODUCTION

Holthuis (1955) established the alpheid genus *Salmoneus* to replace *Jousseaumea* Coutière, 1896, a junior primary homonym of *Jousseaumea* Sacco, 1894 (incorrect original spelling: *Jousseaumia* Sacco, 1894), a genus of prosobranch molluscs (ICZN, 1963). *Jousseaumea* was erected originally for two species, *Jousseaumea latirostris* Coutière, 1896 and *J. serratidigitus* Coutière, 1896. Holthuis (1955) selected *J. serratidigitus* as the type species of *Salmoneus*, despite the fact that *J. latirostris* has page priority (both species were described on the same page, cf. Coutière 1896: 382).

The genus *Salmoneus* now contains at least 20 species worldwide, most of them in shallow, tropical and warm temperate waters (Chace 1972, 1988; Banner and Banner 1973, 1981; Dworschak *et al.* 2000). In all species the orbital hoods are well developed and completely or partly cover the eyes in dorsal view; the rostrum and the extra-corneal teeth are well developed and acute; the chelipeds are asymmetrical in shape and unequal or subequal in size, with the major chela lacking plunger and fossa (snapping mechanism); the second pleopods bear a well developed appendix masculina and an appendix interna in both sexes; the sixth abdominal somite is devoid of a postero-ventral articulated flap; and the posterior margin of the telson is either truncate or bears a variously shaped median notch (Banner and Banner 1973; Chace 1988; Carvacho 1989).

Only two species, *S. tricristatus* Banner, 1959 and *S. sibogae* (De Man, 1910), have been previously reported from Australian waters (Banner and Banner 1973, 1982; Davie 2002). Subsequently *S. sibogae*, together with *S. latirostris*, were placed in the synonymy of *S. serratidigitus* by Banner and Banner (1981). However, morphological variability of *S. serratidigitus s. lat.* (*sensu* Banner and Banner 1981) and differences in colour pattern (cf. Coutière 1899; Banner and Banner 1981) seem to be beyond intraspecific level, and suggest that both *S. sibogae* and *S. latirostris* are valid species.

During a survey of small benthic organisms on Channel Island near Darwin, Northern Territory in 1991, M. Burke (Museum and Art Gallery of the Northern Territory, Darwin, NTM) collected several alpheid shrimp specimens from muddy substrates of mangrove creeks and river mouths. In the same year, P. Alderslade (NTM) collected a further specimen of the same species from Ludmilla Creek mouth on the other side of Darwin. The shrimps were identified as a new species of *Salmoneus* by Dr. Y. Miya (Nagasaki University) and Dr. A. J. Bruce (in 1991 in the NTM, now associated with Queensland Museum, Brisbane), however, the species has remained undescribed. During my visit to the NTM, in August 2001, I had an opportunity to examine several alpheid specimens, including the specimens from Channel Island. The *Salmoneus* species has been confirmed as new and is described herewith.

The collection of the Museum and Art Gallery of the Northern Territory, Darwin, also contains two other interesting specimens of *Salmoneus* collected on coral reefs off northern Queensland. Despite the imperfect condition of these specimens (both were missing major chelipeds), one has been identified as *S. cristatus* (Coutière, 1897), representing a new record for Australia, and the other is tentatively assigned to *S.* aff. *serratidigitus*.

Abbreviations used in the text are as following: NTM, Museum and Art Gallery of the Northern Territory, Darwin; MNHN, Muséum National d'Histoire Naturelle, Paris; RMNH, Nationaal Naturhistorisch Museum, Leiden; USNM, National Museum of Natural History, Smithsonian Institution, Washington D.C.; OUNHM, Oxford University Natural History Museum, Oxford; MCZ, Museum of Comparative Zoology, Harvard University, Cambridge, U.S.A.; NT, Northern Territory; CL, carapace length (in mm), measured from tip of rostrum to posterior margin of carapace; TL, total length (in mm), measured from tip of rostrum to posterior margin of telson.

The holotype and a series of paratypes of the new species are deposited in the collection of the NTM. Additional paratypes are also deposited in other institutions.

SYSTEMATICS

Genus *Salmoneus* Holthuis, 1955

Salmoneus seticheles sp. nov.

Figs 1–5

Type material. HOLOTYPE – 1 female (CL 4.8, TL 14.0), NTM Cr 010571, mouth of Ludmilla Creek, Darwin, NT, 12°24.8' S, 130°51.7' E, LWS, 18 March 1991, hand, P. Alderslade, coll. PARATYPES – 1 female, dissected (CL 5.2, TL 14.8), NTM Cr008266, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 4, 13 July 1991, M. Burke, coll.; 1 ovig. female (CL 5.0, TL 14.5), NTM Cr013580, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 10, 13 July 1991, M. Burke, coll.; 1 ovig. female (CL 4.9, TL 14.2), NTM Cr013581, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 2, 13 July 1991, M. Burke, coll.; 1 young specimen (CL 3.3, TL 10.3), NTM Cr013582, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 9, 13 July 1991, M. Burke, coll.; 1 female (CL 5.0, TL 14.8), NTM Cr013583, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 2, 13 July 1991, M. Burke, coll.; 1 female (CL 4.8, TL 13.9), NTM Cr013584, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 9, 13 July 1991, M. Burke, coll.; 1 ovig. female (CL 5.5, TL 15.4), NTM Cr013585, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 3, 13 July 1991, M. Burke, coll.; 1 specimen (CL 4.8, TL 14.0), NTM Cr013586, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 6, 13 July 1991, M. Burke, coll.; 1 specimen (CL 4.2, TL 12.0), NTM Cr008276, Blackmore River mouth, Channel Island, Darwin, NT, Site 2, Patch B, Quadrat 3, 12°37.3' S, 130°56.6' E, LWS, 13 June 1991, M. Burke, coll.; 1 specimen (CL 4.7, TL 13.8), NTM Cr008277, Blackmore River mouth, Channel Island, Darwin, NT, Site 2, Patch B, Quadrat 2, 12°37.3' S, 130°56.6' E, LWS, 13 June 1991, M. Burke, coll. (specimen parasitized by a bopyrid, latter removed, NTM Cr008574); 1 specimen, possibly female (CL 4.0, TL not measured), USNM 1005100, mouth of Blackmore River, Channel Island, Darwin, NT, Site 2, Patch B, Quadrat 8, 12°37.3' S, 130°56.6' E, LWS, 4 November 1991, M. Burke, coll.; 1 ovig. female (CL 4.7, TL not measured), MNHN–Na 13765, mouth of Blackmore River, Channel Island, Darwin, NT, Site 2, Patch B, Quadrat 10, 12°37.3' S, 130°56.6' E, LWS, 4 November

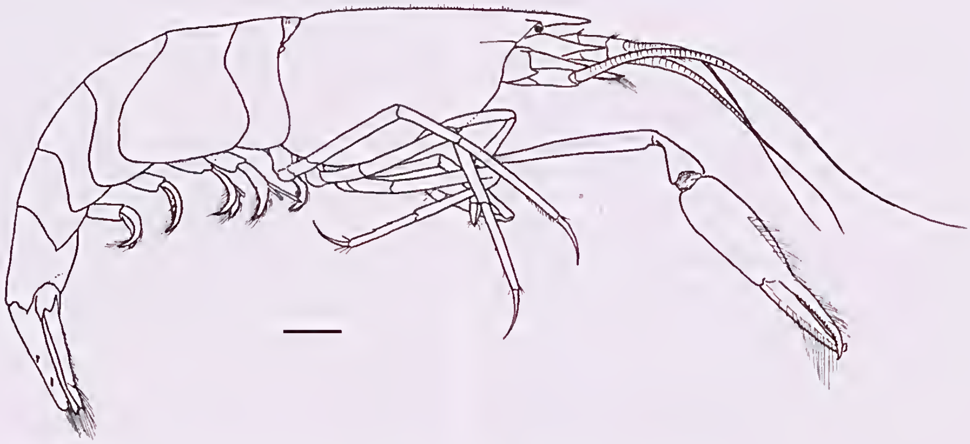

Fig. 1. *Salmoneus seticheles* sp. nov. Holotype NTM Cr010571, female, habitus. Scale: 1 mm.

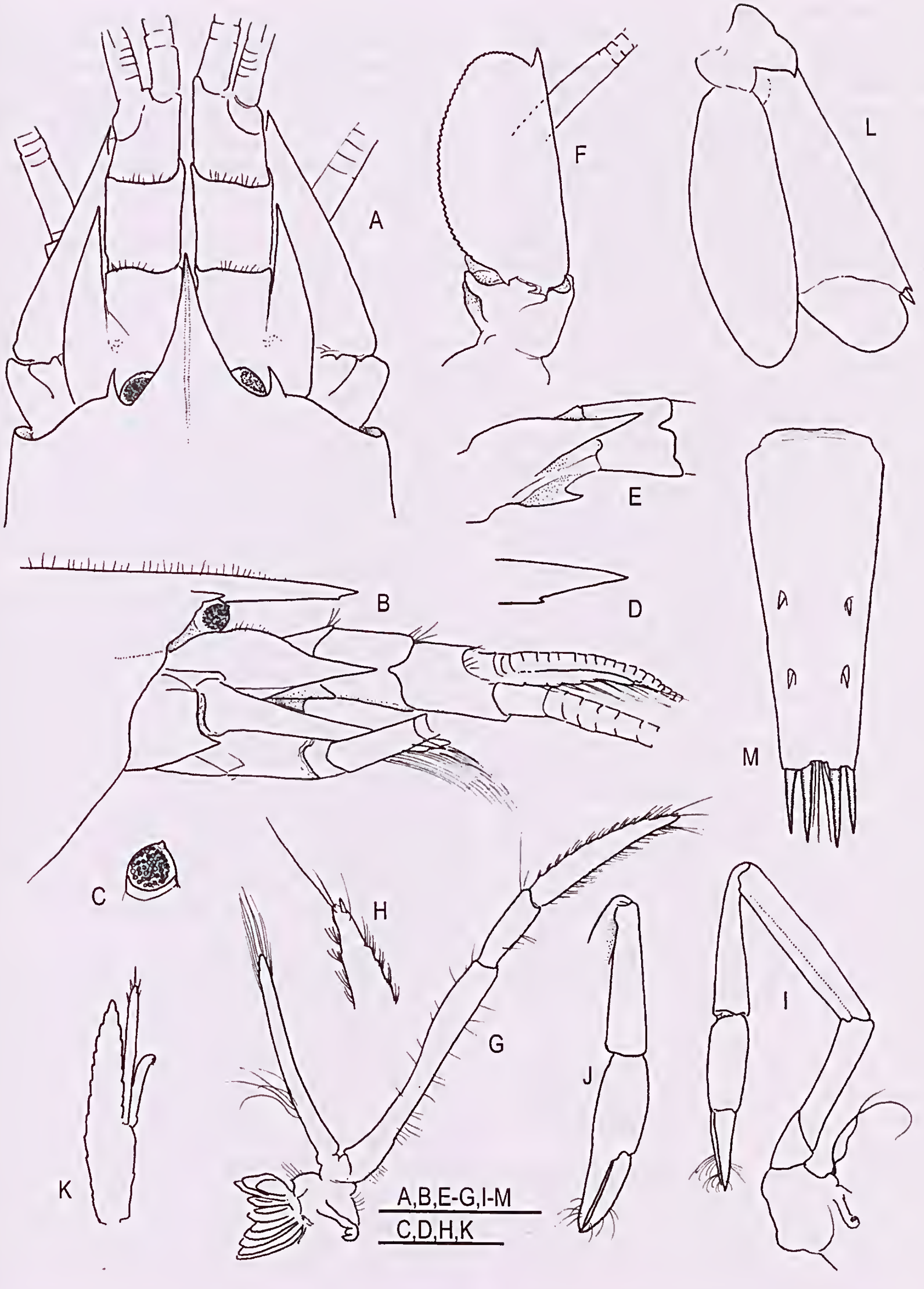

Fig. 2. *Salmoneus seticheles* sp. nov. Holotype NTM Cr010571, female: **A**, frontal region, dorsal view; **B**, same, lateral view; **C**, eyestalk; **D**, distal rostrum, detail. Paratype NTM Cr008266, female; **E**, antennule, detail of first and second articles, lateral view; **F**, antenna; **G**, third maxilliped; **H**, same, distal ultimate segment; **I**, minor cheliped, lateral view; **J**, same, carpus and chela, mesial view; **K**, second pleopod; **L**, uropod; **M**, telson. Scales: upper scale: 1 mm, lower scale: 0.5 mm.

1991, M. Burke, coll.; 1 specimen, possibly female (CL 4.9, TL not measured), OUMNH Zoo 2002–19–0001, mouth of Blackmore River, Channel Island, Darwin, NT, Site 2, Patch A, Quadrat 3, 12°37.3' S, 130°56.6' E, LWS, 04 November 1991, M. Burke, coll.; 1 specimen, possibly female (CL 4.5, TL not measured), RMNH D 50012, mouth of Blackmore River, Channel Island, Darwin, NT, Site 2, Patch A, Quadrat 3, 12°37.3' S, 130°56.6' E, LWS, 4 November 1991, M. Burke, coll.; 1 adult male [?] (CL 4.9, TL 14.1), NTM Cr013587, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 6, 13 July 1991, M. Burke, coll.; 1 adult male [?] (CL 4.6, TL *ca* 13.9), MNHN–Na 13693, mouth of Blackmore River, Channel Island, Darwin, NT, Site 2, Patch B, Quadrat 10, 12°37.3' S, 130°56.6' E, LWS, 4 November 1991, M. Burke, coll.

Description. Small-sized alpheid (largest specimens reaching 14.8 mm TL). Carapace covered with fine, erect setae (Fig. 2B). Rostrum broad at base, reaching distal margin of first article of antennular peduncle or slightly beyond it, with a small, but distinct subapical tooth (Fig. 2D); rostral carina feebly developed. Orbital teeth well developed, acute, slightly curved mesially. Eyes partly visible dorsally between orbital teeth and base of rostrum, partly exposed laterally (Fig. 2B), with tiny tubercle on anterior surface (Fig. 2C); cornea well developed, but not occupying entire distal surface of eye peduncle. Pterygostomial angle rounded.

Antennular peduncle robust, second article shorter than visible portion of first article; stylocerite acute, reaching to about 1/2–3/4 length of second article; antennular ventral carina bearing strong, acute tooth (Fig. 2E); outer flagellum subdivided almost at base, aesthetasc-bearing ramus well developed, consisting of at least five articles. Antenna robust, basicerite with strong ventro-lateral tooth; carpocerite short and robust, reaching beyond mid-length of scaphocerite and only to distal end of first article of antennular peduncle; scaphocerite broad, oval (Fig. 2F), with strong disto-lateral tooth, not overreaching distal end of antennular peduncle.

Mouthparts typical for *Salmoneus* and most Alpheidae. Third maxilliped slender; tip with small subterminal spinule (Fig. 2H); coxa with ear-shaped lateral plate and strap-like epipod; arthrobranch present, well-developed (Fig. 2G).

First pereiopods or chelipeds asymmetrical in shape and unequal in size, and dimorphic, most specimens bearing a major cheliped and a much smaller minor cheliped (with 50/50 percentage of handedness) characteristic of many other species of *Salmoneus*; two specimens bearing a major cheliped and only a slightly smaller, differently shaped and armed "subminor cheliped".

Major cheliped (Figs 3A–C, 4A) with ischium and merus slender, unarmed, slightly flattened on inner surface; carpus short, cup-shaped (Fig. 3A); chela almost rounded in cross-section, slightly depressed; palm approximately as long as fingers, smooth except for deep proximal depression at articulation with carpus (Figs 3C, 4A); pollex and dactylus very slightly curved medially (Fig. 3A), almost straight in lateral view except for crossing tips (Fig. 3B); lower margin of distal portion of palm and pollex, and upper margin of dactylus furnished with row of long, fine setae (Figs 3B, 4A); cutting edges each bearing 15–18 rounded teeth (Figs 3B, 4A).

Minor cheliped (Fig. 2I, J) much smaller than major cheliped, with carpus subequal to ischium, and merus approximately 1.2–1.3 times longer than carpus; chela simple, unarmed. Subminor cheliped (Fig. 4B) only slightly shorter than major cheliped (Fig. 5), but much larger and stouter than minor cheliped, with palm being at least 1.5 times longer than pollex, latter distinctly shorter than dactylus (Fig. 4B); cutting edges armed with two larger rounded teeth, much larger than those of major cheliped; lower margins of propodus and dactylus furnished with long, fine, simple (not setulose) setae as in major cheliped (cf. Figs 4A and 4B).

Second pereiopod (Fig. 3D) slender; merus 1.5 times longer than ischium; carpus five-jointed, first joint longer than four others combined; chela simple. Third pereiopod (Fig. 3E) slender; ischium armed with two spines; merus unarmed; carpus with slender distal spinule or spine-like seta; propodus with four small spines or paired spines, distal spines longest; dactylus very slender and curved, more than 1/2 length of propodus; fourth pereiopod similar to third pereiopod; fifth pereiopod with much longer carpus and propodus (Fig. 3F); propodus armed only with one small spine and pair of apical spines; propodal grooming brush well developed, with about 12 rows of short stiff setae (Fig. 3G).

Abdomen somewhat elongate (Fig. 1); first to fourth segments rounded, fourth segment with postero-ventral margin slightly angular; fifth segment with postero-ventral margin pointed; sixth segment without distinct articulated flap; pre-anal plate rounded and medially depressed. Second pleopod of all specimens examined (including ovigerous females) with appendix interna and appendix masculina, latter twice as long as former and exceeding endopod (Fig. 2K). Uropod with exopod bearing straight diaresis and short disto-lateral spine (Fig. 2L). Telson sub-rectangular (Fig. 2M), tapering distally, with two pairs of dorsal spines, first and second pair situated at about 1/2 and posterior 3/4 of telson length, respectively; posterior margin truncate, with shallow rectangular median notch, four setae arising from median notch, and two pairs of strong postero-lateral spines (inner spines slightly longer than outer spines, Fig. 2M); anal tubercles absent. Ovigerous specimens with eggs large, oval (about 0.8 x 0.6 mm diameter) and not numerous (usually less than 20).

Gill formula typical for genus: pleurobranchs above first to fifth pereiopods; podobranch absent; one arthrobranch associated with third maxilliped; strap-like epipods (mastigobranchs) on coxae of third maxilliped to fourth pereiopod; setobranchs on coxae of first to fifth pereiopods; exopods on first to third maxilliped.

Colour in life. Unknown.

Distribution and habitat. Presently known only from Ludmilla Creek (type locality) and Channel Island, Darwin, Northern Territory, Australia; mud bottom in mangrove forests.

Etymology. The specific name refers to the diagnostic long setae fringing the lower and the upper margins of the major chela.

Remarks. The genus *Salmoneus* can be divided in two species groups, the smaller *S. jarli* (Holthuis, 1951) species group and the larger *S. serratidigitus* (Coutière, 1896) species group. The four species of the *S. jarli* group are all found in the eastern Atlantic Ocean from the Mediterranean Sea to the Cape Verde Islands (Holthuis 1951; Fransen 1991; Dworschak *et al.* 2000).

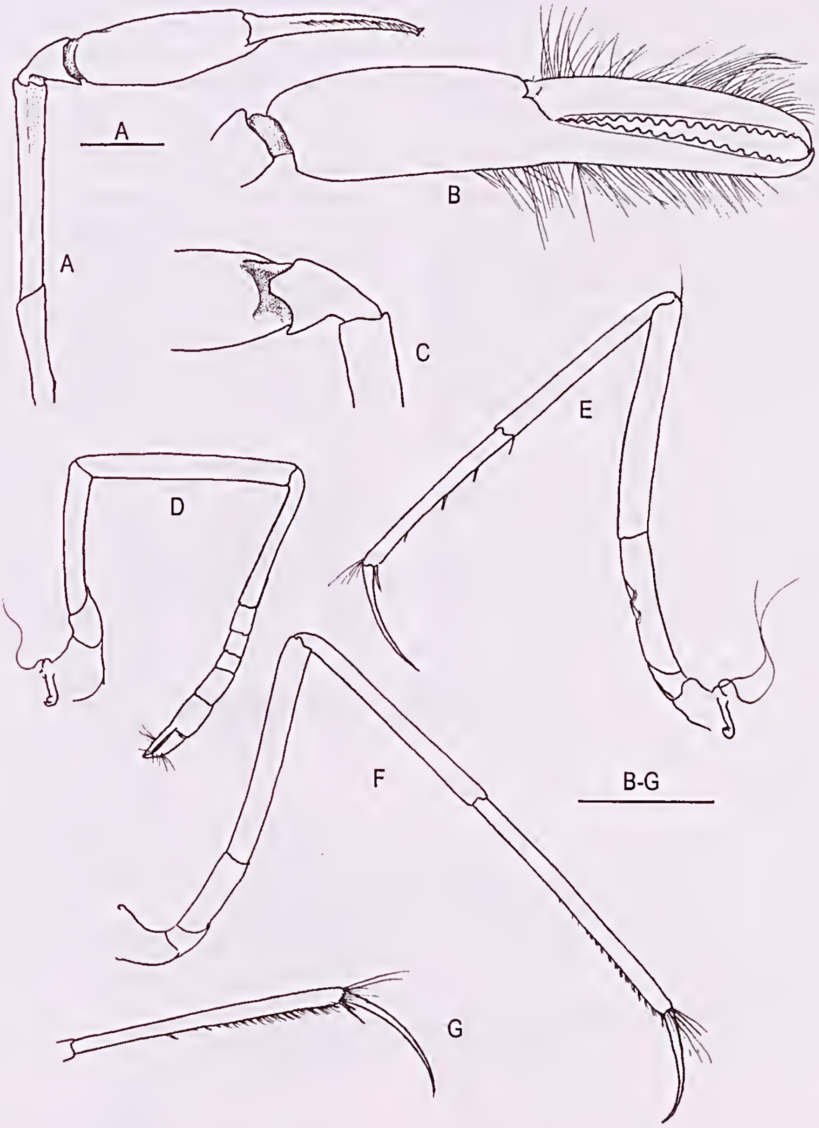

Fig. 3. *Salmoneus seticheles* sp. nov. Paratype NTM Cr008266, female: **A**, major cheliped; **B**, same, chela; **C**, same, distal merus, carpus and proximal palm, ventral view; **D**, second pereiopod; **E**, third pereiopod; **F**, fifth pereiopod; **G**, same, propodus and dactylus. Scales: 1 mm.

These species are characterized by the slender (minor) cheliped being longer than the stout (major) cheliped. In contrast, all species of the *S. serratidigitus* group are characterized by the minor cheliped being much smaller and less robust than the major cheliped. The 16 species of this group are distributed in the Indo-Pacific from the Red Sea to the Gulf of California (Banner and Banner 1981), as well as in the Western Atlantic from Florida to Brazil (Chace 1972; Christoffersen 1982; Felder and Manning 1986; Holthuis 1990) and Ascension Island in the central Atlantic (Manning and Chace 1990).

Salmoneus seticheles is assigned to the *S. serratidigitus* species group. However, because of the polymorphism of the chelipeds the new species occupies a somewhat isolated position within this group. Most specimens of *S. seticheles* have a major cheliped and a much smaller minor cheliped, which is typical of the *S. serratidigitus* group. A few paratypes have only the major cheliped (the other cheliped could be either minor or subminor), or only the minor cheliped (the opposite cheliped obviously would be major). The remaining two specimens have a major cheliped and a subminor cheliped, and in one of these two specimens (MNHN–Na 13693), both chelipeds are still attached to the body (Fig. 5). The subminor cheliped is only slightly smaller than the major cheliped and differs from the latter by the proportions of the chela, and more importantly, by the fingers not being serrated with small teeth, as in the major cheliped, but instead, armed with a few much larger teeth. The subminor cheliped is very different from the minor cheliped in being much more robust, with the chela enlarged and armed with teeth (cf. Figs 2I and 4B). Since the major cheliped of specimens with the typical minor cheliped and those with the subminor cheliped is almost identical, the subminor cheliped must be homologous with the minor cheliped.

The completely different shape and size of the minor cheliped could be an indication that two different species are involved. However, in this case there are several reasons to consider that the two specimens with the subminor cheliped belong to *S. seticheles*. With the exception of the subminor cheliped they present no substantial morphological differences to the specimens bearing typical minor chelipeds. The chela of the subminor cheliped is furnished with the similar, long and flexible setae as are found on the chela of the major cheliped (Fig. 4). Furthermore, the two specimens with the subminor cheliped were collected at the same localities as all the other specimens.

The nature of the unusual cheliped polymorphism in *S. seticheles* is unknown, but it is not impossible that the smaller cheliped is sexually dimorphic in this species, a feature not uncommon in the Alpheidae. In this hypothesis, the ovigerous and the non-ovigerous

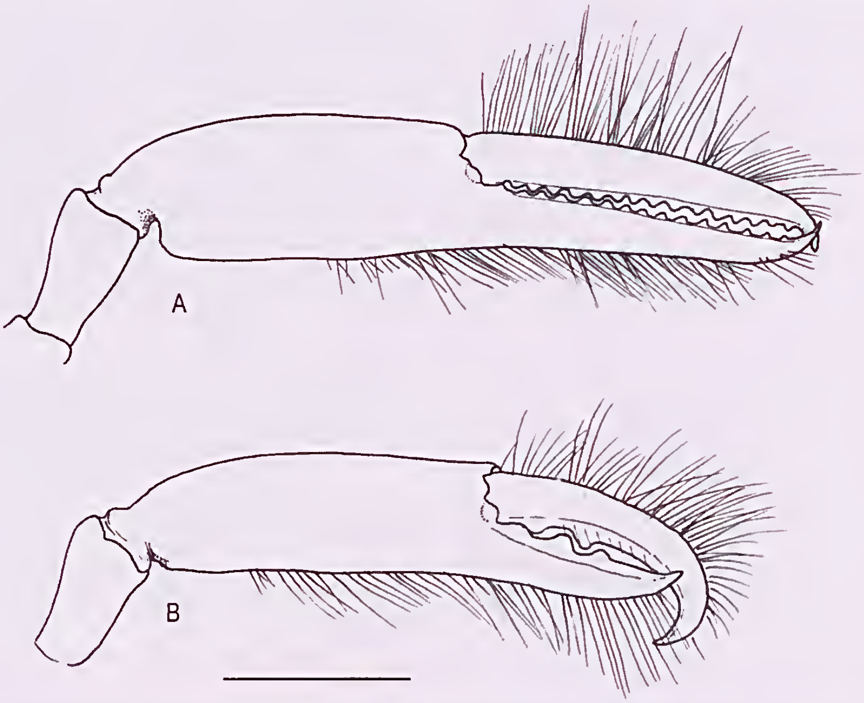

Fig. 4. *Salmoneus seticheles* sp. nov. Paratype NTM Cr013580, ovigerous female: **A**, major cheliped, carpus and chela. Paratype NTM Cr013587, possibly male: **B**, subminor cheliped, carpus and chela. Scale: 1 mm.

specimens with a typical minor cheliped are females, and the two non-ovigerous specimens with a subminor cheliped are males. The presence of a well developed appendix masculina in both sexes in all species of *Salmoneus* (Carvacho 1989) prevents this feature being used to sex the non-ovigerous individuals. Another external feature, which is sometimes used to determine the sexes in caridean shrimps, is the shape of the abdominal pleurae. This, however, is similar between the males and the females in all species of *Salmoneus*, and does not permit a clear separation of the sexes. The position of the gonopores on the basis of coxae of third and fifth pereiopod (female and male, respectively), cannot be ascertained due to the small size of shrimps. Therefore, the assumption that in the new species the smaller cheliped is sexually dimorphic (minor cheliped in females, subminor cheliped in males) remains tentative.

Within the *S. serratidigitus* group, *S. seticheles* appears to be closest to *S. tafaongae* Banner and Banner, 1966, from Samoa. Banner and Banner (1966a) described *S. tafaongae* on the basis of a single, fragmentary specimen lacking first pereiopods, and did not provide figures to illustrate the most important characters of this species. The authors also noted that "it was unfortunate that this single specimen was not more nearly intact, and that the small chela and second legs were lost after the initial examination". In this condition the holotype of *S. tafaongae* is difficult to use for comparison with other species (except for the frontal region). Further, the holotype was not located in the collections of the Bernice P. Bishop Museum, Honolulu, or the National Museum of Natural History, Smithsonian Institution, Washington, D.C., where it was probably deposited. Nevertheless, the poor original description of *S. tafaongae* provides enough information to discriminate *S. seticheles* from *S. tafaongae*. In both species the corneas are dorsally exposed between the orbital teeth and the base of the rostrum; the rostrum bears a small subterminal tooth on the inferior margin; the posterior margin of the telson bears a shallow trapeziform cleft; and the third to fifth pereiopods are slender and have a long, slender dactylus. However, in *S. tafaongae* the rostrum is three times as long as broad at its base and reaches to the end of antennular peduncle, while in *S. seticheles* the rostrum is approximately 1.5 times as long as broad and reaches slightly beyond the distal margin of the first antennular article. The ratio of articles of the minor cheliped from ischium to dactylus was noted as 10: 10: 11: 10: 3 in *S. tafaongae* (carpus longest) while *S. seticheles* presents a ratio equal to about 10: 18: 10: 10: 4 (merus longest, Fig. 3D). Also, the spines on the posterior margin of telson appear to be shorter, only 1.2 versus 1.6 times as long as the width of the posterior margin. In *S. tafaongae* the extra-corneal teeth (erroneously called "supra-corneal spines") are upturned, while in the new species they are not. Finally, the holotype of *S. tafaongae* was collected on the "outer portion of fringing reef, shoreward of surf zone, about one ft [0.3 m] below low water" (Banner and Banner 1966a), while the type series of *S. seticheles* was collected at low tide in soft muddy substrates of the mangroves.

Only five other *Salmoneus* species have partly exposed eyes in the dorsal view, but none of them has the major chela furnished with the elongate, flexible setae, as in *S. seticheles*. *Salmoneus gracilipes* Miya, 1972, can be separated from the new species by the longer stylocerite, more robust major chela, and less

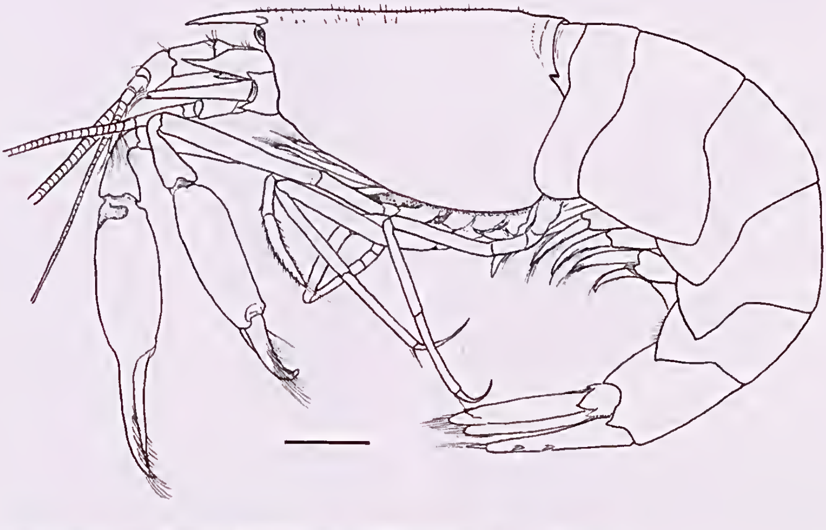

Fig. 5. *Salmoneus seticheles* sp. nov. Paratype MNHN–Na 13693, possibly male. Habitus.

slender dactylus of the third to fifth pereiopods (Miya 1972: pl. 3). *Salmoneus latirostris* (Coutière, 1896) is different from *S. seticheles* in several features, including the frontal margin and the more robust and much shorter dactylus of the third pereiopod (Coutière 1899). The other species of *Salmoneus* having partly exposed eyes, *S. bruni* Banner and Banner 1966, *S. rostratus* Barnard, 1962 and *S. singaporensis* Anker, in press, have very different major chelipeds (Barnard 1962; Banner and Banner 1966b; De Grave and Wilkins 1997; Anker in press), and are not closely related to *S. seticheles*. Among the species characterized by the eyes concealed in dorsal view, none have the third to fifth pereiopods with a long, slender dactylus, and the major chela fringed with long, flexible setae.

Bruce and Coombes (1997) reported an unidentified species of *Salmoneus* from Bullocky Point and Darwin Harbour under the name "*Salmoneus* sp. nov. ? (*cf. tafaongae* ?)", and added that the specimens were "currently under study by Dr Y. Miya". The identity of these specimens remains unknown; they could belong to *S. seticheles* or to another species. No specimens from Bullocky Point are present in the material described here as *S. seticheles*.

Salmoneus cristatus (Coutière, 1897)

Fig. 6

Jousseaumea cristata Coutière, 1897: 234; Coutière 1898: 40; Coutière 1899: 71, fig. 22 (see Chace and Forest 1970 for all page numbers).

Salmoneus cristatus (Coutière). – Holthuis 1958: 18, fig. 7; Banner and Banner 1966b: 40, fig. 10; Johnson 1976: 42; Bruce 1976: 44; Banner and Banner 1981: 54, fig. 6; Banner and Banner 1983: 88.

Material examined. 1 ovigerous female (CL 5.9 mm), major cheliped missing, NTM Cr010678, MV *NJoy* anchorage, Ashmore Reef, Coral Sea, Queensland, Australia, 10° 26.66' S 144° 26.82' E, HL 93–9, surface, 16 January 1993, night light, H.K. Larson *et al*. coll.

Remarks. Although the specimen from the Coral Sea (Fig. 6) is missing its major cheliped, there is little doubt that it belongs to *S. cristatus*. Especially characteristic for this species is the sharp rostral carina followed by a mid-dorsal carina not reaching the posterior margin of the carapace (Fig. 6A). *Salmoneus cristatus* is one of the better known *Salmoneus* species, with descriptions and figures published by Coutière (1899), Holthuis (1958) and Banner and Banner (1966b, 1981). Coutière (1899) described the colour pattern of *S. cristatus* as semi-transparent with red transverse bands; a more detailed colour description was provided by Holthuis in Banner and Banner (1981).

The opportunity is taken here to add some rarely observed but potentially interesting features to the previous descriptions of this species. These features could be valuable for taxonomy and phylogeny of the genus *Salmoneus*. The third maxilliped of *S. cristatus* appears to be typical for *Salmoneus* in that the coxal lateral plate above the strap-like epipod is oval-rounded in shape, not produced (Fig. 6E), while the tip of the ultimate segment is armed with two or three small spines. The appendix masculina on the second pleopod only slightly exceeds the appendix interna. The pre-anal plate of the sixth abdominal segment is posteriorly produced, but distally rounded, not pointed, as in some other species of the genus.

Salmoneus cristatus has been previously reported from the Indian Ocean, including the Red Sea (Holthuis 1958; Banner and Banner 1981), Djibouti, Gulf of Aden – the type locality (Coutière 1897, 1899), Kenya, Madagascar, Seychelles (Bruce 1976; Banner and Banner 1983), and Phuket, Thailand (Banner and Banner 1966b). This record considerably extends the range of this species to north-eastern Australia and, for the first time, from the Indian Ocean to the Pacific Ocean.

Salmoneus aff. *serratidigitus* (Coutière, 1896)

Fig. 7

Material examined. 1 ovigerous female, (CL 4.9 mm), major cheliped missing, NTM Cr008975, SE Cape York Peninsula, Coral Sea off Queensland, 11°37.6' S 142°58.2' E, Station 77, beam trawl, 15 m, from sponge, 1 December 1991, A.J. Bruce and R. Williams, coll.

Description. The most important diagnostic features of this incomplete specimen are as following: rostrum as long as broad at its base, reaching almost to distal margin of second article of antennular peduncle (Fig. 7A); lateral margin concave in dorsal view, dorsal carina feebly developed (Fig. 7A); orbital teeth small, acute (Fig. 7B); eyes completely concealed in dorsal view, anterior portion visible in lateral view (Fig. 7B); stylocerite reaching to rostral tip and nearly to distal margin of second article of antennular peduncle; minor cheliped with carpus slightly shorter than merus (Fig. 7C); carpus of second pereiopod five-jointed, with ratio: 10: 3: 1.5: 2: 4 (Fig. 7D); third pereiopod with two spines on ischium, dactylus less than half as long as propodus (Fig. 7E); pre-anal plate rounded, not produced; posterior margin of telson with deep median cleft (Fig. 7F), inner posterior spines twice as long as outer spines, and 1/5 longer than width of posterior margin. Field notes indicate that the colour was "yellowish, ova bright orange, antennae also bright orange, antennules less", and that the specimen was collected from a sponge trawled from 15 m.

Remarks. The specific identity of this incomplete female cannot be determined without the major cheliped. It belongs most probably to the *Salmoneus serratidigitus* species complex, which includes

S. serratidigitus and two other nominal species, *S. sibogae* and *S. latirostris*, placed in the synonymy of *S. serratidigitus* by Banner and Banner (1981). *Salmoneus* sp. aff. *serratidigitus* appears to be close to *S. latirostris* in the shape of the rostrum and extracorneal teeth (cf. Fig. 6 and Coutière 1899: 71, fig. 21), and differs from the neotype of *S. serratidigitus* from Djibouti, as redescribed and refigured by Banner and Banner (1981), and from *S. sibogae*, as illustrated by De Man (1915), in the shape of the rostrum, and also in having a shorter stylocerite and deeper postero-median cleft on the telson. However, the uniform yellow colour of the present specimen suggests that it cannot belong to *S. latirostris*, which has bright red transverse bands across the carapace and the abdomen (Coutière 1899; Holthuis 1958). On the other hand, the colour pattern of this incomplete specimen is similar to the patterns described for *S. serratidigitus* and *S. sibogae*. The colour of *S. serratidigitus* was described as uniform yellow-

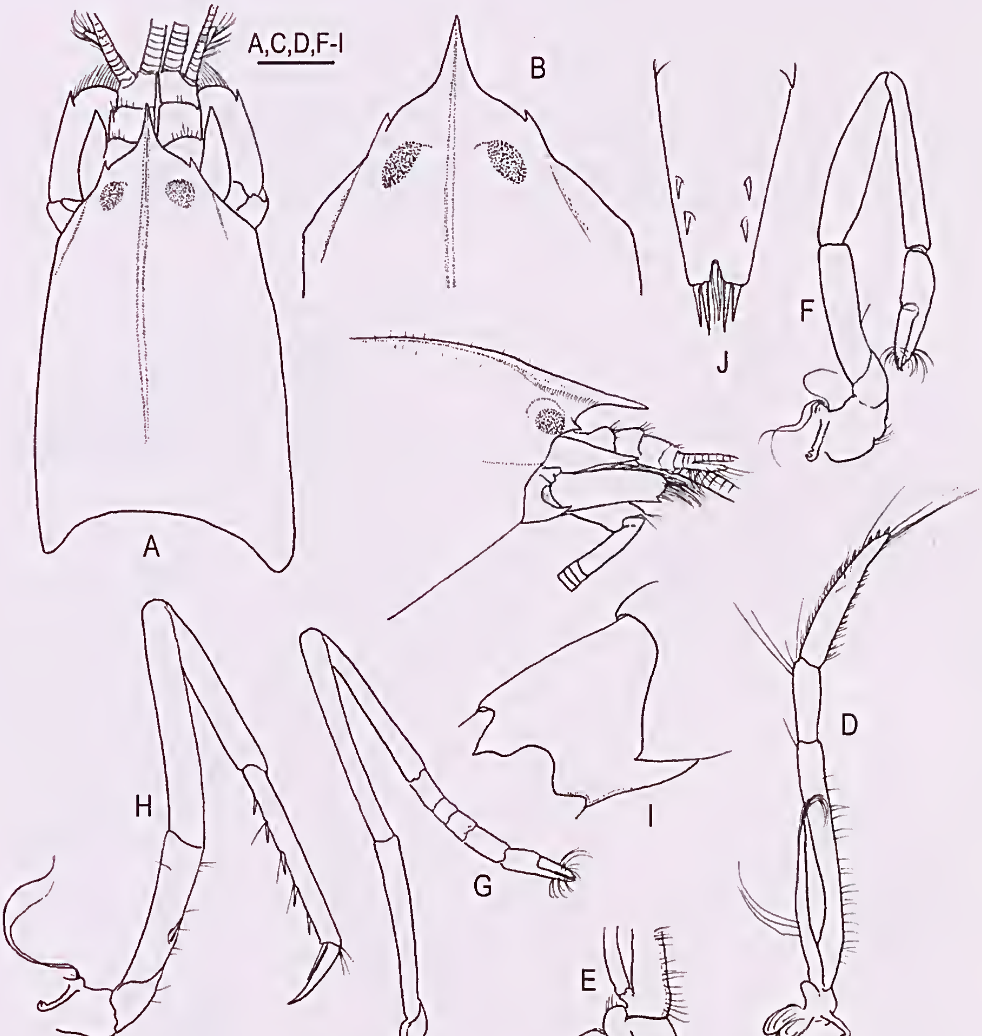

Fig. 6. *Salmoneus cristatus* (Coutière, 1897). NTM Cr010768, ovigerous female from Ashmore Reef, Queensland: **A**, carapace and frontal region, dorsal view; **B**, frontal margin, dorsal view; **C**, same, lateral view; **D**, third maxilliped; **E**, same, different aspect of basal portion; **F**, minor cheliped; **G**, second pereiopod; **H**, third pereiopod; **I**, posterior margin of fifth and sixth abdominal segments; **J**, telson. Scales: 1 mm.

orange by Coutière (1899), and "yellow or bright yellow, one specimen with orange-red viscera showing through the carapace, another specimen uncolored, with eggs and gonads orange" by Holthuis in Banner and Banner (1981). The colour of *S. sibogae* was described as "translucent white with an orange liver [digestive gland]" (Banner and Banner 1982) or "bright yellow to muddy white, eggs red" (Banner and Banner 1968). However, most other *Salmoneus* species also have uniformly yellow or creamy-whitish coloration (e.g., Edmondson 1930; Ríos 1992; Dworschak *et al.* 2000).

Salmoneus serratidigitus was very briefly described by Coutière (1896) from the Red Sea, and subsequently reported from the Red Sea (Banner and Banner 1981), Gulf of Aden (Coutière 1899), East Africa, Madagascar, Seychelles (Banner and Banner 1983), Indonesia (Banner and Banner 1985), Hong Kong (Bruce 1992), Japan (Hayashi 1995; Nomura *et al.* 1998), Micronesia (Miya 1984), Kiribati (Hayashi 1995), Galapagos (Wicksten 1993) and Gulf of California (Wicksten 1983). *Salmoneus latirostris* was originally described from the Red Sea (Coutière 1896), and was reported only from Djibouti in the Gulf of Aden (Coutière 1899). *Salmoneus sibogae* was originally described from Indonesia (De Man 1910, 1911, 1915), and subsequently found in the Red Sea (Holthuis 1958), Hong Kong, Philippines (Banner and Banner 1978), Australia (Banner and Banner 1982), Micronesia, Kiribati, Fiji and French Polynesia (Banner and Banner 1964, 1966a, 1967, 1968).

The type of *S. serratidigitus* from the Red Sea could not be located in the MNHN, but a specimen labelled "*Jousseaumea serratidigitus* (H. Coutière – type) Muséum Paris, Djibouti H. Coutière 109–97", was found in the collection of the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (Banner and Banner 1981). Coutière's handwriting on the label suggests that it was personally identified by him. This specimen (MCZ 5556) was designated as the neotype of *S. serratidigitus*, and

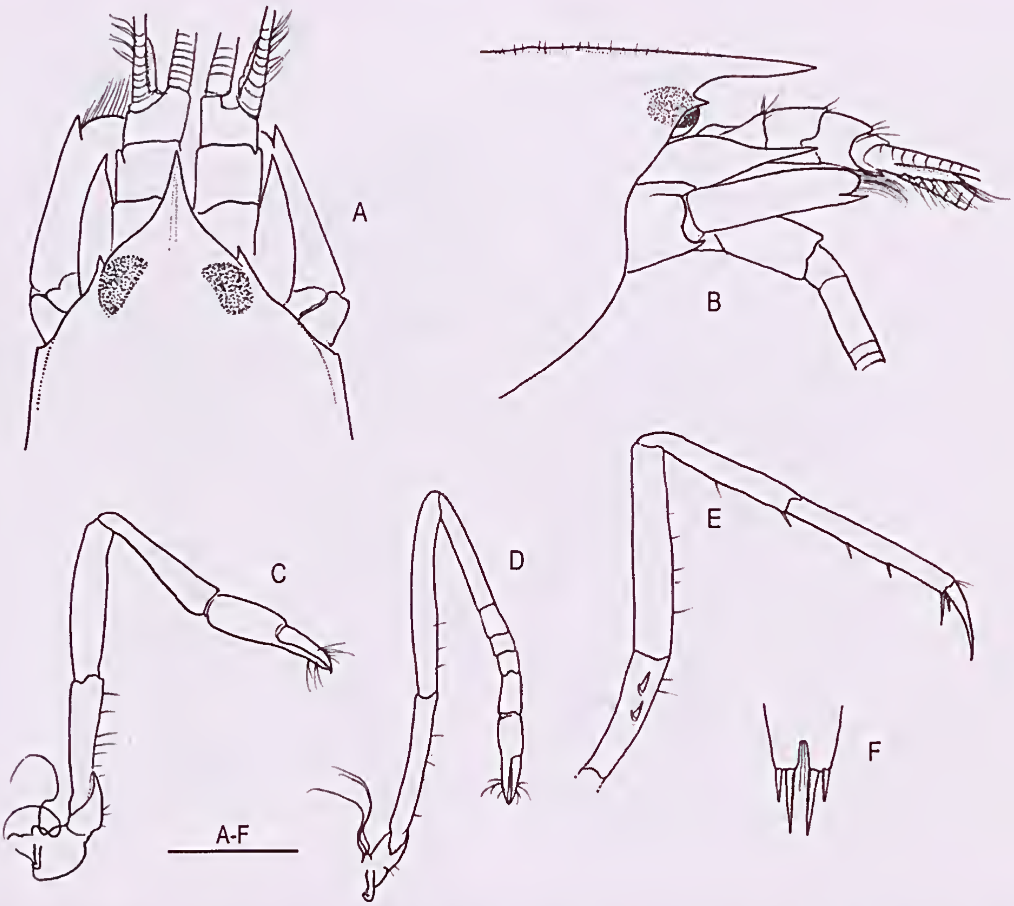

Fig. 7. *Salmoneus* sp. aff. *serratidigitus* (Coutière, 1896). NTM Cr008975, ovigerous female from off SE Cape York, Queensland. **A**, frontal region, dorsal view; **B**, same, lateral view; **C**, minor cheliped; **D**, second pereiopod; **E**, third pereiopod; **F**, telson, posterior margin. Scale: 1 mm.

described and illustrated by Banner and Banner (1981). The holotype of *S. latirostris* from the Red Sea, which according to the inadequately brief description by Coutière (1896) was missing the major cheliped, could not be located in the MNHN. Later Coutière (1899) provided several figures of *S. latirostris*, and noted that the chela of this species was generally similar to that of *S. serratidigitus*, but was more regularly oval and lacking the deep groove on the palm. The "type" of *S. latirostris* from Djibouti, registered under the number MNHN–Na 2781, was found to be *S. cristatus* (see discussion in Banner and Banner 1981). The location of the type of *S. sibogae* remains unknown (Banner and Banner 1981).

Banner and Banner (1981) examined about 20 specimens of *S. serratidigitus* from different localities, including the Red Sea, Madagascar and Gulf of California. They found that the species "show a wide range of variation in characteristics that have been used previously for separation of the species" (e.g., shape and length of rostrum, proportions of some articles in the first, second and third pereiopods, presence of grooves on the major chela, length of the stylocerite, shape of the median cleft on the posterior margin of telson etc, cf. Banner and Banner 1981: 62–63, fig. 7a–g), and placed both *S. latirostris* and *S. sibogae* in the synonymy of *S. serratidigitus*. Thus *S. serratidigitus* is currently interpreted as a morphologically highly variable species, widely distributed in the Indo-Pacific from the Red Sea to the Gulf of California.

However, reporting *S. sibogae* from north-eastern Australia, Banner and Banner (1982: fig. 94) noted and illustrated important morphological differences in the shape and the armature of major chela, the proportions of carpal articles in the second pereiopod and its relative width, between the male and the female specimen. The authors did not know how to evaluate these important differences, but suspected that "they may lie within extremes of variation in Australian populations". In my opinion, the two specimens reported as *S. sibogae* by Banner and Banner (1982) belong to two different species. More than three species are probably involved in the *S. serratidigitus* complex, explaining the morphological variation reported by Banner and Banner (1981). The differences in colour patterns between *S. latirostris* and *S. serratidigitus* are striking (Coutière 1899; Banner and Banner 1981; see also above), and support the discrimination between these two species. Colour patterns are generally constant within the same species, and the slightest differences may indicate the presence of cryptic species (Knowlton and Keller 1985; Knowlton and Mills 1992; Bruce 1987, 1999; Anker 2001). All these findings show that the synonymy of *S. latirostris* and *S. sibogae* with *S. serratidigitus*, as proposed by Banner and Banner (1981), was premature, and would cause confusion in the future. Therefore, I recommend treating both *S. latirostris* and *S. sibogae* as valid species at present, and will attempt a thorough revision of the *S. serratidigitus* species complex in the future.

The other Indo-Pacific species of *Salmoneus* with simple conical (i. e. not extremely slender and elongate) dactyli on the third to fifth pereiopods, and without carinae on the carapace, can be separated from *S.* aff. *serratidigitus* by the combination of several features, including the length and the shape of the rostrum, the shape of the orbital teeth, the length of the stylocerite, and the shape of the posterior cleft on the telson (e.g., De Man 1915; Edmondson 1930; Miya 1972).

DISCUSSION

The alpheid fauna of Australia has been studied by Banner and Banner (1973, 1975, 1982, 1986), Bruce (1983, 1988a, 1988b, 1988c, 1991, 1993, 1994a, 1994b) and Bruce and Coombes (1997). Davie (2002) compiled information on the taxonomy and distribution of all 159 species and subspecies of Australian Alpheidae, many of which are actually species complexes in need of revision (pers. obs.). The present study adds two more species to the list of Australian alpheid shrimps, *Salmoneus cristatus* and *S. seticheles*.

Salmoneus seticheles from the Northern Territory is remarkable within *Salmoneus* in having a dimorphic smaller cheliped. This unique dimorphism is different from the sexual dimorphism of the chelipeds in many species of *Alpheus*, where male and female chelipeds are of similar size (e.g., Banner and Banner 1982). On the other hand, complexly polymorphic or sexually dimorphic chelipeds are known in many species of *Athanas*, e.g., *A. dimorphus* Ortmann, 1890, *A. phyllocheles* Banner and Banner, 1983, *A. polymorphus* Kemp, 1915, and *A. japonicus* Kubo, 1936 (e.g., Coutière 1899; Kemp 1915; Miya and Miyake 1968; Banner and Banner 1973, 1983; Anker, in press). The long, flexible setae, fringing the lower and the upper chela margins in the major and the subminor chelipeds, is another species-specific feature of *S. seticheles*. These setae are possibly used for filtering out food particles and/or for burrow sweeping.

The specific identity of the incomplete specimen from Queensland, here reported as *S.* sp. aff. *serratidigitus*, remains uncertain. The identification of this species will require collection of intact specimens. The morphologically variable *S. serratidigitus s. lat.* (*sensu* Banner and Banner 1981) is most probably a species complex, which also contains *S. latirostris* and *S. sibogae*. After having been placed in synonymy of *S. serratidigitus* by Banner and Banner (1981), both *S. latirostris* and *S. sibogae* are here treated as distinct species. The resurrection of these species appears necessary to avoid further confusion. The taxonomic identity of *S. serratidigitus* is now restricted to the description and figures by Coutière (1896, 1899) and the description and figures of the neotype by Banner and Banner (1981). The revision of the *S. serratidigitus* complex is necessary, but would require recollection of specimens of *S. latirostris* and *S. sibogae* from the type localities (Red Sea, Djibouti, Banda Sea), and examination of numerous other specimens identified as *S. serratidigitus* from the Indo-Pacific, which is beyond the scope of this study.

Noteworthy, two other species of *Salmoneus* were originally described as morphologically variable. The holotype of the western Atlantic *S. cavicolus* Felder and Manning, 1986, an ovigerous female, differs in at several important features from the two "male" paratypes (cf. Felder and Manning 1986: fig. 4b and 4g, 4j, fig. 6e). These differences are clearly not intraspecific, and I believe that at least two different species have been described under the name "*S. cavicolus*" (Anker, in prep.). *Salmoneus sketi* Fransen, 1991, known from two ovigerous females collected in the same marine cave in the Adriatic Sea, is also variable in several features (cf. Fransen 1991: figs 1, 2, 16, 26, 27, 28), which, however, are less conspicuous and could be intraspecific.

Banner and Banner (1981: 52–54) provided a key to 14 species of *Salmoneus*. This key did not include *S. latirostris* and *S. sibogae*. Since 1981 eight additional species have been described in this genus, including *S. seticheles*. Therefore, a new key appears to be necessary. The updated key below includes all valid species of *Salmoneus*, and also *S. latirostris* and *S. sibogae*. However, the use of this key implies that the specimens are intact and have both chelipeds, or at least the major cheliped. The identification of incomplete specimens of *Salmoneus*, e.g., those lacking the major cheliped, is always tentative, even for species having other distinguishing features. The major cheliped is unknown in two species of *Salmoneus* (*S. tafaongae* Banner and Banner, 1966 and *S. hilarulus* (De Man, 1910)). The position of these species in the present key is tentative, and based on the assumption that the chelipeds of *S. tafaongae* would be similar to those of the presumably related *S. rostratus*, whereas the chelipeds of *S. hilarulus* would be similar to those of the possibly closely related *S. serratidigitus*. In Banner and Banner's (1981) key the position of *S. tafaongae* and *S. hilarulus* is not dependent on cheliped features.

Key to world species of *Salmoneus*

Abbreviations used in the key: IWP, Indo-West Pacific; WP, Western Pacific; EP, Eastern Pacific; CP, Central Pacific; IP, Indo-Pacific; WA, Western Atlantic; EA, Eastern Atlantic; CA, Central Atlantic; IO, Indian Ocean.

1a. Major chela without long, flexible setae fringing upper and lower margin of distal palm and fingers 2

1b. Major chela with long, flexible setae fringing upper and lower margin of palm and fingers; smaller cheliped polymorphic: (1) minor cheliped – much smaller and less robust than major cheliped, without long flexible setae, with chela not enlarged and unarmed, (2) subminor cheliped – subequal to major cheliped, with long flexible setae, with chela enlarged and armed with large teeth; eyes visible in dorsal and lateral view; rostrum with subapical inferior tooth (IO: Northern Territory, Australia) .... *S. seticheles* sp. nov.

2a. Chelipeds very unequal in size and asymmetrical in shape: minor cheliped much smaller and less robust than major cheliped; minor chela not especially enlarged or elongate, simple, unarmed 6

2b. Chelipeds subequal in size, asymmetrical or subsymmetrical in shape; minor (slender) cheliped subequal or longer than major (robust) cheliped; minor chela enlarged or elongate, armed or unarmed (EA) 3

3a. Fingers of major chela without teeth; carapace with strong dorsal carina extending from rostrum to anterior third of carapace (EA: Nigeria) .... *S. jarli* (Holthuis, 1951)

3b. Fingers of major chela armed with teeth; carapace with slight carina not extending to anterior third of carapace, or without carina 4

4a. Carpus of major and minor cheliped with strong, acute, ventral tooth; posterior margin of telson with small median notch; stylocerite not reaching distal third of second article of antennular peduncle (EA: Cape Verde) ....
.... *S. caboverdensis* Dworschak, Anker and Abed-Navandi, 2000

4b. Carpus of major and minor cheliped without acute, ventral tooth; posterior margin of telson truncate 5

5a. Rostrum exceeding distal margin of second article of antennular peduncle; telson slender; minor (slender) cheliped with merus six times as long as wide, and carpus subcylindrical (EA: Adriatic Sea) .... *S. sketi* Fransen, 1991

5b. Rostrum not reaching middle of second article of antennular peduncle; telson relatively broad; minor (slender) cheliped with merus four times as long as wide, and carpus vase-shaped, distally widening (EA: Adriatic Sea) .... *S. erasimorum* Dworschak, Anker and Abed-Navandi, 2000

6a. Merus and propodus of major cheliped deeply excavated; posterior margin of telson truncate, without median notch (WA: Bermuda to Brazil, EP: Gulf of California) .... *S. ortmanni* (Rankin, 1898)

6b. Merus and propodus of major cheliped not excavated 7

7a. Fingers of major chela serrated with small teeth along entire cutting margin, except for tips and sometimes distal 1/4 10

7b. Fingers of major chela serrated with larger teeth along proximal 1/2 or 1/3 of cutting margin; eyes visible in dorsal and lateral view 8

8a. Rostrum not reaching distal margin of first article of antennular peduncle, without subapical tooth on ventral margin; post-rostral tubercle absent; eyestalk without antero-median tubercle (WP: Gulf of Thailand) .... *S. bruni* Banner and Banner, 1966

8b. Rostrum exceeding distal margin of first article of antennular peduncle, with subapical tooth on ventral margin 9

9a. Post-rostral tubercle present; rostrum not reaching third article of antennular peduncle; extra-corneal teeth not upturned; eyestalk with small antero-median tubercle (IWP: Madagascar, Thailand, Papua New Guinea) .... *S. rostratus* Barnard, 1962

9b. Post-rostral tubercle absent; rostrum reaching almost to distal margin of antennular peduncle; extra-corneal teeth upturned; large cheliped unknown (WP: Samoa) .... *S. tafaongae* Banner and Banner, 1966

10a. Fingers of major chela with proximal teeth much larger than distal teeth; rostrum exceeding distal margin of first article of antennular peduncle; eyestalk with antero-median tubercle; carpocerite robust, reaching distal margin of scaphocerite blade (WP: Singapore) .... *S. singaporensis* Anker, in press

10b. Fingers of major chela with proximal teeth subequal to distal teeth 11

11a. Carapace densely covered with conspicuous, coarse setae; rostrum exceeding distal margin of second article of antennular peduncle; extra-corneal teeth large, triangular; space between rostrum and extra-corneal teeth broadly U-shaped; telson with shallow, triangular median notch; stylocerite reaching far beyond distal margin of second article of antennular peduncle (CA: Ascension I., WA: NE Brazil) .... *S. setosus* Manning and Chace, 1990

11b. Carapace without setae, or covered with rather inconspicuous, thin setae 12

12a. Carapace with ridges or crests arising in orbital area and running parallel or subparallel to median crest 13

12b. Carapace without ridges or crests 15

13a. Lateral crests of carapace arising from lateral edges of rostrum, medial to extra-corneal teeth, extending only slightly behind eyes; posterior margin of telson with shallow triangular notch; major chela with distal 1/4 of fingers unarmed; rostrum as long as broad at base; extra-corneal teeth acute, directed somewhat mesially; colour pattern: transversely banded with bright red (IWP: Red Sea to Australia) .... *S. cristatus* (Coutière, 1897)

13b. Lateral crests or carinae of carapace arising from extra-corneal teeth; posterior margin of telson with deep, U-shaped notch; distal 1/4 of fingers of major chela with teeth 14

14a. Lateral crests of carapace conspicuous, running parallel to median crest and reaching beyond middle of carapace; rostrum greater in length than basal width, reaching beyond distal margin of second article of antennular peduncle; extra-corneal teeth slender, directed somewhat mesially; colour pattern: semi-transparent, with red chromatophores on posterior abdominal somites and posterior carapace (IWP: E Africa to Polynesia) .... *S. tricristatus* Banner, 1959

14b. Lateral carinae of carapace rather inconspicuous, running obliquely towards median crest, reaching slightly beyond eyes; rostrum equivalent in length to basal width, short, reaching to distal margin of first article of antennular peduncle, not much lower than dorso-median carina in lateral view; extra-corneal teeth broadly triangular, directed slightly laterally (IWP: Red Sea to Hawaii) .... *S. brevirostris* (Edmondson, 1930)

15a. Posterior margin of telson truncate, without median notch (WA) 16

15b. Posterior margin of telson with median notch 17

16a. Rostrum much greater in length than basal width; eyes visible in dorsal view; carapace without small pits; dactylus of third to fifth pereiopods long and slender; second article of antennular peduncle longer than first (WA: Florida) .... *S. cavicolus* Felder and Manning, 1986

16b. Rostrum much broader at base than long; eyes not visible in dorsal view; carapace with small pits; dactylus of third to fifth pereiopods not particularly slender; second article of antennular peduncle as long as first (WA: Caribbean Sea; NE Brazil) .... *S. arubae* (Schmitt, 1936)

17a. Dactylus of major chela reaching far beyond pollex, strongly hooked; carapace inflated; rostrum lower than carapace in lateral view; dactylus short, stout; posterior margin of telson with broad U-shaped notch (WP: S. Japan) .... *S. babai* Miya and Miyake, 1966

17b. Dactylus of major chela subequal to pollex, moderately curved 18

18a. Dactylus of third pereiopod very slender, elongate, 6–10 times as long as broad at base, about half length of propodus; rostrum much longer than broad at base, with small subapical tooth on ventral margin; eyes partly visible in dorsal and lateral view (WP: S Japan to Micronesia) .... *S. gracilipes* Miya, 1972

18b. Dactylus of third pereiopod about 3–5 times as long as broad at base, about 1/3 length of propodus 19

19a. Major chela with cutting margin of fingers bearing not more than seven teeth; posterior margin of telson with broad triangular cleft (CP: Hawaii) .... *S. mauiensis* (Edmondson, 1930)

19b. Major chela with cutting margin of fingers bearing at least eight teeth 20

20a. Rostrum as long as broad at base, lateral margins distally slightly convex 21

20b. Rostrum longer than broad at base, lateral margins not convex 22

21a. Most anterior portion of eyes visible in dorsal view; posterior margin of telson with deep median notch; second pereiopod with ischium bearing one spine; colour pattern: transversely banded with bright red (IO: Red Sea, Gulf of Aden) .... *S. latirostris* (Coutière, 1896)

21b. Eyes not visible in dorsal view; posterior margin of telson with small, shallow median notch; carapace with small pits; second pereiopod with ischium unarmed (CA: Ascension Island, WA: Caribbean Sea) .... *S. teres* Manning and Chace, 1990

22a. Stylocerite not reaching distal margin of second article of antennular peduncle; distal 2/3 of rostrum very slender; telson with both pairs of dorsal spines situated in posterior third; large cheliped unknown (WP: Indonesia) .... *S. hilarulus* (De Man, 1910)

22b. Stylocerite overreaching distal margin of second article of antennular peduncle; at most distal 1/3 of rostrum slender 23

23a. Third pereiopods with ischium bearing two or three spines, and with propodus bearing three to six spines on inferior margin; posterior margin of telson with U-shaped notch and two to four pairs of setae (IP: Red Sea to Gulf of California) .... *S. serratidigitus* (Coutière, 1896)

23b. Third pereiopods with ischium bearing one spine, and with propodus bearing two spines on inferior margin; posterior margin of telson with trapeziform notch and one pair of setae (IWP: Red Sea to Australia) .... *S. sibogae* (De Man, 1910)

Several species of *Salmoneus* appear to be undescribed. One of them has been collected in the eastern Mediterranean Sea (Grippa 2002); it appears to be closely related to the Indo-Pacific *S. serratidigitus*, and would be the first member of the *S. serratidigitus* species group in the eastern Atlantic. At least three undescribed species of *Salmoneus* are known from the Western Atlantic (Anker, in prep.). The first is sympatric with the closely related *S. cavicolus*, presently known only from the type locality in the Indian River estuary in Florida. The second was recently collected in the Atol das Rocas off north-eastern Brazil, and appears to be closest to *S. arubae* and *S. teres*. Schmitt's (1924) record of "*Jousseaumea trigona* Rathbun 1901" (now *Alpheopsis trigonus* (Rathbun)) from Barbados is based on an incomplete specimen of *Salmoneus*, possibly a new species close to the Indo-west Pacific *S. tricristatus* (Anker, pers. obs.). All these undescribed species and the poor taxonomic status of several described species (e.g., *S. serratidigitus*, *S. cavicolus*, *S. tafaongae*) shows that the genus *Salmoneus* clearly needs further taxonomic and phylogenetic work.

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Vir colemani sp. nov., a new commensal pontoniine shrimp (Crustacea: Decapoda: Palaemonidae) from Papua New Guinea

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ABSTRACT

A new species of pontoniine shrimp, *Vir colemani* sp. nov., is described and illustrated. A single specimen of the shrimp was found in association with a coral host, *Plerogyra sinuosa*, from Loloata Island, Papua New Guinea. *Vir colemani* sp. nov. is most closely related to *V. philippinensis* Bruce and Svoboda, 1984, and is distinguishable by its reduced rostral dentition and lack of spines on its ambulatory propods.

Keywords: *Vir colemani* sp. nov., Crustacea, Decapoda, Pontoniinae, Papua New Guinea, commensal, coral host, key to species.

INTRODUCTION

The pontoniine shrimp genus *Vir* was designated by Holthuis (1952) for the accommodation of a single species *Palaemonella orientalis* Dana, 1852, as it differed from all other species of *Palaemonella* in lacking an hepatic spine. Since then only one more species has been added to the genus, *Vir philippinensis* Bruce and Svoboda, 1984, and has since been widely reported in the Indo-west Pacific region, from the Red Sea to Japan and Western Australia and the Great Barrier Reef. *Vir orientalis* has now been reported from Kenya to the Hawaiian Islands. A third species is now described and illustrated and a key provided for the identification of specimens. It may be noted that the new species may be readily distinguished from *V. philippinensis* by its distinctive colour pattern, which first attracted the photographer's attention.

Abbreviations used: CL, post-orbital carapace length; NTM, Museum and Art Gallery of the Northern Territory, Darwin; R, rostral dentition.

SYSTEMATICS

Vir Holthuis, 1952

Vir colemani sp. nov.

(Figs 1–6)

Material examined. HOLOTYPE – ovigerous female, AMPI 1349, Loloata Island, Papua New Guinea, 15 m, on coral, coll. N. Coleman, 2 December 2002, NTM Cr.13446.

Diagnosis. A species of the genus *Vir* with short rostrum, not exceeding antennal peduncle, dentition 4/1, with first tooth situated on carapace, tip minutely bifid; ambulatory propods without spines; dactyl weakly setose, about 3.0 times longer than basal width, 0.3 of propod length.

Description. Body (Fig. 1) robust, subcylindrical, smooth, glabrous.

Rostrum (Fig. 2A) straight, horizontal, reaching almost to end of distal segment of antennal peduncle, about 0.5 of CL, with four acute equally spaced subequal dorsal teeth, each with few short setae distally, first tooth situated on carapace, tip (Fig. 5A) acute, bifid, with three short setae in notch, ventral margin straight, non-setose, with single acute tooth lightly distal to anterior dorsal tooth. Carapace inflated, orbit obsolescent, inferior orbital angle produced (Fig. 2B), rounded, antennal spine well developed, acute, marginal, extending well beyond inferior orbital angle, anterolateral angle of branchiostegite broadly rounded.

Abdomen normal, third tergite not produced, sixth segment about 1.3 times length of fifth, twice as long as deep, with posterolateral and posteroventral angles bluntly produced; pleura of first three segments enlarged, broadly rounded, of fifth and sixth segments small, rounded. Telson (Fig. 2G) about 0.6 of CL, 2.5 times longer than anterior width, lateral margins convergent, sublinear, with two pairs of small subequal dorsal spines at about 0.65 and 0.78 of telson length, separated by 0.14 of the telson length, posterior margin (Fig. 2H) about 0.4 of anterior margin width, rounded, without median process, lateral spines small, similar to dorsal spines, intermediate spines robust, about 0.16 of telson length, submedian spines about 0.65 of intermediate spine length, setulose.

Antennule (Fig. 2C) normal, proximal segment of peduncle (Fig. 2D) with small acute ventromedial tooth,

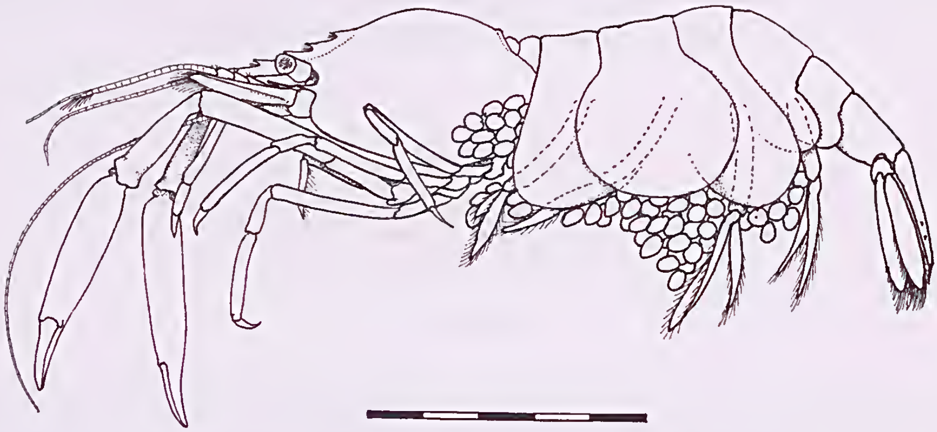

Fig. 1. *Vir colemani* sp. nov., ovigerous female holotype, Loloata Island, NTM Cr.13446. Scale bar in mm.

anterolateral margin (Fig. 5B) convex, setose, with small acute tooth laterally, lateral margin convex, statocyst normal with oval statolith, stylocerite slender, acute, reaching to half segment length; intermediate and distal segments subequal, together about 0.6 of proximal segment length; flagella long, slender, upper flagellum biramous, proximal 11 segments fused, shorter free ramus with three segments, longer with 12 segments, about 0.6 of length of fused segments, with seven groups of aesthetases.

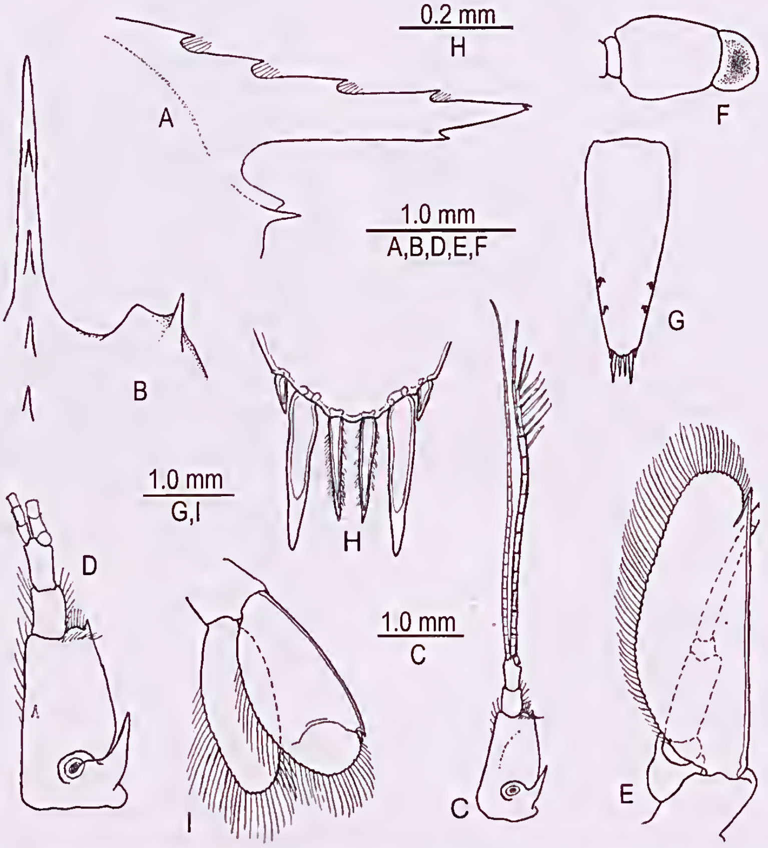

Fig. 2. *Vir colemani* sp. nov., ovigerous female holotype, Loloata Island, NTM Cr.13446. **A**, anterior carapace and rostrum, lateral; **B**, same right dorsal; **C**, antennule; **D**, same, peduncle; **E**, antenna; **F**, eye, dorsal; **G**, telson; **H**, same, posterior spines; **I**, uropod.

Antenna (Fig. 2E) normal; basicerite weakly armed with blunt distolateral lobe only; carpocerite subcylindrical, about 3.0 times longer than wide, reaching to about 0.4 of scaphocerite length, flagellum well developed; scaphocerite extending well beyond antennal peduncle, about 2.6 times longer than greatest width at 0.4 of length, distal margin broadly rounded, about 0.6 of greatest width, lateral margin straight, with strong acute distal tooth, not exceeding distal border of lamella, flagellum well developed.

Eye (Fig. 2F) with feebly pigmented globular cornea, about 0.12 of CL; stalk subcylindrical, 1.4 times longer than width, narrower distally.

Mandible (Fig. 3A) with corpus robust, with small non-setose single segmented palp (Fig. 5E), about 2.6 times longer than width, right molar process (Fig. 5C) distally oblique, with two large blunt teeth posteriorly, small tuft of short setae anteriorly; incisor process (Fig. 5D) distally truncate with three large acute teeth.

Maxillula (Fig. 3B) with distinctly bilobed palp (Fig. 5F), upper lobe non-setose, lower lobe with small uncinate seta; upper lacinia normal, with about 11 robust simple spines distally; lower lacinia lost in dissection.

Maxilla (Fig. 3C) with tapering non-setose palp, basal endite bilobed, lobes similar, slender, with seven to eight slender simple setae distally, coxal endite obsolete, medial margin straight; scaphognathite well developed about 3.5 times longer than wide, anterior lobe narrow, deeply emarginate medially, posterior lobe large, rounded.

First maxilliped (Fig. 3D) with tapering palp, with single preterminal medial seta, basal and coxal endites distinct, basal endite broad, anterolateral border sparsely setose, medial margin straight, with numerous slender simple setae, coxal endite medially biconvex, sparsely setose, exopod well developed, flagellum with numerous plumose setae distally, caridean lobe well developed, narrow, coxa with large triangular epipod, anterior lobe larger than posterior.

Second maxilliped (Fig. 3E) of normal form, exopod well developed with numerous plumose setae distally, coxa with small medial process, epipod small, simple, rounded, without podobranch.

Third maxilliped (Fig. 3F) with endopod slender, reaching to about distal end of carpocerite; ischiomerus and basis distinct, ischiomerus about 5.1 times longer than width, tapering slightly distally, sparsely setose medially, otherwise glabrous, carpal segment about 5.2 times longer than wide, 0.66 of ischiomeral length, subcylindrical, with sparse groups of long simple spiniform setae medially; terminal segment about 0.4 of ischiomeral length, tapering distally with short robust terminal spine (Fig. 5G), medial margin with about six groups of short spines, lateral margin sparsely setose;

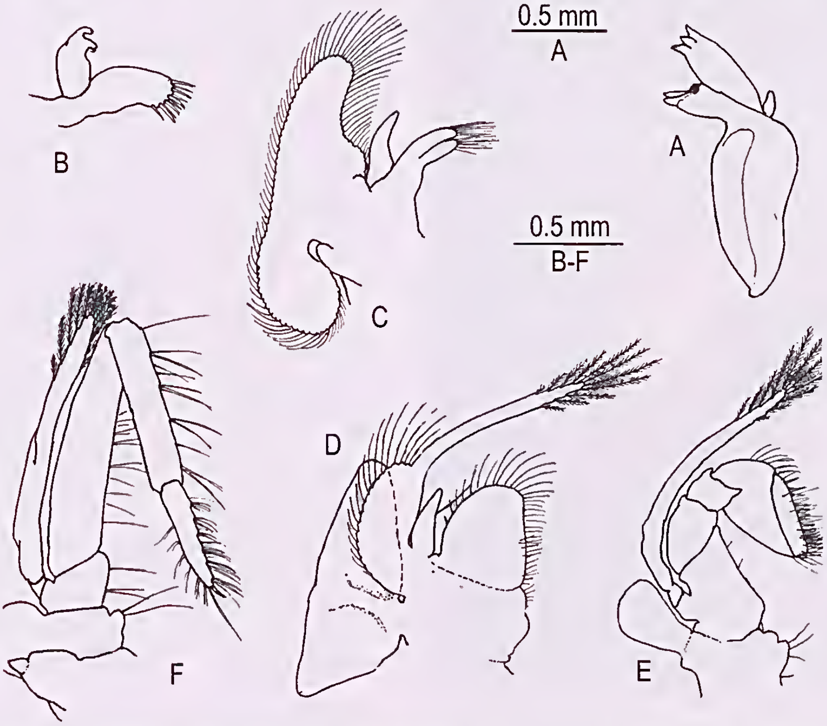

Fig. 3. *Vir colemani* sp. nov., ovigerous female holotype, Loloata Island, NTM Cr.13446. **A**, mandible; **B**, maxillula, lower lacinia lost; **C**, maxilla; **D**, first maxilliped; **E**, second maxilliped; **F**, third maxilliped.

basis normal, exopod well developed with numerous plumose setae distally; coxa with small setose medial lobe, rounded epipod laterally, with rudimentary arthrobranch. Fourth thoracic sternite with strong acute median process.

First pereiopod (Fig. 4A) slender, exceeding carpocerite by carpus and chela; chela (Fig. 4B) normal, slightly compressed, palm twice as long as depth, with three rows of cleaning setae proximoventrally, fingers about subequal to palm length, slender, 4.8 times longer than proximal width, tapering, with small simple hooked tip distally, cutting edges simple, entire; carpus about 1.65 times chela length, slender, 6.3 times longer than distal width, tapering slightly proximally, with several cleaning setae distoventrally; merus subequal to carpus length, uniform, 7.0 times longer than wide; ischium and basis normal; coxa with small setose ventromedial lobe.

Second pereiopods subequal and similar; major pereiopod (Fig. 4C) with chela (Fig. 4D) about 1.56 times CL, palm smooth, about 3.6 times longer than depth, feebly swollen, tapering slightly distally, fingers (Fig. 4E) about 0.5 of palm length, slender, dactylus about 4.2 times longer than proximal depth, dorsal margin convex, tip hooked, acute, cutting edge with two low teeth at half length, distal cutting edge laminar, entire, proximal cutting edge blunt, fixed finger similar, with single acute tooth at half length, distal cutting edge laminar, entire, proximal cutting edge with low tooth with three smaller teeth proximally; carpus (Fig. 4F) about 0.5 of chela length, 4.0 times longer than width, tapering proximally, constricted then flared distally with blunt angular dorsal lobe; merus 0.75 of palm length, 4.7 times longer than central width, subuniform, unarmed; ischium about 0.5 of palm length, 3.5 times longer than distal width, tapering proximally, unarmed. Basis and coxa without special features. Minor second pereiopod similar, chela about 0.98 of major chela length.

Third pereiopod (Fig. 4G) moderately slender, exceeding carpocerite by carpus, propod and dactyl; dactyl simple, moderately curved, about 0.3 of propod length, 3.0 times longer than basal width, corpus 2.1 times longer than basal width, distal width about 0.33 of basal width, convex, dorsal margin with single slender seta at 0.6 of length, with two short slender sensory setae distolaterally, ventral margin sublinear, unguis distinctly demarcated, about 0.5 of corpus length, simple, curved, 3.5 times longer than basal width; propod about 0.5 of CL, 7.5 times longer than

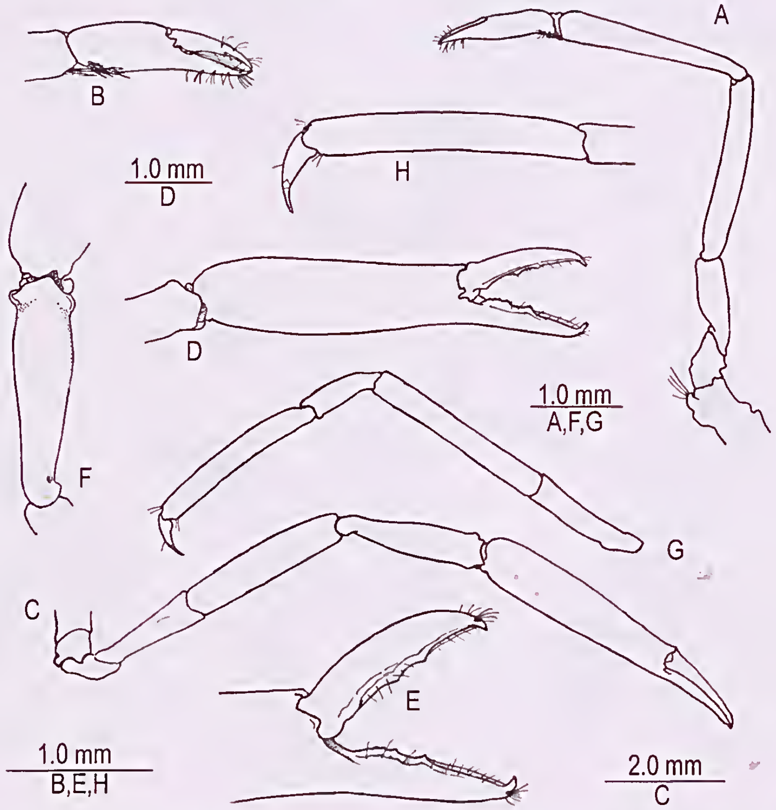

Fig. 4. *Vir colemani* sp. nov., ovigerous female holotype, Loloata Island, NTM Cr.13446. **A**, first pereiopod; **B**, same, chela; **C**, right second pereiopod; **D**, same, chela; **E**, same, fingers; **F**, same, carpus, dorsal; **G**, third pereiopod; **H**, same, propod and dactyl.

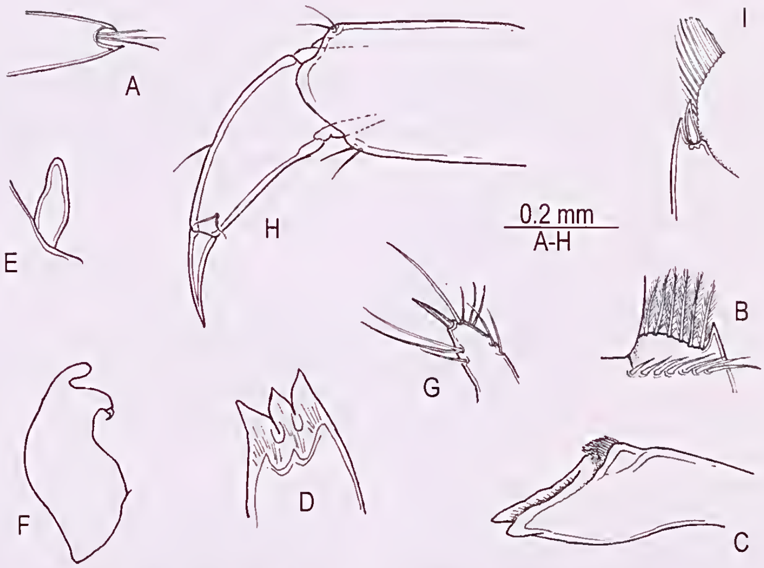

Fig. 5. *Vir colemani* sp. nov., ovigerous female holotype, Loloata Island, NTM Cr.13446. **A**, rostrum, distal end; **B**, Antennal peduncle, proximal segment, distolateral angle; **C**, mandible, molar process; **D**, same, incisor process; **E**, same, palp; **F**, maxillula, palp; **G**, third maxilliped, tip of terminal segment; **H**, third pereiopod, distal propod and dactyl; **I**, exopod of uropod, posterolateral angle.

wide, slightly compressed, uniform, with few small, slender setae distally, without distal or ventral spines; carpus normal, about 0.9 of propod length, unarmed; merus subequal to propod length, 7.0 times longer than wide, uniform, unarmed; ischium, basis and coxa without special features. Fourth pereiopod similar to third, propod about 1.1 of third propod length. Fifth pereiopod similar, propod subequal to third propod length.

Uropod (Fig. 2I) extending well beyond posterior telson spines, with protopodite robust, unarmed; endopod 2.3 times longer than wide, lateral margin feebly convex non-setose with small acute posterolateral tooth distally (Fig. 5I), with larger, curved mobile spine medially; endopod 2.4 times longer than wide, about 0.9 of exopod length.

Ova very numerous and small.

Measurements. Total body length, (approx.) 17.0 mm; carapace and rostrum, 5.7 mm; post-orbital carapace length, 3.7 mm; major second pereiopod, chela, 5.4 mm; minor second pereiopod, chela, 5.2 mm; length of ovum, 6.0 mm.

Colouration. Holotype (Fig. 6) mainly transparent, ovary and ova whitish, intestine red-brown; antennal flagella dark red-brown; eye with two thin longitudinal red brown lines; pereiopods transparent with dark violet articulations, caudal fan colourless.

Another photograph, of a different specimen (not collected) shows a few small blue dots on the dorsal carapace.

Host. *Plerogyra sinuosa* (Dana, 1846) [Scleractinia: Caryophylliidae], known from the Red Sea to the Marshall Islands (Veron and Pichon 1980).

Etymology. Named in honour of Neville Coleman, one of the few underwater photographers who has collected specimens of his subjects over many years.

Fig. 6. *Vir colemani* sp. nov., ovigerous female holotype *in situ* on *Plerogyra sinuosa*, Loloata Island, NTM Cr.13446. Photo: N. Coleman.

Systematic position. The specimen is most closely related to *Vir philippinensis* Bruce and Svoboda, 1984. The only other species of the genus is *V. orientalis* (Dana, 1852). The three species may be separated using the following key.

Key to species of *Vir*

1a. Third pereiopod propod with numerous setae distally; third ambulatory propod about seven times longer than wide, dactylus short and curved; R.7/1 .... *V. orientalis* (Dana, 1852)

1b. Third pereiopod propod sparsely setose distally, dactylus more elongate, weakly curved 2

2a. Rostrum exceeding antennal peduncle, tip acute; distoventral ambulatory propod spinulate; third ambulatory propod about 11.5 times longer than wide; R. 4–8/0–2 .... *V. philippinensis* Bruce and Svoboda, 1984

2b. Rostrum not exceeding antennal peduncle, tip bifid; distoventral ambulatory propod without spinules; third ambulatory propod about 7.5 times longer than wide; R. 4/1 ..... *V. colemani* sp. nov.

Remarks. The shrimps belonging to the genus *Vir* are closely related to those of the genus *Philarius* Holthuis, 1952, and the three species of the *lutescens* group of *Periclimenes* – *P. lutescens* (Dana), *P. consobrinus* De Man and *P. bayeri* Holthuis. All are commensals of scleractinian corals in the Indo-west Pacific. They are characterised by robust subcylindrical bodies with well developed dentate rostra, well-developed exopods on the maxillipeds, and a robust median process on the fourth thoracic sternite, well-developed similar subequal second pereiopods, with simple dactyls on the ambulatory pereiopods. Only in *Vir* is a mandibular palp present and only in *Periclimenes* is an hepatic spine present. A further species of *Vir*, which lacks conspicuous colouration, may exist but has not yet been collected or described (Minemizu 2000).

The two species, *V. philippinensis* and *V. colemani*, may be readily separated in life by their colour patterns. *Vir philippinensis* has continuous very dark bluish lines along the whole lengths of its pereiopods as well as along its antennal flagella (colour figures, Allen and Steene 1994: 147, no locality; Debelius 1998: 204, Red Sea; 1999: 191, Mergui and Suluwesi; Minemizu 2000: 45, Japan; Coleman 1998: 34, Loloata Island, Papua New Guinea), which contrast strongly with the bright violet patches on the pereiopodal articulations in *V. colemani*.

The colour pattern of *V. orientalis* is not well known. Kemp (1922) states that his specimen from the Andaman Islands was completely transparent. He also notes that the ambulatory propod bears a small distoventral spinule and that the mandibular palp is single segmented. The specimens reported by Bruce (1972) from the Fijian Islands had the palp 2-segmented (as in the type material, now lost), and the propods devoid of spines. It associates with *Pocillopora* corals.

Both *V. orientalis and V. philippinensis* have also been recorded from Papua New Guinean waters, both from Hansa Bay by De Grave (2000), the former from *Acropora* sp. and the latter from *Euphyllia* and *Physogyra* spp.

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Short communication

Records of two new ant genera, *Anonychomyrma* Donisthorpe and *Probolomyrmex* Mayr (Hymenoptera: Formicidae), for the Northern Territory

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KEYWORDS: *Anonychomyrma,* Formicidae, Melville Island, Northern Territory, *Probolomyrmex greavesi,* Solar Village.

Andersen (2000) lists 66 ant genera recorded from the monsoonal tropics of northern Australia, out of the 103 total Australian genera (Shattuck 1999). Of the 66 monsoonal genera, six (*Colobostruma* Wheeler, *Dolichoderus* Lund, *Mesostruma* Brown, *Leptomyrmex* Mayr, *Mayriella* Forel, and *Notoncus* Emery) are known from the region only in Queensland, *Willowsiella* Wheeler is known only from Western Australia, and *Amblyopone* Erichson occurs in both Queensland and Western Australia, but remains unrecorded in the Northern Territory. This leaves 58 genera listed from monsoonal Northern Territory (NT), one of which (*Anoplolepis* Santschi) is introduced (Young *et al.* 2001). This represents virtually all known NT ant genera; the only exception is *Adlerzia* Forel, an undescribed species of which has been collected from the Alice Springs region (D. Agosti, personal communication).

Two additional genera, *Anonychomyrma* Donisthorpe (Dolichoderinae) and *Probolomyrmex* Mayr (Ponerinae) have since been collected from the Top End of the NT, and these records are documented here.

Anonychomyrma Donisthorpe, 1947

This genus comprises 30 described species and subspecies, distributed from southern Australia to Malaysia (Shattuck 1992a,b, 1999). The 14 species and subspecies listed from Australia are restricted to higher rainfall regions of the eastern and southern coasts (Shattuck 1999). Three Australian species groups can be recognised (Andersen 1991; these groups were then considered part of *Iridomyrmex*): the *itinerans* group, from subhumid regions of the south-east and south-west; the *nitidiceps* group, widely distributed but most common in southern dry sclerophyll forests and heathlands; and the *biconvexa* group, restricted to wetter forests of the eastern seaboard. The species are highly aggressive and behaviourally dominant members of ant communities where they occur (Andersen 1986).

Three specimens of a species of *Anonychomyrma* were recorded in pitfall traps during a fauna survey of Melville Island conducted by the Biodiversity Unit of the Northern Territory Department of Infrastructure, Planning and Environment during July and August 2001. The specimens were from two locations, "Three Ways" (11°44' S, 130°59' E) and "West Jump-up" (11°35' S, 130°33' E). In both cases the habitat was eucalypt woodland/open-forest with perennial tussock grasses on sandy loam soil.

The species-level taxonomy of *Anonychomyrma* is too poorly resolved to be confident of the identity of the Melville Island species. It is a member of the *nitidiceps* species group, with erect hairs present on antennal scapes, but largely absent from the gaster. The specimens are housed at the CSIRO Tropical Ecosystems Research Centre in Darwin.

Probolomyrmex Mayr, 1901

This extremely rare ponerine genus is distributed throughout the world's tropics, and consists of 13 described species (Bolton 1995), most known only from one or a few records (Taylor 1965). They are small (total length 1.5–2 mm), typically blind ants that nest and forage within soil and litter.

A single species, *P. greavesi* Taylor, has been recorded from Australia. It is one of Australia's rarest ants, previously known only from a handful of records from the eastern seaboard, from Canberra to north Queensland (Shattuck 1999). However, in March 2002 it was collected from leaf litter during an ant survey by CSIRO at Solar Village (12°37' S, 131°06' E), 35 km south-east of Darwin. The vegetation of the collecting site was open forest dominated by *Eucalyptus miniata* and *E. tetrodonta*. Solar Village had been protected from fire for more than 20 years, such that compared with surrounding (frequently burnt) savanna, tree cover was higher, litter was much denser, and grasses were virtually absent (Woinarski *et al.* in press).

Twenty-two specimens (all workers) of *P. greavesi* were collected from a single 30x30 cm litter sample. This is a greater number of individuals than all previous Australian records of the genus combined (S.O. Shattuck, personal communication). Specimens are housed in the Australian National Insect Collection in Canberra, the CSIRO Tropical Ecosystems Research Centre and the Museum and Art Gallery of the Northern Territory in Darwin (NTM I1179; 2 specimens).

DISCUSSION

Many ant taxa are easily overlooked because of their cryptic habits and association with localised habitats. In addition to being rare, a number of NT ant genera are either rainforest specialists (e.g. *Mystrium* Roger, *Turneria* Forel, *Pseudolasius* Emery; Reichel and Andersen 1996) or occur in a broader range of forest habitats but are highly cryptic (e.g. *Leptanilla* Emery, *Machomyrma* Forel, *Rhopalomastix* Forel). *Probolomyrmex* can be placed in the latter category, so it is not surprising that it has hitherto been unrecorded in the Northern Territory. However, the occurrence on Melville Island of a species of *Anonychomyrma* is surprising, given it is a highly active, epigaeic species of savanna woodland, and therefore not so easily overlooked.

The nearest known record of *Anonychomyrma* in Australia is from coastal north Queensland. It has not been recorded from north Queensland west of the Great Dividing Range, or from the coastal plains of the Darwin region, despite extensive collecting. The species might also occur in Arnhem Land, most of which has been poorly collected for ants, or possibly even in South-east Asia. The possibility of it being introduced to Melville Island also cannot be ruled out, although this would seem unlikely given that its two known locations are remote from human settlement. There is therefore a strong likelihood that the Melville Island species is endemic there. Both its records on Melville Island lie within the general area of a proposed major acacia plantation, which raises concerns over its conservation status.

ACKNOWLEDGMENTS

I am most grateful to John Woinarski who led the fauna survey of Melville Island and invited CSIRO to undertake the ant survey at Solar Village. I also thank Alaric Fisher for providing habitat information for the *Anonychomyrma* records, and Tony Hertog and Lyn Lowe for assisting with the Solar Village work.

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A new genus for the Indo-Pacific goby species *Gobius baliurus* Valenciennes (Teleostei, Gobiidae, Gobiinae)

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ABSTRACT

A new genus, *Arcygobius*, is created to include the gobiid fish species previously known as *Gnatholepis baliurus* (Valenciennes) and *Gnatholepis calliurus* Jordan and Seale. It is a gobiine, not a gobionelline (as is *Gnatholepis*), resembles the genus *Acentrogobius* and is distinguished from other Indo-Pacific gobiines by having the gill opening wide and reaching to below mid-eye, cheeks fully scaled, opercle scaled dorsally and with transverse sensory papillae rows ventrally, papillae row *a* below eye formed by many short transverse rows, mouth large and oblique, chin prominent and a distinctive colour pattern. *Isthmogobius* Koumans, based on Bleeker's museum name for the genus, is not available. *Gnatholepis calliurus* is a junior synonym of *Arcygobius baliurus*.

Keywords: new genus, *Arcygobius, Acentrogobius, Gnatholepis, Isthmogobius, Gobius baliurus, Gnatholepis calliurus*, Indo-Pacific.

INTRODUCTION

The gobiid taxon exemplified by the nominal species *Gobius baliurus* Valenciennes, 1837 (Fig. 1), and *Gnatholepis calliurus* Jordan and Seale, 1905 (Fig. 2), has since 1905 usually been placed under *Gnatholepis* Bleeker. It is not a *Gnatholepis*, as *Gobius baliurus* only possesses one anterior interorbital pore and a single epural (*Gnatholepis* has two of each), but this has been ignored by workers for convenience, because no other described genus applied to these names. Characters of *Gnatholepis* were recently reviewed by Randall and Greenfield (2001), and the genus clearly placed in the gobiid subfamily Gobionellinae. Randall and Greenfield refer to *Gobius baliurus* as "genus undetermined". Goren and Dor (1994) placed the species in the large genus *Acentrogobius* Bleeker.

Gobius baliurus belongs to the gobiid subfamily Gobiinae as defined by Pezold (1993), having a single anterior interorbital pore, a single epural, a first dorsal-fin pterygiophore pattern of 22110 (formula as in Birdsong *et al.* 1988), and 26 vertebrae. The species does not agree with the characters of *Gnatholepis*, or any other gobiid genus, although it does appear to be superficially close to genera such as *Asterropteryx* Rüppell, *Exyrias* Jordan and Seale, *Macrodontogobius* Herre and *Tryssogobius* Larson and Hoese by having scaled cheeks. Its wide gill opening, transverse papillae rows on the opercle and the scaled cheeks with papillae set in grooves separate it from these coral reef genera. Additionally, *Exyrias* and *Macrodontogobius* differ from *Gobius baliurus* in having the infraorbital canal extended under the eye, so that the infraorbital pore is widely separated from the pores in the lateral canal (this feature is also shared by *Istigobius* Whitley and *Fusigobius* Whitley). *Tryssogobius* comprises two very small species, which have cycloid scales on the head, a restricted gill opening and much-reduced sensory papillae pattern when compared with *Gobius baliurus*. *Asterropteryx* always has 1–8 spines on the posterior margin of the preopercle.

The genus *Aulopareia* Smith also resembles *Gobius baliurus* in having sealed cheeks and opercles in several species. The genus *Aulopareia* has never been reviewed or clearly defined, but it is presently considered to include only those species lacking an anterior interorbital pore (present in *Gobius baliurus*), having a longitudinally elongate (slit-like) infraorbital pore (which is rounded to oval in *Gobius baliurus*) and a longitudinal papillae pattern. Most *Aulopareia* species have large oblique mouths and live in soft-substrate coastal habitats, not coral reefs, and do resemble *Gobius baliurus* in these respects. There are about 12 nominal species of *Aulopareia* and the genus is in need of definition and review (as is the case for very many gobiids).

The taxon which most closely resembles *Gobius baliurus* is *Acentrogobius viridipunctatus*; the two taxa share several characters. This is discussed further under Remarks.

Early in this study, *Gnatholepis volcanus* Herre (1927) was considered as a possible species of *Arcygobius*. The type and only known specimen, described from Lake Taal in the Philippines, was destroyed during WWII, but it is very likely to have been an *Exyrias*, based on the original description (and see Koumans 1940: 184).

Isthmogobius is a "museum name" of Bleeker, and was first published by Koumans (1931) as a questionable synonym of *Gnatholepis*, with "*Gobius baliurus* C. & V." listed as type species. This is not an available name (IZCN Code Article 11.6). Bleeker (1983: pl. 434a) used the name *Isthmogobius baliurus*, with illustration and text, which would have made the name available if it had been published before 1961. The only other use of the name *Isthmogobius* is in Larson and Murdy (2001), who used the name in a list, in an attempt to place the genus elsewhere other than *Gnatholepis*. Therefore a new generic name is needed, as was earlier pointed out by Bauchot *et al.* (1991).

Fig. 1. Holotype of *Gobius baliurus*, MNHN 733, 67 mm SL female, from Java. Photograph by Rémi Ksas, Muséum National d'Histoire Naturelle, Paris.

Fig. 2. Holotype of *Gnatholepis calliurus*, USNM 51944, 51 mm SL male, from Negros, Philippines. Photograph by Sandra Raredon, National Museum of Natural History, Washington.

Fig. 3. Female, 59 mm SL (above), and 65 mm SL male (below) *Arcygobius baliurus* from Luzon, Philippines, NTM S.14226-010, showing colour pattern.

MATERIAL AND METHODS

Morphometrics and measurements. Measurements were taken using electronic callipers and dissecting stereomicroscope. Counts and methods generally follow Hubbs and Lagler (1970), except for transverse scale counts (TRB), taken by counting the number of scale rows from the anal fin origin diagonally upward and back toward the second dorsal fin base, and head length is taken to the upper attachment of the opercular membrane. Morphometrics are expressed as a percentage of standard length (SL) or head length (HL). In the description, numbers in parentheses after counts indicate the number of specimens with that count, or the range of counts. Pterygiophore formula follows Birdsong *et al.* (1988). Vertebral counts and other osteological information were obtained by clearing and double-staining, using the ethanol method of Springer and Johnson (2000). Terminology for lateral canals and sensory pores follows Hoese and Gill (1993) and Winterbottom (2002). Papillae rows are named based on Sanzo (1911).

Abbreviations. Abbreviations for institutions referred to are as in Leviton *et al.* (1985), with the exceptions of: RUSI – South African Institute for Aquatic Biodiversity (formerly J.L.B. Smith Institute of Ichthyology), Grahamstown; ZRC – Raffles Museum of Biodiversity Research (formerly Zoological Reference Collection), Singapore.

SYSTEMATICS

Arcygobius new genus

Isthmogobius Koumans, 1931 [ex Bleeker], type species *Gobius baliurus* Valenciennes, 1937, by original designation (genus name not available; listed in synonymy of *Gnatholepis*). – Koumans 1953: 168; Bleeker 1983: pls 434–434a; Eschmeyer 1998: 1980, 2489; Larson and Murdy 2001: 3586.

Type species. *Gobius baliurus* Valenciennes, 1937, by original designation.

Diagnosis. A gobiine distinguished by a combination of characters. Gill opening wide, membranes free of isthmus to below eye; predorsal with 8–11 scales, reaching to close behind eyes; cheek and opercle scaled; cheek scales divided into three rows by longitudinal rows of sensory papillae; distinctive transverse sensory papillae pattern on cheek and opercle; sensory pores on head with nasal pore near each posterior nostril, a single anterior interorbital pore, a posterior interorbital pore, a postorbital pore, an infraorbital pore on a short branch of the oculoscapular canal, a posterior otic and intertemporal pore in the anterior portion of the oculoscapular canal, and an anterior and posterior temporal pore in separate posterior portion of the oculoscapular canal; three preopercular pores present; eyes large, dorsolateral; snout pointed; jaws terminal, with chin tip anteriormost; jaws end below anterior half of eye; small, mostly evenly sized teeth in both jaws, outermost row larger but no large canine at side or front of jaw; first dorsal fin triangular, with first or second dorsal spine longest; caudal fin short, rounded; head and body yellowish with four elongate brown blotches along lateral mid-line of body and dense dark brown to black oval spot oriented longitudinally across bases of central caudal fin rays (Fig. 3).

Osteology. Osteology basically similar to gobiines such as *Glossogobius* and *Acentrogobius*. Dorsal pterygiophore formula 3–22110; one epural, two preanal pterygiophores; 10+16 vertebrae; 17 segmented caudal rays, in 9/8 pattern; 7/6 branched caudal rays; 8/7 or 8/8 procurrent rays set in broad cartilage plate. Five branchiostegal rays; posteriormost widely separated from rays 2–4; ceratohyal rectangular, longer than triangular epihyal. No infraorbital bones. No mesopterygoid. Metapterygoid slender, does not reach quadrate, not expanded dorsally (Fig. 4). Symplectic relatively slender, expanded posteroventrally, not in contact with preopercle. Preopercle crescent-shaped, with short groove (for sensory canal) posteriorly and with short dorsal process pointing toward symplectic. Palatine reaching at least halfway down pterygoid, does not reach quadrate. Premaxilla with moderately tall ascending and broad articular processes. Ceratobranchials 1–4 bear up to 12 patches of spined branchial teeth on inner faces; gill rakers ossified. Ceratobranchial 5 narrow, with fine pointed teeth; largest teeth near posterior edge. Lower post-cleithrum present, splint-like. Basihyal spatulate. All four pectoral radials ossified. Scapula foramen closed by strip of cartilage along posterior margin of scapula, which is mostly unossified. Neural spines on first three vertebrae slightly more robust than those immediately behind them; no flanges or bifurcation on these spines.

Etymology. From the Greek *arkys*, a net, as these gobies are usually collected as bycatch by trawl nets; pronounced with hard "c". Gender masculine.

Remarks. The monotypic *Macrodontogobius wilburi* Herre is similar to *Arcygobius* in that there are a number of transverse *a* rows under the eye and scattered transverse rows over the cheek, but it has only one longitudinal cheek row (row *d*). However, *Macrodontogobius* has a small subterminal mouth, a large curved canine tooth at the side of the lower jaw, no transverse papillae rows on the opercle, a gill opening ending just under the opercle, and all scales on the nape and side of head are ctenoid. It inhabits shallow sandy coral reef habitats (lagoonal), in depths of 0–20 m. It seems an unlikely relative of *Arcygobius*.

Exyrias is similar to *Arcygobius* in having scaled cheeks and opercles, but it has a basically longitudinal papillae pattern, a subterminal mouth, ctenoid scales

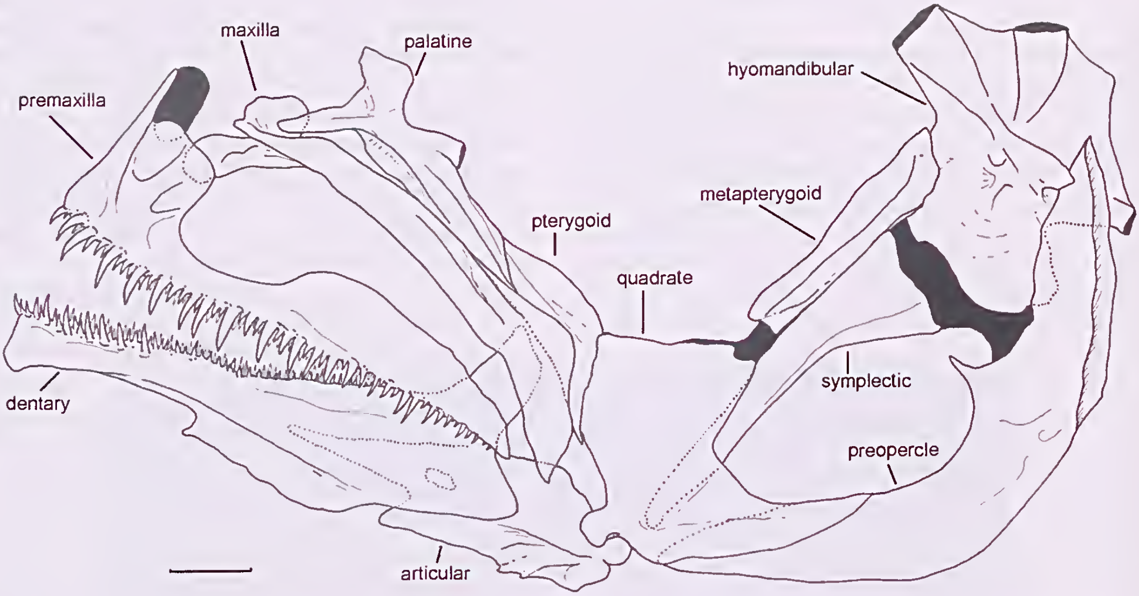

Fig. 4. Jaws and suspensorium of 60 mm SL female *Arcygobius baliurus*, ex AMS I.21901–004, Bolinao fishmarket, Philippines. Scale bar = 1 mm.

on the side of the head, cycloid nape scales, the gill opening restricted to the pectoral fin base, eyes placed close together and high on head, protruding well above body profile, and the first dorsal spines usually elongate and filamentous. Additionally, the mostly coral reef genera *Exyrias*, *Istigobius* and *Fusigobius* all share a variably long branch of the oculoscapular canal extending under the eye and ending in the infraorbital pore (e.g. see Fig. 3 in Murdy and Hoese 1985). *Arcygobius* has a very short branch to the infraorbital pore (Fig. 5).

The genus *Acentrogobius*, as exemplified by the type species *A. viridipunctatus* Valenciennes, shares a number of characters with *Arcygobius*. *Acentrogobius* is presently a catch-all genus which has never been reviewed or even adequately defined, but probably consists of several taxa (which may include species variously placed in *Amoya* Herre, *Arenigobius* Whitley, *Yoga* Whitley, *Yongeichthys* Whitley and a number of undescribed species). Zeehan Jaafar of the National University of Singapore has just commenced a review of the genus (PhD thesis). For purposes of this paper, *A. viridipunctatus* (Fig. 6) and four taxa of similar morphology and transverse sensory papillae (*A. dayi* Koumans, *A. decaryi* Pellegrin, *A. simplex* Sauvage, *A. therezieni* Kiener) are considered to be probably congeneric. These five *Acentrogobius viridipunctatus*-type species have gill membranes attached to the isthmus well behind the rear margin of the preopercle (except for *viridipunctatus*, in which the membranes attach just below or slightly anterior to the margin) versus wide gill opening free of isthmus to below the eye in *Arcygobius*; they have 2–5 rows of teeth, with the outer row teeth in both jaws enlarged and curved, and a large curved canine tooth at the side of the lower jaw versus all teeth small with no distinct canines; the opercle is variably covered with small scales and the cheek naked (*viridipunctatus* has a small patch of scales at the top of the cheek behind the eye) versus large scales covering the cheek and opercle; the predorsal is naked or has 19–31 scales reaching to above the preopercle (*viridipunctatus* has 25–31 predorsal scales which reach to close behind the eyes) versus 8–11 large scales reaching close up to behind the eyes; and the infraorbital pore opens more or less directly from the oculoscapular canal versus the pore opening at the end of a short infraorbital canal. *Acentrogobius viridipunctatus* also differs from other *Acentrogobius* species in having a somewhat horizontally elongate infraorbital pore, similar to the even more elongate pore in *Aulopareia* (*Acentrogobius cyanomos* Bleeker may have a somewhat elongate pore, but a longitudinal papillae pattern).

In summary, *Arcygobius* has a different set of characters from existing gobiine genera, and we consider that it is better to prevent the species from being maintained as a *Gnatholepis* or *Acentrogobius*, by assigning it to its own genus, until further work can be done to clarify relationships. This is not very satisfactory, given the size of the phylogenetic problem waiting to be solved within the Gobiinae, but it is a beginning.

Arcygobius baliurus (Valenciennes, 1837)

(Figs 1–5)

Gobius baliurus Valenciennes, 1837: 61–62 (Java, Indonesia). – Bleeker 1849: 31; Bleeker 1851: 239, 242; Bleeker 1860: 43; Bleeker 1861: 32, 56; Gunther 1861: 18; Karoli 1882: 164; Weber 1913: 465; Bauchot *et al.* 1991: 26; Randall and Greenfield 2001: 1 [genus undetermined].

Gnatholepis calliurus Jordan and Seale, 1905: 796–797, fig. 14 (Negros, Philippine Islands). – Jordan and Richardson 1910: 47; Herre 1927: 130–131, plate 9, fig. 2; Chabanaud 1923: 559; Koumans 1931: 87; Herre 1933a: 5; Herre 1933b: 10; Herre 1934: 82; Herre and Myers 1937: 39; Koumans 1940: 123; Koumans 1953: 170–171; Herre 1953: 750; Böhlke 1953: 112; Eschmeyer *et al.* 1998: 311; Randall and Greenfield 2001: 1 [genus undetermined].

Gnatholipis callurus [*lapsus*] Seale 1910: 285.

Gnatholepis baliurus. – Koumans 1931: 86–87; Fowler 1938: 216; Koumans 1953: 169–170, fig. 41; Herre 1953: 750; Smith 1959: 213, pl. 11H; Smith and Smith 1969: 47, pl. 64H; Goren 1979: 42, fig. 26; Dor 1984: 245; Goren 1986: 650; Devi *et al.* 1993: 813; Lim and Larson 1994: 259; Eschmeyer *et al.* 1998: 189.

Isthmogobius baliurus. – Bleeker 1983: 9, 14, pl. 434a; Larson and Murdy 2001: 3598.

Acentrogobius baliurus. – Goren and Dor 1994: 62.

'Gnatholepis' baliurus. – Larson in Randall and Lim 2000: 638.

Material examined. 85 specimens, 21–69 mm SL. MOZAMBIQUE: RUSI 17280, 7(49–69), Nacala, 25 August 1950, coll. J.L.B. and M.M. Smith. KENYA: NTM S.12551–001, 1(33), Mombasa, June 1985, coll: P. Reay. THAILAND: NTM S.13839–001, 14(39–67), trawled offshore at Sriracha District, Cholburi Province, 20 January 1974, coll: P. Wongrat; NSMT–P55048, 1(57), klong at Pawang, 1 m depth, 24 October 1986, coll. K. Matsuura and R. Arai; NSMT–P55309, 1(62), klong at Pawang, mangroves, 1 m depth, 24 October 1986, coll. K. Matsuura and R. Arai. SINGAPORE: ZRC 31948, 1(59), dredged, Kallang Basin, 4 June 1993, coll. National University of Singapore; ZRC 41564, 1(45), Kallang Basin, 22 March 1990, coll. National University of Singapore; ZRC 41563, 1(49), Kallang Basin, 1989, coll. National University of Singapore; ZRC 19640, 1(62), mullet pond, Pulau Ubin, 30 April 1931, coll. H.W. Fowler; ZRC 19811–19812, 2(53.5–55), Sungei Seletar, 18 December 1968; ZRC 10547, 1(68), Sungei Punggol, 28 March 1967, coll. A. Drahman. INDONESIA: MNHN 733, holotype of *Gobius baliurus* Valenciennes, 67 mm female, Java, coll. Kuhl and van Hasselt. PHILIPPINES: USNM 51944, holotype of *Gnatholepis calliurus* Jordan and Seale, 51 mm male, Negros Island, 1901, coll. Bashford Dean; CAS/SU 26291, 15(40–56), Manila Bay, 11 May 1931, coll. A.W. Herre; AMS I.21901–004, 31(43–64), 2 of which are cleared and double-stained, Bolinao fish market, 16 April 1980, coll. D.F. Hoese; NTM S.14226–010, 5(60–66), Bolinao fish market, Luzon, 7 October 1995, coll: B.C. Russell. MICRONESIA: CAS 53902, 2(21–28.5), Yap Island, mud-bottomed lagoon behind police station, behind causeway, 15 December 1959, coll. Bronson and Sumang.

Other material examined (data not used). USNM 372624, 2, paratypes of *Gnatholepis calliurus*, Negros Island, Philippines; CAS 53925, 1, off Laem Mae Rampung, Gulf of Thailand; CAS 54761, 1, entrance to Trat Bay, Gulf of Thailand; CAS/SU 27849, 2, Sandakan, British North Borneo [Sabah]; CAS 53927, 2, Novotas Fish Landing, Manila Bay, Philippines; CAS 46083, 4, Manila Bay, Philippines; CAS/SU 29686, 2, Pontevedra, Negros Island, Philippines.

Description. Based on 55 specimens, 28.5–69 mm SL. An asterisk indicates the counts of the holotype of *Gobius baliurus* (Fig. 1).

First dorsal VI*; second dorsal I,9–I,10* (modally I,10); anal I,8–9* (modally I,9*), pectoral rays 15–19 (modally 17*), segmented caudal rays usually 17*; caudal ray pattern usually 9/8; branched caudal rays 6/5 to 7/7 (modally 7/6*); unsegmented (procurrent) caudal rays 8/7 or 8/8; longitudinal scale count 22*–26 (mode 24); TRB 7–9 (mode 9, 8 in holotype); predorsal scale count 8–11 (mode 9*); circumpeduncular scales 11–12 (mode 12) (Table 1). Gill rakers on outer face of first arch 2–4 + 11–15 (in 11). Pterygiophore formula 3–22110 (in 25). Vertebrae 10+16 (25), including urostyle. One epural (23). Two anal pterygiophores before haemal spine of first caudal vertebra (25).

Body compressed posteriorly, more rounded anteriorly. Head rounded to somewhat compressed, deeper than wide, HL 27.9–33.8% (mean 30.3) of SL; head depth at posterior preopercular margin 52.3–66.9% (mean 58.6) of HL; head width at posterior preopercular

Table 1. Counts of specimens of *Arcygobius baliurus.*

	Means	Max.	Min.	Mode
Second dorsal rays	9.9	10.0	9.0	10.0
Anal rays	9.0	10.0	8.0	9.0
Pectoral rays right	17.3	19.0	15.0	17.0
Pectoral rays left	17.2	18.0	16.0	17.0
Caudal segmented	17.0	17.0	16.0	17.0
Caudal branched	12.9	14.0	11.0	13.0
Longitudinal scales	24.4	26.0	22.0	24.0
Transverse rows back	8.5	9.5	7.0	9.0
Transv. rows forward	9.6	11.0	8.0	10.0
Predorsal scales	9.7	11.0	8.0	9.0
Caud. peduncle sc.	11.9	13.0	11.0	12.0

margin 50.3–70.5% (mean 56.7) of HL; head profile pointed. Mouth terminal, oblique, forming an angle of about 45° with body axis, chin tip anteriormost, often bony and prominent; jaws generally reaching below anterior half of eye; upper jaw length 37.6–48.8% (mean 44.0) of HL (Table 2). Lips smooth; lower lip thin, fused to underside of head on either side of sharp chin, in some specimens lip partly fused halfway along jaw. Eyes large, oval, dorsolateral, top forming part of dorsal profile, 23.2–29.5% (mean 26.1) of HL. Snout pointed, 22.5–32.2% (mean 26.0) of HL; posterior nostril in triangular to teardrop-shaped, placed almost halfway between eye and upper lip; anterior nostril in short tube, closer to upper lip. Interorbital narrow, 4.1–7.4% (mean 5.6) of HL. Body depth at anus 16.1–23.4% (mean 20.3) of SL. Caudal peduncle compressed, length 23.3–29.6% (mean 26.1) of SL; caudal peduncle depth 9.1–14.0% (mean 12.3) of SL (Table 2).

First dorsal fin triangular, first or second spine longest or equal in length, usually second spine longest; when depressed, spine tips reach second dorsal fin origin or just fall short of first fin element. First dorsal spine 15.4–19.2% (mean 17.5) of SL; second dorsal spine length 14.8–18.9% (mean 16.9) of SL. Second dorsal fin rather low, higher anteriorly than posteriorly, rounded to slightly pointed posteriorly. Anal fin low, anteriormost rays shorter than posterior few rays; fin slightly pointed posteriorly. Second dorsal and anal fin rays do not reach caudal fin when depressed. Pectoral fin pointed, central rays longest, 21.4–27.4% (mean 24.6) of SL; rays all branched but for upper and lowermost ray, fin reaches to at least above anus. Pelvic fins fused, with smooth-edged, deep frenum, fins oval, reaching to anus, 17.9–24.7% (mean 22.2) in SL. Caudal fin short, rounded, 23.3–31.3% (mean 26.6) of SL (Table 2).

Table 2. Measurements of specimens of *Arcygobius baliurus*, expressed as percentage of standard length (SL) or head length (HL).

	Means	Max.	Min.
Standard length	54.6	69.0	28.5
Head length in SL	30.3	33.8	27.9
Head depth in HL	58.5	66.9	52.3
Head width in HL	56.7	70.5	50.3
Body depth in SL	20.3	23.4	16.1
Body width in SL	12.6	14.9	9.5
Caud. ped. length in SL	26.1	29.6	23.3
Caud. ped. length in SL	12.3	14.0	9.1
Snout length in HL	26.0	32.2	22.5
Eye width in HL	26.1	29.5	23.2
Jaw length in HL	44.0	48.8	37.6
Interorbital in HL	5.6	7.4	4.1
Pectoral fin in SL	24.6	27.4	21.4
Pelvic fin in SL	22.2	24.7	17.9
Caudal fin in SL	26.6	31.3	23.3
First D1 fin spine in SL	17.5	19.2	15.4
Second D1 fin spine in SL	16.9	18.9	14.8

No mental fraenum, chin smooth and prominent. Anterior nostril in short round tube higher laterally than medially, placed closer to upper lip than eye. Posterior nostril oval, placed close behind anterior nostril. Gill opening very wide, extending forward to below mid-eye. Gill rakers on outer face of first arch long and slender, crowded near angle of arch; rakers on inner face of first arch short rounded knobs with several spines at tip; outer and inner rakers on all other arches similar to inner face rakers on first arch. Tongue large, tip blunt to bluntly rounded.

Teeth in upper jaw in 3–5 rows, outermost row teeth largest, widely spaced, curved and pointed; innermost row teeth small, sharp and evenly sized, oriented inward; 2–3 middle rows of teeth very small and finely pointed. Teeth in lower jaw similar, in 3–4 rows, but outermost row teeth smaller and slightly more upright than upper jaw outer row teeth. No teeth particularly enlarged; no symphysial or lateral caniniform teeth.

Predorsal scales large, cycloid, reaching close up to behind eyes. Ctenoid scales on side of body extend up to just above pectoral fin base. Dorsal part of operculum with cycloid scales (ventral part covered with complex sensory papillae pattern). Cheek covered with 3–4 rows of cycloid scales, dorsalmost row of largest scales just below eye; scale rows separated by sensory papillae rows *c* and *d* (Fig. 5), and one row of scales below papilla row *d*. No scales on branchiostegal membranes. Prepelvic area, isthmus and pectoral fin base covered with cycloid scales. Belly with ctenoid scales; may have cycloid scales along ventral midline.

Head pores in arrangement characteristic of the Gobiinae, with a nasal pore near each posterior nostril, single anterior interorbital pore, a single posterior interorbital pore (just anterior to first nape scale), a postorbital pore, an infraorbital (or anterior otic) pore on a very short but distinct branch of the oculoscapular canal, a posterior otic and intertemporal pore in the anterior portion of the oculoscapular canal, and an anterior and posterior temporal pore in a short separate posterior portion of the oculoscapular canal (over opercle); three preopercular pores present (Fig. 5).

Sensory papillae pattern in unique transverse pattern, illustrated in Figure 5. Papillae in row *a* proliferated into short transverse rows; opercular papillae also in distinctive pattern, with row *os* rising dorsoposteriorly and many transverse rows between rows *os* and *oi*; similar rows below row *oi*. No papillae in distinct groove on cheek below nostrils. Papillae on chin may be proliferated, obscuring the lines of papillae shown in Figure 5.

Coloration of fresh material. No information is available other than Smith's (1959) plate (reprinted in Smith and Smith 1969) and Bleeker's incomplete figure (1983). Smith (1959) shows a pale yellowish fish with red-brown markings on the head, most prominent being

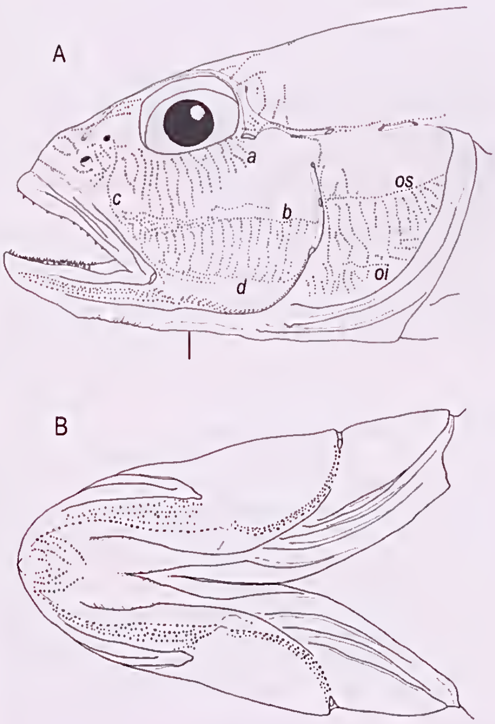

Fig. 5. Lateral line pores and composite sensory papillae pattern of *Arcygobius baliurus*, based on NSMT P–55048, 57 mm SL male, with some details from CAS 46083, 73.5 mm SL female: **A**, lateral view; **B**, ventral view, based on ZRC 31948, 59 mm male, with some details from CAS 46083, 73.5 mm SL female. Scales omitted for clarity. Vertical line shows extent of gill opening.

a broad streak from jaw across cheek and opercle, joining similarly coloured patch on pectoral base, blue spots on the body scales, black mid-body and mid-caudal fin base spots, the first dorsal, anal, pectoral and pelvic fins are plain yellow, the second dorsal fin has a red margin and black-bordered submarginal band, and the caudal fin is yellow barred with pinkish red.

Bleeker's (1983) colour illustration is clearly unfinished, but is quite similar to Smith's, but no blue spots on the body scales are shown, the anal fin is pinkish and there is no brown streak across the side of the head. The red barring on the caudal fin and the darker second dorsal fin margin agrees with Smith (1959). Devi *et al.* (1993) briefly stated that their specimen was "… reddish green above, greenish below … Fins yellow."

Coloration of preserved material. Head and body whitish, yellowish or light brown (depending on preservation history), with scale margins broadly darkened, their centres paler, giving a mottled or reticulate appearance, four elongate to rectangular brown blotches along lateral mid-line of body and most conspicuously, a dense dark brown to black oval spot oriented longitudinally on base of central caudal fin rays (Fig. 3). Snout and area between eye and upper jaw darker than rest of head; in some specimens, dark brown blotch or short bar present below anterior nostril, reaching toward eye; blackish to dark brown spot or blotch over dorsal part of eye; iris pale (may have been golden or silvery gold in life, based on remnant colouring in some specimens), with dorsal portion of eye blackish, giving eye a "hooded" appearance; brownish to golden-brown triangular blotch on centre of opercle, lower part of opercle pale to pearly white. Pectoral fin base pale, slightly darker above and below; some specimens with indistinct brownish bar above and below central portion of fin base. Underside of head, breast and belly pale or whitish.

First dorsal fin dusky to blackish, with narrow darker margin, usually intensified posteriorly as blackish spot; second dorsal fin pale to dusky, margin slightly darker; anal fin dusky to brownish, margin white in some specimens; pectoral fin translucent to faintly dusky; caudal fin pale to brownish, with 5–6 indistinct wavy alternating dark and light bands, most distinct across centre of fin behind large oval dark blotch on central base of fin; pelvic fins whitish with dusky to

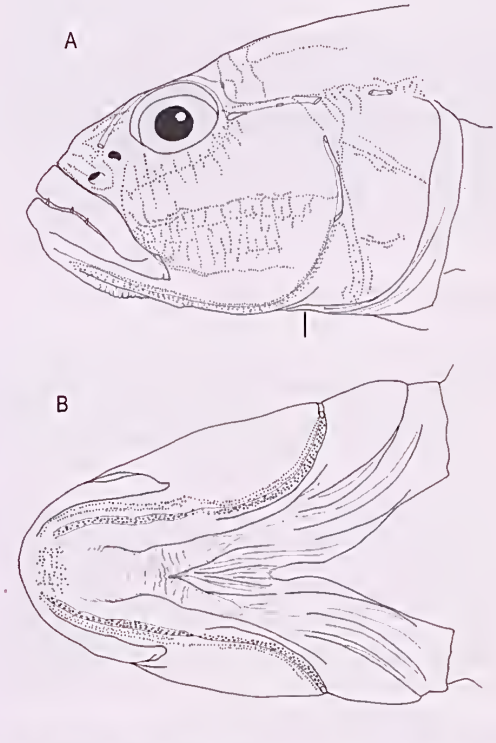

Fig. 6. Sensory papillae pattern and lateral line pores of *Acentrogobius viridipunctatus*, NTM S.11125–002, 78 mm SL female: **A**, lateral view; and **B**, ventral view. Scales omitted for clarity. Vertical line shows extent of gill opening.

brown pigment forming broad mid-line streak or band along fourth and fifth rays, fraenum pale.

Herre (1927: 131) gives a useful description of recently preserved specimens, indicating that the mark on the opercle is a "...dusky, iridescent silver spot" and that the cornea had "blue iridescence".

Distribution. Specimens are known from Micronesia, northern Australia, the Philippines, Singapore, Borneo, Indonesia, Thailand, Andaman Islands, Red Sea, Seychelles and the east coast of Africa. The two small specimens from Yap (Micronesia) are the only ones recorded from the Pacific Plate.

Ecology. Where data are available, it appears that specimens have been obtained by coastal trawling, over soft or mud substrate, in depths of 12–16 m. The species used to form large schools in the Gulf of Thailand, where it is now caught less often (P. Wongrat, pers. comm. 1993). The species is nowhere common in collections, and populations may have been reduced by habitat destruction due to shallow-water trawling. The most recently-collected material seems to be from Singapore, where the species has been found during faunal surveys of artificial boat basins (marinas).

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Additional frogs from the mid-Miocene Camfield beds of Camfield Station, Northern Territory, Australia

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ABSTRACT

Ilia determined to represent new species of the myobatrachid frog genera *Crinia* Tschudi and *Lechriodus* Boulenger have been located in the Camfield beds of the Northern Territory. *Crinia lacinia* sp. nov. and *Lechriodus bauzeorum* sp. nov. are described and additional representatives of the hylids *Litoria curvata* Tyler and *L. conicula* Tyler are reported. To date, all of the ilia in the Bullock Creek Local Fauna are from uniformly small individuals of estimated snout-vent lengths of around 30 mm. Data on the size distributions of extant species in the Northern Territory implies a reliable availability of moisture throughout the year at Camfield during Bullock Creek Local Fauna (mid-Miocene) times.

Keywords: Myobatrachidae, Hylidae, *Crinia*, *Lechriodus*, ilia, fossil, new species, Miocene, Camfield beds, Northern Territory, palaeoenvironment.

INTRODUCTION

The original discovery of nine ilia resulted in the description of three new species of frogs from the mid-Miocene Camfield beds in the Northern Territory (Tyler 1994a). That publication constituted the first record of fossil frogs in the Northern Territory, and was also only the third recorded occurrence of fossil frogs in northern Australia. The Tertiary taxa previously described from the Camfield beds are all members of the family Hylidae, better known as tree frogs, although the family includes fossorial species. Two are members of the extant genus *Litoria* Tschudi and the third is a representative of the extinct genus *Australobatrachus* Tyler, 1976.

As a result of further collections by staff of the Museums and Art Galleries of the Northern Territory, 16 more ilia have been recovered from the Camfield beds. Described below are new species of the myobatrachid genera *Crinia* Tschudi and *Lechriodus* Boulenger, additional representatives of two of the hylid taxa described previously, plus an undetermined species of *Litoria* and one of *Crinia*. The frog fauna of the Camfield beds as it is now understood is summarised in Table 1.

The palaeoclimatic implications of the small body sizes of the Camfield beds frogs are explored by analogy with the distributional pattern of size classes in the modern Northern Territory fauna.

Table 1. Frogs of the Bullock Creek Local Fauna, Camfield beds of the Northern Territory.

Hylidae
Australobatrachus undulata Tyler, 1994a
Litoria conicula Tyler, 1994a
Litoria curvata Tyler, 1994a
Litoria sp. (this work)
Myobatrachidae
Crinia lacinia sp. nov. (this work)
Crinia sp. (this work)
Lechriodus bauzeorum sp. nov. (this work)

MATERIAL AND METHODS

The specimens reported here were extracted from fossiliferous Camfield beds limestone using dilute (~10%) acetic acid. Insoluble residues of acid digestion were passed through a set of screens (4.0, 2.0, 1.0 and 0.5 mm), which were then scanned under the microscope. Frog ilia were recovered only from the 2 mm screen. All specimens are deposited in the palaeontological collections of the Museum and Art Gallery of the Northern Territory (NTM).

Descriptive terminology of ilia follows the nomenclature adopted by Tyler (1976). Illustrations of these specimens were prepared on an Olympus SZH10 Research Stereomicroscope, fitted with an SC35 Type

Table 2. Yield of frog ilia relative to mass of fossiliferous limestone processed and mass of screenings surveyed. nd = no data.

Limestone batch	Quarry	Facies	Estimated mass of limestone processed (kg)	Mass of screenings (insoluble residues) >2mm, <4mm (g)	No. of frog ilia
P8697–	Dromornithid Mountain	conglomeratic limestone and calcimudstone	250	732	2
P87106–	Site Y	calcimudstone	nd	nd	1
P87113–	Site Y	calcimudstone	nd	nd	1
P87114–	Top Site	conglomeratic limestone and calcimudstone	100	219	1
P9215–	Top Site	calcimudstone	15	40	7
P9613–	Site X	calcimudstone	20	31	2
P9967–	Site X	calcimudstone	25	157	1
P9969–	Site X	calcimudstone	200	262	1
P9974–	Top Site	calcimudstone	40	215	2
P933–P938 inclusive	nd	nd	nd	nd	6
TOTAL ILIA					24

12 camera using a Sony UPC–2020 Black and White Printing Pack (Fig. 1A,B), and with a Ricoh Caplio RR30 digital camera (Fig. 1C,D).

The comparative osteological material of extant species used is housed in the Herpetological Laboratory of the Department of Environmental Biology at the University of Adelaide.

OCCURRENCE OF FROGS IN THE CAMFIELD BEDS

The Camfield beds, in the north central Northern Territory, consist of discontinuous outcrops of calcareous siltstone and sandstone, gypsiferous siltstone, limestone and cherty limestone (Randal and Brown 1967; Murray and Megirian 1992). The frog ilia described here, and those described previously by Tyler (1994a) were all collected from a *ca* 1 km^2 outcrop at about 17°7' S, 131°31' E. The outcrop and the various named fossil quarries which have produced frog ilia are depicted in Murray and Megirian (1992: fig. 3).

The Bullock Creek Local Fauna (LF) comes predominantly from conglomeratic limestone and calcimudstone facies of the formation, which Murray and Megirian (1992) interpreted as representing stream channel and lacustrine (oxbow) environments of a carbonate-depositing stream system. The Bullock Creek LF is considered to be mid-Miocene on the basis of marsupial stage-of-evolution biochronology (e.g. Woodburne *et al.* 1985; Rich 1991; Murray *et al.* 2000).

Frog ilia are infrequent in the Camfield beds, with only 24 specimens recovered so far. Approximately 650 kg of fossiliferous limestone yielded 16 of the specimens (Table 2). Of these, 13 were recovered from massive calcimudstone, and three from sites where conglomeratic limestone is associated with calcimudstone. (Two additional specimens (P87106–48, P87113–58) came from calcimudstone, but no data are available on the mass of limestone processed, and no sedimentological information or mass estimates are available for the quarried blocks that yielded specimens P933 to P938 inclusive – Table 2). The statement in Tyler (1994a) to the effect that the Top Site and Dromornithid Mountain quarries are in conglomeratic limestone requires clarification. Fossiliferous conglomeratic limestone is present at both these localities, but so too is fossiliferous calcimudstone, and both facies have been quarried. Bedding in the formation is poorly developed, and facies transitions are typically gradational. Consequently both facies may have been sampled in the same quarried block. Limestone batches P87114– (Top Site) and P8697– (Dromornithid Mountain) were at least in part conglomeratic, as indicated in Tyler (1994a). Batch P9974– (Top Site), however, was entirely calcimudstone (Table 2).

SYSTEMATICS

Order ANURA Rafinesque
Family Myobatrachidae Schlegel
Lechriodus Boulenger
Lechriodus bauzeorum sp. nov.

(Fig. 1A)

Material. HOLOTYPE – NTM P9215–2, proximal portion of a right ilium; Top Site, Bullock Creek Locality, Camfield Station, NT (17°00' S, 131°30' E); Bullock Creek Local Fauna, mid-Miocene.

Description of holotype. Only the proximal portion of the ilial shaft remains. The shaft is missing superiorly from a position approximately 0.5 mm

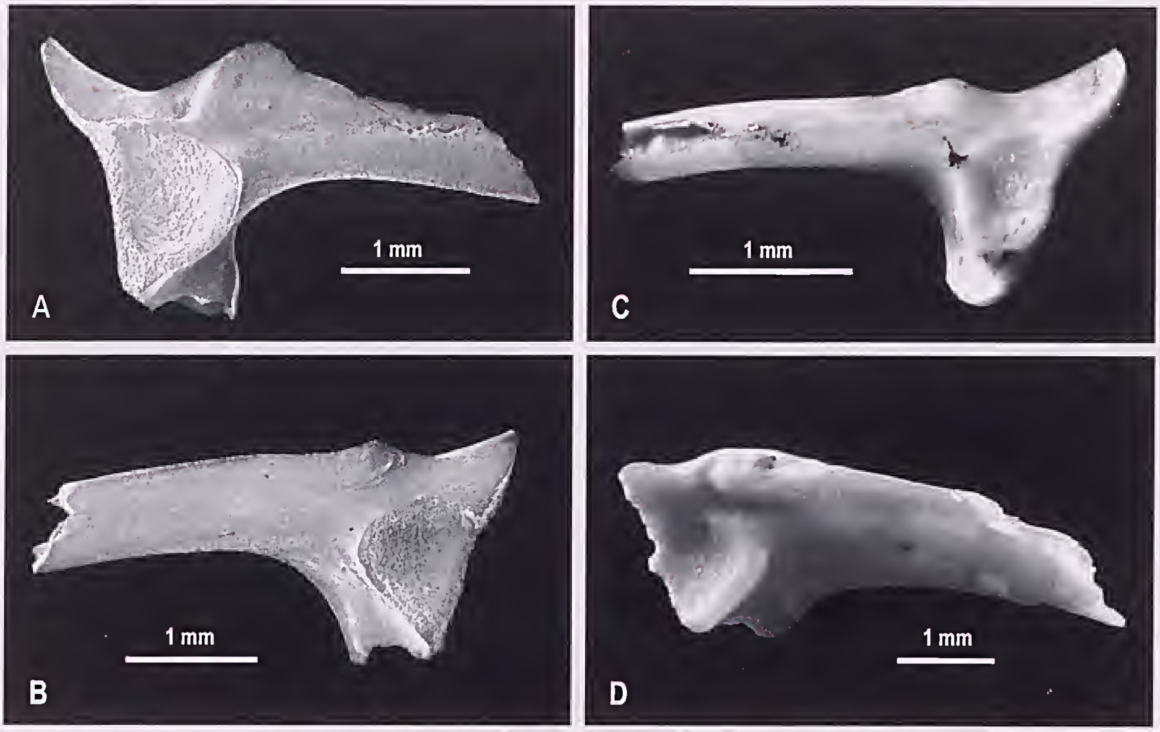

Fig. 1. A, Holotype of *Lechriodus bauzei* sp. nov. NTM P9215–2, right ilium in lateral view. **B**, Holotype of *Crinia lacinia* sp. nov. NTM P9215–14, left ilium in lateral view. **C**, *Crinia* sp. NTM P9215–17, left ilium in lateral view. **D**, *Litoria* sp. NTM P87113–58, right ilium in lateral view.

anterior to the acetabular fossa, and terminates inferiorly approximately 3.0 mm anterior to the fossa, nevertheless there is a sufficient amount of the shaft to exhibit the commencement of the broad, flaring dorsal crest so characteristic of the genus (Tyler 1976).

The acetabular fossa is large and well defined, with a narrow but prominent rim. The preacetabular zone is very narrow and the ventral acetabular expansion is incomplete but evidently well developed and slightly protrudes anteriorly, so creating a weakly sigmoid anterior profile.

The dorsal prominence and dorsal protuberance are not differentiated from the proximal portion of the ilial shaft. The dorsal acetabular expansion is complete, narrow and acutely pointed. It is separated from the shaft by a shallow depression.

Comparison with other species. Four extant and two extinct congeners are known. The extant species are *L. fletcheri* (Boulenger) of coastal south-east Australia and *L. melanopyga* (Doria), *L. aganoposis* Zweifel and *L. platyceps* Parker of New Guinea. Of these species, the Camfield specimen resembles the ilium of *L. aganoposis* most closely, differing principally in the dorsal crest arising at a point adjacent to the posterior margin of the acetabular fossa, whereas in *L. aganoposis* the dorsal crest arises adjacent to the posterior margin of the fossa (Tyler 1989: fig. 3D).

The two known extinct species are *L. intergerivus* Tyler, 1989 from the late Oligocene to mid-Miocene of the Carl Creek Limestone, Riversleigh Station, Queensland and *L. casca* Tyler and Godthelp, 1993 from the Early Eocene of Murgon, Queensland. Several hundred ilia of *L. intergerivus* have been recovered and it is evident from a comparison of the two taxa that the depth and extent of the flared ilial shaft of *L. bauzeorum* is proportionately more pronounced than in the former species. The preacetabular zone tends to be variable in shape but is more reduced in *L. bauzeorum* than in *L. intergerivus*.

In *L. casca* the flaring of the ilial shaft is greatly reduced (much less than in *L. bauzeorum*), but the lateral indentation of the shaft is more pronounced.

Comment. Although described from a single, incomplete bone, wider studies of extant and fossil species indicate clearly that ilial characters, and particularly the depth of the ilial shaft flange just anterior to the acetabular fossa, are reliably diagnostic (Tyler 1976, 1989; Tyler and Godthelp 1993).

Etymology. Named in honour of Robert and Elizabeth Bauze of Adelaide for the support that they have given to palaeontology.

Crinia Tschudi

Crinia lacinia sp. nov.

(Fig. 1B)

Material. HOLOTYPE – NTM P9215–14, proximal portion of left ilium. PARATYPES – P9215–3, left ilium; P9213–15, left ilium; P9215–16 right ilium. All from Top Site; other data as for *Lechriodus bauzeorum* (above).

Description of holotype. Ilial shaft slender and slightly curved (Fig. 1B). Lacks dorsal crest, but with shallow and poorly defined lateral indentation. Distal end of shaft incomplete, approximately one-half believed to be lacking, based upon comparing the distal portion with complete ilia of other species.

Acetabular fossa large and deep, and with prominent elevated rim. Dorsal margin of acetabular fossa entirely superior to inferior margin of ilial shaft. Preacetabular zone extremely prominent and expanding progressively inferiorly. Inferior margin of subacetabular expansion lacking. Dorsal acetabular expansion slightly raised. Dorsal prominence slightly raised and angular in profile. No evidence of dorsal protuberance. Length of specimen: 3.5 mm.

Description of paratypes. There are three paratypes – two left ilia, NTM P9215–3 and P9215–15, and a right, P9215–16. The shafts of P9215–3 and P9215–16 are broken at approximately the same position as the holotype, and their preserved lengths are 6.0 and 4.0 mm respectively. P9215–15 is more complete, but from a much smaller individual. Each is extremely similar to the features of the holotype, with a broad and evenly rounded preacetabular zone. The dorsal prominence is angular in profile in P9215–3 and rounded (possibly as a result of abrasion) in P9215–15 and P9215–16. The dorsal acetabular expansion is slightly raised in each of the paratypes.

Comparison with other species. With the exception of the extant species *Crinia remota* (Tyler and Parker), which has been found in a cave deposit of Holocene or late Pleistocene age, the only other fossil *Crinia* known is *C. presignifera* Tyler, 1991, from the late Oligocene or early Miocene of Riversleigh Station, Queensland. The nature of the preacetabular zone distinguishes the two species very clearly, for it is very poorly developed (scarcely extending beyond the anterior rim of the acetabular fossa) in *C. presignifera*, and very well developed in *C. lacinia*. Data on extant species are provided by Tyler (1976).

It is also likely that *C. lacinia* grew to a larger size than *C. presignifera*. An incomplete paratype of *C. lacinia* (P9215–3), measures 6.0 mm and the bone is estimated to have had a total length of around 11.0 mm or 12.0 mm. In contrast, the largest complete ilium of *C. presignifera* measures 7.1 mm (Tyler 1991).

Etymology. The Latin *lacinia* means a lappet or fringe, and here refers to the very broad preacetabular zone.

Crinia sp.

(Fig. 1C)

Material. NTM P9215–17, left ilium lacking approximately one-half of the shaft of the dorsal acetabular expansion and a significant portion of the preacetabular and subacetabular zones. Top Site; other data as for *Lechriodus bauzeorum* (above).

Comments. Identification is based upon the cylindrical form of the ilial shaft bearing a slight medial and longitudinal indentation, the ilial curvature, weak development of the dorsal prominence and posterior position of the acetabular fossa. Poor development of the preacetabular zone precludes the possibility of this species representing *C. lacinia*.

Family Hylidae Gray

Litoria Tschudi

Litoria curvata Tyler, 1994

Material. NTM P87106–48, left ilium; P9215–18, left ilium: all from Top Site. P9613–1, left ilium; 9613–2, right ilium; P9967–1, right ilium; P9969–1, left ilium: all from Site X. Other data as for *Lechriodus bauzeorum* (above).

Comments. All of the specimens have incomplete shafts. The least damaged is P9613–1 which has a length of 9.6 mm. All specimens exhibit the diagnostic features of the holotype, being an almost straight ilial shaft, a pronounced laterally projecting dorsal prominence, and a broad, flanged and evenly-curved preacetabular zone.

Litoria conicula Tyler, 1994

Additional material. NTM P9974–2, left ilium; Top Site, other data as for *Lechriodus bauzeorum* (above).

Comments. Previously known exclusively from the holotype taken at the Bullock Creek locality, this specimen resembles the holotype very closely and shares the distinctive dorsal prominence, which is triangular in profile.

Litoria sp.

(Fig. 1D)

Material. NTM P87113–58, right ilium; Site Y, other data as for *Lechriodus bauzeorum* (above).

Comments. This specimen differs from the two named fossil species of *Litoria* from the Camfield beds (and from other genera) in the very weak development of the dorsal acetabular expansion. The preacetabular zone is evenly rounded and the dorsal prominence is not pronounced, but is abraded laterally and its actual shape is uncertain. Comparison has been made with a large collection of extant species without finding any evidence of affinity to any of the species groups recognised by Tyler and Davies (1978).

DISCUSSION

One of the more significant questions that can be posed about the Camfield beds is the nature of the mid-Miocene landforms, and the climate at the time that the fossil material was deposited. Because frogs lose water rapidly through their skin they have to either remain in contact with moisture, or avoid exposure to aridity. It follows that an understanding of the likely ecological requirements of the various frog taxa recovered will contribute to the interpretation of the nature of the mid-Miocene environment at Bullock Creek.

Following Bureau of Meteorology (1989), the present climate of the Northern Territory can be described in general terms as follows. The northern half (i.e. north of *ca* 20° S) lies in the 'summer rainfall – tropical' climatic zone. Summers are characterised by heavy periodic rains (heavier in coastal and elevated areas), with generally hot and humid conditions. Winters are generally rainless, mild to warm, and dry. The southern half of the Northern Territory lies in the 'arid' (mainly summer rain) – 'subtropical' climatic zone. Summers are characterised by variable rain, hot to extremely hot and very dry conditions, while winters are characterised by irregular light rain, mild to warm and dry conditions.

The transition from the one climatic zone to the other is not abrupt, but bisects a fairly even, more or less latitudinal climatic gradient, consistent with the lack of major influential physiographic features (e.g. high mountain ranges, rift valleys, inland seas, etc.). Median annual rainfall grades from about 1600 mm on the north coast to less than 200 mm at the Northern Territory / South Australia border, with average annual temperatures grading from about 27°C in the north to 21°C in the south. An additional significant gradient in relation to the present discussion is the annual rainfall variability, which is low to moderate in the Top End, and extreme in the south. Thus, the north experiences marked seasonal (winter) aridity with reliable summer rain, whereas the south is subject to low, highly irregular rainfall and extended periods of drought.

Tyler (1994b) found that in the Northern Territory, frog species diversity correlates strongly with median annual precipitation, which is consistent with the findings of Pianka and Schall (1981) for the whole continent. Pianka and Schall (1981) examined vertebrate species diversity in relation to five climatic variables, and found that for frogs, species diversity correlated only (though strongly) with median annual rainfall. The 24 known frog ilia from Bullock Creek represent seven species (five determined and two undetermined at species level). Unfortunately, the available sample size is too small to reach any conclusion about what the total frog diversity at Bullock Creek might have been during Bullock Creek LF time (mid-Miocene), and thereby permit an estimation of the possible median annual precipitation.

Tyler (1994b) also found that the size of frogs in the Northern Territory was inversely correlated to median annual precipitation. The relationship of frog size to average annual temperature was not examined, but given that both median annual precipitation and average temperature decrease toward the south through the Northern Territory, as outlined above, it could be expected that a similarly strong inverse correlation exists between frog size and average annual temperature. In terms of physiological capacity to handle water stress, a preponderance of smaller frogs at northern Northern Territory latitudes is perhaps more significantly correlated to the presence of reliable moisture in the environment throughout the year. In the Northern Territory analogy, places with reliable surface moisture are not sustained by direct precipitation throughout the year, rather they are sustained by regional groundwater discharge and soil moisture during the dry season. Elsewhere in Australia, small frogs are also found in uniform rainfall zones. While small frogs may be indicative of the presence of reliable moisture in the environment, they are uninformative about rainfall distribution over the seasonal cycle.

The uniformly small size of the Camfield beds frogs is therefore an indication of the presence of permanent moisture in the depositional environment, which is consistent with the presence of a diverse aquatic element (crocodilians, chelid turtles, teleost fish, lungfish, aquatic molluscs, ostracods, charophyta, cyanobacterial stromatolites) in the Bullock Creek Local Fauna (Murray and Megirian 1992). The fossil frogs, with estimated *ca* 30 mm snout-vent lengths, were smaller on average than those present today in the north of the Northern Territory (=38 mm, Tyler 1994b), suggesting that the Bullock Creek palaeoclimate was physiologically less stressful on frogs than the present most optimal environments of, for example, Kakadu in the northern Northern Territory. This inference is consistent with some other palaeoclimatic data. For example, during the mid-Miocene, Bullock Creek was at about latitude 30° S (i.e. about 13° further south than today), and sea-surface temperatures around the continent were about 18°C (e.g. Savin *et al.* 1985). This indicates that latitudinal temperature gradients across the continent were probably considerably lower than today, with mild to warm conditions throughout, rather than cool to mild in southern parts and warm to hot in northern parts as it is today.

Tyler (1994a) hypothesised that seasonal aridity was probably not a feature of Bullock Creek palaeoclimate, citing the small size of frogs and absence of fossorial species as evidence. On the other hand, Murray and Megirian (1992) attributed the uniformly small size of teleost fishes in the Camfield beds to seasonal aridity. In the light of the preceding discussion, the presence of small frogs does not exclude the possibility of seasonal aridity.

The presence of only one specimen of *Lechriodus* in the fauna merits comment because there is a progressive reduction in the incidence of this genus from the Oligocene in the Carl Creek Limestone at Riversleigh, north-western Queensland (Tyler *et al.* 1990), and this reduction has been interpreted to be a consequence of environmental change. Riversleigh at 19° S is at similar latitude to Bullock Creek (17° S), and their positions relative to each other were constant throughout the Tertiary. In the earliest of the Riversleigh sites where there are adequate sample sizes, the incidence of *Lechriodus* in the frog fauna is as high as 80.8%. At the youngest site the incidence is only 35.5%. Sample sizes at the various sites ranged from 17 to 110. The one specimen in the Bullock Creek Local Fauna equates to 4% of the total individuals recovered. It is tempting to suggest that the proposed demise of the Riversleigh frogs (attributed to a reduction in forest habitat in response to increasing aridity) applied equally to Bullock Creek at a similar time.

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Bougainvillia balei Stechow, 1924: 58. – Stechow 1925: 199, fig. B; Watson 1996: 78.

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