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A preliminary account of *Cycas* (Cycadaceae) in Queensland

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Abstract

Hill, K.D. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, NSW, Australia, 2000) 1992. A preliminary account of Cycas *(Cycadaceae) in Queensland.* Telopea *5(1): 177–206.* Taxonomic studies initiated by the late John Maconochie on *Cycas* have been continued. Nine species are recognised in Queensland, six of them newly described here (**C. brunnea**, **C. couttsiana**, **C. megacarpa**, **C. ophiolitica**, **C. platyphylla** and **C. silvestris**). The circumscriptions of *C. media* R. Br. and *C. cairnsiana* F. Muell. are clearly defined, with reference to the type specimens and recent collections from around the type localities, and the names *C. gracilis*, *C. normanbyana* and *C. kennedyana* are placed in the synonymy of *C. media*. Species definition in the *C. circinalis* – *C. rumphii* complex is discussed with reference to the new species *C. silvestris* described from Cape York Peninsula.

Introduction

The genus *Cycas* has long presented problems for taxonomists (e.g. Bentham 1873). The late John Maconochie commenced a major project on this group in Australia but died in a motor accident before nearing completion of it. His notes and specimens have been made available to me to allow continuation of this work.

Terminology

Morphological terminology follows Johnson (1959, see also Johnson & Wilson 1990), with the exception that the terms *peduncle*, *microsporophyll* and *megasporophyll* (and derived terms) are used where appropriate (in place of *cone-stalk*, *male sporophyll* and *female sporophyll* respectively). Measurements of pinnae and associated angles are all taken at the mid-point of the axis bearing the pinnae (both basal and apical pinnae may be very different from median pinnae in form and arrangement). The two angles associated with the pinnae are the angle included by opposing pinnae (this angle when low, i.e less than 120°, gives the frond a keeled or V-shaped section), and the angle between an individual pinna and the rhachis measured in the plane of the rank of pinnae. *Seed* is used for the mature structure developed from the fertilised megaspore including all testa layers and excluding the stipe and lamina of the megasporophyll. The widened infertile apex of the megasporophyll is referred to as the *lamina* (following Carruthers 1893, Zamora & Co 1986), and the remainder of the megasporophyll as the *stipe* (Johnson 1959). The microsporophyll is described in three sections, the *fertile zone* (the broad area bearing the microsporangia), the *sterile zone* (the infertile more or less continuous apical extension from the fertile zone), and the usually sharply upturned apical spine (the *apical spine*). Measurements given for stem diameter refer to diameter at the narrowest point. Minimum diameter is fairly consistent within and between species, whereas maximum diameter can vary widely depending on age, injury history and the number of crowns on the plant.

Taxonomic history

Cycas was described by Linnaeus (1753) with a single species *C. circinalis*, although much of the material he cited has since been separated as different taxa. *C. circinalis* as now circumscribed is based on *Todda Panna* of Rheede (1682), from the Malabar coast of southwestern India. *C. circinalis* and the segregate taxon *C. rumphii* Miq. (type from the Moluccas) nevertheless remain a difficult and unresolved complex (see Stapf 1916, Smith 1979).

Robert Brown (1810) then recognised two taxa in Australia, *C. media* and *C. angulata*.

The next major study of *Cycas* was that of Miquel, who published a series of works on the cycads (1840, 1842, 1868, 1869). He published *C. gracilis* and *C. armstrongii* from Australia, the latter being the first non-Queensland species to be described.

Bentham (1873) reduced all Australian species to *C. media*, with the qualification that the group was complex and required further critical study, particularly in the field.

Mueller (1874, 1876, 1882) described *C. kennedyana*, *C. normanbyana* and *C. cairnsiana*. The first two in particular were described from inadequate material. These two were thought to occur in mixed stands with *C. media* in the Townsville to Mackay region by early collectors (Fitzalan 1882).

Gardner (1922, 1923) recognised two further taxa, *C. basaltica* and *C. lane-poolei*, both from the Kimberley region of Western Australia. At about the same time, Fitzgerald (1918) described *C. furfuracea* from the same region.

The Australian species were then treated by Schuster (1932), who made no advances in the understanding of the group (see comments by Johnson (1959) and Read & Solt (1986) on the value of the Schuster study).

Johnson (1959) revised the Australian cycads excluding *Cycas* and established the currently accepted family placement. He recognised some of the problems in *Cycas*, stating that 'a difficult and protracted task awaits any responsible monographer of the genus'.

Maconochie commenced a revision of Australian *Cycas*, but had made little progress on the Queensland taxa. He had, however, recognised some of the problems, and described two new taxa in Western Australia and the Northern Territory (*C. pruinosa* and *C. calcicola*, described in 1978).

The present study

The present study originated out of an undertaking to prepare a treatment of the 'gymnosperms' for the Flora of Australia project in 1985. During the course of this preparation, it became clear that the taxonomic *status quo* was not adequate in the case of the genus *Cycas*. I was able to undertake a number of field trips through tropical Australia in 1984, 1986, 1988, 1990 and 1991 as part of a major study of *Eucalyptus*, allowing opportunity to also examine populations of most Australian *Cycas* across their full range in the field. Preliminary notes by John Maconochie were also made available by DNA. My field observations have been combined with the observations of a number of astute amateur 'cycadologists' (see acknowledgements), gradually leading to better understanding of the genus in Australia. Specimens held by BRI, CANB, CBG and DNA have been also examined.

This account is restricted to Queensland taxa. There are also several new taxa in the

Northern Territory, some of which are under study by botanists in Darwin (Chirgwin, in press and in prep.). The work of Maconochie (1978) completed the catalogue of *Cycas* species in northern Western Australia.

Hybridism

Evidence is mounting to suggest that there are weak fertility barriers between cycad species (Vorster 1986, Norstog 1990). This is shown by the numbers of natural hybrids being discovered. The lack of pollinator specificity, when combined with the apparently weak inherent fertility barriers, results in the major reproductive barrier between *Cycas* species in nature being geographic separation. Consequently, populations of natural *Cycas* species are geographically distinctly separated, and hybrid and intermediate zones are found where different species have spread to within pollination range of each other.

Naturally occurring hybrids and intergrades have been recorded from the Northern Territory, where four species grow in relatively close proximity and hybrids are reported between *C. armstrongii* and *C. conferta*, *C. calcicola* and *C. armstrongii*, and *C. calcicola* and *C. maconochii*. In Queensland, the Irvinebank cycad population is morphologically and geographically intermediate between *C. media* and *C. platyphylla*, and also shows the considerable variability to be expected in hybrid swarms.

Breakdown of breeding barriers would also appear to have contributed to the complexity of the *C. media* complex in eastern Queensland. Here, it seems that several discrete species have arisen at some time in the past, probably when the range of an ancestral taxon was fragmented by climatic change. More recently, their ranges have expanded to meet and overlap. This has resulted in the present zones of intergradation in this complex in Queensland. Areas of hybridism are discussed below under the species involved, but in summary are as follows:

1. *C. media* – *C. platyphylla* near Irvinebank, mentioned above.

2. *C. media* – *C. ophiolitica* in the area between Mackay and St Lawrence.

3. *C. ophiolitica* – *C. megacarpa* in the area between Rockhampton and Mt Morgan.

Taxonomic treatment

Cycas *L.*, Sp. Pl. 1: 1188 (1753); Gen. Pl. edn 5: 495 (1754).

TYPE: *Cycas circinalis* L.

Dioecious palm-like shrubs with erect, pachycaul, cylindrical stems clad with persistent frond-bases (stems subterranean in some extra-Australian taxa). Fronds loosely pubescent when young, pinnate, spirally arranged, produced in seasonal growth flushes interspersed with cataphylls, lower pinnae often reduced to spines. Longitudinal ptyxis erect or rarely reflexed, horizontal ptyxis circinate. Pinnae with a single thick midrib and no lateral veins; stomata confined to abaxial surface in most species; individual ptyxis involute. Trichomes transparent, branched or simple. Microsporophylls aggregated into determinate cones and bearing numerous microsporangia (pollen-sacs) on abaxial surfaces, with a simple sterile tip, which is often produced into an upturned spine; microsporangia opening by slits; pollen cymbiform, monosulcate. Megasporophylls spirally arranged in an indeterminate terminal rosette with the central axis continuing vegetative growth. Ovules two to many (rarely one),

marginally inserted on the stipe and directed obliquely outwards ('ascending'); sporophyll apically dilated, pinnatifid, pectinate, toothed or entire. Seeds with a yellow, orange or brown fleshy outer sarcotesta, and with or without spongy tissue beneath the inner woody sclerotesta. Endosperm haploid, derived from the female gametophyte. Embryo straight; with 2 cotyledons that are usually united at the tips; seeds platyspermic; germination cryptocotylar. $2n = 22$ (Sax & Beale 1934; counts on three extra-Australian species).

The generic name is from the supposed Greek 'kykas', used by Theophrastus. This was an error of transcription for 'koikas,' the accusative form of 'koix', for the Egyptian Doum-palm, *Hyphaene thebaica* (L.) Mart.

About 30 species, chiefly Australian (about 20 species) and Chinese (about 10 species). The genus also occurs in Malesia, Japan and South-east Asia, with outliers in Polynesia, Madagascar and East Africa. Plants are commonly understorey shrubs in forest, woodland or savanna habitats. Several species are cultivated as ornamentals; of these the Japanese species *C. revoluta* Thunb. is the most widely grown, including in Australia.

Most plant parts contain toxic methylazoxymethyl glycosides at some stage of their development (cycasin and compounds derived from it), and various species have been recorded as human and livestock poisons. *Cycas media* in particular is known as 'ricketty bush' in parts of Queensland, and is widely known as a cause of the degenerative neuromuscular disease 'rickets' in cattle. All cycads were listed as noxious weeds in Queensland until recently for this reason, and many landholders have conducted cycad eradication programs, and are still doing so in some areas.

Several Australian species were important food sources for Australian Aborigines, who made a flour or sago from the starchy endosperm after removing the toxic elements with an extensive leaching and cooking process.

The genus *Cycas* is a coherent natural group with no sister genera, and with few obvious infrageneric subdivisions. The few attempts at infrageneric subdivision have differed substantially, and there is no accepted classification (Schuster 1932, Smitinand 1971, Dehgan 1987). All of the Australian species and some of the taxa from Papua New Guinea form a group defined by the combination of glabrous ovules, a non-pectinate megasporophyll lamina, and the absence of a spongy layer in the seeds. These characters are implicit in all species descriptions below.

The seed number per megasporophyll given is also the usual number observed, in all species some plants may develop as few as one seed on a megasporophyll, particularly in stressed plants or on the first or last megasporophylls of a seasonal flush. Seeds are slightly dorsiventrally flattened in all Australian species, and the measurements of diameter given below apply in all cases to the widest diameter. All Queensland species also have more or less mucronulate pinnae (with a fine apical spine developed from an extension of the midrib).

Key to the species

1 Margins of pinnae revolute; pinnae narrow (mostly less than 4 mm wide) ..... **6. C. cairnsiana**

1* Margins of pinnae flat or recurved, not revolute; pinnae more than 4 mm wide

2 Fronds flat (opposing pinnae at c. 180 degrees)

3 Pinnae mostly more than 10 mm wide; fronds with up to 150 pinnae ..... **1. C. silvestris**

3* Pinnae mostly less than 9 mm wide; fronds with more than 160 pinnae ..... **2. C. media**

2* Fronds keeled (opposing pinnae at less than 150 degrees)

4 New growth with mainly white trichomes ..... **7. C. couttsiana**

4* New growth with mostly brown or orange trichomes

5 New growth green ..... **3. C. megacarpa**

5 New growth blue

6 Brown trichomes on new growth; cataphylls not densely woolly

7 Pinnae mostly less than 6.0 mm wide; pinnae 6–9 mm apart on rachis; seeds not pruinose ..... **9. C. angulata**

7* Pinnae 6.0 mm wide or wider; pinnae 9–13 mm apart on rachis;seeds distinctly pruinose ..... **8. C. brunnea**

6* Orange trichomes on new growth; cataphylls densely woolly

8 Pinnae 6.0–7.5 mm wide; fronds keeled at 80–120 degrees ..... **4. C. ophiolitica**

8* Pinnae 4.5–6.0 mm wide; fronds keeled at 45–60 degrees ..... **5. C. platyphylla**

1. Cycas silvestris *K. Hill*, **sp. nov.**

Ab aliis speciebus australiensibus pinnis adultis latioribus tenuioribusque distinguitur.

TYPE: QUEENSLAND: Cook District: c. 0.75 km NW of Bolt Head, *J. Clarkson 8813 & J. Neldner*, 14 July 1990 (holo NSW, iso BRI, MBA).

Stem to 3 m tall, rarely to 4 m, 10–15 cm diam. Fronds 100–200 cm long, flat in section (opposing pinnae inserted at 180 degrees on rhachis), with 90–150 pinnae; rhachis terminated by paired pinnae or a short spine (4–5 mm long); petiole glabrous, 40–50 cm long; median pinnae at 80–90 degrees to rhachis, 150–300 mm long, 9.0–15.0 mm wide, glabrous, glossy mid-green, flat in section, decurrent for 5–9 mm, narrowed to 4–5 mm at base (narrowed to 30–40% of maximum width), 12–14 mm apart on rhachis; midrib not or slightly raised above, prominent below. New growth densely tomentose with grey-white and some pale orange-brown trichomes, usually persistent. Cataphylls slender, grey to orange-brown-tomentose. Microsporangiate cones not seen. Megasporophylls 25–30 cm long, brown-tomentose, with 2–10 ovules; lamina 30–40 mm long, 15–22 mm wide, narrowly triangular, regularly dentate, apical spine 8–15 mm long. Seeds ovoid, green becoming yellowish, not pruinose, 30–35 mm long, 25–30 mm diam.; sarcotesta 1.5–2 mm thick. Fig. 1.

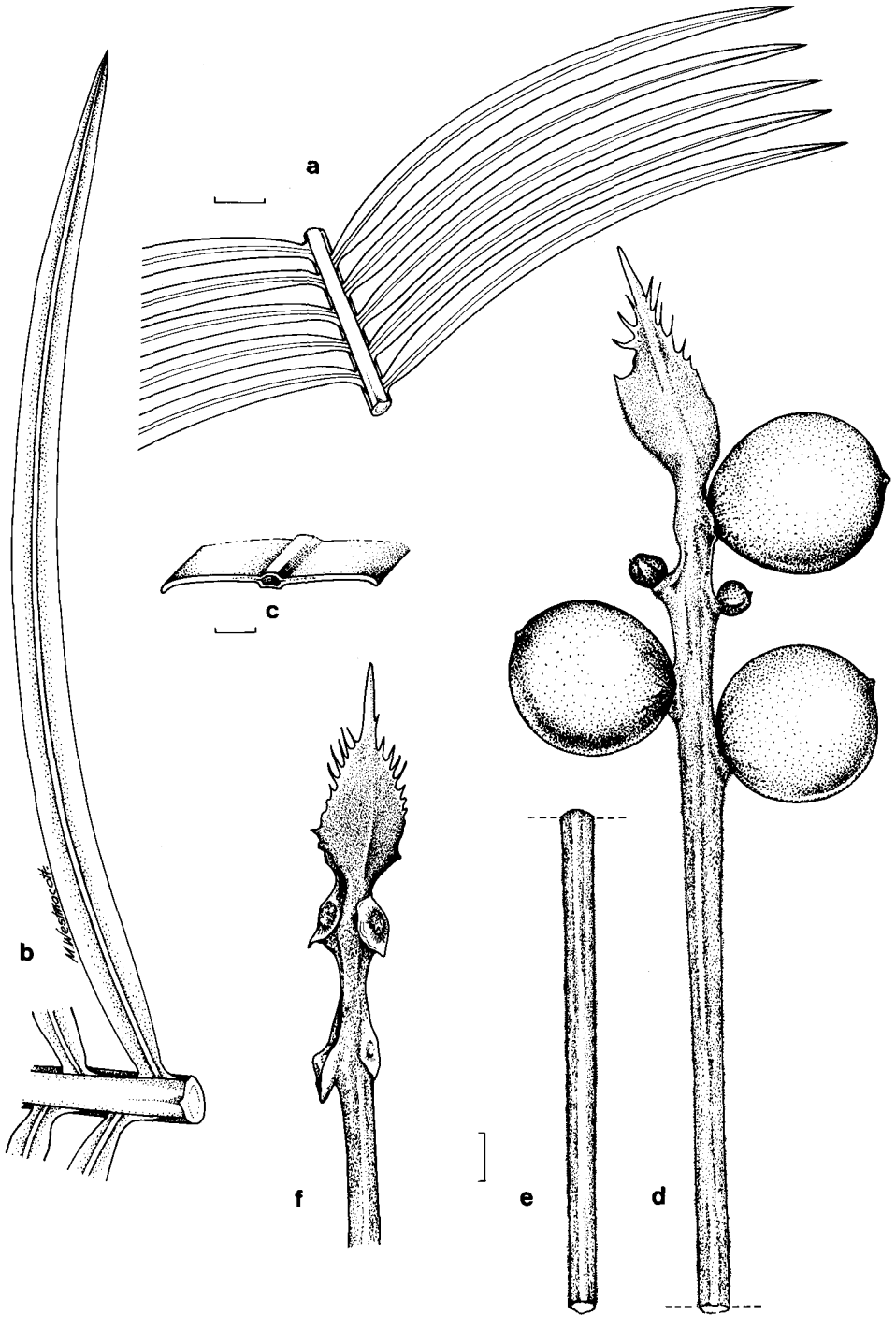

Fig. 1. *Cycas silvestris*. **a**, part of frond; **b**, pinna; **c**, section of pinna; **d**, **e**, megasporophyll with seeds and stipe (in two sections); **f**, tip of megasporophyll (a, b, c, f, from *Hill 1818*; d, e, from *Clarkson 8813*). Scale bar: a, b, d, e, f = 1 cm; c = 2 mm.

Distinguished from other Australian species by the broader and relatively thinner adult pinnae. The broad, falcate pinnae and the non-pectinate megasporophyll apex with a distinct apical spine are similar to those of the complex surrounding *C. circinalis* L. and *C. rumphii* Miq., which comprises an unknown number of taxa ranging from India and East Africa to Fiji. Seeds, however, lack the spongy layer present in both *C. circinalis* and *C. rumphii* (Dehgan & Yuen 1983). *C. silvestris* also differs from superficially similar taxa on South Pacific Islands (*C. seemanii* A. Br.) in the strongly spinose petiole in seedling plants (the Pacific Island plants have no or rarely few spines in seedling material) and the small seeds. Three taxa in this group are known from Papua New Guinea, although precise definition is unclear on available materials. Two near-coastal taxa correspond more or less with *C. rumphii* and *C. undulata* Desf., and *C. scratchleyana* F. Muell. is apparently an endemic species from higher elevations and more inland sites. These all differ from *C. silvestris* in the large seeds. Material from Vanuatu and New Caledonia corresponds more with typical *C. rumphii* (the same coastal taxon that is present in New Guinea). *C. papuana* F. Muell. has been erroneously placed with the *C. circinalis* – *C. rumphii* complex by some authors (White 1922, Kanehira 1938), but in fact is close to *C. armstrongii* Miq.

The status of *C. circinalis* and *C. rumphii* is still unresolved (Smith 1979). The species are taken as distinct here (Table 1, following Stapf 1916). In the protologue of *C. circinalis*, Linnaeus (1753, 1754) cites treatments of *Cycas* from eight earlier works, including at least three taxa as they are at present circumscribed, but also stating 'Habitat in India'. Stapf (1916) states '... the *Cycas circinalis* of India represented by Rheede's *Todda Panna* (Hort. Malab. iii tab 13–21 [Rheede 1682]), the accepted basis of Linnaeus's species.' This can be accepted as a lectotypification, with the series of cited illustrations constituting the type.

C. silvestris is known only from subcoastal forests near the northeastern tip of Cape York Peninsula, to the north and south of the Olive River estuary (Fig. 2). These quite rich and complex rainforests and *Melaleuca*-dominated forests occur on white siliceous old beach-dune sands.

The epithet is from the Latin *silvestris*, 'of the forests', in reference to the closed forest habitat.

CONSERVATION STATUS: 2V-. This taxon is known from few small stands that are not conserved.

SELECTED SPECIMENS (from 4 examined): QUEENSLAND: Cook District: c. 1 km N of Olive River mouth, *Webb & Tracey 13741*, 12 Sep 1974 (QRS, BRI); 1 km SW of Bolt Head, *Hill 1818, Hind & Healey*, 26 July 1986 (NSW).

Table 1. Differences between *C. circinalis*, *C. rumphii* and *C. silvestris* (after Stapf 1916)

	C. circinalis (Bangalore)	C. rumphii (Singapore)	C. silvestris
Fronds (length)	150–250 cm	100–200 cm	100–200 cm
Pinnae (per frond)	80–100	50–70	90–150
Pinnae (length)	18–24 cm	20–30 cm	15–30 cm
Pinnae (width)	9–13 mm	15–17 mm	9–15 mm
Midrib on upper surface	raised	flat	raised
Seed (length)	25–50 mm	50–75 mm	30–35 mm
Seed (spongy layer)	present	present	absent

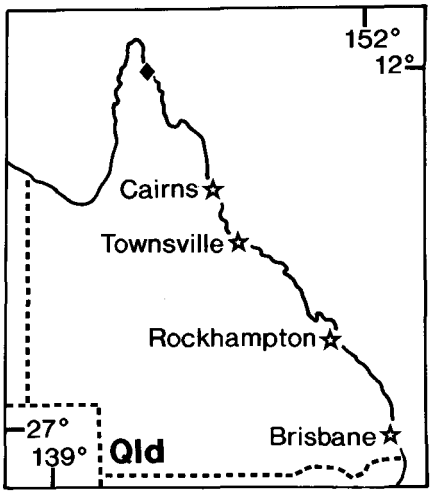

Fig. 2. Distribution of *C. silvestris*.

2. Cycas media *R. Br.*, Prodr.: 348 (1810).

TYPE CITATION: '(T.) v.v.'.

TYPE: *R. Brown* (holo BM, Bennett's numbering 3106 p.p., photo seen). Probably collected on 16 Oct 1802 from Calder Island, in the Cumberland Group off Mackay (Groves & Moore 1989). Bennett allocated the same number (3106) to Brown's collections of both *C. media* and *C. angulata* (below).

Cycas gracilis Miq., Versl. K. Acad. Wet. Amsterdam 15: 366 (1863). TYPE CITATION: 'in regione fluminis Burdikin [sic], prope Prom. Upstart: F. MUELLER.' TYPE: QUEENSLAND: near Cape Upstart, F. Mueller (holo U 028108, photo seen).

Cycas normanbyana F. Muell., Fragm. 8: 169 (1874).

Cycas rumphii Miq. subsp. *normanbyana* (F. Muell.) Schuster, in Engl., Pflanzenr. 99: 75 (1932). TYPE: QUEENSLAND: Port Denison, *E. Fitzalan*, Apr 1874 (holo MEL 68048, photo seen). Although the specimens were labelled 'Port Denison', this was merely the port from which they were dispatched to Mueller. Fitzalan in his correspondence to Mueller gave the actual locality of collection as 'near the Burdekin River estuary'.

Mueller distinguished this taxon by the curled fronds and 4-seeded megasporophylls. Both of these characters occur in most populations of *C. media*.

Cycas gracilis Miq. var. *glauca* Regel, Act. Hort. Petropol. 4: 282 (1876). TYPE CITATION: 'C. media h. Van Houtte.- C. Boddami h. Haage et Schm.- Macrozamia latifrons h. Bull.- C. Normanbyana h. Belg.' TYPE: probably from cultivated material in collections of or supplied by the above (not seen).

Cycas gracilis Miq. var. *viridis* Regel, Act. Hort. Petropol. 4: 282 (1876). TYPE CITATION: 'C. gracilis h. Paull.- C. Riumiana h. Turic. Habitat in Nova Hollandia tropica.' TYPE: probably from cultivated material in collections of or supplied by the above (not seen).

Cycas kennedyana F. Muell., Austral. Chem. Drugg. 4(47): 85 (1882). TYPE CITATION: 'In the Normanby-Ranges, near Port Denison; Eugene Fitzalan, Esq.' TYPE: QUEENSLAND: Port Denison, *E. Fitzalan*, 1881 (holo MEL 68039, 68044, photos seen). Fitzalan (1882) stated that this species occurred in mixed stands with *C. media* through the Normanby Range, which lies about the Normanby gold mine, southwest of Bowen (the locality 'Port Denison' on the specimen label was merely the point from which the specimens were dispatched to Mueller).

Mueller distinguished this species by the curled fronds, the 2-seeded megasporophylls and the blunt tips on the microsporophylls. The first two characters occur in most populations of *C. media*. Study of populations around the type locality has revealed no microsporophyll material matching the type, and it can only be concluded that Mueller drew up his diagnosis from damaged material. A sheet regarded as part of the type (MEL 68044) has some damaged microsporophylls with no upturned spine, but also has others with a distinct though small upturned apical spine. The two sheets labelled as 'Type' in MEL (above) also do not include any leaf material.

ILLUSTRATION: Elliot & Jones (1984: 149).

Stem to 3 m tall, rarely to 6 m, 10–18 cm diam. Fronds 90–180 cm long, flat in section or almost so (opposing pinnae inserted at 150–180 degrees on rhachis), with 160–300 pinnae; rhachis terminated by paired pinnae or a spine; petiole glabrous or lightly grey-tomentose, 30–40 cm long; median pinnae at 60–90 degrees to rhachis, 160–260 mm long, 6.0–10.0 mm wide, glabrous, glossy mid-green, flat in section, decurrent for 2–3 mm, narrowed to 2.5–4.0 mm at base (30–50% of maximum width), 7–13 mm apart on rhachis; midrib not or slightly raised above, prominent below. New growth densely tomentose with pale orange-brown trichomes, not persistent. Cataphylls slender, pale grey-brown-tomentose, to 12 cm long. Microsporangiate cones ovoid, 15–25 cm long, 8–15 cm diam. Microsporophyll fertile zone 16–22 mm long, 8–12 mm wide, abruptly narrowed; sterile zone 8–11 mm long, recurved; apical spine sharply upturned, 6–10 mm long. Megasporophylls 20–30 cm long, ferruginous- or grey-tomentose, with 4–10 ovules (occasionally fewer); lamina 35–90 mm long, 17–30 mm wide, narrowly triangular, regularly dentate, apical spine 15–40 mm long. Seeds ovoid, green becoming orange-yellow, not pruinose, 31–38 mm long, 26–32 mm diam.; sarcotesta 3–4 mm thick. Fig. 3.

Distinguished in Australia by the glabrous, glossy green fronds with more or less flat pinnae, and the relatively small seeds. The similar *C. silvestris* has broader pinnae and smaller seeds, and the similar *C. megacarpa* has usually shorter, more keeled leaves with fewer pinnae, larger seeds, and a more slender trunk.

Widespread and locally common in open or closed forest or occasionally rainforest in eastern Queensland, from south of Mackay to the tip of Cape York Peninsula, and into Papua New Guinea (Fig. 4a). Plants from northern parts of Cape York Peninsula often show strongly keeled pinnae (V-shaped in section). Plants from southeastern Papua New Guinea (Port Moresby district) match these northern forms, and may belong to the same taxon. These are placed in *C. media* for the moment, but further study is required to evaluate possible differences. Plants from the Western Province of Papua New Guinea (including the type of *C. papuana* F. Muell.) are not the same, and more nearly match *C. armstrongii* Miq. from the Northern Territory. Occurrences from northern parts of Papua New Guinea are similar to *C. media*, but differ in the more persistent tomentum. These probably represent *C. schumanniana* Lauterb. Plants from near-coastal sites in the Cooktown district have wider and more distinctly falcate pinnae, possibly indicating some introgression from *C. silvestris*.

The names *C. kennedyana* and *C. normanbyana* have been widely applied to forms of *C. media*, and also erroneously to two undescribed species from south of the range of

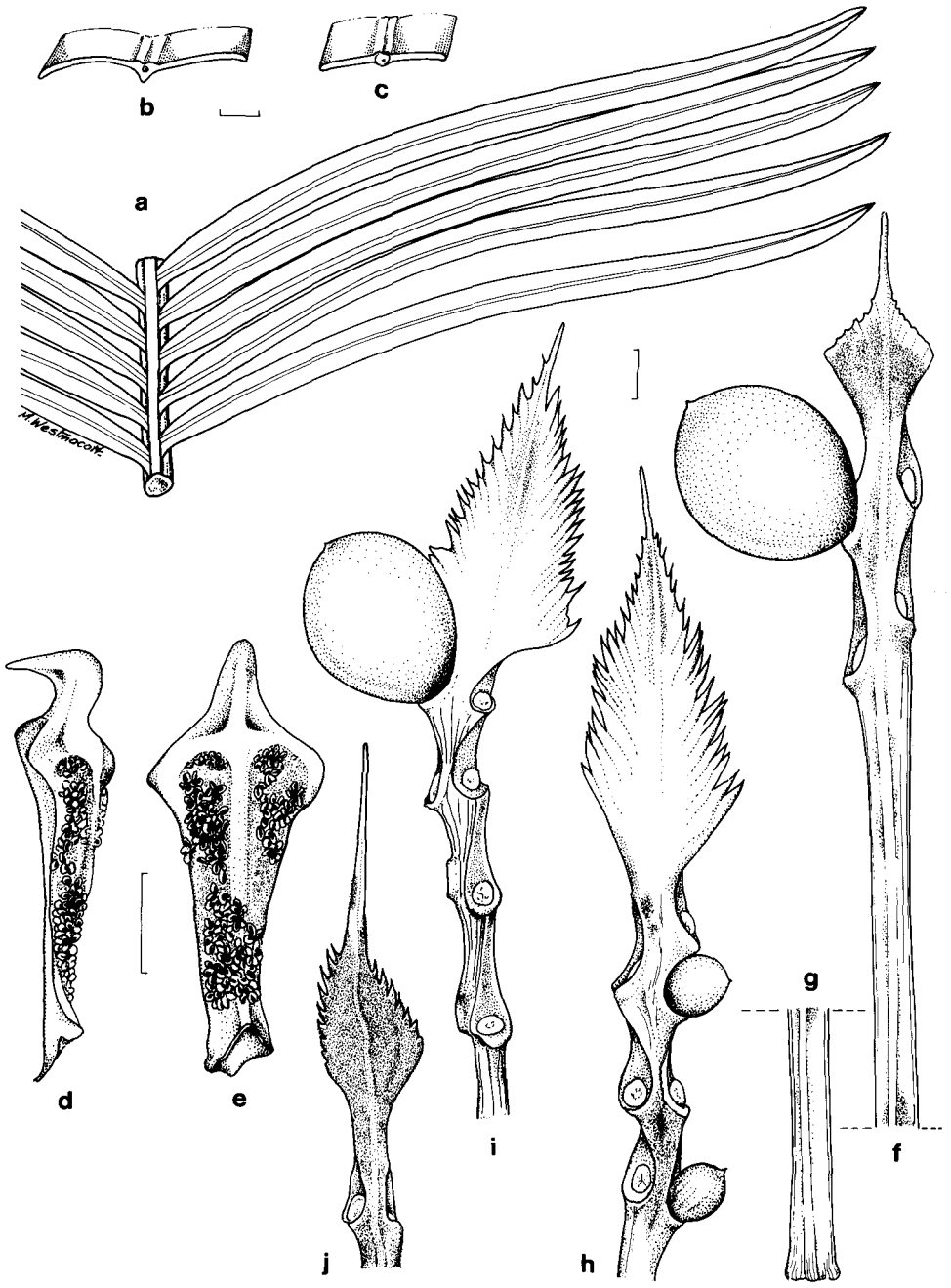

Fig. 3. *Cycas media*. **a**, part of frond; **b**, **c**, section of pinnae; **d**, **e**, microsporophyll; **f**, **g**, megasporophyll with seed and stipe (in two sections); **h**, **i**, **j**, tips of different megasporophylls (a, c, h, from *Hill 3713;* d, e, f, g, from *Hill 3711;* b, i, from *Hill 3777;* j from *Hill 3785*). Scale bar: a = 1 cm; b, c = 2 mm; d–i = 1 cm.

C. media. The diagnostic features of these 'taxa' as originally described occur at random through most populations of *C. media*, and *C. media* is here regarded as a highly variable and widespread species. The distinguishing features given above are, however, constant and may be used to diagnose this taxon throughout its range.

Seeds of *C. media* were an important food source for Aboriginal people.

CONSERVATION STATUS: not considered to be at risk.

SELECTED SPECIMENS (from 31 examined): QUEENSLAND: Cook District: 3.8 km N of Moreton telegraph station, *Hill 1779*, 22 July 1986 (NSW); c. 29 km N of Silver Plains homestead, *Hind 2289*, 14 Aug 1978 (NSW); 7 km along Silver Plains track from Coen road, *Maconochie 2690*, 15 June 1981 (DNA, BRI, NSW); base of Grassy Hill, Cooktown, *Hill 3774 & Stanberg*, 2 Aug 1990 (NSW); 0.9 km N of Wujal Wujal (Bloomfield), *Hill 3777 & Stanberg*, 3 Aug 1990 (NSW, BRI); 31 miles [c. 50 km] N of Cairns, *Byrnes 2422 a*, 9 Nov 1971 (DNA, NSW); 5 miles [8 km] from Gordonvale on Atherton road, *Briggs 1971*, 3 Aug 1968 (NSW); crest of Herberton Range on Atherton–Herberton road, *Hill 3768 & Stanberg*, 1 Aug 1990 (NSW). North Kennedy District: 40 km S of Ingham, *Maconochie 2733*, 24 June 1981 (DNA, BRI, NSW); Storth, *Hill 3713 & Stanberg*, 25 July 1990 (NSW); Cape Upstart, SW side, *Hill 3711 & Stanberg*, 25 July 1990 (NSW). South Kennedy District: track over Normanby Range on Mt Hector station, *Hill 3784, 3785 & Stanberg*, 6 Aug 1990 (NSW, BRI); 1 km S of Kuttabul road on Seaforth–Mackay road, *Hind 2869 A & B*, 29 Dec 1980 (NSW). Port Curtis District: c. 13 km S of Clareview on Bruce Highway, *Hind 2858*, 25 Dec 1980 (NSW). PAPUA NEW GUINEA: Rigo Road, at '17 mile', Port Moresby Subdistrict, Central District, *Streimann NGF 39487*, 25 June 1969 (NSW ex LAE).

INTERGRADING POPULATIONS (fig. 4b): *C. media* – *C. ophiolitica*

QUEENSLAND: Port Curtis District: 25.5 km from Bruce Highway at St Lawrence towards Croydon, *Hill 3788 & Stanberg*, 6 Aug 1990 (NSW, BRI); 48 km N of Marlborough, *Hind 2878*, 30 Dec 1980 (NSW).

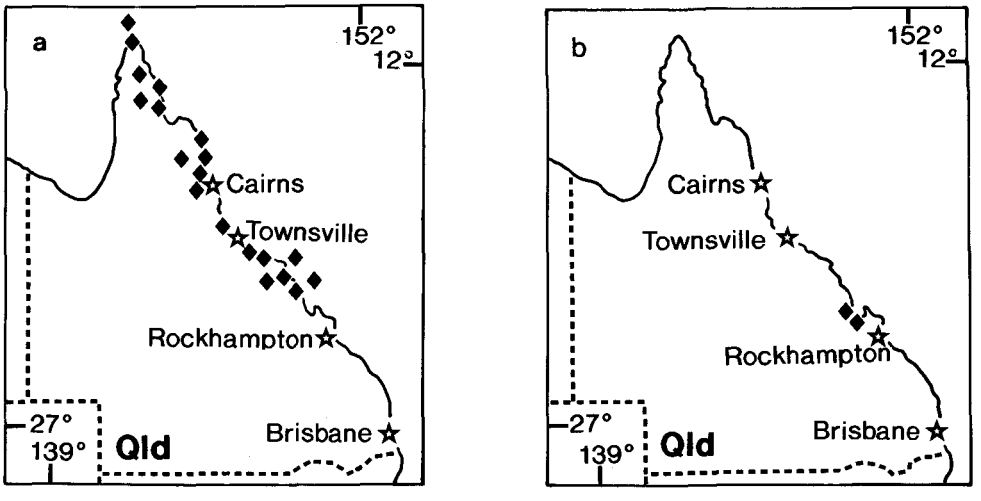

Fig. 4. a, Distribution of *C. media*; **b**, distribution of *C. media* – *C. ophiolitica* intergrades.

3. Cycas megacarpa *K. Hill*, **sp. nov.**

Inter species australienses combinatione pinnarum latarum viridiumque, fructuum grandium non glaucorumque, distinguitur.

TYPE: QUEENSLAND: Port Curtis District: W side of Blackmans Gap, 20.9 km from Bruce Highway at Miriam Vale on Manypeaks road, *K.D. Hill 4142 & L. Stanberg*, 1 Oct 1991 (holo NSW; iso BRI, CANB, DNA).

Stem to 3 m tall, rarely to 6 m, 8–14 cm diam. Fronds 70–110 cm long, openly keeled (opposing pinnae inserted at 90–135 degrees on rhachis), with 120–170 pinnae; rhachis terminated by paired pinnae or a spine; petiole glabrous or grey-tomentose, 20–36 cm long; median pinnae at 40–70 degrees to rhachis, 120–200 mm long, 5.0–7.5 mm wide, glabrous, glossy mid- to dark green, flat or slightly keeled in section, decurrent for 2–3 mm, narrowed to 2.5–4.0 mm at base (40–60% of maximum width), 5–12 mm apart on rhachis; midrib not or slightly raised above, prominent below. New growth densely tomentose with orange-brown trichomes, usually not persistent. Cataphylls slender, orange-brown-tomentose, to 7 cm long. Microsporangiate cones ovoid, c. 18 cm long, c. 7 cm diam. Microsporophyll fertile zone c. 25 mm long, c. 11 mm wide, abruptly narrowed; sterile zone c. 7 mm long, recurved; apical spine sharply upturned, 5–8 mm long. Megasporophylls 14–25 cm long, brown- and grey-tomentose, with 2–4 ovules; lamina 40–70 mm long, 15–32 mm wide, narrowly triangular, regularly dentate, apical spine 8–20 mm long. Seeds ovoid, green becoming yellowish, not or slightly pruinose, 38–50 mm long, 35–45 mm diam.; sarcotesta 4–5 mm thick. Fig. 5.

Distinguished within Australia by the green fronds with broad pinnae, and the large non-glaucous seeds. Adult fronds are also generally smaller and more keeled, the trunk is more slender, and seeds are larger than those of the similar *C. media*.

Scattered and localised on clay-loam soils over various substrates, usually on sloping country in wet eucalypt forests or rainforests. This species ranges from near Mount Morgan south to near Goomeri, occurring in locally more mesic microhabitats, becoming quite sporadic and occurring further inland in the south of the range (Fig. 6a). Populations near Mt Morgan show extensive intergradation with *C. ophiolitica*, but also have larger seeds than more southerly occurring plants.

C. megacarpa has been cultivated in Australia under the name *C. kennedyana*, but the type of the latter name belongs to *C. media* (which see).

The epithet is from the Greek *mega-*, large, and *karpos*, fruit, referring to the distinctive large seeds.

CONSERVATION STATUS: 3VC. Although locally abundant, the eucalypt forest habitat of this species is not well conserved, and there is considerable risk of habitat removal for forestry and pastoral activity.

SELECTED SPECIMENS (from 12 examined): Queensland: Port Curtis District: Kroombit Tops, *Gillison 2520, Brooker & Nix*, 24 July 1976 (CANB, NSW); W side of Blackmans Gap, Manypeaks Range, *Hind 2881*, 31 July 1980 (NSW); 3.7 km E of junction of Monto road and Gladstone road, *Hind 2882*, 31 July 1980 (NSW). Burnett District: 6.1 km N of Kalpowar railway station on road to Manypeaks, *Hind 2883*, 31 July 1980 (NSW); 6.9 km from Mt Perry on Eidsvold road, *Hill 3803 & Stanberg*, 8 Aug 1990 (NSW, BRI); Goodnight scrub, 18.2 km from Mt Perry – Gayndah road, *Hill 3807 & Stanberg*, 9 Aug 1990 (NSW, BRI). Wide Bay District: Woowonga Range, N of Biggenden, *Young 279 & Randall*, Sep 1979 (BRI); Kinbombi, S of Kilkivan, *Rogers*, June 1957 (BRI).

INTERGRADING POPULATIONS (fig. 6b): *C. megacarpa – C. ophiolitica*

QUEENSLAND: Port Curtis District: 21.8 km from Bruce Highway towards Mt Morgan, *Hill 3799, 3800 & Stanberg*, 8 Aug 1990 (NSW); 10 km E of Mt Morgan, *Hind 2844*, 21 Dec 1980 (NSW).

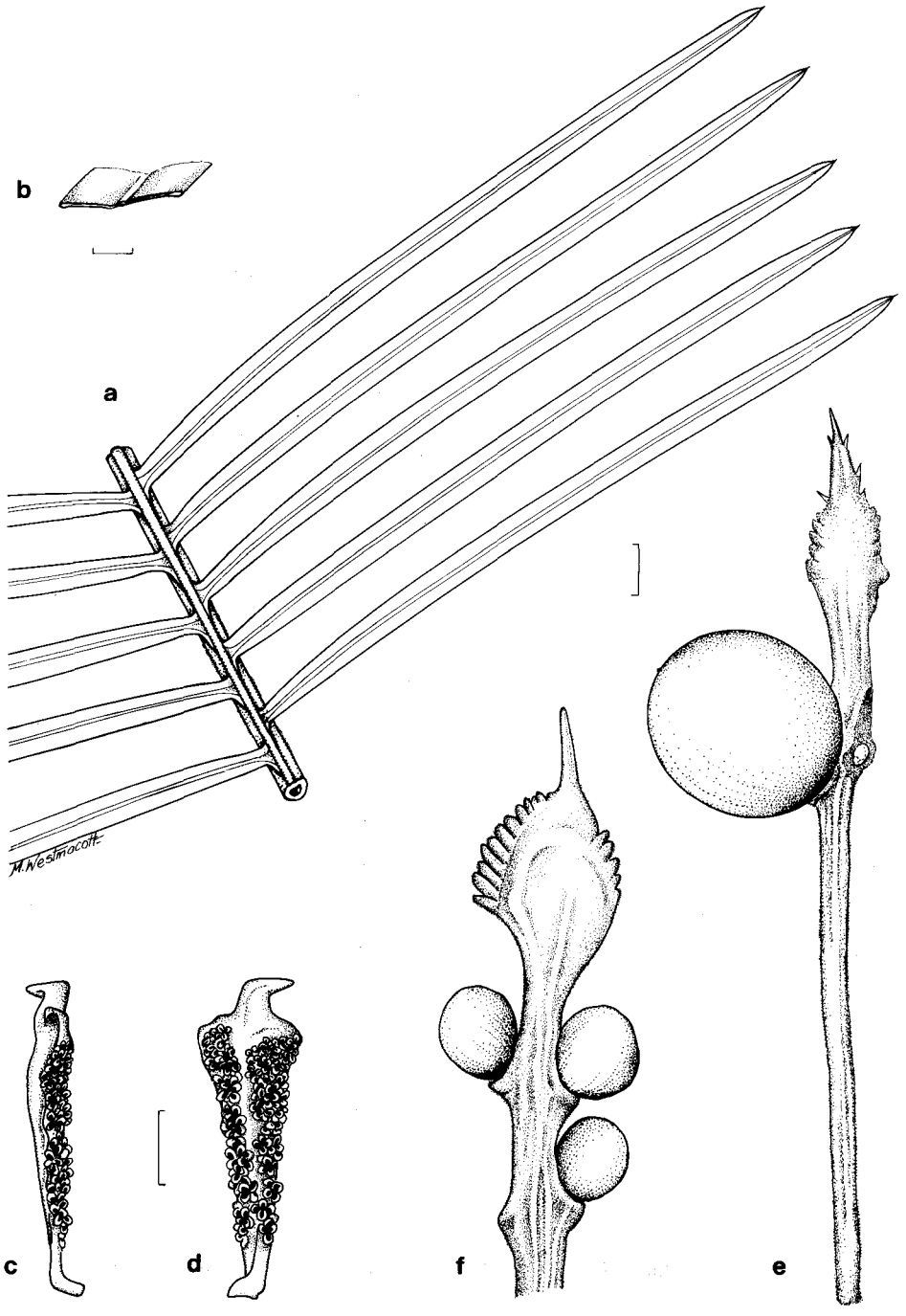

Fig. 5. *Cycas megacarpa*. **a**, part of frond; **b**, section of pinna; **c**, **d**, microsporophyll; **e**, megasporophyll with seed and stipe; **f**, tip of megasporophyll (a, b, e, from *Hill 4142*; c, d, from *Hind 2881*; f from *Hind 2882*). Scale bar: a, c, d, e, f = 1 cm; b = 2 mm.

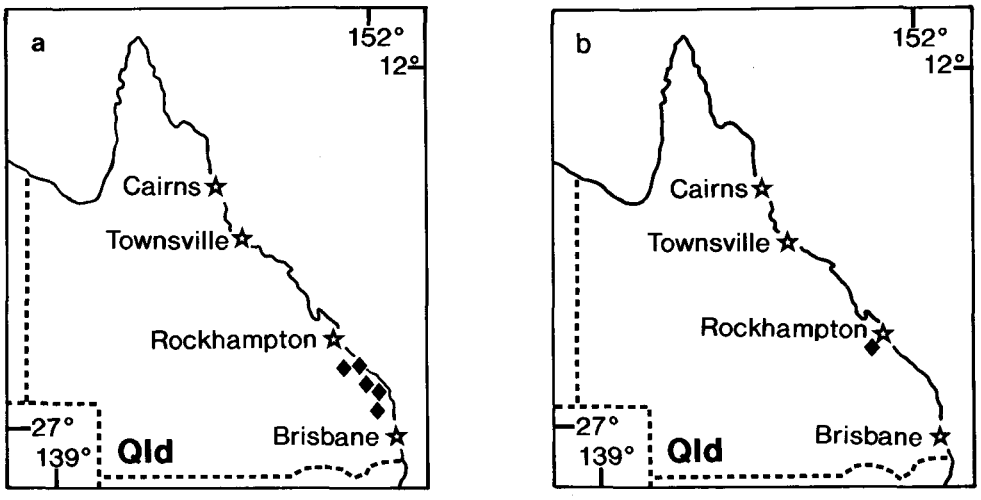

Fig. 6. a, Distribution of *C. megacarpa*; **b**, distribution of *C. megacarpa* – *C. ophiolitica* intergrades.

4. Cycas ophiolitica *K. Hill*, **sp. nov.**

Inter species australienses combinatione pinnarum latarum confertarumque carinatarumque plus minusve glaucarumque, petiolorum cinereo- vel albotomentosorum, fructuum parvorum, distinguitur.

TYPE: QUEENSLAND: Port Curtis District: 48.6 km S of Marlborough on Bruce Highway, *K.D. Hill 4140 & L. Stanberg*, 1 Oct 1991 (holo NSW; iso BRI, CANB, K, DNA).

Stem to 2 m tall, rarely to 4 m, 14–20 cm diam. Fronds 95–140 cm long, keeled in section (opposing pinnae inserted at 80–120 degrees on rhachis), with 170–220 pinnae; rhachis usually terminated by a spine; petiole usually grey- or light brown-tomentose, 18–35 cm long; median pinnae at 45–70 degrees to rhachis, 140–240 mm long, 6.0–7.5 mm wide, grey-white tomentose or glabrous, glossy dark green, flat in section, decurrent for 1.5–3 mm, narrowed to 3.5–5.0 mm at base (55–80% of maximum width), 6–9 mm apart on rhachis; midrib not or slightly raised above, prominent below. New growth densely tomentose with grey-white and some pale orange-brown trichomes, usually persistent. Cataphylls slender, orange-brown-tomentose. Microsporangiate cones ovoid, c. 17 cm long, c. 8 cm diam. Microsporophyll fertile zone 22–26 mm long, 10–14 mm wide, abruptly narrowed; sterile zone 10–15 mm long, recurved; apical spine sharply upturned, 7–11 mm long. Megasporophylls 18–30 cm long, brown-tomentose, with 2–6 ovules; lamina 40–70 mm long, 12–30 mm wide, narrowly triangular, regularly dentate, apical spine 8–20 mm long. Seeds ovoid, green becoming yellowish, usually more or less pruinose, 29–33 mm long, 28–32 mm diam.; sarcotesta 2.5–3.5 mm thick. Fig. 7.

Distinguished in Australia by the relatively broad, crowded, keeled and more or less glaucous pinnae, the grey- or white-tomentose petioles, and the small seeds. Pinnae are generally narrower and more crowded than those of both *C. media* and *C. megacarpa*, and ovules are fewer in number than those of *C. media*. Fronds are also more frequently (but not always) terminated by a spine rather than a pair of pinnae (both *C. media* and *C. megacarpa* show about equal development of terminal spine or

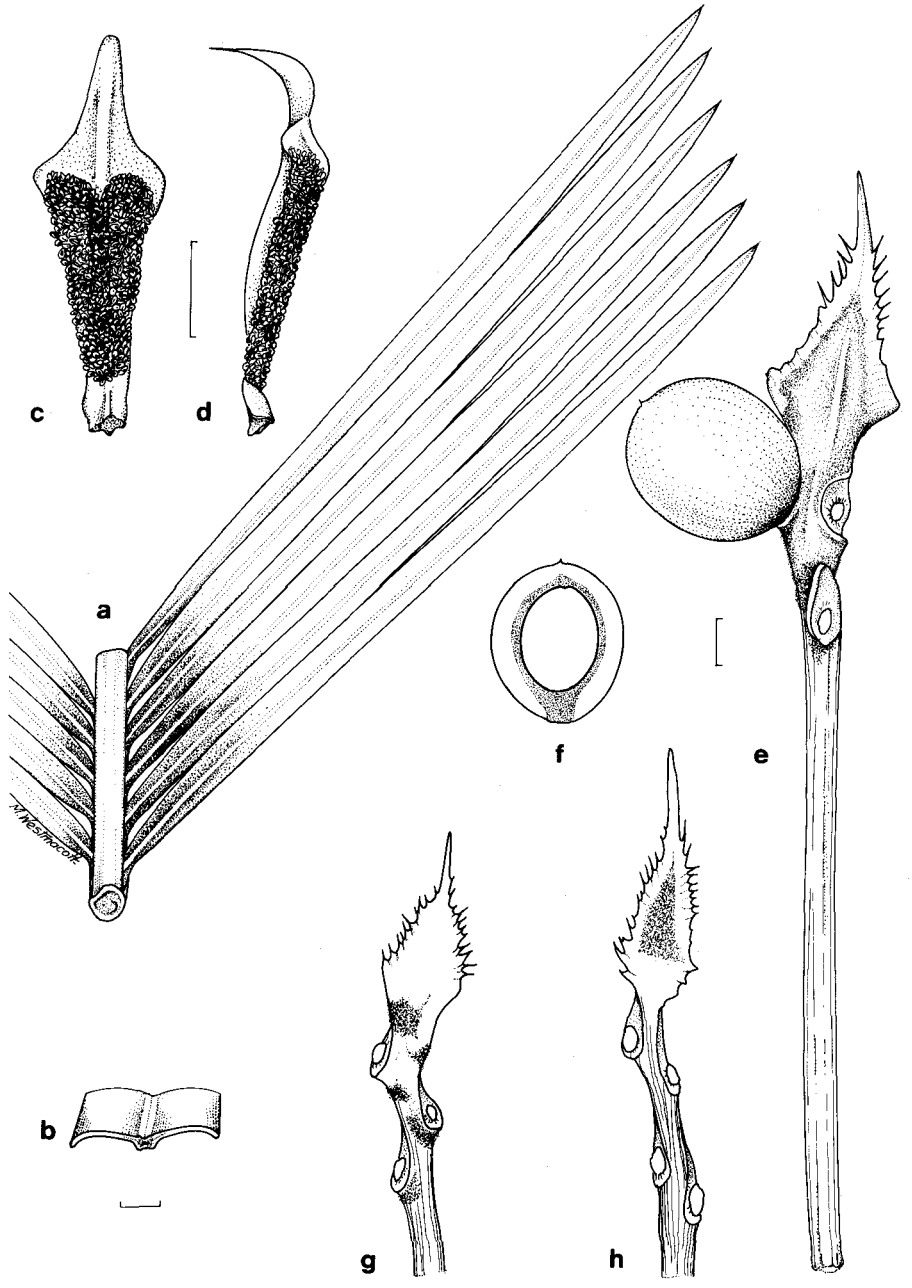

Fig. 7. *Cycas ophiolitica*. **a**, part of frond; **b**, section of pinna; **c**, **d**, microsporophyll; **e**, megasporophyll with seed and stipe; **f**, longitudinal section of seed; **g**, **h**, tips of different megasporophylls (a, b, e, f, g, h, from *Hill 4141A*; c, d, from *Hill 4141B*). Scale bar: a, c, d, e, f = 1 cm; b = 2 mm.

pinnae). Pure forms are quite blue in new growth, becoming dark green with age, and have narrow, stiff pinnae. In these characters, *C. ophiolitica* resembles both *C. platyphylla* and *C. couttsiana*. It differs from the former in the somewhat longer and broader pinnae on longer fronds with longer petioles and the lesser amount of orange tomentum around the cataphylls, and from the latter in lacking the persistent white trichomes and by the less keeled fronds.

This species reaches its best development on red clays over serpentinites in the region between Marlborough and Rockhampton (Fig. 8). Substantial intergradation occurs with *C. media* and *C. megacarpa* respectively north and south of this region (figs. 4b, 6b, specimens cited under those taxa), and plants from throughout the range may show characters of these taxa.

The 'core' form is in cultivation (mostly as wild-collected plants) as *Cycas* 'Marlborough Blue'. Some of the intergrading material is also cultivated as *C. normanbyana*, although the type of the latter name belongs to *C. media* (which see).

The epithet is from the Greek, *ophis, ophios*, serpent or snake, and *lithos*, stone or rock, in combination 'ophiolite' as used for the rock serpentinite, referring to the main occurrence of this species on serpentinite-derived soils.

CONSERVATION STATUS: 2V-. The habitat is poorly conserved (or unconserved), and the species is also under significant commercial collecting pressure.

SELECTED SPECIMENS (from 17 examined): QUEENSLAND: Port Curtis District: 49.9 km W of Marlborough on old highway, *Hill 3789 & Stanberg*, 7 Aug 1990 (NSW, BRI); 13.2 k S of Marlborough on Bruce Highway, *Hill 3791 & Stanberg*, 7 Aug 1990 (NSW); 15 km S of Marlborough on Bruce Highway, *Maconochie 2758*, 27 June 1981 (DNA, BRI); 48.6 km S of Marlborough on Bruce Highway, *K.D. Hill 4141A,B & L. Stanberg*, 1 Oct 1991 (NSW); 36 miles [58 km] S of Marlborough on Bruce Highway, *Rodd 1163*, 14 Aug 1970 (NSW); 1 km from Bruce Highway on Yeppoon road, *Hill 3796 & Stanberg*, 7 Aug 1990 (NSW, BRI).

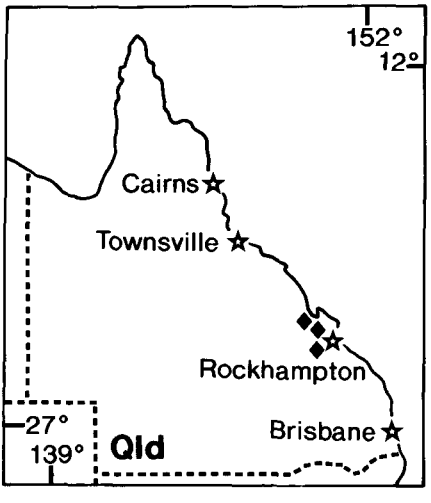

Fig. 8. Distribution of *C. ophiolitica*.

5. Cycas platyphylla *K. Hill*, **sp. nov.**

Inter species australienses frondibus pruinosis maturitate flavovirescentibus, pinnis modice latis marginibus recurvatis, tomento cataphyllorum aurantiaco, apice sterili megasporophyllorum lato, distinguitur.

TYPE: QUEENSLAND: Cook District: 4.3 km from Petford on Herberton road, *K.D. Hill 3764 & L. Stanberg*, 1 Aug 1990 (holo NSW; iso BRI, CANB, DNA, MEL).

ILLUSTRATION: Elliot & Jones (1984: 147), as *C. cairnsiana*.

Stem to 2 m tall, rarely to 4 m, 10–15 cm diam. Fronds 55–110 cm long, sharply keeled in section (opposing pinnae inserted at 45–60 degrees on rhachis), with 120–260 pinnae; rhachis usually terminated by a spine; petiole glabrous, 12–24 cm long; median pinnae at 45–60 degrees to rhachis, 90–170 mm long, 4.0–6.0 mm wide, glabrous, semi-glossy, mid-green to yellow-green, flat in section, decurrent for 2–4 mm, narrowed to 3.0–4.0 mm at base (65–85% of maximum width), 5–10 mm apart on rhachis; midrib not or slightly raised above, prominent below. New growth densely tomentose with ferruginous trichomes, not persistent. Cataphylls slender, thickly orange-brown-tomentose. Microsporangiate cones ovoid, 15–20 cm long, 8–11 cm diam. Microsporophyll fertile zone 22–26 mm long, 9–13 mm wide, abruptly narrowed; sterile zone 7–10 mm long, recurved; apical spine sharply upturned, 6–9 mm long. Megasporophylls 16–32 cm long, loosely ferruginous-tomentose, with 4–6 ovules; lamina 50–80 mm long, 16–37 mm wide, narrowly triangular, regularly finely dentate, apical spine 20–25 mm long. Seeds ovoid, green becoming yellowish, strongly pruinose, 30–40 mm long, 27–38 mm diam.; sarcotesta 3–4 mm thick. Fig. 9.

Distinguished in Australia by the initially bluish fronds becoming yellowish green, the moderately broad pinnae with recurved margins, the thick orange tomentum around the cataphylls, and the broad lamina of the megasporophylls.

Known from the Petford district on the northwestern Atherton Tableland, and a disjunct population about 250 km to the south on Wandovale station (Fig. 10a). In both localities, it occurs in open grassy ironbark-dominated woodland on shallow loamy soils on stony slopes over acid to intermediate volcanics.

The name *C. cairnsiana* has been misapplied to this taxon by botanists and growers alike. The type locality of *C. cairnsiana* was unknown for a long period, but has been recently rediscovered.

An extensive and variable population in the Irvinebank–Ravenshoe–Mt Garnet district (fig. 10b) on the western Atherton Tableland is intermediate in all respects between *C. platyphylla* and *C. media*. This occurrence is regarded as a highly variable breeding population that was originally of hybrid origin between these two taxa, but would now have limited scope for genetic interchange with the parent species.

The epithet is from the Greek *platys*, broad, and *phyllon*, leaf, in reference to the broad sterile tip of the megasporophyll.

CONSERVATION STATUS: 2V-. The range of this species is small, and none of the habitat is conserved. The species is also under threat from commercial collectors.

SELECTED SPECIMENS (from 11 examined): QUEENSLAND: Cook District: between Lappa and Petford, 80 km W of Mareeba, *Moriarty 1454*, 24 Aug 1973 (CANB, BRI); Lappa Junction, *Martin & Gould*, Apr 1965 (BRI); 1 km from Lappa Junction on road to Petford, *Clarkson 4248*, 13 Jan 1982 (BRI); 4 km from Petford towards Lappa Junction, *Maconochie 2675*, 13 June 1981 (DNA, NSW); 4.3 km from Petford on Herberton road, *Hill 3763 & Stanberg*, 1 Aug 1990 (NSW); 57.6 km from Chillagoe on road to Petford, *Hind 6094 & Holland*, 21 Oct 1990 (NSW). North Kennedy District: Montgomery Range, Wandovale station, *Hill 4137, 4138 & Stanberg*, 28 Sep 1991 (NSW, BRI, CANB).

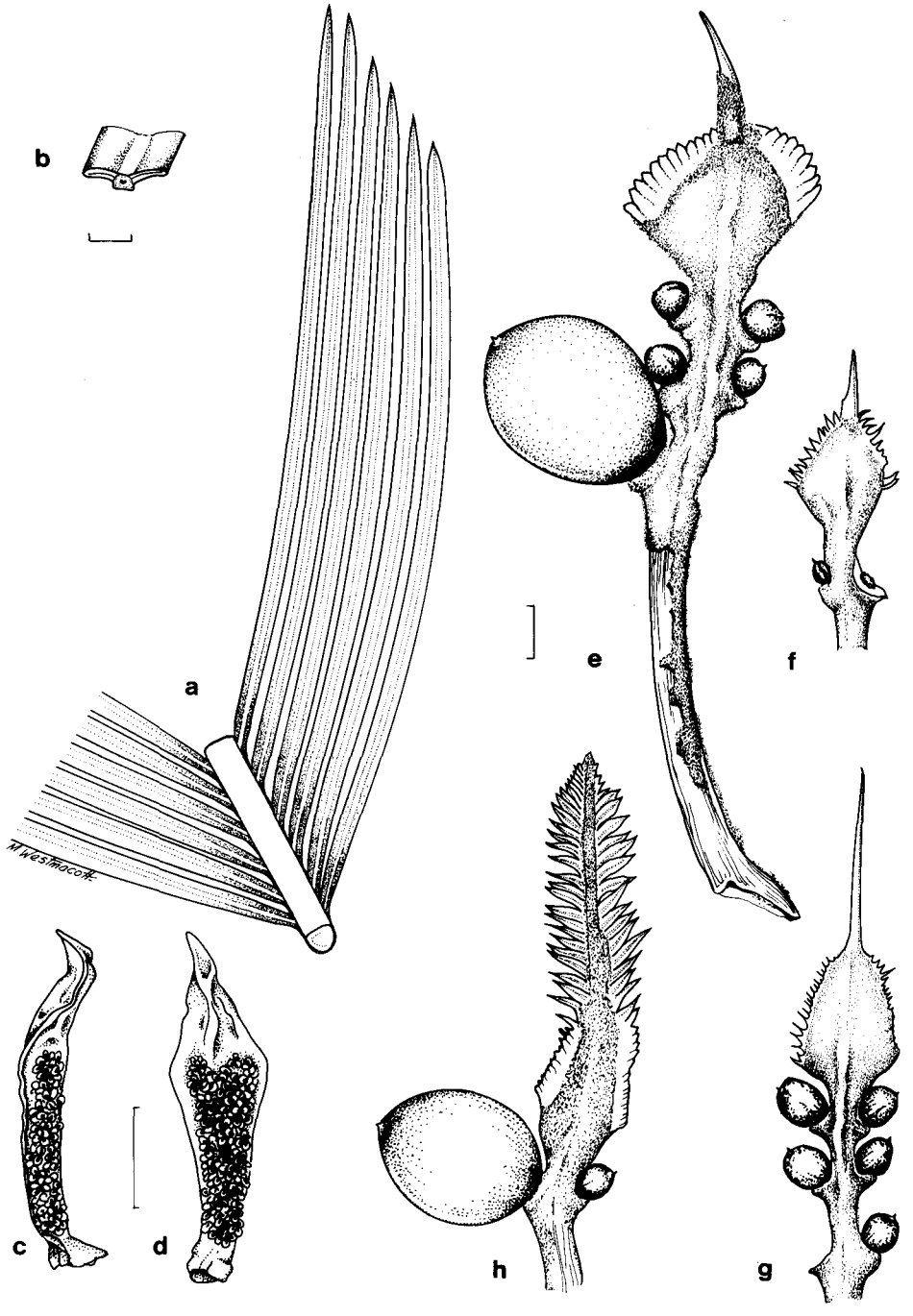

Fig. 9. *Cycas platyphylla.* **a**, part of frond; **b**, section of pinna; **c**, **d**, microsporophyll; **e**, megasporophyll with seed and stipe; **f**, **g**, **h**, tips of different megasporophylls (a, b, g, h, from *Hind 6094*; c, d, from *Hill 3763*; e from *Hill 3764*; f from *Hill 4137*). Scale bar: a, b, d, e, f = 1 cm; c = 2 mm.

INTERGRADING POPULATIONS: *C. platyphylla – C. media*

QUEENSLAND: Cook District: Stannary Hills, *Gittins*, June 1962 (NSW); 1.5 km E of Irvinebank, *Hill 3766 & Stanberg*, 1 Aug 1990 (NSW, BRI, CANB, DNA, MEL); 2 km E of Irvinebank, *Maconochie 2668*, 13 June 1981 (DNA, BRI, NSW).

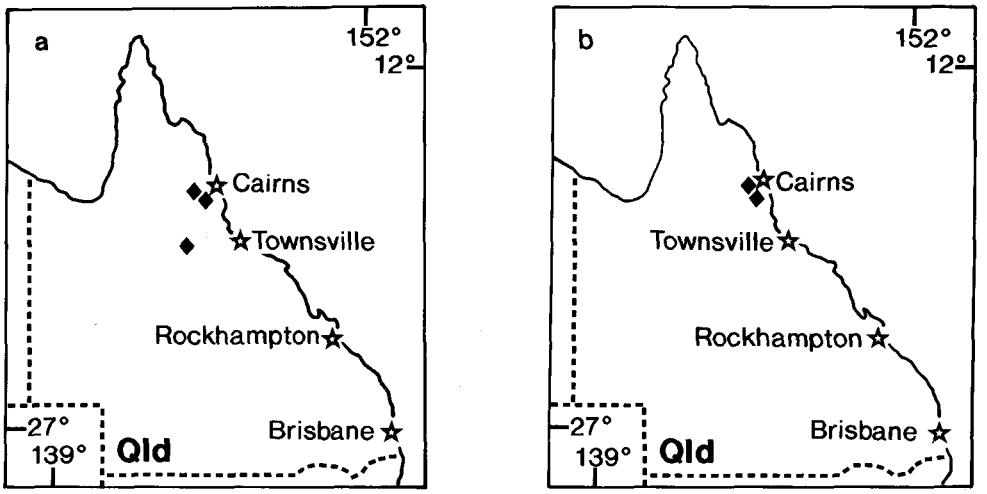

Fig. 10. a, Distribution of *C. platyphylla*; **b**, distribution of *C. media – C. platyphylla*.

6. Cycas cairnsiana *F. Muell.*, Fragm. 10: 63 (1876).

TYPE CITATION: 'Ad montes Newcastle-Range; Armit.'

TYPE: holo MEL (photo seen). This matches most nearly the material collected recently from the O'Briens Creek locality.

Stem to 2 m tall, rarely to 5 m, 12–16 cm diam. Fronds 60–110 cm long, strongly keeled in section (opposing pinnae inserted at 30–90 degrees on rhachis), with 180–280 pinnae; rhachis usually terminated by paired pinnae; petiole glabrous, 18–27 cm long; median pinnae at 20–60 degrees to rhachis, 80–180 mm long, 2.0–3.0 (rarely to 4.0) mm wide, glabrous, strongly waxy glaucous light blue, strongly recurved or revolute in section, decurrent for 2–3 mm, narrowed to 2.0–3.0 mm at base (80–100% of maximum width), 5–6 mm apart on rhachis; midrib not or slightly raised above, prominent below. New growth densely loosely tomentose with thick orange-brown trichomes, not persistent. Cataphylls slender, thickly bright orange-brown-tomentose. Microsporangiate cones ovoid, 16–20 cm long, 7–10 cm diam. Microsporophyll fertile zone 22–34 mm long, 12–15 mm wide, abruptly narrowed; sterile zone 12–15 mm long, recurved; apical spine sharply upturned, 6–9 mm long. Megasporophylls 16–21 cm long, loosely orange-brown-tomentose, with 2–4 ovules; lamina 40–70 mm long, 15–25 mm wide, narrowly triangular, regularly dentate, apical spine 15–20 cm long. Seeds ovoid, green becoming yellowish, strongly white-pruinose, 36–42 mm long, 30–37 mm diam.; sarcotesta 3–4 mm thick. Fig. 11.

Distinguished in Australia by the dense but very loose orange tomentum on new growth, the glabrous, strongly waxy and very glaucous mature fronds and seeds, and the very narrow pinnae with strongly recurved margins.

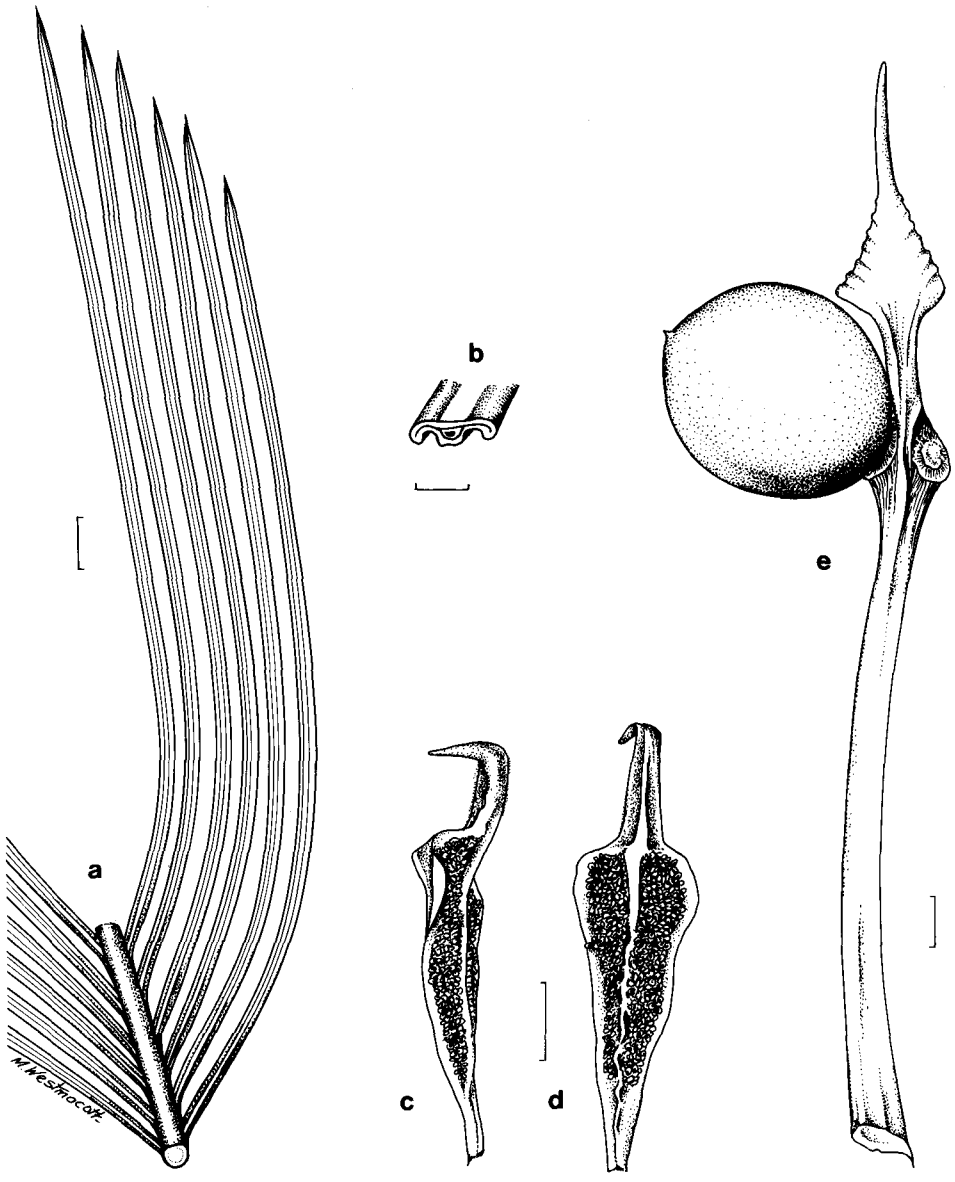

Fig. 11. *Cycas cairnsiana*. **a**, part of frond; **b**, section of pinna; **c**, **d**, microsporophyll; **e**, megasporophyll with seed and stipe (from *Hill 3756*). Scale bar: a, c, d, e = 1 cm; b = 2 mm.

Known from only two rather extensive and scattered populations about the Newcastle Range in the drier country of northeastern Queensland, on shallow to skeletal gritty soils over siliceous granites (Fig. 12). Plants from the population near Forsayth have slightly wider pinnae than those from near Mt Surprise.

CONSERVATION STATUS: 2V-. Although both known populations are large, neither area is conserved and the striking appearance of this plant places it under considerable long-term threat from commercial collectors.

SPECIMENS EXAMINED: QUEENSLAND: Cook District: O'Briens Creek, 42 km by road from Mt Surprise, *Hill 3757 & Stanberg*, 31 July 1990 (NSW, BRI); Robin Hood station, c. 1 km E of homestead, *Hill 3756*, 30 July 1990 (NSW); heads of the Robinson and Percy Rivers, *Armit*, 1876 (BRI, NSW).

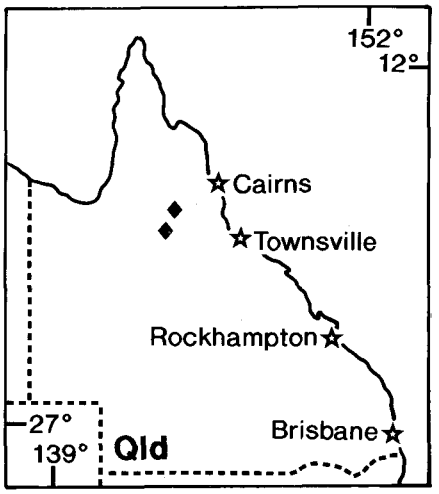

Fig. 12. Distribution of *C. cairnsiana*.

7. Cycas couttsiana *K. Hill*, **sp. nov.**

Inter species australienses pinnis latis subsecundisque glaucisque marginibus leviter recurvatis vel fere planis, tomento albo persistentique, fructibus valde glaucis, distinguitur.

TYPE: QUEENSLAND: Burke District: Chudleigh Park station, Gregory Range, on the upper Stawell River, *Hill 3738 & Stanberg*, 29 July 1990 (holo NSW; iso BRI, CANB, DNA, K, MEL).

Stem to 3 m tall, rarely to 7 m, 14–20 cm diam. Fronds 100–130 cm long, strongly keeled in section (opposing pinnae inserted at 30–90, sometimes to 150 degrees on rhachis), with 180–270 pinnae; rhachis usually terminated by a spine; petiole usually grey-tomentose, 17–21 cm long; median pinnae at 40–80 degrees to rhachis, 170–210 mm long, 4.5–6.0 mm wide, glabrous above, usually sparsely white-tomentose below, dull blue-green, margins recurved, decurrent for 2–5 mm, narrowed to 3.0–4.5 mm at base (60–80% of maximum width), 5–9 mm apart on rhachis; midrib not or slightly raised above, prominent below. New growth densely tomentose with grey-white and some pale orange-brown trichomes, usually persistent. Cataphylls slender, thinly pale grey-brown-tomentose. Microsporangiate cones ovoid, 15–20 cm long, 7–9 cm diam.

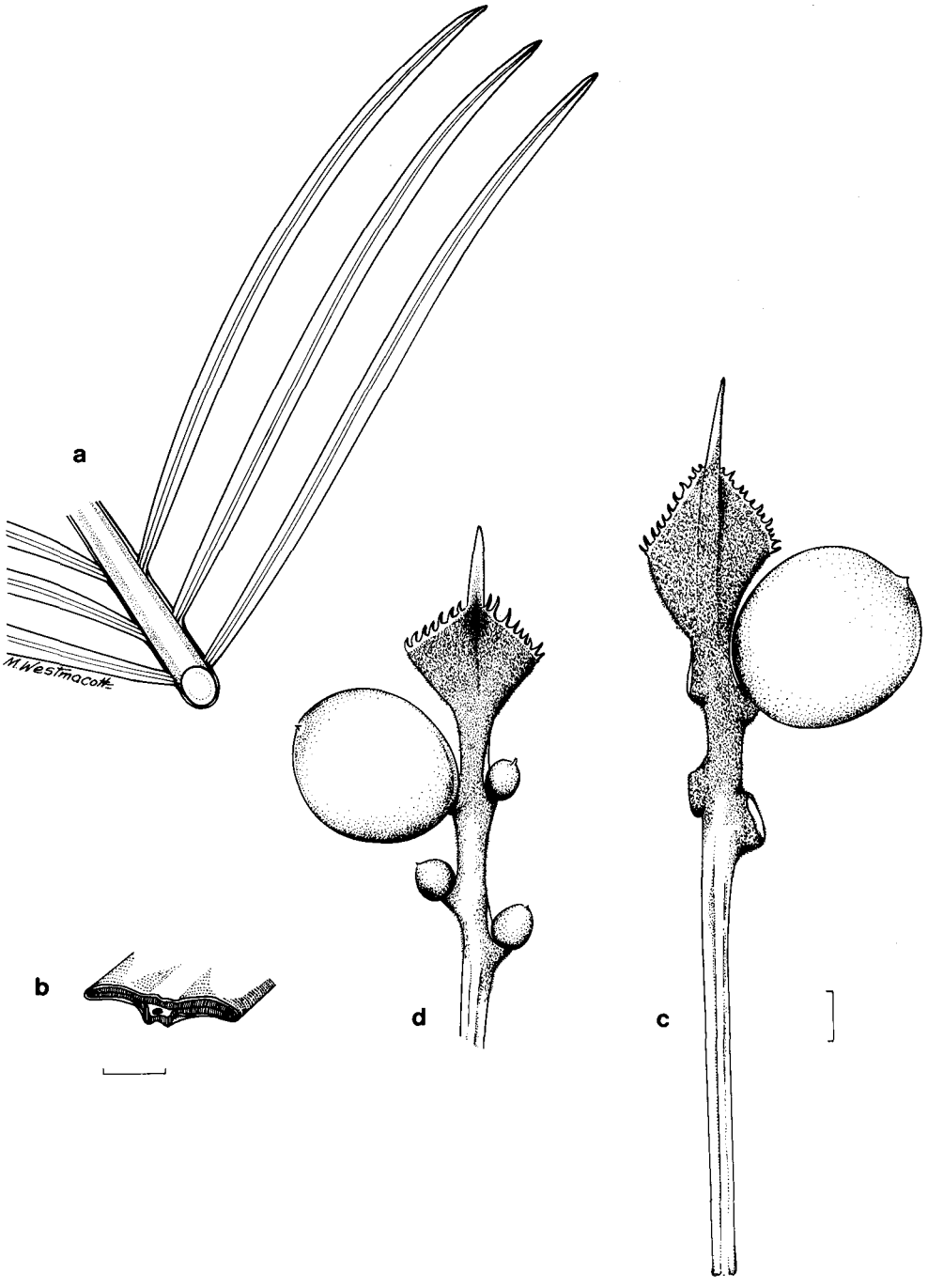

Fig. 13. *Cycas couttsiana*. **a**, part of frond; **b**, section of pinna; **c**, megasporophyll with seed and stipe; **d**, tip of megasporophyll with seed (a, b, c, from *Hill 3738*; d, from *Hill 3726*). Scale bar: a, c, d = 1 cm; b = 2 mm.

Microsporophyll fertile zone c. 25 mm long, c. 12 mm wide, abruptly narrowed; sterile zone c. 8 mm long, recurved; apical spine sharply upturned, c. 8 mm long. Megasporophylls 16–26 cm long, grey-tomentose, with 4–6 ovules; lamina 40–60 mm long, 20–30 mm wide, narrowly triangular, regularly dentate, apical spine 15–25 mm long. Seeds ovoid, green becoming yellowish-brown, strongly pruinose, 35–46 mm long, 28–38 mm diam.; sarcotesta 3–4 mm thick. Fig. 13.

Distinguished in Australia by the relatively broad, subsecund, bluish pinnae with slightly recurved to almost flat margins, the persistent white tomentum, and the strongly glaucous seeds. This species is similar to *C. brunnea* and *C. angulata*, but the plants are less robust and it lacks dark brown trichomes. *C. angulata* differs from the other two species in being less glaucous.

Known from several populations in the southern Gregory Range of Queensland (Fig. 14). It occurs in open grassy woodlands on red sandy loams derived from basalt or dolerite. An occurrence represented by a collection ostensibly from near Pentland (below) could not be corroborated during recent enquiries around this area.

The epithet honours Pat and David Coutts, leaseholders of 'Chudleigh Park' station and cycad enthusiasts, who brought this taxon to my attention and who are taking steps to ensure its conservation in the habitat.

CONSERVATION STATUS: 3R- (or 2R-). Although restricted, several of the known populations are large and not under substantial threat.

SPECIMENS EXAMINED: QUEENSLAND: Burke District: 'Chudleigh Park' station, Gregory Range, on the upper Stawell River, *Hill 3726, 3730, 3740 & Stanberg* (from separate populations), 29 July 1990 (NSW); 'Chudleigh Park' station, c. 20 miles [32 km] W of homestead, *Neal*, 11 Apr 1965 (BRI); Betts Creek, Pentland, *Carson*, Jan 1960 (BRI).

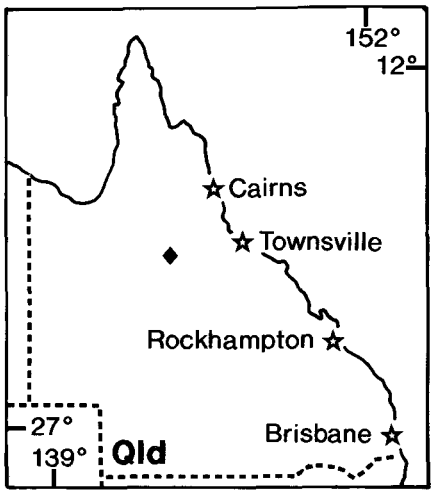

Fig. 14. Distribution of *C. couttsiana*.

8. Cycas brunnea *K. Hill*, **sp. nov.**

Inter species australienses pinnis latis glaucisque et late patentibus marginibus leviter recurvatis vel fere planis, trichomatibus frondium juvenilium brunneis, fructibus grandibus et valde glaucis, distinguitur.

TYPE: QUEENSLAND: Burke District: Running Waters, Lawn Hill Creek (18°43'S 138°28'S, *Maconochie 1661*, 16 Nov 1972 (holo DNA, iso BRI).

Stem to 2 m tall, rarely to 5 m, 17–23 cm diam. Fronds 120–170 cm long, usually keeled in section (opposing pinnae inserted at 90–135 degrees on rhachis), with 160–240 pinnae; rhachis usually terminated by a short spine (to 10 mm); petiole glabrous or grey-tomentose, 28–60 cm long; median pinnae at 40–50 degrees to rhachis, 170–270 mm long, 6.0–7.5 mm wide, glabrous or loosely grey-white-tomentose, distinctly blue when new, becoming glossy greyish green, flat or keeled in section, with usually slightly recurved margins, decurrent for 2–6 mm, narrowed to 4–5 mm at base (55–75% of maximum width), spaced at 9–13 mm on rhachis; midrib not or slightly raised above, prominent below. New growth densely tomentose with brown trichomes, cataphylls orange-brown-tomentose. Microsporangiate cones ovoid, c. 21 cm long, c. 13 cm diam. Microsporophyll fertile zone c. 39 mm long, c. 19 mm wide; sterile zone c. 17 mm long, not recurved; apical spine slender, sharply upturned, c. 28 mm long. Megasporophylls 28–32 cm long, orange-tomentose, with 4–6 ovules; lamina 45–80 mm long, 18–22 mm wide, narrowly triangular, regularly finely dentate, apical spine 16–32 mm long. Seeds ovoid, green becoming orange, pruinose, 36–39 mm long, 28–32 mm diam.; sarcotesta 2–4 mm thick. Fig. 15.

Distinguished in Australia by the relatively broad bluish pinnae with slightly recurved to almost flat margins on openly keeled fronds, the dark brown trichomes on new growth, and the large, strongly glaucous seeds. Most similar to *C. angulata* in habit, the large seeds, the dark brown tomentum, and the regularly finely dentate megasporophyll lamina, but distinguished from that species by the broader, flatter pinnae (margins less recurved) which are more widely spaced on the rhachis, the generally more strongly glaucous leaves and seeds, and the smaller seeds.

Known from several populations in the headwaters of Lawn Hill Creek and its tributaries in Queensland, and on Wollogorang station in the Northern Territory (Fig. 16). The Lawn Hill Creek occurence is on limestone or alluvium derived from limestone, in exposed situations along small, open creek valleys. The Wollogorang occurrences are small relictual stands in sandy alluvium in gorges in siliceous sandstone.

The epithet is from the late Latin *brunneus*, brown, in reference to the brown trichomes on new growth that distinguish this from related taxa.

CONSERVATION STATUS: 3RC. Although restricted, some populations are within a national park and not under substantial threat.

SELECTED SPECIMENS (from 6 examined): QUEENSLAND: Burke District: Running Waters, Lawn Hill Creek (18°43'S 138°28'S, *Maconochie 1659*, 16 Nov 1972 (DNA, NSW); Bubbling Brook, Lawn Hill Station (18°43'S 138°27'E), *Latz 1620C*, 24 July 1971 (DNA, BRI); c. 30 km E of 'Highland Plains' station (18°43'S 138°28'E), *Maconochie 1658*, 16 Nov 1972 (DNA, BRI); Colless Creek, Lawn Hill Natl Park, *O'Keefe*, Aug 1990 (NSW); Colless Creek, Lawn Hill Natl Park, *Hill 4136 & Stanberg*, 28 Sep 1991 (NSW). NORTHERN TERRITORY: Darwin & Gulf District: Wollogorang station, upper Settlement Creek, *Hill 4135 & Stanberg*, 27 Sep 1991 (NSW, CANB, DNA).

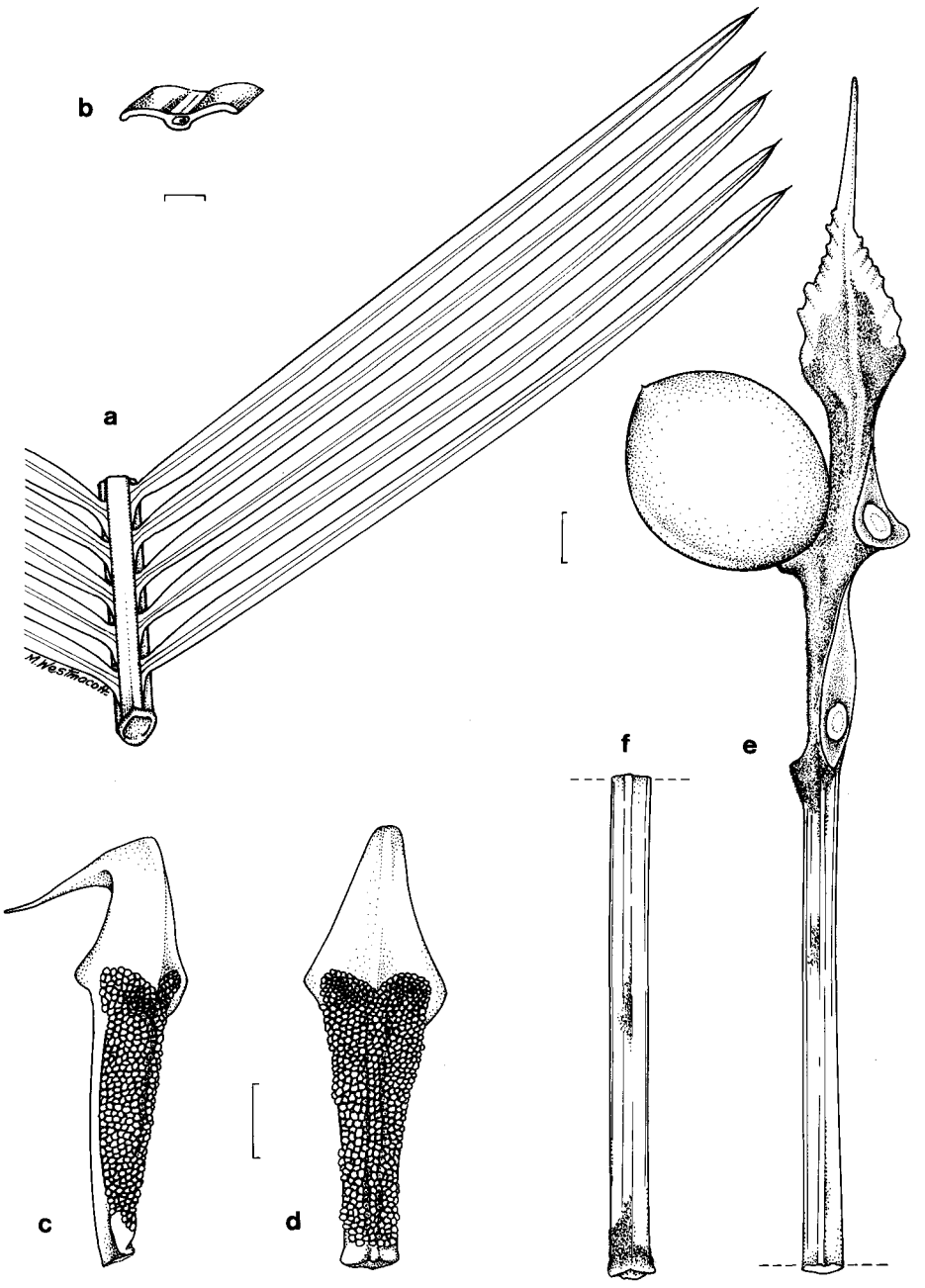

Fig. 15. *Cycas brunnea*. **a**, part of frond; **b**, section of pinna; **c**, **d**, microsporophyll; **e**, **f**, megasporophyll with seed and stipe (in two sections) (a, b, e f from *O'Keefe*, Aug 1990; c, d, from *Hill 4136*). Scale bar: a, b, d, e, f = 2 cm; c = 5 mm.

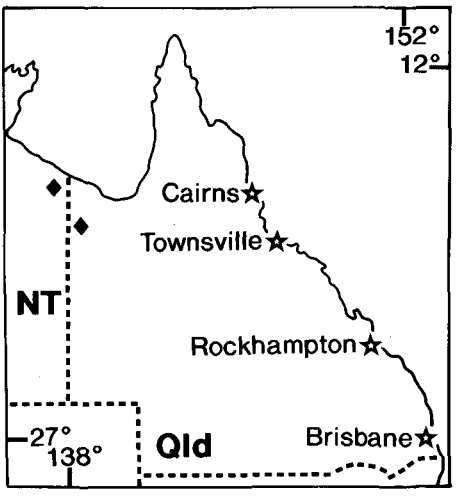

Fig. 16. Distribution of *C. brunnea*.

9. Cycas angulata *R. Br.*, Prodr., 348 (1810).

TYPE CITATION: '(T.) v.v.'

TYPE: *R. Brown* (holo BM, Bennett's numbering 3106 p.p., no original label, photo seen). Probably collected on 3–4 Dec 1802 from Bountiful Island, near Mornington Island in the Gulf of Carpentaria (Groves & Moore 1989). Recent recollections on that island have included this taxon (*Clarkson 7649*).

Stem to 5 m tall, rarely to 12 m, 15–25 cm diam. Fronds 110–170 cm long, usually keeled in section (opposing pinnae inserted at 90–135 degrees on rhachis), with 180–320 pinnae; rhachis terminated by paired pinnae; petiole glabrous or grey-tomentose, 28–52 cm long; median pinnae at 40–60 degrees to rhachis, 140–230 mm long, 4.5–6.5 mm wide, glabrous, distinctly blue when new, becoming glossy greyish green, flat or keeled in section, with recurved margins, decurrent for 2–4 mm, narrowed to 3–5 mm at base (70–80% of maximum width), spaced at 6–9 mm on rhachis; midrib not or slightly raised above, prominent below. New growth densely tomentose with white and orange trichomes. Cataphylls densely orange-tomentose. Microsporangiate cones ovoid, c. 20–25 cm long, c. 12–15 cm diam. Microsporophyll fertile zone 30–40 mm long, 15–20 mm wide; sterile zone 15–20 mm long, not recurved; apical spine slender, sharply upturned, 20–30 mm long. Megasporophylls 25–50 cm long, grey to orange-tomentose, with 6–12 ovules; lamina 50–105 mm long, 25–35 mm wide, narrowly triangular, regularly finely dentate, apical spine 12–38 mm long. Seeds ovoid, green becoming orange, not pruinose, 45–60 mm long, 40–50 mm diam.; sarcotesta 3–4 mm thick. Fig. 17.

Distinguished in Australia by the very robust habit, the keeled fronds with long bluish pinnae arranged at a relatively low angle to the rhachis, and the long megasporophylls with large numbers of large seeds and a relatively short, finely toothed lamina.

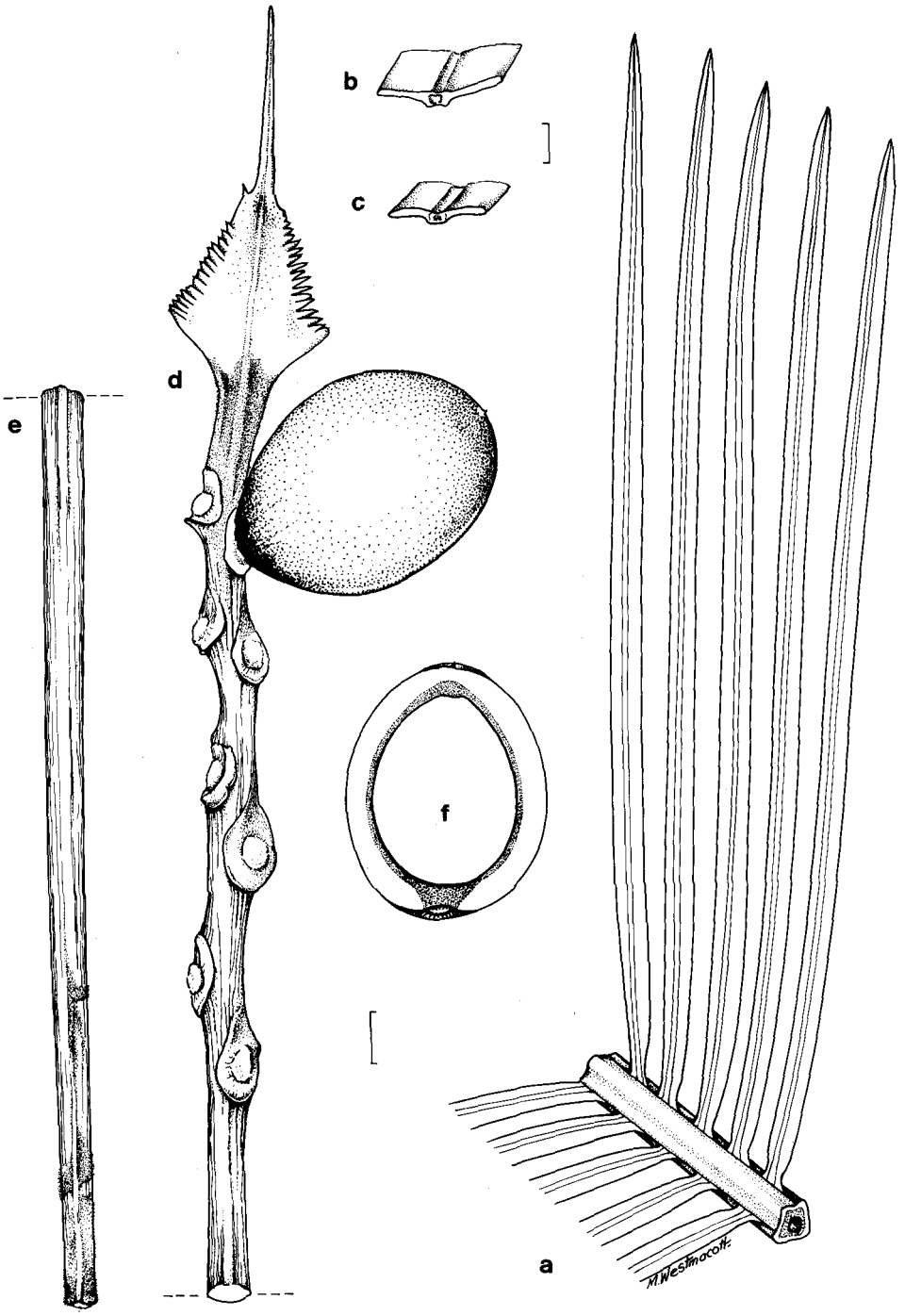

Fig. 17. *Cycas angulata*. **a**, part of frond; **b**, **c**, sections of pinnae; **d**, **e**, megasporophyll with seed and stipe (in two sections); **f**, longitudinal section of seed. (a, b, d, e, f, from *Hill 4132*; c, from *Hill 1146*). Scale bar: a, d, e, f = 1 cm; b, c = 2 mm.

A distinctive localised species, known from the lower reaches of the Wearyan, Foelsche and Robinson Rivers near Borroloola, and from the Bountiful Island group further east in the Gulf of Carpentaria (Fig. 18). In both areas it occurs in open grassy woodland or grassland on flat country on sandy alluvium.

This species forms local cycad-dominated woodlands in parts of the Northern Territory, but is less abundant in Queensland, where it is known at present only from offshore islands.

CONSERVATION STATUS: not considered to be at risk.

SELECTED SPECIMENS (from 6 examined): QUEENSLAND: Burke District: Bountiful Island (16°39'S 139°52'E), *Clarkson 7649 & Dillewaard*, 4 Dec 1988 (MBA, NSW). Northern Territory: Darwin & Gulf District: Wearyan River crossing on Borroloola – Burketown road, *Hill 1146, Johnson & Benson*, 6 Aug 1984 (NSW); 2 miles [3.2 km] E of Wearyan River, *Byrnes 2782*, 14 Sep 1972 (DNA, NSW); Manangoora station, at homestead, *Hill 4132 & Stanberg*, 26 Sep 1991 (NSW, CANB, DNA).

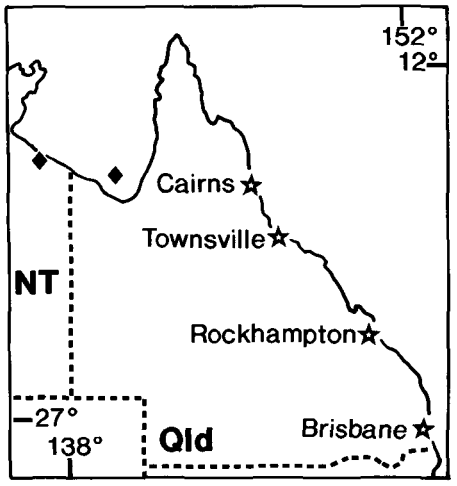

Fig. 18. Distribution of *C. angulata*.

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