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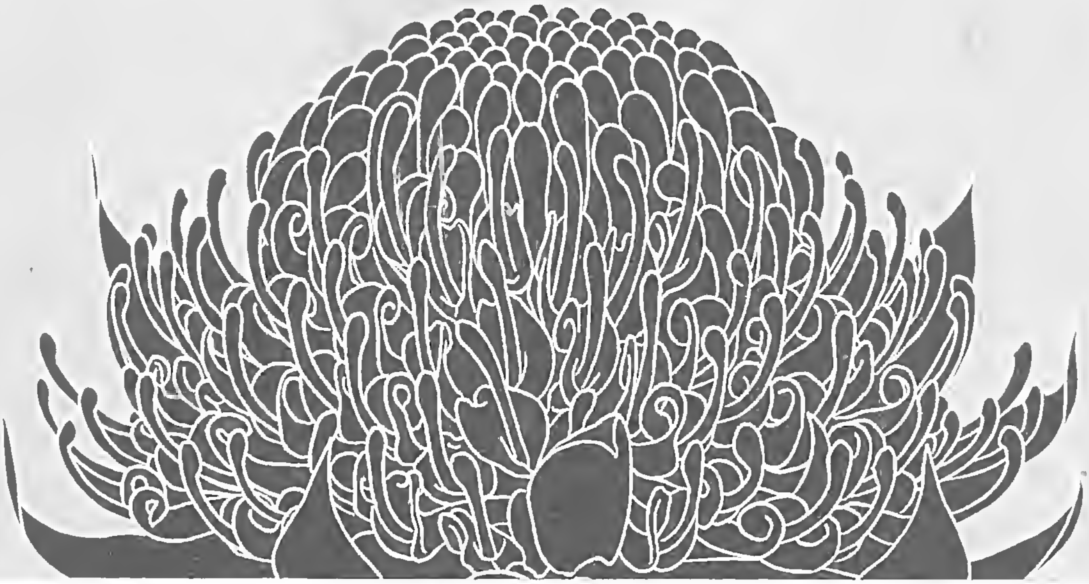

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Typification of some names in *Eucalyptus* (Myrtaceae), Part 1

A.R. Bean

Queensland Herbarium, Brisbane Botanic Gardens, Mt Coot-tha Road, Toowong, Queensland 4066, Australia.
Email: tony.bean@epa.qld.gov.au

Abstract

Eleven names in *Eucalyptus* are newly typified, and the typification is clarified for a further four names. The species involved are all indigenous to Queensland or New South Wales. Full discussion of relevant type specimens is provided, and other nomenclatural notes are included. Information provided in recent nomenclatural references for eucalypts is discussed, especially where the conclusions differ from the views expressed here.

Introduction

There remain significant numbers of accepted *Eucalyptus* species names that have never been formally typified. This paper clarifies the typification for 15 names in *Eucalyptus*, including eleven names that are newly typified. Nomenclatural information offered by Brooker et al. (1984), Chippendale (1988), Hill (2002–04) and Slee et al. (2006) are discussed, especially where it is inconsistent or differs from the current view. Some miscellaneous errors from these publications are also brought to notice.

The Articles referred to in this paper e.g. Article 9.5, are all from the latest version of the International Code for Botanical Nomenclature (McNeill et al. 2006).

The species are arranged alphabetically by currently accepted name.

Typification

Eucalyptus argophloia Blakely, Key Eucalypts 256 (1934).

Type: Queensland. 12 miles N of Chinchilla, *R.C. Beasley s.n.*, May 1933 (**lecto** NSW [NSW40185], here designated; isolecto BRI [AQ094179]; K [K000347651]).

The protologue says "between 6 and 7 miles north of Chinchilla; 1 mile east of Branch Creek, Burncluith, about 12 miles north of Chinchilla. It is more plentiful in the latter locality (R.C. Beasley, April and May 1933)".

There are two known gatherings by Beasley that correspond to the citation in the protologue. One has a label saying "12 miles N of Chinchilla, May 1933". Specimens from this gathering are present at NSW, BRI and K. The sheet at NSW is here chosen

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as the lectotype. It has pressed but unmounted branchlets bearing juvenile leaves, adult leaves, mature buds and flowers. There are some mature fruits in a packet.

Specimens from the second gathering are present at BRI and K. They have a Queensland Herbarium label saying "Chinchilla, April 1933, R.C. Beasley" and bear the same range of material.

Eucalyptus bridgesiana R.T.Baker, Proc. Linn. Soc. New South Wales 23: 164 (1898).

Type: New South Wales. Albury, *Andrews s.n.*, 21 June 1897 (**lecto** NSW [NSW314589], here designated).

The protologue states "Hab. - VICTORIA: Gippsland ('But But,' 'Apple- tree,' 'Apple-tree Box,' 'White Box,' A. W. Howitt, F.G.S.). N.S.WALES: Colombo ('Apple-top Box,' W. Baeuerlen); Albury ('Apple,' Dr. Andrews); Gerogery ('Woolly-butt,' J. Manns); Rylstone ('Woolly-butt,' R.T.B.); Bathurst ('Bastard Box,' W. Woolls)."

The Gerogery and Bathurst specimens are apparently no longer extant; the Colombo specimen does not match the protologue and belongs to a different species (*E. angophoroides*); the Rylstone collection is of poor quality with immature fruits and leaves only; one of the Albury sheets (NSW314593) comprises mixed material (this species and *E. goniocalyx*); the Gippsland material is atypical, and was collected from an area where this species and *E. angophoroides* are thought to intergrade (Brooker & Slee 1996).

The sheet chosen here as lectotype (NSW314589) has pressed but unmounted branchlets bearing adult leaves, immature fruits, two mature fruits in a packet and a few mature fruits attached to a twig. All material is in agreement with the protologue. It is consistent with a single gathering, and was collected before the publication of the name.

The identity of "Dr Andrews" is not known. This person does not seem to be any of the four "Andrews" listed in Hall (1978). Baker gave no clarification in the protologue, or in any other publication I have seen. Many New South Wales "Andrews" collections from around the turn of the century are referrable to Ernest Clayton Andrews, but he was never referred to as "Doctor" Andrews.

Eucalyptus conica H.Deane & Maiden, Proc. Linn. Soc. New South Wales 24: 612 (1900); *E. baueriana* var. *conica* (H.Deane & Maiden) Maiden, Proc. Linn. Soc. New South Wales 27: 216 (1902).

Type: New South Wales. 2 miles NE of Cowra, *R.H. Cambage s.n.*, 24 July 1899 (**lecto** NSW [NSW320940], here designated).

The protologue does not specifically mention any specimens, but it does say "on the Lachlan [River] it is called 'Apple Box' (R.H.C.)", and this may be considered a citation. "R.H.C." stands for Richard Hind Cambage, a noted botanical collector of the late 19th and early 20th centuries. The town of Cowra is situated on the Lachlan River. There are five Cambage specimens at NSW collected from near Cowra, apparently associated with three gatherings: two from "2 miles NE of Cowra" with different collection dates, and one from "6 miles SE of Cowra, 200 yards from the Lachlan River". All are consistent with the protologue, and all were collected before the publication of the name. The sheet NSW320940 is here selected as the lectotype. It has pressed but unmounted branchlets bearing adult leaves, mature buds and open flowers, and there is an attached packet containing a single fruit.

Hill (2002–04) suggested that *Eucalyptus baueriana* var. *conica* was described as a new taxon, and so he proposed a separate type specimen for the varietal name. However I have taken the view that Maiden (1902) intended "var. conica" as a new combination.

Eucalyptus decorticans (F.M.Bailey) Maiden, Crit. revis. Eucalyptus 5: 231 (1921); *E. siderophloia* f. *decorticans* F.M.Bailey, Queensland Agric. J. 26: 127 (1911).

Type citation: "Hab.: Eidsvold, Dr. T.L. Bancroft". **Type:** Queensland. Eidsvold, *T.L. Bancroft s.n., anno* 1911 (**lecto** BRI [AQ 099803], here designated (possibly holo)).

Bailey's description of the basionym in the Queensland Agricultural Journal is very brief, mentioning only the tree and the decortication of bark from the upper branches. He failed to describe the leaves, buds, flowers or fruits. It is nevertheless a valid description. Consideration was given by the present author to the possibility that Maiden's description of *E. decorticans* in *Crit. revis. Eucalyptus* 5: 231 could be thought of as a *sp. nov.*, rather than a new combination. However, a statement by Maiden therein quashes that possibility, *viz.* "I have therefore pleasure in bringing Mr. F. M. Bailey's forma *decorticans* (of *E. siderophloia*) up to specific rank …".

Chippendale (1988) cited the type of *E. decorticans* as "Eidsvold, Qld, *T.L.Bancroft s.n.*; holo: BRI; iso: FRI, K." However, the situation is not so straightforward.

The type folder for *E. decorticans* at BRI currently contains seven sheets of pressed and mounted material. All of that material is consistent with the taxon named by Bailey. That is, it matches other specimens collected of the ironbark species with smooth upper branches occurring in the Eidsvold area.

None of these seven sheets has an original label written by Bailey. Instead, all have a relatively recent type-written label stating "Eidsvold Burnett District. Queensland./ DR. T. L. Bancroft./ (Part of the type gathering of E. siderophloia F. V. Muell. var. decorticans F. M. Bailey)".

One sheet in particular casts serious doubt on the status of these specimens as original material. The said sheet has a determinavit slip with the word "Holotype" anonymously written on it. The sheet includes some branchlets bearing juvenile leaves, tied together with some cotton thread. Attached to this cluster of branchlets is a small label, also attached by cotton thread, which reads "Sucker leaves of E. decorticans", in the handwriting of T.L. Bancroft. Because the epithet *decorticans* was in existence when the label was written, it is clear that the material on this sheet is not original. By association, the other six sheets are almost certainly not original material. Furthermore, it seems highly unlikely that all seven sheets are from the same gathering, as they variously include immature buds, mature buds, immature fruits and mature fruits.

I have found only one sheet at BRI (AQ 099803) that has a label with Bailey's handwriting and has plant material conspecific with other collections of the gum-topped ironbark from the Eidsvold area. This sheet bears two pressed and mounted branchlets with adult leaves, and in a fragment packet there are two mature fruits. The label is old and has faintly stamped on it "Hab Eidsvold/ Dr Bancroft/ 1911". On this label, F.M. Bailey has written "Eucalyptus ?leucoxylon, FvM/ cannot be sure from the specimen. the only eucalypt specimen shoots bearing fruits in the packet/ FMB." The date "1911" stamped on the label is worrying, as this is the same year as the publication of the name. However, the fact that Bailey's *E. ?leucoxylon* identification is written actually *on* Bancroft's "1911" label supports the idea that the label and hence the specimen were available to Bailey before the publication of *E. siderophloia* f. *decorticans*. Unfortunately there is no surviving correspondence between Bailey and Bancroft that is relevant to this species.

This sheet is accepted as original material, and in view of the lack of other relevant specimens bearing Bailey's hand, it is here designated as lectotype.

Eucalyptus dunnii Maiden, Proc. Linn. Soc. New South Wales 30: 336 (1905).

Type: New South Wales. Acacia Creek, Macpherson Range, *W. Dunn 88*, 1 May 1905 (**holo** NSW (3 sheets) [NSW313318, NSW314312 & NSW313319]).

The protologue says "Acacia Creek, Macpherson Range, New South Wales side" and "(William Dunn, Forest Guard; specimen No. 88)". The name was published in September 1905 (Chapman 1991).

Maiden referred to a single specimen when he specified "W. Dunn 88", and it is clearly the holotype, but due to mistakes by later authors, some clarification is necessary here.

There are two specimens at NSW that were undoubtedly used by Maiden when drawing up his description:

1. a collection made on the 1st May 1905, comprising three sheets of pressed but unmounted material. Two sheets have branchlets bearing adult leaves, mature buds and flowers and an occasional fruit. The third sheet bears branchlets with juvenile leaves. Attached to one of the sheets of flowering specimens is a letter by Dunn prefaced 'No. 88'. The sheet bearing the juvenile leaves also has an original label by Dunn saying "No. 88/Eucalyptus "White Gum"/suckers/W.D.". These three sheets comprise the holotype. No duplicates of it are known.

2. a collection made on the 8th May 1905, comprising a single sheet. It bears mature fruits and immature buds, and there is no indication of a collector number.

Chippendale (1988) cited the type as "Acacia Ck, Macpherson Ra., NSW, 8 May 1905, W. Dunn 88 (holo: NSW; iso: BM, K)". In doing so, he has confused the two gatherings outlined above by associating the collection number "88" with the collection dated "8th May". Furthermore, the specimens at K and BM cited by Chippendale (*loc. cit.*) as isotypes are not original material. They were collected in October 1905, after the publication of the name.

Similarly, Hill (2002-04) cited a specimen at BRI as an isotype. The BRI specimen is also part of Dunn's October 1905 gathering and therefore not original material.

Eucalyptus fibrosa subsp. ***nubilis*** (Maiden & Blakely) L.A.S.Johnson, Contrib. New South Wales Nat. Herb. 3(3): 119 (1962), as *E. fibrosa* subsp. *nubila*; *E. siderophloia* var. *glauca* Maiden, Proc. Linn. Soc. New South Wales 24: 461 (1900); *E. nubilis* Maiden & Blakely, Crit. revis. Eucalyptus 8: 38 (1929).

Type: New South Wales. Dubbo-Coonamble road, *J.L. Boorman s.n.*, November 1897 (**lecto** NSW [NSW129812], *fide* Brooker et al. (1984: 522)).

The protologue says "Dubbo district (H. Deane, Nov., 1892; J.V. de Coque and J.L. Boorman, Nov., 1897)."

Brooker et al. (1984) have lectotypified the name thus: "Types: *E. fibrosa*, near the Brisbane River, Queensland, F. von Mueller; subsp. *nubila*, Dubbo-Coonamble Road, New South Wales, J.L. Boorman (NSW 129812)".

The lectotype is labelled *Eucalyptus siderophloia* var. *glauca* by Maiden, and it has written on the label "NSW 129812". This sheet gives the locality as "Dubbo-Coonamble road", it gives Boorman as collector with the date "Nov 1897". It comprises pressed but unmounted branchlets bearing juvenile leaves, adult leaves and mature fruits.

At first, it would seem that this specimen may not be one of those cited in the protologue, because the name of De Coque does not appear on the label. However, attached to the sheet is a portion of a letter (probably written by Boorman) that says (in part) "This is the plant that Mr D Coque wished Mr Maiden to make a special note of as he is of an opinion that it is quite distinct from any of the other three ironbarks of the district…"

Maiden, having read this, presumably felt that both Boorman (the specimen collector) and De Coque (who drew Boorman's attention to it) deserved to be mentioned.

Johnson (1962) changed Maiden & Blakely's epithet from *nubilis* to *nubila*, claiming that the original spelling was "clearly an unintentional error for *nubila*. Latin *nubilus* means 'dark or gloomy', reflected in Blakely's English name 'Dusky-leaved Ironbark', while *nubilis* means 'marriageable', inapplicable here". He further wrote, "Mr H.K. Airy Shaw, of Kew, has expressed the view (in litt.) that '*nubilis*' is an unintentional orthographic error which should be corrected." Maiden & Blakely did not comment on the etymology of their epithet, but because Blakely (1934) continued to use the same spelling, we can be sure *nubilis* was not an "unintentional error". Nor is it an orthographic error to be corrected (under Article 60), as *nubilis* is the correct feminine form of the Latin adjective *nubilis* meaning either "marriageable" or, according to Stearn (1992: 453), "ready for pollination".

The species epithet is not correctable under the Code, and the original spelling is restored here.

Eucalyptus laevopinea R.T.Baker, Proc. Linn. Soc. New South Wales 23: 414 (1898).

Type citation: "Nullo Mountain, Rylstone (J. Dawson); Never Never Mountain, Rylstone (R.T.B.), Gulf Road, Rylstone (R.T.B.)". **Type:** New South Wales. Nulla [Nullo] Mtn [near Rylstone], *J. Dawson s.n.*, 3 August 1898 (**lecto** BRI [AQ099608], here designated; isolecto: K [K000279885]).

The name was published on 9 December 1898 (Chapman 1991).

Maiden (1920: 329) wrote "Nullo Mountain, Rylstone, and Gulf road, Rylstone (R. T. Baker); the type". This cannot be considered a lectotypification, as Maiden has cited two of the three syntypes.

The lectotypification made by Brooker et al. (1984) with the words "Type: Nullo mountain, near Rylstone, NSW, R.T.Baker" is not priorable, because the citation in the protologue specified that the Nullo Mountain specimen was collected by J. Dawson.

All of the specimens at NSW from Nullo Mountain have been ascribed to R.T. Baker (hence not matching the cited specimens), although for one specimen (NSW329636), the collector name R.T. Baker has been crossed out and replaced (in L.A.S. Johnson's handwriting) by "(prob.) Dawson". No specimens matching the protologue and with the locality "Never Never Mtn" have been located. There is one specimen at NSW from Gulf Road, collected by Baker, but it is of poor quality.

Specimens dated 3/8/98 are present at BRI and K. The labels for these specimens are in R.T. Baker's handwriting and both say "Eucalyptus laevopinea R.T.B./ Myrtaceae/ Nulla Mt/ 3/8/98". The plant materials present on these two specimens match very well, confirming that they are from the same gathering. The sheet at K specifies the collector as "J. Dawson". The BRI specimen does not specify a collector, but as there are no other existing collections with this date, Dawson may be assumed. The BRI sheet is in full agreement with the protologue and is here selected as the lectotype. It has pressed and mounted branchlets bearing adult leaves and young buds, and there are mature fruits in a packet.

Eucalyptus longifolia Link, Enum. Hort. Berol. Alt. 2: 29 (1822).

Type citation: "Hab. in Australia". **Type:** New South Wales. Mt Hercules road, Razorback Range, 11 km SSW of Camden, *R.G. Coveny 7541, D.H. Benson & H. Bryant,* 17 March 1976 (**neo** NSW [NSW340964], here designated; isoneo BRI, CANB, K).

Link (1822) published the name *Eucalyptus longifolia* in an enumeration of plants growing at the Berlin Botanic Gardens. Although Link's description is almost 100 words long and includes measurements of leaves, petioles and peduncles, it is not diagnostic and it could apply to a number of species.

Lindley (1826) also adopted the name *Eucalyptus longifolia,* without making any reference to Link, and it is clear that he was unaware of Link's name. Lindley's publication apparently prompted Link to immediately publish an illustration of his *E. longifolia* (Link & Otto 1826). In the accompanying discussion Link & Otto stated that Lindley's *E. longifolia* was a different species, and that Link's name was published first. This illustration is sufficiently detailed to make the application of the name unambiguous.

Hill (2002–04) stated that a type specimen is present at B, "in herb. B. Auerswald", but the curator at Berlin Herbarium (R. Vogt, pers. comm. April 2008) has assured me that no *E. longifolia* material is present at B.

A flowering specimen at BM from "Herb. B. Auerswald" has been annotated by G.M. Chippendale as "probably an isotype" of *E. longifolia,* on the basis that the label "appears to be in Otto's writing". However, there are serious discrepancies between the protologue and this specimen:

The protologue states that the operculum is conical, but there is no mention of flowers. It also states the leaves to be "6 inches to a foot [15–30 cm] long" and "one inch and eight lines [4.2 cm] wide". In *E. longifolia,* leaves of this size typically occur on young plants less than three metres high at about the stage when they develop their first inflorescences.

The BM specimen bears flowers, but no opercula remain. It has leaves 7–13 cm long and 1.1–2.2 cm wide. In *E. longifolia,* these leaf dimensions are typical of specimens collected from mature trees, where fully developed adult leaves prevail.

The BM specimen differs sufficiently from the protologue to discount it as original material.

No original material could be found at other major European herbaria and so it is necessary to designate a neotype. The specimen selected here as neotype was collected near Sydney. The Sydney area is very likely to be the provenance of the seed collection from which plants were raised and described by Link.

Eucalyptus macarthurii H.Deane & Maiden, Proc. Linn. Soc. New South Wales 24: 448 (1899).

Type: New South Wales. Argyle, *W. Macarthur 142, anno* 1854 (**lecto** K [K000279769], *fide* Brooker et al. (1984: 466)).

The protologue states: "Sir William Macarthur collected its timber for the Paris Exhibition of 1855, it bearing the number 142 of the indigenous woods of the southern district...In the year 1864 Miss Atkinson (afterward Mrs. Calvert) collected it...Her original specimens are in the National Herbarium of Victoria,...Probably both Miss Atkinson and Dr. Woolls collected specimens,..." and "…confined to the counties of Camden and Argyle, N.S.W., as far as known at present."

Brooker et al. (1984) cited the type as follows: "Type: vicinity of Berrima, NSW, 1854, W. Macarthur (No 142)". In so doing they have lectotypified the name. The only known specimen corresponding to this citation is at K, and it is in accord with the protologue. Chippendale (1988: 357) and Slee et al. (2006) listed a syntype specimen for NSW from Macarthur's gathering, but neither Hill (2002–04) nor the present author could confirm its presence there.

It is doubtful whether Deane and Maiden ever saw *Macarthur 142*, or used it in drawing up their description of the species, but according to Article 9.2, Note 2, there is no requirement for a specimen to have been seen or used, it just has to be cited.

The label on the lectotype reads "Paris Exhib/ Sydney Woods/ Wooly gum of Argyle/ No 142/ Eucalyptus viminalis Lab/ 40–80 feet/ N.S. Wales/ W. Macarthur 1854".

Maiden (1916) explained that the name "Argyle" used by Macarthur refers to the County of Argyle, which is south-west of Sydney around the towns of Goulburn and Berrima. Brooker et al. (1984) apparently reinterpreted this as "vicinity of Berrima".

Eucalyptus microcorys F.Muell., Fragm. 2: 50 (1860).

Type: New South Wales. Hastings River, *H. Beckler s.n.*, undated [January-February 1860] (**lecto** MEL [MEL75551], here designated; isolecto K).

Mueller gave the following citation in the protologue: "In silvis ad flumina Hastings et McLeay River. Dr. Beckler. Ad flumen Brisbane. F.M.". There are two gatherings extant that can be associated with this citation. The first was collected near the Brisbane River by Mueller, and the other at the Hastings River by Beckler. The specimens of both gatherings are in agreement with the protologue. The Beckler gathering from Hastings River is of better quality, and the specimen at MEL is here designated as the lectotype. There is apparently no material collected by Beckler from the McLeay River now extant.

Eucalyptus ochrophloia F.Muell., Fragm. 11: 36 (1878).

Type: ?Paroo River, *?E. Palmer*, undated (**lecto** MEL [MEL703966], here designated).

No specimens were cited by Mueller in the protologue, but he did mention two locations: "Ad ripas et in planitiebus secus fluvios Warrego et Paroo". Only two specimens have been located that can be considered original material of this name. The first is a specimen at K with a label bearing the words "Warrego River" in Mueller's handwriting. Chippendale (1988) listed F. Mueller as the collector of this specimen. That cannot be correct, as Mueller never visited south-western Queensland, but the collector of the specimen remains obscure.

The second is a specimen housed at MEL [MEL703966], bearing the label "Euc ochrophloia FvM 'Yellowjacket' " in Mueller's handwriting. This sheet has no information on the collector, collection date or locality, but mounted on it is a square of paper with a Latin description by Mueller comparing this species with *E. gracilis*. It repeats almost word for word a part of the description given in the protologue. The presence of this Latin description strongly suggests that Mueller used this specimen when compiling his manuscript of *E. ochrophloia*. The specimen mounted on MEL703966 is entirely consistent with the protologue and it is here designated as the lectotype of *E. ochrophloia*.

Another significant specimen of *E. ochrophloia* annotated by Mueller is to be found at MEL [MEL704020]. It is not original material as it was collected in 1884, after the publication of the name. The label for the specimen is written in the handwriting of F.M. Bailey, and states "specimen collected by E. Palmer Esq. M.L.A. on the Bulloo & Paroo". Mounted beside the specimen is a letter from Bailey to Mueller which says in part "our mutual friend Mr E. Palmer has just given me a few very nice fresh specimens of the gum you will remember I sent to you some years ago, the Paroo Yellow Jacket, and you named it *Eucalyptus ochrophloia*…". This letter provides strong evidence that Bailey sent at least one of the specimens mentioned above, and gives the only clue that MEL703966 *may* have been collected by Palmer from the Paroo River. It seems that Bailey on both occasions passed the entirety of the *E. ochrophloia* material to Mueller, as there are no specimens at BRI that bear Bailey's or Palmer's name, or any early collections without date and collector that could correspond to a Palmer collection.

Eucalyptus oreades R.T.Baker, Proc. Linn. Soc. New South Wales 24: 596 (1900); *E. virgata* var. *altior* H.Deane & Maiden, Proc. Linn. Soc. New South Wales 26: 124 (1901); *E. altior* (H.Deane & Maiden) Maiden, Crit. Revis. Eucalyptus 6: 272 (1922), *nom. illeg.*

Type: "near Lawson, Apr 1899, Baker & Smith", *fide* Brooker et al. (1984: 314); **lecto:** New South Wales. Adelina Falls, Lawson, *R.T. Baker & H.G. Smith s.n.*, 22 April 1899 (NSW [NSW325376], here designated; isolecto: K [K000279928], NSW [NSW325377, NSW325378 & NSW325379]).

The protologue says "Hab. - Lawson (H.G. Smith and R.T.B.); Mount Victoria and road to Jenolan Caves (R.H. Cambage.)"

Brooker et al. (1984) achieved a first-step lectotypification with the statement "Type: near Lawson, Apr 1899, Baker & Smith". There is only one known gathering that matches this citation, but there are specimens of it at both K and NSW. NSW 325376 is here designated as the (second-step) lectotype.

G.M. Chippendale annotated four sheets at K as isosyntypes, but only one sheet is indisputably a type. The other sheets have no label indicating their origin or date of collection.

Eucalyptus planchoniana F.Muell., Fragm. 11: 43 (1878).

Type: Queensland. Eight Mile Plains, *F.M. Bailey s.n.*, undated (**lecto** MEL (2 sheets) [MEL705638 & MEL703450], here designated; isolecto BRI [AQ024086, sheet 2 & sheet 3]).

Mueller described *E. planchoniana* using material collected by F.M. Bailey. The protologue includes the statement "In collibus aridis subarenosis prope sinum orarium

Moreton-Bay; F. Bailey". Other salient parts of the protologue read "Flores evolutos nondum accepi" and "antherae tantum in junioribus alabastris observatae". These both indicate that Mueller saw only young (immature) buds.

There are three specimens at MEL annotated as "Euc. planchoniana" by Mueller.

The first sheet, MEL1611102, has three leafy branchlets mounted on it, two with mature buds and open flowers, and a third bearing a single fruit. This sheet has a label written by Mueller saying "Moreton Bay, February 1879, F.M. Bailey".

The second sheet, MEL705638, has a single leafy branchlet mounted on it, bearing immature buds and no fruits. The label says "Eucalyptus near eximia Schau/ Hab on poor sandy dry ridges Eight Miles Plains/ FMB" in the handwriting of F.M. Bailey, and then "Euc planchoniana FvM" in the handwriting of Mueller.

The third sheet, MEL 703450, has no mounted material, but there are some mature fruits in a fragment packet, some of which have been dissected. Its label says "Eight Miles Plain" in Mueller's handwriting.

Chippendale (1988) cited the type as "8 Mile Plains, Moreton Bay, 1879, *F.M. Bailey s.n.*; holo: MEL; iso: BRI, NSW". Chippendale annotated MEL1611102 as "holotype or isotype". However, that sheet is not original material as the date on the label (February 1879) is later than the publication of the name. Furthermore, Mueller stated in the protologue that he saw only immature buds, whereas this specimen bears mature buds and open flowers.

MEL705638 is considered to be original material because the label is in the handwriting of F.M. Bailey, and the habitat information given by Bailey on the label ("on poor sandy dry ridges") is almost literally translated by Mueller in the protologue ("In collibus aridis subarenosis"). The presence of only immature buds is in agreement with the protologue. MEL703450 is also considered to be original material, and part of the same gathering as MEL705638, because Mueller described fruits and seeds, and those are absent from the latter. These two sheets are therefore chosen as lectotype.

At BRI there is material mounted on three sheets that has been annotated as "isotype". One sheet has mounted on it some flowering branchlets, and some fruits in a packet. This is not original material, for the reasons outlined above. The other two sheets bear branchlets with immature buds, consistent in size and appearance to the lectotype. One of these sheets has a label in Bailey's handwriting saying "A stringybark eucalypt from 8m Plains FMB/ E sp new near E. eximia, Schau". These two BRI sheets are considered to be part of the same gathering as the lectotype, and hence they are designated as isolectotype.

The label of the lectotype gives the locality as 'Eight Mile Plains'. This name is still in current use for a suburb of Brisbane, south of the city centre. Bailey almost certainly obtained his specimens from the nearby Toohey Forest - Griffith University area, where *E. planchoniana* is still quite common today.

Eucalyptus propinqua H.Deane & Maiden, Proc. Linn. Soc. New South Wales 10 (2nd series): 541 (1896).

Type: New South Wales. Stroud Rd, *A. Rudder s.n.*, 10 February 1893 (**lecto** NSW [NSW 308067], *fide* Chippendale (1988: 203).

No specimens were cited in the protologue, the only information being "Range. - From the Hawkesbury River northwards at least as far as the Tweed River."

Maiden (1917) stated: "Type. Dungog-Stroud Road, N.S.W. (A. Rudder)".

There is a specimen at NSW whose label reads "Stroud Rd, 10 Feb 1893, A. Rudder". It comprises pressed but unmounted branchlets bearing adult leaves, mature buds and open flowers. There is also a relevant specimen at BRI. Its label has the printed heading "National Herbarium of New South Wales", and written below, in Maiden's handwriting, is "Stroud, 1895, A. Rudder". Both specimens are in accord with the protologue. The citation by Maiden (1917) does not constitute a lectotypification, since it encompasses two different gatherings.

The 1893 specimen at NSW was effectively selected as lectotype by Chippendale (1988) with the statement "T: Dungog-Stroud Road, N.S.W., 10 Feb. 1893, *A. Rudder s.n.*; holo: NSW". Under Article 9.8, the use of the term "holotype" by Chippendale is correctable to "lectotype".

Eucalyptus quadrangulata H.Deane & Maiden, Proc. Linn. Soc. New South Wales 24: 451 (1899).

Type: "Hill Top, Box Knob. The type (J.H.M.)", *fide* Maiden (1915: 77); **lecto:** New South Wales. Hill Top, Box Knob, *J.H. Maiden s.n.*, January 1896 (**lecto** NSW [NSW317818], here designated; **isolecto** NSW [NSW317817, NSW317819 & NSW317820].

The protologue says "found only in the neighbourhood of Hill Top, about 70 miles south of Sydney". According to Article 37.3, Note 2, the naming of a locality in the protologue without any reference to a collector does not constitute a specimen citation. Hence Hill (2002-04) was correct in saying "No type was cited".

Maiden (1915) stated "Hill Top, Box Knob. The type (J.H.M.)" There is only one known gathering from this location that was collected by J.H. Maiden alone, and the specimens at NSW are the only ones known. Therefore this constitutes the first-step in lectotypification. The lectotype chosen here from this gathering comprises pressed but unmounted branchlets bearing adult leaves, almost-mature buds and mature fruits.

The lectotypification by Brooker et al. (1984), i.e. "Type: Hilltop, New South Wales, Sept. 1899, J.H. Maiden and J.L. Boorman" is not valid, as Maiden had previously chosen a different gathering as the type.

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I am grateful to the Directors of the National Herbarium of Victoria (MEL) and the National Herbarium of New South Wales (NSW), for allowing my access to the collections, and to the staff of those institutions for assistance during my visits. Jeremy Bruhl (Australian Botanical Liaison Officer at K, 2007–08) kindly sent images of eucalypt types or potential types; I acknowledge the Board of Trustees, Royal Botanic Gardens, Kew, and the Natural History Museum London (BM) for allowing specimen images to be supplied to me. Rod Henderson reviewed an earlier draft of this paper. The ever-helpful Val Stajsic promptly supplied information about some specimens held at MEL. My sincere thanks are due to Gillian Perry — she has borne the brunt of my nomenclatural queries, and has been of enormous help in clarifying numerous issues in relation to the ICBN.

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Naming *Stylidium* (Stylidiaceae): an historical account, with specific reference to *S. graminifolium* and *S. lineare*

Juliet A. Wege

Western Australian Herbarium, Department of Environment and Conservation, Locked Bag 104, Bentley Delivery Centre, Western Australia 6983

Abstract

An overview of the debate surrounding the correct generic name for the triggerplants (*Stylidium* Sw., *Candollea* Labill., *Ventenatia* Sm.; Stylidiaceae) is provided. The authorship of *Stylidium* and the four species published in Willdenow's *Species Plantarum* in 1805 is here attributed to Swartz in Willdenow rather than Swartz ex Willdenow, since Willdenow clearly credits these taxa to Swartz; however, the month of publication of these taxa could not be verified. The nomenclatural implications of a publication date subsequent to that of *Candollea*, also published in 1805, are discussed. *Stylidium graminifolium* Sw., previously thought to be based on a gathering by Banks and Solander, is shown to be based on a collection by Dr John White, first Surgeon-General of New South Wales. The type of *S. lineare* Sw. was similarly collected by White. A revised type citation and synonymy are provided for both species and lectotypes selected for *Stylidium graminifolium* var. *angustifolium* Mildbr., *Ventenatia major* Sm. and *V. minor* Sm.

Introduction

The first known herbarium collections of the triggerplant genus *Stylidium* Sw. (Stylidiaceae) are those made by Sir Joseph Banks and Daniel Solander in 1770 during their momentous voyage of discovery under Captain Cook. They made collections of seven species, one from Botany Bay and the remainder at the Endeavour River, with Solander later giving these collections the manuscript name *Lobeliastrum* (Diment et al. 1984). However, Solander and Banks never published the results of their voyage and it was 40 years before Robert Brown (1810) provided their collections with formal names.

Although additional triggerplant collections were made during the 18th century from Australia (Jacques-Julien Houtton de Labillardière, John White, David Nelson) and south-east Asia (John Koenig), the genus was not formally named until the early nineteenth century, at which time three generic names were applied: *Candollea* Labill. (Labillardière 1805), *Stylidium* Sw. (in Willdenow 1805) and *Ventenatia* Sm. (Smith 1806). An overview of the ensuing debate surrounding the correct generic name for the triggerplants is provided by both Raulings and Ladiges (2001) and Jackson and Wiltshire (2001); however, these accounts differ in several respects.

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Furthermore, new information has come to light following examination of botanical literature and herbarium specimens housed at various institutions in Europe, necessitating this review. Special attention is paid to the type collections of both *S. graminifolium* Sw., a species widespread in south-eastern Australia, and the New South Wales endemic *S. lineare* Sw.

Generic Name

Swedish Professor Peter Olof Swartz described four species of *Stylidium* in a manuscript he sent Carl Ludwig Willdenow, then Director of the Berlin Botanical Garden, in the Spring of 1803 (Willdenow 1807: 53). This manuscript was destined for publication in Volume 5 of *Neue Schriften Gesellschaft Naturforschender Freunde zu Berlin*; however, it was not published until 1807 when it appeared in Volume 1 of *Magazin Gesellschaft Naturforschender Freunde zu Berlin*, a new series of the same journal. In the intervening period, the genus was published by Willdenow in *Species Plantarum* (1805) in which he credits the genus and the four species in question to Swartz.

In the same year, Labillardière described six species of triggerplant under the name *Candollea* (Labillardière 1805). These findings were announced at the French Institute on July 8th 1805 and subsequently printed in *Annals du Muséum d'Histoire Naturelle, Paris*. Upon becoming aware of Swartz's work, Labillardière immediately accepted the name *Stylidium* in *Novae Hollandiae Specimen Plantarum* (Labillardière 1806a) and reapplied the name *Candollea* to a genus in Dilleniaceae. In both cases, his use of the name *Candollea* was illegitimate since Brisseau-Mirbel (1803) had earlier applied the name to a genus in the Polypodiaceae.

James Edward Smith unwittingly provided a third name for the triggerplants, describing two species in his *Exotic Botany* under *Ventenatia* (Smith 1806). *Ventenatia* was treated as a synonym of *Stylidium* by Willdenow (1807) who drew attention to its previous use by both Cavanilles (1797, Epacridaceae) and Palisot de Beauvois (1805, Flacourtiaceae); the name had also been applied by Trattinnick (1802, Euphorbiaceae). Upon accepting the name *Stylidium*, Smith (1807) observes that this generic name had previously been used by Loureiro (1790, Alangiaceae), later commenting that "there is great probability of his [Loureiro's] genus not being a good one and we hope our *Stylidium* will remain undisturbed" (Smith 1819).

Throughout the 19th century, the name *Stylidium* was retained for the triggerplants by the majority of botanists (e.g. Willdenow 1807, Salisbury 1808, Brown 1810, Endlicher et al. 1838, de Candolle 1839, Lindley 1839, Sonder 1845, Bentham 1868, Bentham & Hooker 1876); however, Ferdinand von Mueller was adamant that the correct name for the genus was *Candollea* and he therefore made the required new combinations for species previously published under *Stylidium* (Mueller 1882). Despite Mueller's conviction, only Schönland (1894), de Wildman (1900), Britten (1905) and Maiden and Betche (1916) followed Mueller's lead, and the name *Stylidium* remained in common usage (e.g. Fitzgerald 1902, Moore 1902, Diels & Pritzel 1905, Mildbraed 1908, Fitzgerald 1918, Moore 1920, Ostenfeld 1921, Domin 1923, Domin 1930, Schwarz 1927). On this basis, Thomas Sprague of the Royal Botanic Gardens, Kew submitted a proposal to the 1930 International Botanical Congress in Cambridge to conserve the name *Stylidium* Sw. against *Stylidium* Lour. (Sprague 1929). He further argued his case on the grounds that *Stylidium* Sw. is the type of the family name Stylidiaceae, and that it would be confusing to use the name *Candollea* since it had been applied by

Labillardière to another Australian genus. The formal conservation of *Stylidium* does not, however, appear in the list of accepted proposals in the Cambridge Code. Whilst Sprague's recommendation was approved by the appropriate Group Committee, it was still subject to approval by the General Committee and therefore by the next Congress in Amsterdam in 1935 (Briquet 1935). Although approved in Amsterdam (Sprague 1940), no official Code was produced from this congress due to the threat of war and as a result the formal conservation of *Stylidium* first appears in print in the Stockholm Code (Lanjouw 1952).

On the authorship and publication date of *Stylidium*

Four species of *Stylidium* were published in Willdenow's *Species Plantarum*: two from south-east Asia (*S. tenellum* Sw. and *S. uliginosum* Sw.) and two from Australia (*S. lineare* Sw. and *S. graminifolium* Sw.). Willdenow clearly attributes these taxa to Swartz, citing Swartz's unpublished manuscript subsequent to the genus name as well as after the species diagnoses, which are identical to those in Swartz's (1807) manuscript. I argue that in accordance with IBCN Art. 46.2, and in agreement with Sprague (1929) and Lanjouw (1952), the authorship of these four species and of the genus should be attributed to Swartz in Willdenow (i.e. *Stylidium* Sw.) and not Swartz ex Willdenow, as has commonly been the case. Accordingly, the type specimens for these taxa are those viewed by Swartz and not by Willdenow.

Raulings and Ladiges (2001: 903) state that *Stylidium* was published in December 1805 (i.e. after *Candollea*), whereas Bailey (1917: 3278) and Jackson and Wiltshire (2001: 939) suggest that it was named a few months earlier than *Candollea*. I have been unable to verify the publication date: a month is not provided on the frontispiece of the relevant volume of *Species Plantarum* nor is it given by Stafleu & Cowan (1988: 303). Similarly, I have not been able to confirm the month of publication of *Candollea*, even though Labillardière is known to have verbally presented his paper on the genus on the July 8th 1805. Whilst Salisbury (1808) states that "…a full extract from this, with figures and dissections, was immediately printed in the Annales du Museum", there is no indication on the frontispiece of the relevant volume of this journal of the date it was printed.

It is of note that Willdenow (1807), in an article that follows Swartz's 1807 publication, accepts the name *Stylidium* commenting that in such situations it is preferable to retain the first designation. Similarly, Labillardière (1806b: 400) states "Le genre que j'ai publié dans le Annales du Museum d'histoire naturelle, à la page 451 du VI.^{e} volume, sous le nom de *Candollea*, avoit été désigné peu de temps auparavant sous celui de *Stylidium*, par M. Swartz" [The genus that I published under the name of *Candollea* in *Annals du Museum d'Histoire Naturelle*, on p. 451 of volume 6, was designated a little time beforehand by Swartz under the name of *Stylidium*]. However, it is unclear whether Willdenow and Labillardière are referring to the publication of *Stylidium* in Willdenow's *Species Plantarum* or its description in Swartz's completed, but as yet unpublished manuscript. The possibility therefore remains that *Stylidium* was published subsequent to *Candollea*. This would have no nomenclatural repercussions at the generic level since *Stylidium* has been conserved; however, there would be implications at the species level (i.e. for the species named by both Labillardière and Swartz), as discussed in the notes under *S. graminifolium* and *S. lineare* below.

The type collections of *S. graminifolium* and *S. lineare*

According to two recent taxonomic treatments of the *S. graminifolium* complex, Swartz provided no information about the specimen he used to describe *S. graminifolium* (Jackson & Wiltshire 2001, Raulings & Ladiges 2001). Both studies conclude that Swartz, who worked in London at the Banksian Herbarium during 1786 and 1787, based his description on the collection of this taxon by Banks and Solander from Botany Bay. A specimen from this voyage, housed at the Natural History Museum, London and comparable to the drawing published in Banks' Florilegium, was chosen as a suitable lectotype.

During his time in London, Swartz wrote most of his *Prodromus*, a work on West Indian botany which was the forerunner to the larger *Flora Indiae Occidentalis* (Stearn 1980, Nicolson & Jarvis 1990). I have found no evidence to suggest that he looked at material of *S. graminifolium* at this time, nor to support the suggestion by Jackson and Wiltshire (2001: 939) that a duplicate specimen of *S. graminifolium* was taken by Swartz with Banks' permission to publish a description. Moreover, the decision to lectotypify a specimen collected by Banks and Solander is in conflict with information provided by Swartz (1807).

After his description of *S. lineare*, but in reference to both *S. lineare* and *S. graminifolium*, Swartz (1807: 51) states: "Diese beyde Arten sind aus Neu Holland, und wie ich vermuthe, wachsen sie in der Nähe von Port Jackson. Ich habe sie der Güte meines verehrungswürdigen Freundes, des Herrn Doctor Smith in England, zu verdanken. Er hat mir beyde unter dem Namen Species No. 1 und 2 novi generis Orchidearum mitgetheilt" [Both of these species are from Australia and I presume grow in the vicinity of Port Jackson. I am indebted to the generosity of my admirable friend in England, Dr Smith. He has given both specimens to me and communicated them under the names Species 1 and 2, a new genus of Orchidaceae].

The two specimens in question were collected by Dr John White, the first Surgeon-General of New South Wales. White, who arrived with the First Fleet in 1788, collected flora in the vicinity of Sydney and sent his specimens to Smith (Orchard 1999). Smith, initially thinking that these collections corresponded to a new genus of Orchid, sent duplicates to Swartz, who had a special interest in Orchidaceae. Unaware of the description of *Stylidium* that appeared in Willdenow's *Species Plantarum*, Smith (1806) used White's collections to describe *Ventenatia major* Sm. (*S. graminifolium*) and *V. minor* Sm. (*S. lineare*). Curiously, Smith later lays claim to having first applied the name *Stylidium* to the triggerplants: "*Stylidium*, was first so called by the writer of the present article, who sent specimens under that name to Labillardière and Swartz, and the latter published an account of the genus…" (Smith 1819).

The specimens sent to Swartz by Smith are located in Swartz's herbarium at the Swedish Museum of Natural History (S). Two sets of handwriting are evident on each specimen label: Smith's and Johan Wikström's, Swartz's successor. On the label for *S. lineare* (Fig. 1), Smith writes "novum genus Orchidearum No. 2". Wikström subsequently writes "J.E. Smith scripsit et misit" [J.E. Smith has written it and sent it] and replaces Smith's family placement with the genus name *Stylidium*. Wikström also annotates the sheet with Swartz's genus name and indicates that the specimen is part of Swartz's herbarium. On the label for *S. graminifolium* (Fig. 2), Smith writes "alia species generis No. 2" [another species of genus No. 2]. Wikström similarly annotates the label as having been written by Smith, and notes Swartz's species name on both the label and the sheet.

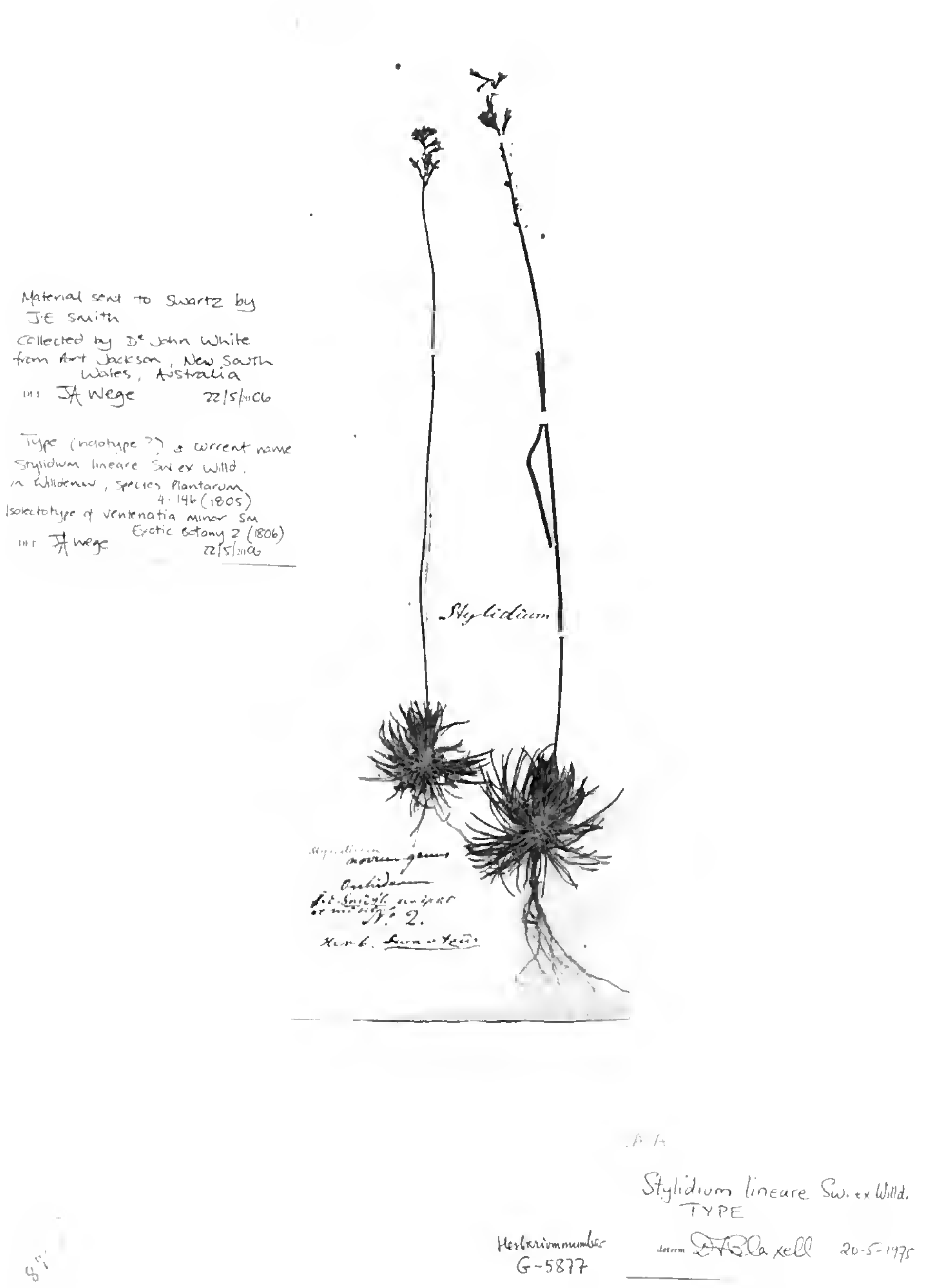

Fig. 1. Holotype of *Stylidium lineare* Sw. (S), collected by Dr John White and sent to Swartz by J.E. Smith.

The specimen of *S. lineare* (Fig. 1) comprises two individuals; the specimen on the right, which has had some flowers removed, is comparable to Swartz's illustration (Swartz 1807: Tab. 1, Fig. 2). The specimen of *S. graminifolium* (Fig. 2) is fragmentary, comprising two scape portions and lacking leaf material. The scape on the left hand side, which has similarly had some flowers removed, is a reasonably good match for the illustration provided by Swartz (1807: Tab. 1, Fig. 1). The whereabouts of the leaf rosette, also illustrated by Swartz, is unknown.

There are duplicates of White's two *Stylidium* collections in Thunberg's herbarium at Uppsala University; an individual of each species has been mounted together on the same sheet (UPS-THUNB 21556). There is an annotation on the reverse of the sheet in Swartz's hand that reads "ex Novae Hollandiae per Smith"; however, it is not clear whether this material was used by Swartz to compile his description. In view of the good comparison between Swartz's drawings and the material housed at S, the specimens at S are treated below as holotypes.

Stylidium graminifolium Sw., in Willd., Sp. Pl. 4(1): 146 (1805).
Candollea graminifolia (Sw.) F.Muell., *Syst. Cens. Aust. Pl.*: 85 (1882).

Type citation: "Swartz Nov. Act. Soc. Natur. Scrut. Berol. 5. p … [Ges. Naturf. Fruende Berlin Mag. Neuesten Entdeck. Gesammten Naturk. 1: 49] f. 2 [f. 1]."

Type specimen: Port Jackson, New South Wales, *J. White s.n., s. dat.* (holo: S 06-3470!; iso: LINN, Smith Hb. 1416.1!, LINN, Smith Hb. 1416.2! 2nd scape from right, LIV!, UPS-THUNB 21556! right hand specimen).

Ventenatia major Sm., *Exot. Bot.* 2: 13, t. 66 (1806); *Stylidium majus* (Sm.) Druce, *Bot. Soc. Exch. Club Brit. Isles* 4: 649 (1917), nom illeg., nom. superfl. **Type:** Port Jackson, New South Wales, *J. White s.n., s. dat.* (lecto, here designated: LINN, Smith Hb. 1416.1!; isolecto: LINN, Smith Hb. 1416.2! 2nd scape from right, LIV!, S 06-3470!, UPS-THUNB 21556! right hand specimen).

Stylidium canaliculatum Poir., in Lamarck, Encyclopédie Méthodique, Botanique Suppl. 5: 412 (1817), *nom illeg., nom. superfl.* **Type citation:** Nouvelle-Hollande (Smith, *l.c.*).

Type specimen: Port Jackson, New South Wales, *J. White s.n., s. dat.* (holo: P, *n.v.*; iso: LINN, Smith Hb. 1416.1!, LINN, Smith Hb. 1416.2! scape portion 2nd from right, LIV!, S 06-3470!, UPS-THUNB 21556! right hand specimen).

Stylidium graminifolium var. Hook., *Fl. Tasman.* 1: 235 (1856).

Stylidium graminifolium var. *angustifolium* Mildbr., in Engler, Pflanzenr. Heft 35, IV. 278: 73 (1908). **Type citation:** Victoria: bei Melbourne (F. v. Mueller!); Dandenong (F. v. Mueller!); oberer Yarra River (F. v. Mueller!). **Type specimen:** near Melbourne, *F. Mueller s.n., s. dat.* (lecto, here designated: W!).

Stylidium graminifolium var. *album* F.M.Bailey, The Queensland Flora 3: 887 (1900). **Type:** Cleveland, *W.R. Kefford s.n., s. dat.* (holo: BRI, *n.v.*).

Notes: a neotype was chosen by Raulings and Ladiges (2001: 925) for *Stylidium graminifolium* var. *angustifolium* since the original material used by Mildbraed (1908) in Berlin was destroyed in WWII. A syntype that conforms to Mildbraed's description of this taxon has since been located at the Natural History Museum in Vienna (W) and is chosen here as a suitable lectotype. Raulings and Ladiges (2001: 925) lectotypified Smith's illustration of *V. major* after failing to find a suitable specimen during a visit

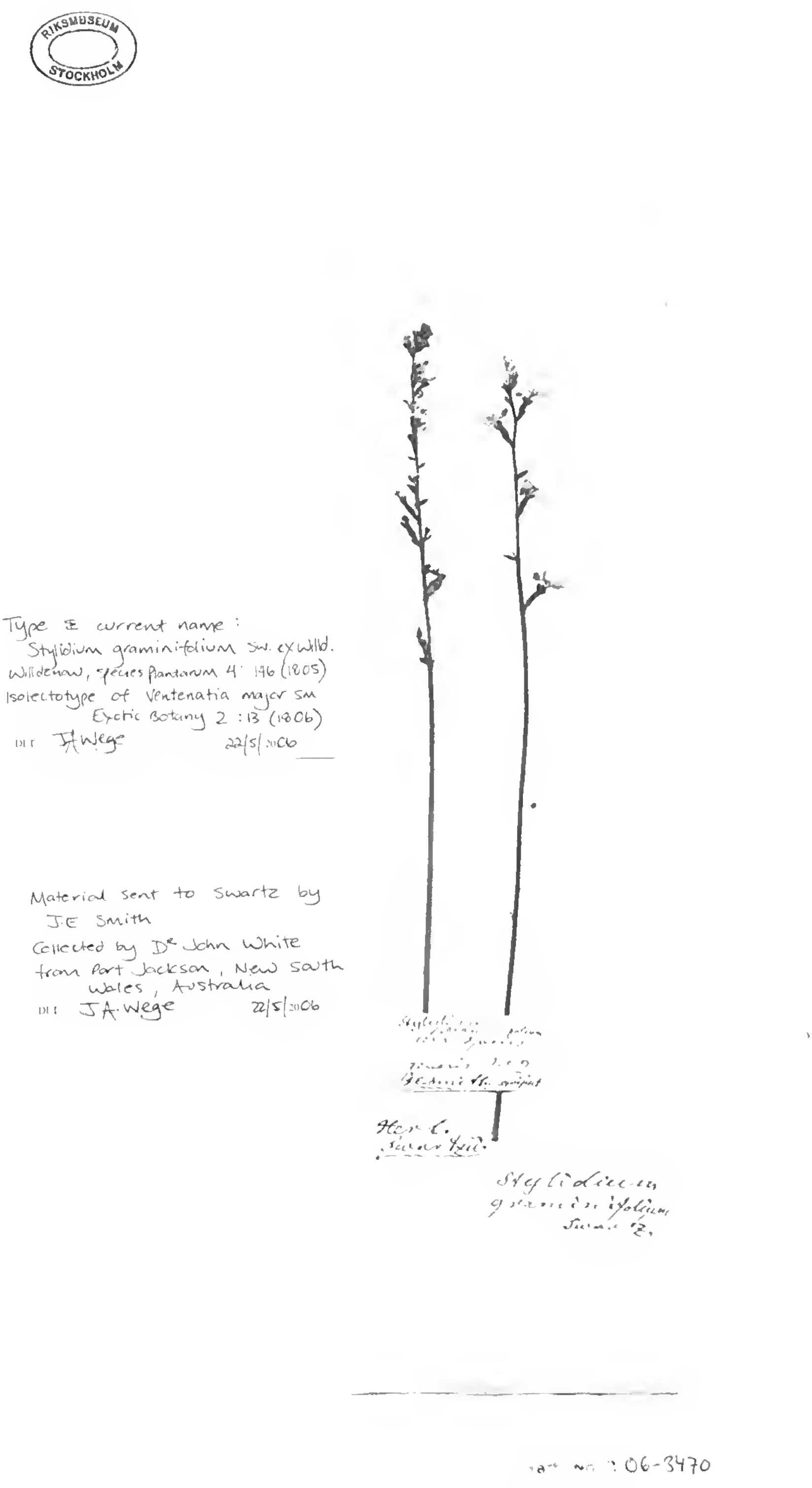

Fig. 2. Holotype of *Stylidium graminifolium* Sw. (S), collected by Dr John White and sent to Swartz by J.E. Smith.

to the Linnaean Society of London. I have located relevant specimens in the Smith Herbaria at the Linnaean Society and the National Museums Liverpool. It is likely that at the time of Raulings' visit to London, the specimen at the Linnaean Society was on loan to the National Museums Liverpool, being cleaned and databased at the as part of the Smith Herbarium Conservation Project. In accordance with IBCN Art. 9.10, *V. major* is relectotypified herein; the designated specimen conforms to Smith's original description of the species.

Jackson and Wiltshire (2001: 942, 953) consider *Candollea serrulata* Labill. and *C. umbellata* Labill. to be synonymous with *S. graminifolium* whereas Raulings and Ladiges (2001: 928) place both taxa into synonymy under the recently reinstated *S. armeria* (Labill.) Labill. If the former interpretation is accepted, and the publication date of *Candollea* is found to precede that of *Stylidium*, then the name *S. graminifolium* would need to be conserved against both *C. serrulata* and *C. umbellata*. Despite having examined types for all of Labilladiere's names, I am unable to confidently resolve this discrepancy at this point in time. An accurate interpretation of these types is dependent on a detailed knowledge of the full range of variation exhibited by *S. graminifolium* and allied taxa and I have little material at hand and a very limited field knowledge. A full taxonomic revision of this complex appears necessary in view of the different taxonomic outcomes presented in the two aforementioned studies.

Stylidium lineare Sw., in Willd. *Sp. Pl.* 4(1): 146 (1805). *Candollea linearis* (Sw.) F.Muell., *Syst. Cens. Aust. Pl.:* 85 (1882).

Type citation: "Swartz Nov. Act. Soc. Natur. Scrut. Berol. 5. p … [Ges. Naturf. Fruende Berlin Mag. Neuesten Entdeck. Gesammten Naturk. 1: 50] f. 2."

Type specimen: Port Jackson, New South Wales, *s. dat.*, *J. White s.n.* (holo: S G-5877!; iso: LINN, Smith Hb. 1416.2! excluding 2nd scape from right, LIV!, MANCH! MEL 2235241!, UPS-THUNB 21556! left hand specimen)

Candollea setacea Labill., *Ann. Mus. Hist. Nat.* 6: 455 (1805); *Stylidium setaceum* (Labill.) Labill., *Nov. Holl. Spec. Plant.* 2: 65 (1806). **Type citation:** "terra van-Leuwin." **Type specimen:** [likely to have been gathered at Port Jackson, New South Wales, collector unknown, probably *Leschenault* or *J. White*] (holo: FI 113185).

Ventenatia minor Sm., *Exotic Bot.* 2: 15, t. 67 (1806). **Type:** Port Jackson, New South Wales, *J. White s.n.*, *s. dat.* (lecto, here designated: LINN, Smith Hb. 1416.2! excluding 2nd scape from right; iso: LIV!, MANCH!, MEL 2235241!, S G-5877!, UPS-THUNB 21556! left hand specimen).

Stylidium planifolium Poir., in Lamarck, Encyclopédie Méthodique, Botanique Suppl. 5: 412 (1817), nom illeg., nom. superfl. **Type citation:** "Nouvelle - Hollande (Smith, *l.c.*)." **Type specimen:** Port Jackson, New South Wales, *J. White s.n.*, *s. dat.* (holo: P, *n.v.*; iso: LINN, Smith Hb. 1416.2! excluding 2nd scape from right, LIV!, MANCH! S G-5877!, UPS-THUNB 21556! left hand specimen).

Stylidium aciculare Sond., in Lehmann, J.G.C. *Pl. Preiss.* 1(3): 373, adnote (1845). **Type:** Nov. Hollandia, *J.S.C.D. D'Urville*, *s. dat.* (holo: B, Herb. Kunth, *n.v.*, destroyed in WWII).

Notes: LINN Smith Hb. 1416.2 comprises four individuals and two scape portions of *S. lineare* (collectively the lectotype of *V. minor*, as designated above) as well as a single scape portion of *S. graminifolium* (second from the right). The two species are superficially similar and therefore this intermixing is not surprising. Differences in scape indumentum between the two species are useful when identifying inflorescence fragments: unlike *S. graminifolium*, in which the scapes have glandular hairs along their entire length, *S. lineare* has scapes in which the glandular hairs are restricted to the upper portion.

To date, there has been confusion as to the correct identity of *S. setaceum* (Labill.) Labill. (*Candollea setacea* Labill.), recorded from "terra van-Leuwin" by Labillardière (1805, 1806a) and published, rather unusually, without an illustration. Labillardière (1806a) considered *S. setaceum* a separate taxon to *S. lineare* in view of its apparent lack of appendages in the throat of the flower; however, I have examined the holotype of *S. setaceum* and am confident that it is conspecific with *S. lineare*. The presence of throat appendages — which can be readily overlooked or misinterpreted on pressed *Stylidium* specimens — could not be confirmed since this would have caused unacceptable damage to the specimen; however, features of leaf morphology, indumentum distribution, and inflorescence structure were without doubt comparable to *S. lineare*. If the publication date of *S. lineare* is found to be later than *C. setacea* then the name *S. lineare* would need to be conserved against *C. setacea* in order for it to be retained. If a precise publication date cannot be determined, then it may be prudent to formally reject the name *C. setacea*.

Labillardière miscommunicated the type locality of *S. setaceum*, an error he repeated for several other Australian taxa (Nelson 1974, 1975). Specimens with the label "terra van-Leuwin" were supposedly collected in the vicinity of Esperance in Western Australia, Labillardière's only known landfall in this State (Nelson 1975); however, *S. lineare* is endemic to the east coast of Australia. As a consequence, *S. setaceum* was tentatively regarded by Bentham (1868) and Nelson (1974, 1975) as conspecific with *S. spinulosum* R.Br., a species endemic to the south coast of Western Australia which has a very similar leaf morphology to *S. lineare*; however, both authors noted the possibility of *S. setaceum* being synonymous with *S. lineare*. Although Mildbraed (1908: 72) treated *S. setaceum* as a synonym of *S. lineare*, he did so with a degree of doubt. Both *S. lineare* and *S. spinulosum* are restricted to regions of Australia that were not visited by Labillardière. Nelson (1974, 1975) tentatively suggested that Leschenault de la Tour collected the type of *S. setaceum* from King George Sound in Western Australia, in which case the name *S. setaceum* would have nomenclatural priority over *S. spinulosum* (published by Robert Brown in 1810). Phenology records do not support this suggestion: the holotype of *S. setaceum* is in very early flower and yet *S. spinulosum* does not flower in February, the time of Leschenault's visit to Albany.

The type of *S. setaceum* is likely to have been collected from Port Jackson in New South Wales, but it is unclear who made this gathering. It may have been acquired by Leschenault who visited Port Jackson and is known to have given material to Labillardière (Nelson 1974, 1975); however, it is equally plausible that the type was collected by John White, first Surgeon-General of New South Wales. Smith (1819) states that he sent duplicates of White's *Stylidium* collections to Labillardière.

There has been similar confusion as to the true identity of *S. aciculare*, which Sonder (1845) based on a collection in Kunth's herbarium made by d'Urville. Bentham (1868: 11), who did not view the type, placed *S. aciculare* into synonymy under *S. spinulosum*; however, Mildbraed (1908: 72), who did view d'Urville's collection, treated it as a distinct taxon with close affinity to *S. lineare*. The name has never been applied in

Australia. It is not known whether d'Urville made the collection on the east or west coast; he twice visited Australia and made collections from both New South Wales and King George Sound (Orchard 1999). Furthermore, the holotype was destroyed in World War II (Botanical Museum Berlin-Dahlem 1999) and no duplicates are known, making the application of this name difficult. Sonder (1845) describes the scape of *S. aciculare* as glabrous and the inflorescence glandular, and therefore I tentatively regard it as a synonym of *S. lineare* rather than *S. spinulosum.*

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A new subfamilial and tribal classification of Restionaceae (Poales)

Barbara G. Briggs[1] and H. Peter Linder[2]

[1]*Botanic Gardens Trust Sydney, Mrs Macquaries Road, Sydney NSW 2000, Australia.*
Email: barbara.briggs@rbgsyd.nsw.gov.au
[2]*Institute of Systematic Botany, University of Zurich, Zollikerrstrasse 107, CH-8008 Zurich, Switzerland*
Email: plinder@systbot.uzh.ch

Abstract

Restionoideae Link, with the newly described Sporadanthoideae and Leptocarpoideae, represent major clades of Restionaceae distinguished by analyses of chloroplast DNA data. These subfamilies are supported by features of morphology, culm anatomy, pollen and phytochemistry. Sporadanthoideae occur in Australia and New Zealand, Leptocarpoideae principally in Australia but with representatives also in New Zealand, New Guinea, Aru Islands, Malesia, Hainan Island and Chile, while Restionoideae are in sub-Saharan Africa and Madagascar. Two tribes, Restioneae Bartl. and Willdenowieae Mast. are recognised within Restionoideae, but their circumscriptions are very different from those of the tribes previously recognised within African Restionaceae. The relationship of Centrolepidaceae to Restionaceae remains unresolved, as sister group or embedded within the latter, but there is some support for Centrolepidaceae embedded within Australian Restionaceae and sister to Leptocarpoideae. This highly distinctive clade may be recognised as subfamily Centrolepidoideae Burnett if included within Restionaceae. Tribe Haplantherae Benth. & Hook. f. has the same circumscription as Restionaceae, as currently recognised, and Restio Rottb. is designated as the lectotype of this tribal name.

Introduction

Restionaceae have been the subject of much detailed morphological, anatomical and evolutionary study but lack a classification of major infrafamilial groups that is consistent with current phylogenetic inferences. Relevant data have come from morphological studies (Linder 1984, 1985; Meney & Pate 1999; Linder et al. 2000), including anatomical (especially Cutler 1969) and palynological investigations (Chanda 1966, Chanda & Ferguson 1978, Linder & Ferguson 1985). Flavonoid constituents were investigated by Harborne (1979), Harborne et al. (2000) and Williams et al. (1998). Clearer indications of relationships have recently come from DNA-based phylogenetic investigations (Briggs et al. 2000; Linder et al. 2003, 2005; Hardy & Linder 2005, 2007; Linder & Hardy 2005; Moline & Linder 2005; Hardy et al. 2008; Briggs et al. submitted) which also confirmed that Centrolepidaceae was either closely related to Restionaceae or embedded within it.

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The phylogenetic hypotheses that are a basis for the suprageneric taxa recognised here are largely inferred from analyses of chloroplast DNA data which have proved more phylogenetically informative than study of the highly reduced vegetative structures and small wind-pollinated flowers. Indeed, homoplasious reduction in floral and vegetative structures has led morphological comparison often to produce erroneous conclusions. For example, the multiple losses of the distinctive and prominent culm anatomical feature of pillar cells in Australian Restionaceae only became apparent when a molecular phylogeny was developed (Briggs et al. 2000). More comprehensive morphological study, combined with DNA data has, however, added resolution to the phylogeny of the African members (Hardy et al. 2008).

When Restionaceae (as Restiaceae) was originally described by Robert Brown (1810) it was much more inclusive than the family now recognised. Diverse genera have been transferred to Anarthriaceae, Centrolepidaceae, Ecdeiocoleaceae, Eriocaulaceae or Xyridaceae. The separation of Anarthriaceae and Ecdeiocoleaceae was initially largely based on differences in their vegetative anatomy (Cutler & Airy Shaw 1965). DNA-based phylogenies (Briggs et al. 2000, Bremer 2002, Chase et al. 2006 and other studies in Columbus et al. 2006, Marchant & Briggs 2007, Briggs et al. in press) show Ecdeiocoleaceae to be more closely allied to Poaceae than to Restionaceae, whereas most DNA data show Anarthriaceae as sister to (Restionaceae plus Centrolepidaceae). While molecular data (Briggs et al. 2000) showed that *Lyginia* and *Hopkinsia* formed a clade with *Anarthria*, the recognition of the separate families Lyginiaceae and Hopkinsiaceae (Briggs & Johnson 2000) was based on the very divergent culm anatomy. However, an enlarged Anarthriaceae, including the three genera, is now generally accepted.

Centrolepidaceae Endl. (1836) **or Centrolepidoideae** Burnett (1835)

Centrolepidaceae have long been considered to be closely related to Restionaceae or a derivative of it (Dahlgren et al. 1985, Linder & Rudall 1993, Kellogg & Linder 1995, Linder et al. 2000) and together they form a robustly supported monophyletic group in chloroplast DNA studies of Poales (Briggs et al. 2000, Bremer 2002, Briggs et al. in press). Similarities in embryology have been especially noted (Hamann 1962, 1975, Prakash 1969, Rudall and Linder 1988, Linder & Rudall 1993), as well as the similarity of Centrolepidaceae plants to Restionaceae seedlings (Linder & Caddick 2001). Restionaceae, as in many other Poales, show a relatively fast rate of nucleotide substitution and long branches in molecular phylograms, but Centrolepidaceae have exceptionally long branches. Although the currently available plastid DNA sequence data (Briggs et al. in press) suggest that Centrolepidaceae is embedded in Restionaceae, as sister to Leptocarpoideae, the alternative arrangement as sister to Restionaceae cannot yet be convincingly rejected (Fig. 1).

If a position embedded within Restionaceae is accepted, this clade would be known as subfamily Centrolepidoideae Burnett (1835, page 416), see also Reveal (2007). Centrolepidoideae differ conspicuously from other Restionaceae in their diminutive size, sometimes annual habit, unreduced leaves, lack of perianth, and in the floral structures which have been regarded as pseudanthia of male flowers reduced to a single stamen and female flowers to a single carpel (Hamann 1962, 1975; Cooke 1998) but could also be highly modified flowers (Sokoloff et al. submitted). The pollen of Australian Restionaceae have been described as 'centrolepidoid' (Chanda 1966, Chanda & Rowley 1967, Ladd 1977, Chanda & Ferguson 1979, Johnson & Briggs 1981) but Linder and Ferguson (1985) drew attention to important features of Centrolepidaceae pollen such as the granular rather than colummellate interstitium, lack of endexine and differences in the aperture and scrobiculi. *Centrolepis* (c. 26 spp., Cooke 1998), *Gaimardia* (4 spp.) and *Aphelia* (6 spp.) occur in southern temperate regions and mountains of the tropics: in Australia, south-east Asia, Pacific Islands and southern South America.

Major clades of Restionaceae

In addition to Centrolepidoideae, if included in Restionaceae, three major clades are now distinguished and here recognised as subfamilies: Sporadanthoideae and Leptocarpoideae are here newly described, along with Restionoideae (subdivided into two tribes, Restioneae and Willdenowieae). Relationships among the subfamilies are still not robustly resolved (Briggs et al. in press) but there is support for a clade of (Sporadanthoideae + Leptocarpoideae + Centrolepidoideae), with these either forming a trichotomy or grouped as (Sporadanthoideae (Leptocarpoideae + Centrolepidoideae)) (Fig. 1a). Thus the primarily Australian clade forms a sister group to the African Restionoideae. This topology is not supported by parsimony analyses of *trn*K and *trn*L-F data (Fig. 1b), but evidence from slowly evolving genes and from Bayesian or maximum likelihood analyses are considered more reliable in investigating ancient relationships (Jiang et al. 2008) than parsimony results from fast-evolving genes. The latter are more subject to artifacts arising from long-branch attraction.

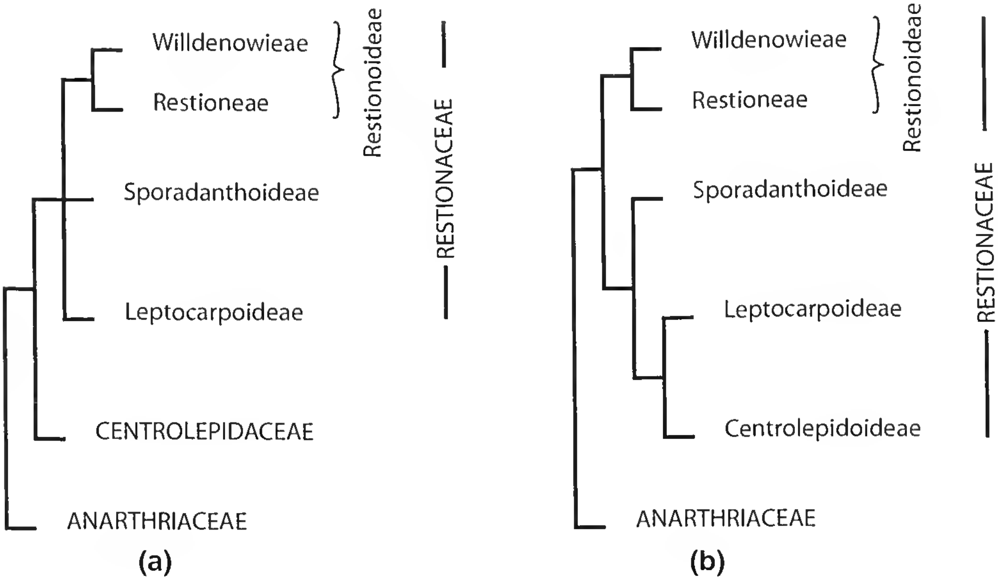

Fig. 1. Alternative positions of the centrolepid clade: (a) sister to Restionaceae (family Centrolepidaceae), as found from parsimony analysis of *trn*K or *trn*L–F; (b) embedded in Restionaceae (subfamily Centrolepidoideae) and sister to Leptocarpoideae, as found from *rbc*L data or from Bayesian analysis of *trn*K or *trn*L-F (Briggs et al. in press).

Previous subfamily and tribal nomenclature and classifications

The earliest valid use of names at subfamily and tribal rank based on *Restio* (Reveal 2007) are Restionoideae Link, Handbuch 1: 134. Jan-Aug 1829, and at tribal rank Restioneae Bartl., Ord. Nat. Pl.: 36. Sep 1830. These names are adopted here, as is Willdenowieae (Willdenovieae) Masters in A. DC., Monogr. Phan. 1: 314. Jun 1878. The circumscription of these taxa is, however, very different from when these names were first applied. In Bartling's treatment, Restioneae equates to the whole of Restionaceae (excluding Centrolepidaceae) as here recognised (examples from all major clades being included), whereas the two other subfamilies consisted of genera now placed in Centrolepidaceae, Anarthriaceae and Eriocaulaceae.

Haplantherae and Diplantherae. Bentham and Hooker (1883) divided Restionaceae, as then circumscribed, into two tribes: Haplantherae with one anther loculus and Diplantherae with two anther loculi. This classification was also used by Gilg-Benedict (1930) and these tribes were subsequently referred to as Restioneae and Anarthrieae (Hamann 1964). The latter tribe consisted of *Ecdeiocolea* F. Muell., *Anarthria* R.Br. and *Lyginia* R.Br. Subsequently *Ecdeiocolea* and *Anarthria* were excluded from Restionaceae with the description of Ecdeiocoleaceae and Anarthriaceae by Cutler and Shaw (1965). As mentioned above (Briggs et al. 2000), DNA data later showed that *Ecdeiocolea* is more closely allied to Poaceae than to Restionaceae and that *Lyginia*, *Hopkinsia* and *Anarthria* form a clade that is sister to (Restionaceae + Centrolepidaceae). So all members of Diplantherae are now excluded from Restionaceae.

Since Haplantherae has a circumscription equivalent to that of family Restionaceae, as the latter is now recognised, it is appropriate that it be typified by the same type. We therefore designate a lectotype.

Restionaceae tribe Haplantherae Benth. & Hook.f., *Genera Plantarum* vol. 3: 1028. Lectotype (here designated) *Restio* Rottb.

Restioideae and Willdenowieae. Masters (1878) recognised two tribes, Restioideae, with two or three (or one by abortion) ovary loculi and capsular fruit, and Willdenowieae (originally Willdenovieae) with a one-locular ovary and a nut fruit. These tribes formalised a grouping of genera largely based on the same criteria as that presented (without formal naming of groups) by Lindley (1836, p. 386), but which Lindley attributed to Nees von Esenbeck. Nees made important contributions to knowledge of Restionaceae (especially Nees 1830, 1846). The character of number of ovary loculi does not provide a satisfactory classification since there has been homoplasious reduction in carpel number in many groups within the clades now distinguished (Linder 1992a,b; Ronse Decraene et al. 2002).

When originally described, both of the tribes recognised by Masters included Australasian members as well as African ones. Indeed, it was only following the work of Gilg-Benedict (1930), Cutler (1969, 1972) and Linder (1984, 1985) that the names *Mastersiella* Gilg-Benedict and *Calopsis* Beauv. ex Desv. were adopted for African members, in contrast to the Australian *Hypolaena* R.Br. and *Leptocarpus* (Labill.) R.Br. More recently, the Australian taxa formerly included in *Restio* were separated from the African genus *Restio* (Briggs & Johnson 1998a, b), so that each of the genera now recognized can be assigned to the African clade or to one of the largely Australasian clades and subfamilies. This fulfils the prediction of Cutler (1972) that, when revised, no genus would be common to Australia and Africa. Our circumscription of tribes also shows no agreement with the classification of the African members by Pillans (1928), who included in Restionoideae only *Restio* and *Chondropetalum* (the latter now included in *Elegia*), placing all other genera in Willdenowieae.

Characters distinguishing subfamilies and tribes

Morphology. As a result of highly reduced structures and numerous homoplasious changes, neither external vegetative nor floral morphology offer features that we find useful in characterising the subfamilies, apart from Centrolepidoideae. Features are mostly not unique to a subfamily or are absent from some members of the subfamily, often by loss of the feature. For example, spikelet structure is widely found but in Sporadanthoideae the inflorescence is not always organised into spikelets: *Lepyrodia* and *Sporadanthus* lack spikelet structure, possibly having lost this feature, whereas *Calorophus* shows spikelet structure in both male and female inflorescences. However, lack of spikelet structure is not unique to Sporadanthoideae since, in Restionoideae, *Elegia* and males of *Willdenowia* do not have flowers aggregated into distinct spikelets.

Tribe Willdenowieae differs from Restioneae in that the pericarp is usually heavily lignified and the floral pedicel sometimes becomes thickened and functions as an elaiosome, and the gynoecium has two styles. Ronse Decraene et al. (2001) found a concordant pattern of loss of the anterior carpel and displacement of the remaining carpels throughout Willdenowieae, indicating that these aspects of floral development were synapomorphic. Linder (1992b) also found a single pattern of carpel development in the tribe, as well as a single origin of the hard, woody nutlet.

Pollen morphology. Pollen grains of the Sporadanthoideae and Leptocarpoideae are both of the type termed Australian restionoid (as 'Australian restioid') (Linder & Ferguson 1985), whereas the Restionoideae have African restionoid pollen. Thus pollen of the two Australasian subfamilies does not show the tectum raised around the large and usually irregular aperture, so that there is no distinct annulus; also there is no thickened foot layer. In the Restionoideae the tectum is raised around the relatively small aperture and some members have a thickened foot layer (Linder 1984, Linder et al. 1998).

Embryology. Proliferating antipodals were reported in Restioneae but were absent from those Sporadanthoideae and Leptocarpoideae studied (Rudall & Linder 1988). However, only a minority of genera have been sampled and there are no reports for Willdenowieae.

Culm anatomy. Differences in culm anatomy between African and Australasian members have long been recognised (Cutler 1969, Johnson & Briggs 1981, Linder 2000). Anatomical features are also reported for African members by Linder (1984) and Australian genera by Pate and Delfs (1999) and Meney et al. (1999).

Most of the following terms used for the distinctive anatomical cell types or structures were defined by Cutler (1969) who clearly recognised their taxonomic significance and pointed out differences between those Australian and African taxa that were at that time considered to be congeneric.

Protective cells: modified cells of the chlorenchyma with slightly to moderately thickened lignified walls surrounding a substomatal cavity forming a tube extending all or part way through the chlorenchyma. These occur in Restionoideae and Sporadanthoideae, being absent from Leptocarpoideae. Analogous protection of the substomatal cavity in members of the *Desmocladus* group and *Alexgeorgea* within Leptocarpoideae is by elongated and thick-walled epidermal cells. Using a broader definition of protective cells, Linder (2000) regarded epidermally-derived protective cells and chlorenchyma-derived protective cells as an example of convergence.

Pillar cells: elongate, palisade-like cells of the parenchyma sheath, usually with moderately thickened (lignified) walls, radiating from the sclerenchyma sheath to the epidermis, dividing the chlorenchyma into longitudinal bands. Since they arise from the parenchyma sheath, pillar cells are not homologous with *'false pillar cells'*. Pillar cells are restricted to Leptocarpoideae, and are present in *Eurychorda*, sister group to the rest of that subfamily, as well as in ten other leptocarpoid genera. However, there appear to have been homoplasious losses of this feature in at least four leptocarpoid clades (Briggs et al. 2000).

'False pillar cells' (Linder 1984, 2000) are lignified cells of the chlorenchyma that extend outwards from ridges of the sclerenchyma in some species. These are unique to the Willdenowieae, but are found only in a small minority of the species and genera.

Girders: sclerenchyma ridges opposite the outer vascular bundles, extending from the sclerenchyma sheath all or part-way through the chlorenchyma. These occur in Leptocarpoideae, although in only a few genera; they were designated as 'ribs opposite vascular bundles' by Linder (2000).

Ribs: sclerenchyma ridges alternating with the outer vascular bundles, extending from the sclerenchyma sheath all or part-way through the chlorenchyma (Cutler 1969, p. 327). They are a feature of most Willdenowieae.

Silica bodies: sphaeroidal-nodular bodies or granular sand may be present, especially in the parenchyma sheath (between the chlorenchyma and the sclerenchyma cylinder) or in the outer layer of the sclerenchyma. Silica bodies are absent from Anarthriaceae (Cutler 1969, Prychid et al. 2004). Such inclusions are widespread in the commelinid families, so presumably their loss is a synapomorphy of that family. Within Restionaceae, silica bodies are found in members of all subfamilies and tribes but are reported as absent from some genera, especially in the Restioneae (*Elegia*, *Staberoha*, *Rhodocoma*).

Phytochemistry. The subfamilies show significant differences in the flavonoid constituents of their culms (Harborne 1979, Williams et al. 1998, Harborne 2000, Harborne et al. 2000). Myricetin is reported only in Sporadanthoideae (present in *Lepyrodia* and *Sporadanthus*, although absent from *Calorophus*). Leptocarpoideae are characterised by flavones, commonly luteolin and hypolaetin, as well as sulphated flavonoid derivatives. Restionoideae show flavonols, commonly derivatives of myricetin and its methyl ethers larycitrin and syringetin, and also proanthocyanidins.

Description of subfamilies of Restionaceae

Sporadanthoideae B.G.Briggs & H.P.Linder, **subfam. nov.**

A Restionoideis et Leptocarpoideis combininatione characterum sequentium distinguenda: chlorenchyma continua, cellulis columnaribus nullis; parietes cellularum cavitates substomatales cingentes incrassati; flores in spiculis aggregati vel singulatim in inflorescentia portati; apertura pollinis ampla, irregularis, stratum fundum crassum deficiens.

Type genus: *Sporadanthus* F.Muell. Type: *Sporadanthus traversii* (F.Muell.) F.Muell. ex Kirk.

Flowers aggregated or not aggregated into spikelets; pollen with the tectum not raised around the large (8–25 μm) and usually irregular aperture and lacking a thickened foot layer (Australian restionoid type); proliferating antipodal cells in embryo sac lacking (so far as known); protective cells lining substomatal cavities present; chlorenchyma not interrupted by pillar cells or 'false pillar cells' or sclerenchyma girders or ribs; silica bodies or granular silica often present in epidermis and sometimes in ground tissue and parenchyma sheath; the flavonols myricetin and quercitin often present, flavones and protoanthocyanidins mostly absent.

A subfamily of three genera and about 31 species (including some not formally named), occurring in Australia and New Zealand. Sporadanthoideae equates with the *Lepyrodia* group of Briggs and Johnson (1999) and Briggs et al. (2000), but with the combined *Lepyrodia* and *Calorophus* groups of Johnson and Briggs (1981). The three genera recognized in the Sporadanthoideae, *Lepyrodia* R.Br. (species: 13 described, about 9 undescribed), *Sporadanthus* F.Muell. (7 described, 1 undescribed), and *Calorophus* Labill. (2 spp.), did not form a monophyletic group in a morphological cladistic study (Linder et al. 2000) but the clade is supported in most DNA analyses (Marchant & Briggs unpublished data).

Leptocarpoideae B.G.Briggs & H.P.Linder, **subfam. nov.**

A Restionoideis et Sporadanthoideis combininatione characterum sequentium distinguenda: chlorenchyma continua vel cellulis columnaribus vel costis schlerenchymatis interrupta; parietes cellularum cavitates substomatales cingentes non incrassati; flores in spiculis aggregati; apertura pollinis ampla, irregularis, stratum fundum crassum deficiens.

Type: *Leptocarpus* R.Br. (nom. cons.). Type (type. cons.): *L. tenax* (Labill.) R.Br.[1]

Flowers in spikelets; pollen lacking a thickened foot layer and the tectum not raised around the large (8–25 μm) and usually irregular aperture (Australian restionoid type); protective cells absent; pillar cells in the chlorenchyma present or absent; sclerenchyma girders mostly absent but when present opposite vascular bundles; 'false pillar cells' and sclerenchyma ribs absent; silica bodies often present in parenchyma sheath and epidermis; flavones luteolin and hypolaetin often present, flavonols and protoanthocyanidins mostly absent.

A subfamily with 28 genera currently recognised and about 117 species (including some not formally named), occurring in Australia, New Zealand, New Guinea, Aru Islands, Malesia, Hainan Island and Chile. Leptocarpoideae equates to the *Leptocarpus* group of Johnson and Briggs (1981) but to the combined *Winifredia*, *Desmocladus*, *Loxocarya* and *Leptocarpus* groups of Briggs and Johnson (1998a, 1999), together with

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[1] The proposal of this new conserved type (Briggs 2001, 2005) was recommended by the Committee for Spermatophyta (Brummitt 2005: p. 1096), endorsed by the General Committee (Barrie 2006: p. 800) and approved at the XVII International Botanical Congress (McNeill et al. 2005) but unfortunately the listing of the conserved type in the International Code of Botanical Nomenclature (Vienna Code) (McNeill et al. 2006: p. 270) was not changed to incorporate this decision. This oversight should be corrected in the next issue of the Code.

Alexgeorgea which was ungrouped. It also corresponds to the combined *Desmocladus*, *Loxocarya* and *Leptocarpus* clades of Linder et al. (2000) derived from morphological cladistic study.

The Leptocarpoideae are discussed by Briggs and Johnson (1999) and Meney and Pate (1999). The *Desmocladus* and *Leptocarpus* groups based on morphology of Briggs and Johnson (1998a, 1999) and Linder et al. (2000) are supported by DNA data but the *Loxocarya* group is paraphyletic and these groups do not adequately represent the main clades within Leptocarpoideae. Especially, the position of *Eurychorda* as sister-group to the remainder of Leptocarpoideae was not expected from morphological studies. The status of several genera is under review following results from analyses of DNA data.

Genera currently recognised: *Alexgeorgea* (3 species), *Apodasmia* B.G.Briggs & L.A.S.Johnson (3 described, 1 undescribed), *Baloskion* Raf. (8), *Catacolea* B.G.Briggs & L.A.S.Johnson (1), *Chaetanthus* R.Br. (3), *Chordifex* B.G.Briggs & L.A.S.Johnson (within which the previously described genera *Acion*, *Guringalia* and *Saropsis* [Briggs & Johnson 1998a] have been synonymised [Briggs & Johnson 2004]) (20), *Coleocarya* S.T.Blake (1), *Cytogonidium* B.G.Briggs & L.A.S.Johnson (1), *Dapsilanthus* B.G.Briggs & L.A.S.Johnson (4), *Desmocladus* Nees (15), *Dielsia* Gilg (1), *Empodisma* L.A.S.Johnson & D.F.Cutler (2), *Eurychorda* B.G.Briggs & L.A.S.Johnson (1), *Harperia* W.Fitzg. (4), *Hypolaena* R.Br. (8), *Kulinia* B.G.Briggs & L.A.S.Johnson (1), *Lepidobolus* Nees (6 described, 3 or 4 undescribed), *Leptocarpus* R.Br. (2 described, 1 undescribed), *Loxocarya* R.Br. (5), *Meeboldina* Suess. (5 described, 6 undescribed), *Melanostachya* B.G.Briggs & L.A.S.Johnson (1), *Onychosepalum* Steud. (3), *Platychorda* B.G.Briggs & L.A.S.Johnson (2), *Stenotalis* B.G.Briggs & L.A.S.Johnson (1), *Taraxis* B.G.Briggs & L.A.S.Johnson (1), *Tremulina* B.G.Briggs & L.A.S.Johnson (2), *Tyrbastes* B.G.Briggs & L.A.S.Johnson (1), *Winifredia* L.A.S.Johnson & B.G.Briggs (1).

Within Leptocarpoideae, pillar cells appear to be a pleisiomorphous character (Briggs et al. 2000), being present in eleven genera including *Eurychorda* which appears in molecular phylogenetic trees as sister to the remainder of the subfamily. The loss of pillar cells is, however, a homoplasy shown in the *Desmocladus* group (absent throughout), *Winifredia* group (pillars present in *Taraxis*; absent in *Empodisma* and *Winifredia*) and *Loxocarya* group (present in *Alexgeorgea*, western Australian *Chordifex*, *Dielsia*, *Eurychorda* and *Loxocarya*; absent in *Baloskion*, eastern Australian *Chordifex* (Briggs & Johnson 2004), *Cytogonidium*, *Dielsia*, *Melanostachya*, *Tremulina*, *Platychorda* and *Tyrbastes*). They are present throughout the *Leptocarpus* group.

Restionoideae Bartl.

Type: *Restio* Rottb. (nom. cons.) Lectotype: *Restio triticeus* Rottb. (McVaugh 1968).

Flowers mostly in spikelets; pollen with the tectum raised around the relatively small (4–10 µm) aperture and some members with thickened foot layer (African restionoid type); embryo sac often with proliferating antipodals; protective cells present lining substomatal cavities; pillar cells absent; sclerenchyma ribs sometimes present, alternating with outer vascular bundles; 'false pillar cells' sometimes present; silica bodies often present in the parenchyma sheath or the outer layer of the sclerenchyma cylinder; proanthocyanidins mostly present; glycosides of myricetin, larycitin and syringetin sometimes present.

A subfamily of about 350 species, occurring in sub-Saharan Africa and Madagascar, with principal diversity in the Cape Floristic Region of South Africa. Restionoideae comprises the African clade of Restionaceae, postulated to be a monophyletic group by Johnson and Briggs (1981) on the basis of morphological and anatomical features. Subsequently, morphological (Linder et al. 2000) and DNA studies (Eldenäs & Linder 2000, Linder et al. 2003, Briggs et al. in press) have corroborated its monophyly. Its morphology and members are described and discussed by Linder (1984; 1985; 1991a, b). Genera currently recognised are listed under the tribes.

Description of tribes within Restionoideae

Two tribes are recognised within Restionoideae, corresponding to the major clades apparent in most analyses of DNA data (Linder et al. 2003, Hardy et al. 2008, Briggs et al. in press). That the genera now placed in Willdenowieae formed a clade was also apparent from analyses of morphological data (Linder 1984, 1991b; Linder et al. 2000). Linder (1991b) observed that the *Willdenowia* clade is strongly supported by several unique morphological synapomorphies derived from a wide range of organs. The Restioneae, however, were not recognised as a clade (including *Staberoha* and *Ischyrolepis*) until molecular data were available.

Restioneae Bartl., Ord. Nat. Pl.: 36. Sep 1830.

Restioideae Mast. In A. & C. de Candolle, Monograph Phanerogamarum vol. 1: 218–398. 1878

All carpels fertile or variously reduced, styles 3, 2 or 1; fruits soft-walled nuts or capsules; young seed coat tanniniferous; pollen aperture various; sclerenchyma ribs absent; false pillar cells absent; chlorenchyma cells radially elongated; silica bodies often present in the parenchyma sheath but absent from the sclerenchyma.

Linder (1992b) found homoplasy in the patterns of carpel loss in the tribe, in contrast to the single pattern shown in the Willdenowieae. There was also evidence of multiple origins of unlignified nutlets in Restioneae. The evolution and ecology of members of the Restioneae have been investigated by Linder and Mann (1988), Linder and Hardy (2005), Hardy and Linder (2005), Linder et al. (2005) and Moline and Linder (2005).

A tribe of about 300 species, including many as yet undescribed species, Restioneae comprises the *Thamnochortus*, *Restio* and *Elegia* clades of Linder (1984). Genera currently recognised in Restioneae: *Askidosperma* Steud. (12), *Calopsis* Beauv. (23), *Elegia* L. (51, within which the previously recognised genera *Chondropetalum* Rottb. and *Dovea* Kunth have been synonymised [Moline & Linder 2005]), *Ischyrolepis* Steud. (c. 48), *Platycaulos* H.P. Linder (c. 8), *Restio* Rottb. (c. 93), *Rhodocoma* Nees (7), *Staberoha* Kunth (c. 9), *Thamnochortus* Berg. (33).

Analyses of chloroplast DNA data and morphology (Eldenäs & Linder 2000, Hardy et al. 2008) show that *Restio* and *Calopsis* are polyphyletic and changes to the generic classification are expected (Linder & Hardy in prep.).

Willdenowieae Masters in A. DC., Monogr. Phan. 1: 314. Jun 1878 (*Willdenovieae*).

Type: *Willdenowia* Thunb. Lectotype: *W. striata* Thunb. (Linder 1984: p. 67)

Mostly with a single functional carpel, and with carpels 2 and 3 fused; styles 2; young seed coat not tanniniferous; fruits mostly large woody nuts, often on fleshy pedicels; pollen aperture with foot layer scarcely thickened, border region ± sharply raised forming a very regular ring (aperture type 2b of Linder 1984); sclerenchyma ribs alternating with the outer vascular bundles mostly present; false pillar cells present or absent; chlorenchyma cells often radially short and squat; silica bodies usually present in the sclerenchyma.

A tribe of about 50 species, Willdenowieae equates to the *Ceratocaryum–Willdenowia* clade of Linder (1984) and many of the taxa are myrmechorous (Linder 1991a). Genera currently recognised in the Willdenowieae: *Anthochortus* Nees (15), *Cannomois* Beauv. ex Desv. (6), *Ceratocaryum* Nees (6), *Hypodiscus* Nees (15), *Hydrophilus* HPLinder (1), *Mastersiella* Gilg-Ben. (13), *Nevillea* Esterh. & H.P.Linder (2), *Willdenowia* Thunb. (12).

Molecular-based phylogenetic work (Eldenäs & Linder 2000, Hardy et al. 2008) suggests that a number of the genera are not monophyletic.

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Four new species related to *Bossiaea bracteosa* F.Muell. ex Benth. in south-eastern Australia

K. L. McDougall

Department of Environment and Climate Change, PO Box 733, Queanbeyan NSW 2620, Australia
Email: keith.mcdougall@environment.nsw.gov.au

Abstract

Bossiaea bracteosa F.Muell. ex Benth. has long been regarded as a widely distributed shrub, occurring in Victoria, New South Wales and the Australian Capital Territory. Most of its populations, however, are highly localised, poorly represented in herbaria and occur in disparate habitats. Following re-examination of herbarium collections and further collecting of isolated populations in New South Wales and the Australian Capital Territory, four species are here described as new: ***B. bombayensis*** K.L.McDougall, ***B. fragrans*** K.L.McDougall, ***B. grayi*** K.L.McDougall, and ***B. milesiae*** K.L.McDougall. The circumscription of *Bossiaea bracteosa* is emended and is here regarded as a Victorian endemic.

Introduction

Species of *Bossiaea* (Bossiaeeae: Fabaceae) lacking typical photosynthetic leaves are characterised by flattened branches (cladodes) and leaves that are reduced to scales. A recent review of *Bossiaea* in Western Australia (Ross 2006) identified five new taxa of leafless species in addition to the eight taxa that had previously been recognised. The variability in morphology and habitat within some other currently recognised species suggests that additional new taxa await elucidation.

In south-eastern Australia, many leafless Bossiaeas are extremely localised in their distribution and poorly represented in herbarium collections. One species, *Bossiaea bracteosa* F.Muell. ex Benth., characterised by its caducous bracteoles, has been regarded as occurring in Victoria, New South Wales (N.S.W.), and the Australian Capital Territory (A.C.T.). A population from Wombat Forest near Melbourne has recently been described as a new species, *B vombata* (Ross 2008). Most populations of *Bossiaea bracteosa*, as currently circumscribed, are highly disjunct and occur in a range of habitats: Australian Alps (Victoria; subalpine woodland), Snowy River (Victoria; habitat unknown), Bega area (N.S.W.; riparian), Murrumbidgee River (A.C.T.; riparian), Shoalhaven River (N.S.W.; riparian) and Abercrombie Caves (N.S.W.; dry woodland). Based on leaf scale length and general morphological characters, there are clear differences between populations of *Bossiaea bracteosa* from the Australian Alps (where the Type was collected) and other populations for which adequate herbarium

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material is available. Recent collections from N.S.W. and the A.C.T. have clarified the patterns of variation within older herbarium material of what has previously been classified as *B. bracteosa*, leading to the delimitation of four new taxa within this group. These are described below.

Diagnostic characters

In the species described below, some characters seem to have no diagnostic value or require further investigation before they can be reliably used to distinguish these taxa. For instance, all species are glabrous apart from minute hairs at the nodes, on the apices of floral bracts and on the inner surface of calyx lobes. Scattered, appressed hairs on young cladode branches are found in collections of all species except *B. fragrans* but little material of this species is available to confirm its diagnostic value. An exfoliating waxy coating has been noted in dried specimens of *B. bracteosa sens. lat.* (Ross 1996). This conspicuous feature seems to be common to all species except *B. milesiae*. However, it has limited diagnostic value because not all dried specimens within a species display this character.

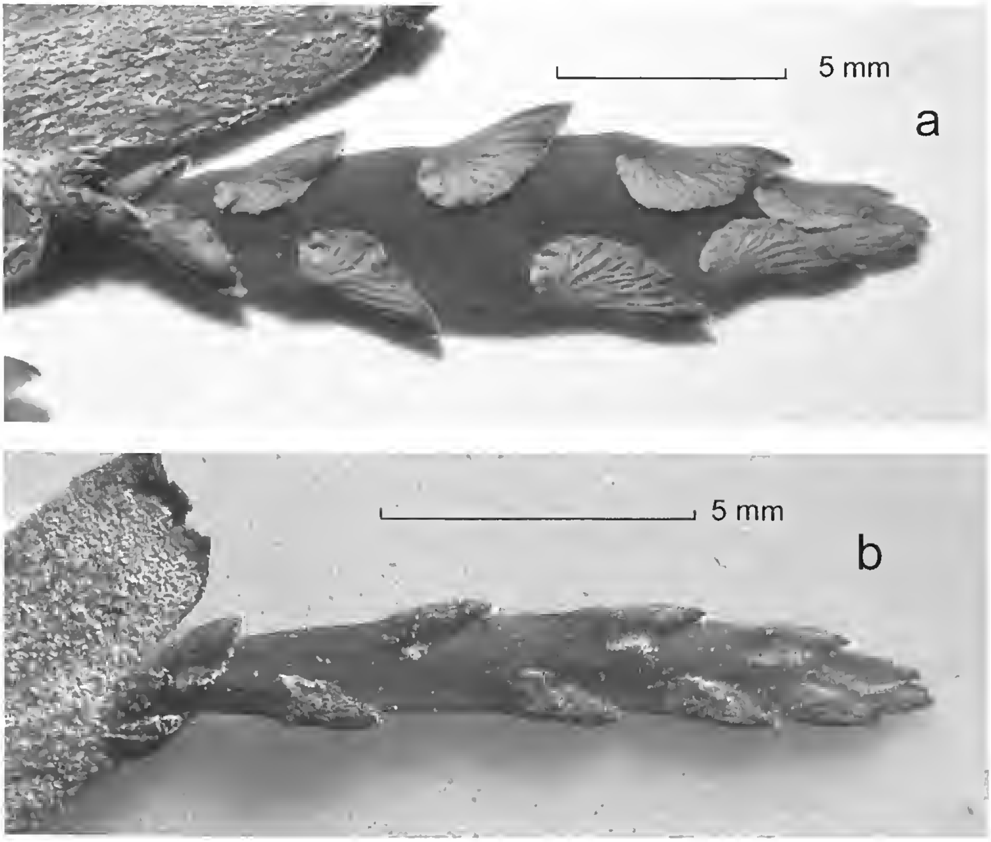

Fig. 1. Leaf scales on new cladode growth (undamaged). **a**, *Bossiaea bracteosa* (*N.G. Walsh 5716*) – long leaf scales with broad cordate bases and prominent venation; **b**, *Bossiaea grayi* (*K.L. McDougall 1272*) – short leaf scales with truncate bases and obscure venation

The most useful diagnostic characters are cladode size and colour; leaf scale size, shape, and venation; pedicel length; equality or not of calyx lobes; flower length and colour; staminal filament colour; and pod size and colour.

Cladodes

Reproductive cladodes are distinctive in width, margins and colour for most species. *Bossiaea bombayensis* has narrow, dark green, sub-flexuose reproductive cladodes that are predominantly red when young. *Bossiaea bracteosa* and *B. fragrans* have broad, glaucous-green reproductive cladodes. In these species, the margins are typically sinuate and the nodes are sometimes incised. *Bossiaea grayi* and *B. milesiae* have reproductive cladodes of intermediate width. Those of *B. grayi* are grey-green with straight margins (although slightly indented at the nodes), while those of *B. milesiae* are light green with straight to sinuate margins.

Leaf scales

Leaf scale length and venation is the principal character separating *Bossiaea bracteosa sens. strict.* from the other species. The leaf scales of *B. bracteosa* are > 2.5 mm long with broad cordate bases and prominent venation. The other species have relatively short leaf scales (generally < 1.5 mm long) with truncate bases and obscure venation (Fig. 1). Leaf scales are best viewed on young cladode branches because many become damaged or dislodged on older cladodes.

Flowers

Bossiaea bombayensis, *B. bracteosa* and *B. grayi* appear to have strictly one flower per node whereas *B. fragrans* and *B. milesiae* may have more than one. Multiple flowers seem to be common in *B. fragrans* but very rare in *B. milesiae*. Pedicels are short and hidden by floral bracts in *B. bracteosa*, *B. bombayensis* and *B. grayi*, and longer and exposed at flowering time in *B. fragrans* and *B. milesiae*. Floral bracts are largely persistent in *B. bracteosa*, *B. bombayensis* and *B. grayi*, whereas they are usually caducous in *B. fragrans* and *B. milesiae*. All but the outer few bracts, i.e. those closest to the cladode, are caducous in *B. fragrans* and *B. milesiae*. Calyx lobes are equal or subequal in *B. bracteosa*, *B. bombayensis* and *B. grayi* and distinctly unequal in *B. fragrans* and *B. milesiae*. The calyx of *B. bombayensis* is distinctively heavily tinged with red throughout, except for the tips of the lobes, which are golden brown. The calyces of other species tend to be green throughout. *Bossiaea bombayensis* has shorter corollas than the other species, whereas *B. fragrans* generally has the longest corollas. Although the external colour of the standard can be variable in *B. bracteosa*, *B. grayi* and *B. fragrans*, that of *B. bombayensis* is almost entirely red and that of *B. milesiae* is entirely yellow or apricot (apart from faint red striations). Staminal filaments are red in *B. grayi*, *B. fragrans and B. milesiae* or colourless or almost so in *B. bracteosa* (and sometimes *B. milesiae*) but the filaments of *B. bombayensis*, are distinctively alternately red and colourless.

Pods

Pod size differs between species (see dimensions below). However, abnormally small pods are common in all species and measurements should be made of a range of pods. Typical pods of *B. bombayensis* are smaller in length and width than other species and heavily tinged with red when immature.

Key to leafless Bossiaea with caducous bracteoles in eastern Australia

1 Flowers >15 mm long; keel longer than standard; ovules c. 20 .... ***B. walkeri***

1 Flowers <15 mm long; keel shorter than or ± equal to standard; ovules < 10 2

2 Upper 2 calyx lobes c. quadrangular contrasting strongly with the triangular lower lobes; pedicels exceeding floral bracts at flowering by 1–2 mm 3

2 Calyx lobes all triangular; pedicels not or hardly exceeding the floral bracts at flowering 4

3 Reproductive branches of cladodes mostly > 8 mm wide, becoming incised; standard 9–10 mm long; stipe of pods < 3 mm long; at least some nodes with > 1 flower .... ***B. fragrans***

3 Reproductive branches of cladodes mostly < 8 mm wide, not becoming incised; standard 7–9 mm long; stipe of pods ≥ 3 mm long; nodes rarely with > 1 flower .... ***B. milesiae***

4 Scales mostly 3–5 mm long .... ***B. bracteosa***

4 Scales mostly < 2 mm long 5

5 Corolla yellow or whitish, without any other coloration .... ***B. vombata***

5 Corolla with some purple, orange or red coloration as well as yellow 6

6 Cladodes dark green in fresh material; reproductive branches of cladodes usually < 4 mm wide; calyx lobes < 1.5 mm long .... ***B. bombayensis***

6 Cladodes grey green in fresh material; reproductive branches of cladodes usually > 4 mm wide; calyx lobes ≥ 1.5 mm long .... ***B. grayi***

1. ***Bossiaea bracteosa*** F.Muell. ex Benth., *Flora Australiensis* 2: 166 (1864).

Type: Victoria, Mitta Mitta (subalpine), *F. Mueller s.n., s.d.* (MEL 20333); lectotype *fide* A.T. Lee, *Contrib. New South Wales Natl. Herb.* 4:98 (1970).

Erect to spreading, suckering shrub 0.7–2 m high. Cladodes flattened, winged, becoming round or oval in cross-section; reproductive branches of cladodes oblong to narrowly ovate, green to glaucous-green, 7–12 mm wide, winged, rarely incised at the nodes, glabrous apart from minute hairs in the axils of the scale leaves and on the surface of new growth. Leaf scales 2.7–5 mm long, broadly ovate with cordate bases and acuminate to acute apices, reticulate venation prominent, glabrous apart from marginal cilia. Flowers 1 per node; pedicel 1.5–2 mm long, glabrous, obscured by floral bracts. Floral bracts imbricate, increasing in size from outer to inner, glabrous apart from marginal hairs, especially towards the apex, chestnut brown, the largest persistent bract c. 2.5 mm long with a broadly acute to obtuse, lacerated apex. Bracteoles caducous. Calyx glabrous apart from hairs on the margins and inner surface of the lobes apically, green, 4.5–5.5 mm long including 5 ± equal, triangular lobes 1.4–2 mm long, 1–1.3 mm wide. Corolla with standard 8.5–10 mm long including a claw 2.5–4 mm long, 10.5–11.5 mm wide, exceeding other petals, bright yellow to apricot internally with faint red striations, suffused with red externally; wings 7.5–9.5 mm long including a claw 3–4 mm long, yellow, glabrous; keel 7.5–9.5 mm long including a claw 3–4 mm long, dark red, glabrous. Ovary 5–6 mm long, (6–)8-ovulate, glabrous; style 4–5 mm long. Staminal filaments 3–4.5 mm long, ± colourless; sheath 4–6 mm long, ± colourless. Pods oblong, 2.3–3.2 cm long, 0.6–1 cm wide, glabrous, reddish brown when mature; stipe c. 2 mm long, obscured by remains of calyx. Seeds broadly elliptic to slightly reniform, 3–3.5 mm long, 1.5–2 mm wide, reddish brown to mid-brown.

Flowering: November—December (rarely in January).

Vernacular name: Mountain Leafless Bossiaea.

Selected specimens examined: Victoria: Eastern Highlands: Mountain Ash Spur between The Crinoline and Mount Skene, *J. Blackburn s.n.*, Dec 1950 (MEL 1529686); Black Range, 40 km NW of Maffra township, *J. Piggin s.n.*, May 1976 (CANB 602968); Snowfields: Mount Hotham area, *S.J. Forbes 410 & L. Ahern*, 20 Nov 1979 (MEL 594573, NSW 567293); c. 6 km SE of Hotham village on the Omeo Rd, *M.G. Corrick 7138*, 25 Jan 1981 (MEL 596957, NSW 567294).

Distribution and habitat: *Bossiaea bracteosa* is endemic to the Australian Alps of north-eastern Victoria (between elevations of 1000 and 1600 m), occurring mainly in the Dargo – Hotham area and the headwaters of the Macalister River (Fig. 2). It has been recorded in shrubby Snow Gum woodland, on shallow soils derived from sedimentary or basalt material.

Conservation status: this species is regarded as rare in Victoria but not necessarily threatened (Department of Sustainability and Environment 2005). Many collections note that it is common and most populations are in conservation reserves.

Notes: *Bossiaea bracteosa* is distinguished from the species described below by its prominent leaf scales, which have cordate bases and distinct venation. It is similar to *B. bombayensis* and *B. grayi* in having calyces with approximately equal lobes, persistent floral bracts and short, obscure pedicels but differs from those species in its relatively short and broad distal cladodes.

2. *Bossiaea bombayensis* K.L.McDougall, sp. nov.

B. bracteosae *F. Muell. ex Benth. affinis sed squamis foliorum brevioribus, cladodiis angustioribus, floribus et fructibus minoribus differt.*

Type: New South Wales: Southern Tablelands: Shoalhaven River, Bombay, 9 km W of Braidwood, *K.L. McDougall 1325* & *C.L. McDougall*, 10 Oct 2008; holo. NSW 777997; iso. CANB 778404, MEL 2312599.

Wiry shrub to 1 (–1.5) m high. *Cladodes* flattened, winged, glabrous apart from minute hairs in the axils of the scale leaves and scattered hairs 0.2–0.5 mm long on new growth, becoming round or oval in cross-section; reproductive branches of cladodes sub-flexuose, dark green (predominantly red when young), 2.3–4.5 mm wide, winged, not becoming incised at the nodes. *Leaf scales* 0.7–1.2 mm long, dark brown, glabrous apart from marginal cilia. *Flowers* solitary at the nodes; pedicels 1.5–2.5 mm long, glabrous, obscured by floral bracts. *Floral bracts* imbricate, dark brown to golden brown, mostly persistent, increasing in size from outer to inner, glabrous apart from marginal hairs, especially towards the apex, the largest of the persistent bracts 1.5–2 mm long with a broadly acute apex. *Bracteoles* caducous. *Calyx* glabrous apart from hairs on the margins and inner surface of the lobes apically (occasionally also on the outer surface of lobes), green with red spots, often heavily tinged with red abaxially, 4–5 mm long including the 5 ± equal, triangular lobes 0.9–1.4 mm long, c. 1 mm

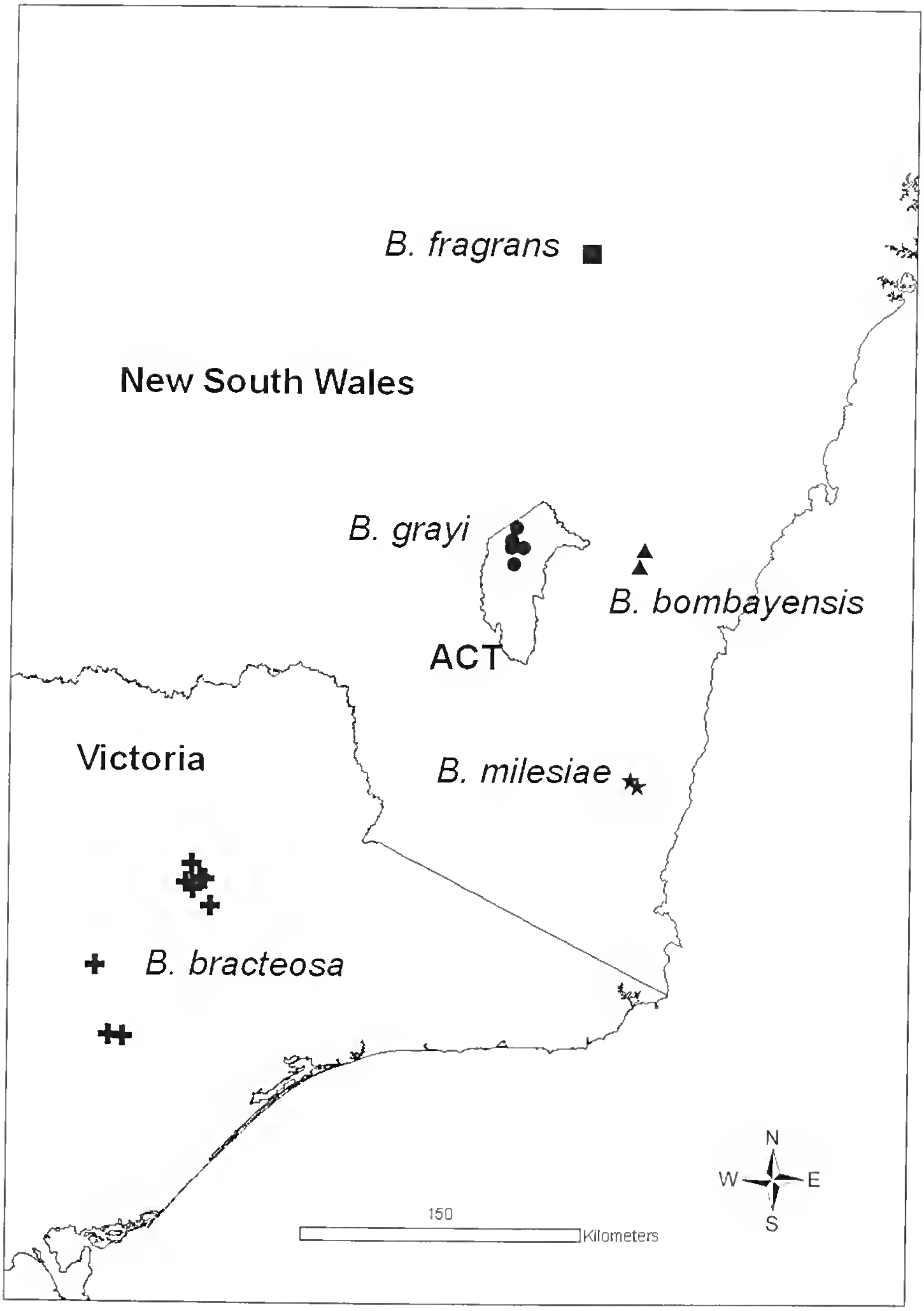

Fig. 2. Location of the five species of *Bossiaea* in south-eastern Australia.

wide, heavily tinged with red, often with golden brown tips. Corolla with standard 6.5–8 mm long including a claw 2–3 mm long, 9.5–11 mm wide, equal to or just exceeding other petals, deep yellow internally with red basal markings and faint red longitudinal striations radiating from the base to the edge of the lamina, predominantly deep red externally; wings 6.5–7.5 mm long including a claw 2.2–2.8 mm long, yellow, with red markings near base internally and externally, glabrous; keel 6.5–7.5 mm long including a claw 2.5–3 mm long, dark red with a pale base, glabrous. *Ovary* c. 5 mm long, 6–7(–8)-ovulate, glabrous; style 3.5–4 mm long. *Staminal filaments* 4–5 mm long, alternately red and colourless; sheath 3.5–4.5 mm long, colourless. *Pods* oblong, (1.4–)2–2.6 cm long, 0.4–0.6 cm wide, glabrous, red at first, ultimately dark green with thickened reddish-brown edges and red markings; stipe 1–2.5 mm long, obscured by remains of calyx. *Seeds* elliptic to subreniform, 2.3–2.5 mm long, 1.3–1.5 mm wide, pale brown with dark mottles (Fig. 3).

Flowering: September–October. Fruits dehisce: by mid-December.

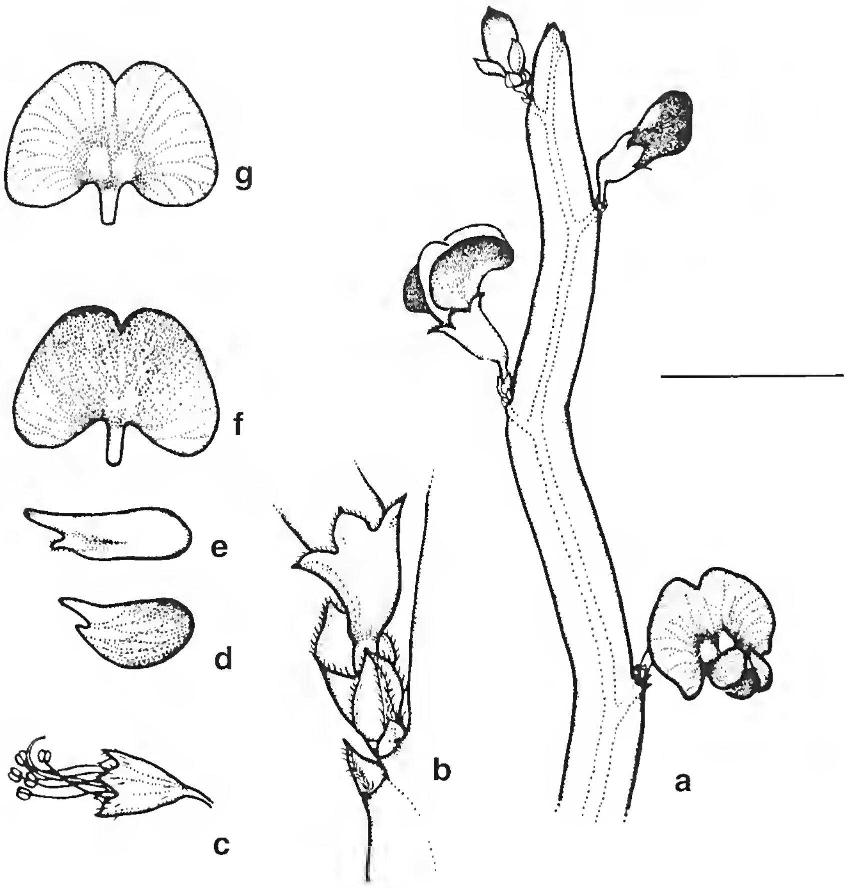

Fig. 3. *Bossiaea bombayensis.* **a,** cladode; **b,** floral bracts; **c,** calyx, stamens and style; **d,** keel; **e,** wing; **f,** standard (adaxial); **g,** standard (abaxial) (*K.L. McDougall 1200*). Scale bar: a, c–g = 10 mm; b = 15 mm.

Selected specimens examined: New South Wales: Southern Tablelands: Shoalhaven River, west of Braidwood, *R.H. Cambage s.n.*, 30 Oct 1908 (NSW 44157); Shoalhaven River, Warri Bridge, 13 km NNW of Braidwood, *M.D. Crisp 7724* & *I.R. Telford*, 14 Feb 1986 (CBG 8600454); Crown Reserve, Shoalhaven River, Bombay west of Braidwood, *K.L. McDougall 855*, 11 Oct 2000 (MEL 2097557); Shoalhaven River, Little Bombay, *K.L. McDougall 1198*, 21 Sep 2006 (NSW).

Distribution and habitat: *Bossiaea bombayensis* grows in a steeply incised valley of the Shoalhaven River, near Braidwood on the Southern Tablelands (Fig. 2). It is mainly found on sandy, rocky slopes and terraces above the frequent flood line in a shrubland of *Callitris endlicheri*, *Grevillea arenaria*, *Lomandra longifolia*, *Micrantheum hexandrum*, *Pomaderris andromedifolia* and *Leptospermum polygalifolium*. *Bossiaea bombayensis* rarely extends into dry sclerophyll woodland (comprising *Eucalyptus mannifera*, *E. rubida* and *E. dives*) on upper slopes above the river. Recruitment appears to be continuous as there is a range of plant sizes including seedlings. There have been no fires in this part of the Shoalhaven River valley in recent times so the species is not reliant on fire for regeneration. Scarification and dispersal of seed by floodwater may be important in the survival and spread of *B. bombayensis*.

Conservation status: although locally abundant, this species is restricted to a narrow, riparian corridor of about 12 km on the Shoalhaven River between Bombay and Warri, west of Braidwood. Competitive weeds (especially *Cytisus scoparius*, *Salix* spp. and *Rubus* spp.) are common and a significant threat to *Bossiaea bombayensis* and other native species along this section of river.

Etymology: *Bossiaea bombayensis* is named after the location in which most of the population is found. The Shoalhaven River at Bombay is a significant place of recreation for people of the Braidwood area and an important refuge for native flora and fauna within a largely cleared landscape.

Notes: *Bossiaea bombayensis* is distinguished from *B. fragrans* and *B. milesiae* by its equal to almost equal calyx lobes, from *B. bracteosa* by its much shorter, truncate leaf scales, and from *B. grayi* by its narrow, dark green cladode branches, smaller flowers and pods, alternating red and colourless staminal filaments, and general reddish appearance (of its flowers, new growth, calyx and pods).

3. *Bossiaea grayi* K.L.McDougall, sp. nov.

B. bracteosae *F. Muell. ex Benth. affinis sed squamis foliorum brevioribus et cladodiis angustioribus cinereis differt.*

Type: Australian Capital Territory: Murrumbidgee River, 1 km downstream from Kambah Pool, *I.R. Telford 8553*, Sep 1980; holo. CBG 8007070; iso. BISH 599975, MEL 641512, NSW 567291.

Erect shrub to 1.5 m high. *Cladodes* flattened, winged, glabrous apart from minute hairs in the axils of the scale leaves and scattered hairs on new growth, becoming round or oval in cross-section; reproductive branches of cladodes grey-green, linear, (3–)4–6 mm wide, winged, not becoming incised at the nodes. *Leaf scales* 1–2.2 mm long, dark brown, glabrous apart from marginal cilia. *Flowers* solitary at the nodes; pedicels 1–2 mm long, glabrous, obscured by floral bracts. *Floral bracts* imbricate, dark brown, mostly persistent, increasing in size from outer to inner, glabrous apart from marginal hairs, especially towards the apex, the largest of the persistent bracts c. 2.5 mm long with a broadly acute apex (often lacerated). *Bracteoles* caducous. *Calyx* glabrous apart from hairs on the margins and inner surface of the lobes apically, green, 5–6.5 mm long; lobes triangular, ± equal, 1.5–2.5 mm long, 1.2–1.5 mm wide, sometimes tinged with red. Corolla with standard 9.5–11 mm long including a claw 3–3.5 mm long, 11–12.5 mm wide, exceeding other petals, deep yellow internally with red basal markings and faint red longitudinal striations radiating from the base to the edge of the lamina, suffused with red externally; wings 9–10 mm long including a claw 3–3.5 mm long, yellow, with red markings near base, glabrous; keel 9–10 mm long including a claw 3–3.5 mm long, dark red, glabrous. *Ovary* 5–6.5 mm long, 6-ovulate, glabrous; style c. 4.5 mm long. *Staminal filaments* 3.5–4 mm long, tinged with red; sheath 4–5 mm long, mostly colourless. *Pods* oblong, 2–2.9 cm long, 0.6–1 cm wide, glabrous, dark reddish brown when mature; stipe 2.4–3.7 mm long. *Seeds* 2.8–3 mm long, 1.7–1.8 mm wide, tan to dark brown (Fig. 1).

Flowering: September–October. Fruit dehisces: December.

Selected specimens examined: Australian Capital Territory: Murrumbidgee and Cotter junction, *R.H. Cambage s.n.*, 5 Nov 1911 (NSW 44156); Molonglo River, directly south of Lower Molonglo Sewage Treatment Plant, *N. Taws 310 & A. Scott*, 18 Dec 1993 (CBG 9316417, MEL 2086950); Murrumbidgee River, 1 km downstream from Kambah Pool, *I.R. Telford 8553*, Sep 1980 (MEL 641512); west bank of Paddys River, *A.V. Slee 3123 & J. Johnston*, 3 Mar 1991 (CANB404588); cultivated, Australian National Botanic Gardens (Origin: Cotter Pumping Station), *K.L. McDougall 1271*, 24 Sep 2007 (NSW).

Distribution and habitat: known only from the banks of the Murrumbidgee River and its tributaries in the Australian Capital Territory (Fig. 2). *Bossiaea grayi* grows in sand amongst boulders on river banks dominated by *Casuarina cunninghamiana* or occasionally in shrubland of rock outcrops close to the river.

Conservation status: although this species has been recorded from several locations in the A.C.T. and, according to herbarium label notes, was locally common at some, it could not be found at any of the sites during surveys in spring 2006 and 2007. All sites were severely burnt in January 2003. The regeneration of exotic species (e.g. *Rubus* spp., *Conium maculatum*, *Eragrostis curvula*) was prolific after the fires and may have hindered the recruitment of *B. grayi*. Three small populations have since been located (Luke Johnston, A.C.T. Department of Parks, Conservation and Lands & Paul Carmen, Australian National Botanic Gardens, pers. comm.).

Etymology: the species is named in honour of Max Gray, retired CSIRO taxonomist, co-author of the "Flora of the A.C.T." and an early collector of this species. During my career, Max has given me invaluable encouragement and inspiration. As a homophone, the name is also highly descriptive of the cladode colour and general appearance of *B. grayi*.

Notes: *Bossiaea grayi* is distinguished from *B. fragrans* and *B. milesiae* by its equal to almost equal calyx lobes, from *B. bracteosa* by its much shorter, truncate leaf scales, and from *B. bombayensis* by its broader, grey green cladode branches, larger flowers and pods, and red staminal filaments.

In cultivation in the Canberra Botanic Gardens, *Bossiaea grayi* suckers vigorously. This behaviour was not evident in the wild, perhaps because of the lack of soil (and opportunity for suckering) in the one natural population seen.

A specimen from the Snowy River, in eastern Victoria (*L. Hodge s.n.*, Nov 1957, MEL 1529684) may also be *B. grayi*. This specimen is small and has only one flower with equal to almost equal calyx lobes and a pale-coloured standard. In its dimensions of cladode width, leaf scale length and flower length it is at the lower end of the range for *B. grayi*. Its identification will await relocation of the population and collection of good fertile material.

4. ***Bossiaea fragrans*** K.L.McDougall, **sp. nov.**

B. bracteosae *F.Muell. ex Benth. affinis sed squamis foliorum brevioribus, pedicellis longioribus, lobis calycis inaequalibus et floribus saepe ultra unum per axillam differt.*

Type: New South Wales: Central Tablelands: Abercrombie Karst Conservation Area, *K.L. McDougall 1268*, 21 Sep 2007; holo. NSW 785656; iso. CANB 766110, MEL 2318267.

Erect shrub 1–2.5 m high. *Cladodes* flattened, winged, becoming round or oval in cross-section but retaining remnants of wings; reproductive branches of cladodes glaucous green, oblong-linear to narrowly oblanceolate or irregular, (6–)8–14 mm wide, winged, glabrous apart from minute hairs in the axils of the scale leaves, becoming incised at the nodes. *Leaf scales* 1.5–1.9 mm long, dark brown, glabrous apart from marginal cilia. *Flowers* 1(–6) per node; pedicels 2.5–3 mm long, glabrous, exceeding persistent floral bracts by 1–2 mm at anthesis. *Floral bracts* imbricate, narrowly ovate, increasing in size from outer to inner, the largest of the persistent bracts c. 1.5 mm long with an acute apex, glabrous apart from marginal hairs, especially towards the apex, chestnut brown, all but a few bracts caducous prior to anthesis. *Bracteoles* caducous but rarely one or both present at anthesis. *Calyx* glabrous apart from hairs on the margins and inner surface of the lobes apically, green, 4.5–5 mm long; lobes c. 1 mm long, the 2 upper lobes c. 1.5 mm wide, rounded-truncate with acute, diverging apices, the lower 3 triangular, c. 1 mm wide, with acute apices. Corolla with standard 10.5–12 mm long including a claw 3–4 mm long, 12.5–15 mm wide, exceeding other petals, yellow internally and heavily tinged with red externally, with red basal markings and red longitudinal striations radiating from the base to the edge of the lamina; wings 10–11 mm long including a claw 3–4 mm long, yellow, with red markings near base and occasionally extending to edge of lamina, glabrous; keel 10–11 mm long including a claw 3–4 mm long, dark red, glabrous. *Ovary* 5.5–6 mm long, 5–6-ovulate, glabrous; style 2.5–4 mm long. *Staminal filaments* 4–5 mm long, red; sheath 4–5 mm long, red. *Pods* oblong, 2.4–3.8 cm long, 0.8–1 cm wide, glabrous, dark green with reddish-brown markings when mature; stipe 2.5–3 mm long. *Seeds* elliptic to sub-reniform, 3.0–3.2 mm long, 1.8–2 mm wide, dark brown (Fig. 4).

Flowering: September–October. Fruits dehisce: by December.

Specimens examined: New South Wales: Central Tablelands: Abercrombie Caves, *E.F. Constable s.n.*, 24 Mar 1955 (NSW44119); Abercrombie Caves, east of Grove Creek, *K.L. McDougall 999 & D. Monahan*, 25 Oct 2001 (MEL 2210156); Abercrombie Caves, east of Grove Creek, *K.L. McDougall 1270*, 21 Sep 2007 (NSW 785652).

Distribution and habitat: known from two populations in Abercrombie Karst Conservation Area, south of Bathurst (Fig. 2). The species occurs in open White Box (*Eucalyptus albens*) woodland. Despite their occurrence near Abercrombie Caves, a limestone feature, the populations occur on slate and volcanic substrates. Seeds are heavily predated by insects and few pods have been found with fully developed seeds.

Conservation status: there are currently fewer than 20 plants known of this species. The populations are threatened by competition from the introduced grass Serrated Tussock (*Nassella trichotoma*) and grazing by goats.

Etymology: the epithet of this species refers to its fragrant flowers. This feature was very obvious when sample bags containing specimens were opened. Collections of other leafless Bossiaeas from the A.C.T. and N.S.W. that I have made have not displayed this attribute. The diagnostic value of this character is uncertain but the fragrance of the *B. fragrans* collections was very strong and pleasant.

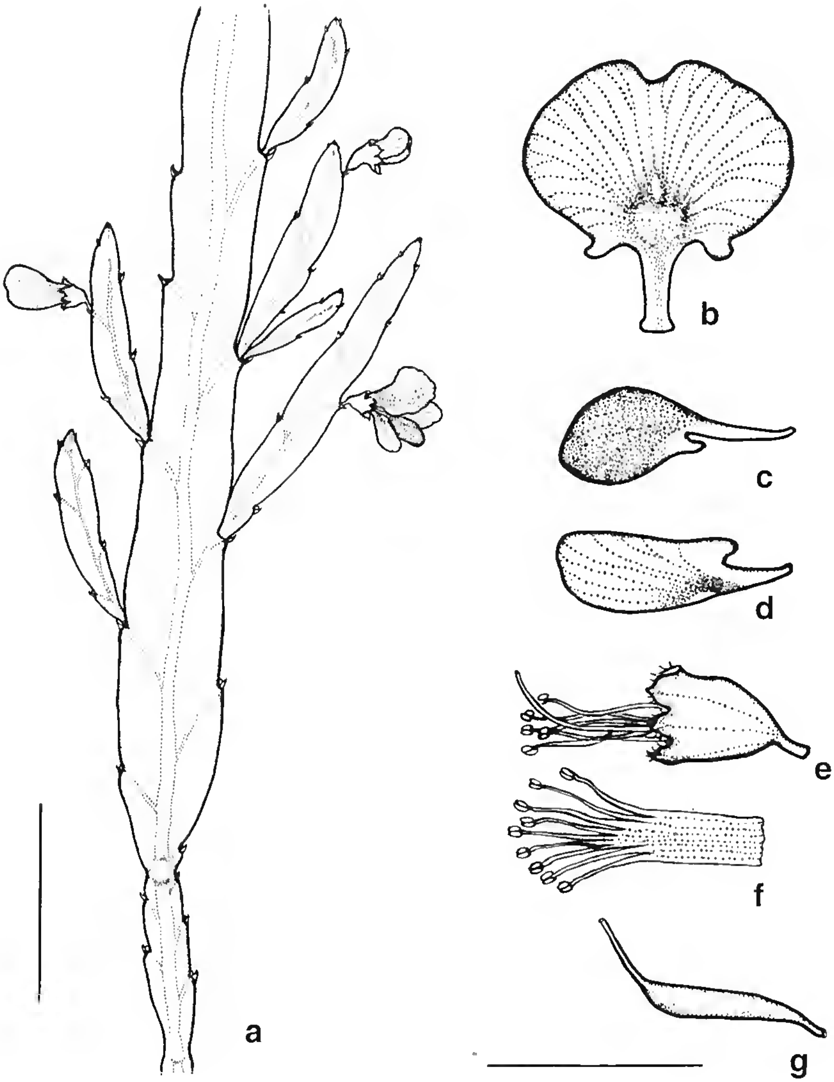

Fig. 4. *Bossiaea fragrans*. **a**, cladodes; **b**, standard; **c**, keel; **d**, wing; **e**, calyx, stamens and style; **f**, staminal filaments and sheath; **g**, ovary (*K.L. McDougall 1268*). Scale bar: a = 20 mm; b–g = 10 mm.

Notes: of the five taxa described in this paper, *Bossiaea fragrans* is most similar to *B. milesiae* in having asymmetrical lobes, longer pedicels and largely caducous floral bracts. It differs from *B. milesiae* in its broader, glaucous cladode branches, longer corollas and darker coloured standards. The two species also occupy very different habitat.

One collecton of *B. fragrans* (*K.L. McDougall 1270*), made in 2007 from a population containing a single plant, has as many as six flowers per node. Some flowers of this collection are also irregular (e.g. with two ovaries and corollas per calyx, with four wings or with a wing fused to the calyx). Collections in the same year from plants of a second, larger population, however, had only 1 or 2 flowers per node. Type material (*K.L. McDougall 1268*) for this species was taken from the second population.

The collection by Constable (NSW 44119) describes plants as being 1.8–2.8 m in height. The tallest extant plant is about 1.3 m tall while most are less than 1 m in height.

5. *Bossiaea milesiae* K.L.McDougall, **sp. nov.**

B. bracteosae *F. Muell. ex Benth. affinis sed squamis foliorum brevioribus, pedicellis longioribus, floribus majoribus saepe luteis et lobis calycis inaequalibus differt.*

Type: New South Wales: South Coast: Brogo River, c. 25 km NNW of Bega (c. 1 km downstream from Brogo Dam), *K.L. McDougall 1193, J. Miles & P. Jeuch*, 12 Sep 2006; holo. NSW 785654; iso. CANB 766111, MEL 2318264.

Shrub to 2 m high. *Cladodes* flattened, winged, glabrous apart from minute hairs in the axils of the scale leaves (and scattered hairs on new growth), becoming round or oval in cross-section; reproductive branches of cladodes light green, oblong-linear to narrowly oblanceolate, 4–8(–10) mm wide, winged, not becoming incised at the nodes. *Leaf scales* 1.2–1.8 mm long, glabrous, dark brown apart from marginal cilia. *Flowers* 1(–3) per node; pedicels 2.5–3 mm long, glabrous, exceeding persistent floral bracts by 1–2 mm. *Floral bracts* imbricate, narrowly ovate, increasing in size from outer to inner, the largest of the persistent bracts c. 1.5 mm long with an acute apex, glabrous apart from marginal hairs, especially towards the apex, chestnut brown, all but a few of the bracts caducous prior to anthesis. *Bracteoles* caducous. *Calyx* glabrous apart from hairs on the margins and inner surface of the lobes apically, bright green, 4.5–5.3 mm long; lobes 1–1.2 mm long, the 2 upper lobes c. 1.5 mm wide, rounded-truncate with acute, diverging apices, the lower 3 triangular, c. 1 mm wide, with acute apices. Corolla with standard 9.5–11 mm long including a claw 3.5–4 mm long, c. 12 mm wide, exceeding other petals, deep yellow to apricot internally with red basal markings and distinct red longitudinal striations radiating from the base to the edge of the lamina, yellow to apricot externally; wings 8.5–10 mm long including a claw 2.5–3.5 mm long, yellow, with red markings near base internally, glabrous; keel 9–10 mm long including a claw 3–3.5 mm long, red with a pale base, glabrous. *Ovary* 5–5.5 mm long, 6–7-ovulate, glabrous; style 3.5–4 mm long. *Staminal filaments* 3.5–4.5 mm long, red towards the stamens; sheath 4–5 mm long, colourless. *Pods* oblong, 2.7–3.5 cm long, 0.7–0.9 cm wide, glabrous, dark reddish-brown when mature; stipe 3–4.7 mm long. *Seeds* elliptic to subreniform, 2.5–3.5 mm long, 2–2.5 mm wide, tan (Fig. 5).

Flowering: August–September. Fruits dehisce: December–January.

Selected specimens examined: New South Wales: South Coast: Lower banks of Brogo River, 0.5 km downstream from wall of Brogo Dam, *J. Miles s.n.*, 9 Sep 1997 (MEL 2040660); upper end of Brogo Dam on banks of Brogo River, *J. Miles s.n.*, 29 Dec 2001 (MEL 2114662).

Distribution and habitat: *Bossiaea milesiae* appears to be confined to the Brogo River catchment near Bega (South Coast) in the vicinity of Brogo Dam (Fig. 2). It is locally abundant in riparian vegetation at the break of slope above the river and, in places, in the rocky and sandy river beds. Associated species include *Acacia mearnsii*, *Allocasuarina littoralis*, *Angophora floribunda*, *Bursaria spinosa*, *Eucalyptus viminalis*, *Eucalyptus tereticornis*, *Imperata cylindrica*, *Lomandra longifolia* and *Tristaniopsis laurina* (Jackie Miles, pers. comm.).

Conservation status: rare but not obviously threatened at present. Locally abundant.

Etymology: *Bossiaea milesiae* is named after Jackie Miles, a botanist from Brogo, who alerted me to this species. Jackie has made numerous collections from south-eastern N.S.W. and contributed greatly to knowledge about rare and threatened plants in this region.

Notes: *Bossiaea milesiae* differs from *B. bombayensis*, *B. bracteosa* and *B. grayi* in having unequal calyx lobes. From *Bossiaea fragrans* it is distinguished by it narrower, green cladode branches, shorter corollas and the absence of red markings on the outer surface of the standard.

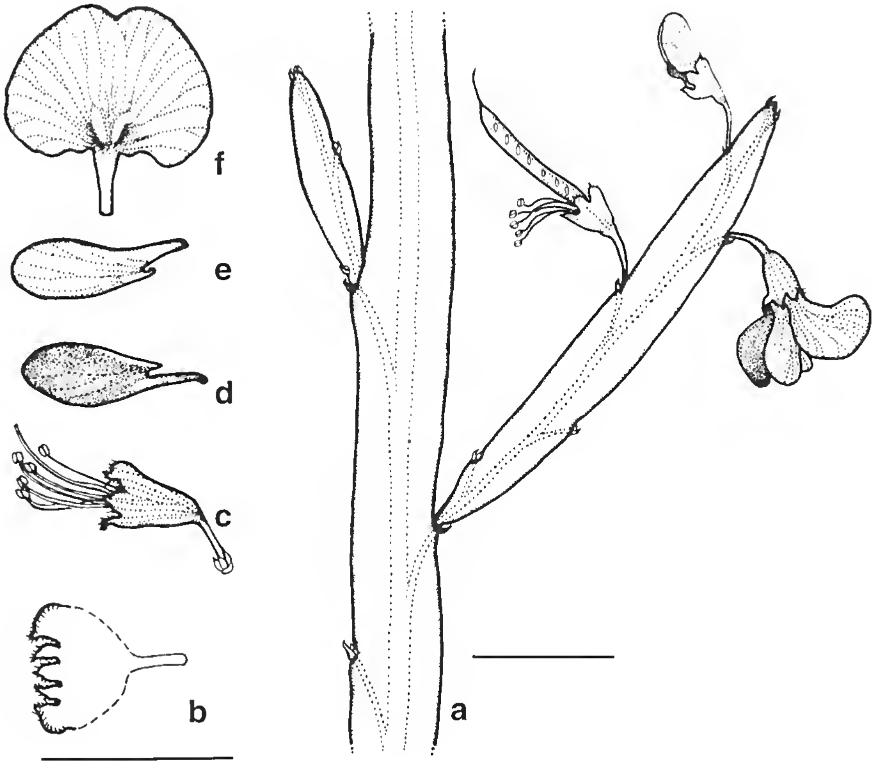

Fig. 5. *Bossiaea milesiae*. **a,** cladode; **b,** calyx (opened); **c,** calyx, stamens and style; **d,** keel; **e,** wing; **f,** standard (*K.L. McDougall 1194*). Scale bar: a = 10 mm; b–f = 10 mm.

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A new genus *Austrohondaella* (Bryopsida, Hypnaceae) from Australasia

Zen Iwatsuki[1], H. P. Ramsay[2] and A. J. Fife[3]

[1] *The Hattori Botanical Laboratory, Okazaki Branch, 10–3 Mutsuna-shin-machi, Okazaki-shi, Aichi-ken 444–0846, Japan.*
[2] *National Herbarium of New South Wales, Royal Botanic Gardens, Sydney 2000 NSW Australia.*
[3] *Manaaki Whenua - Landcare Research, P.O. Box 40, Lincoln 7640, New Zealand.*
Author for correspondence: hpramsay@ozemail.com.au

Abstract

The taxonomic position of *Isopterygium limatum* (Hook.f. & Wilson) Broth. has been re-evaluated. Some morphological characters, such as cylindric capsules, conic and non-rostrate opercula, well-differentiated annuli, pseudoparaphyllia shape, and axillary, papillose rhizoids suggest that the species should be excluded from the genus *Isopterygium*. A new genus, *Austrohondaella* Z.Iwats., H.P.Ramsay & Fife is therefore described here for *Isopterygium limatum*. This new genus should be classified in the family Hypnaceae.

Introduction

During studies on the genus *Isopterygium* for the floras of Australia and of New Zealand, it was noted separately by Fife and Iwatsuki that certain characteristics such as the erect capsule and operculum form, presence of an annulus, form of pseudoparaphyllia, and axillary and papillose rhizoids in *Isopterygium limatum* were not characteristic of the genus *Isopterygium* as outlined by Iwatsuki (1970, 1987) and Iwatsuki and Ramsay (2009). The common morphological features such as lanceolate leaves with a usually entire leaf margin, papillose axillary rhizoids and a differentiated annulus suggest that it might be a species of *Isopterygiopsis* (Fife in Seppelt 2004: 186). However, other features of *I. limatum* such as its erect capsules, bluntly conic opercula, narrowly foliose pseudoparaphyllia, etc are not consistent with this suggestion.

Sporophytic characters of *I. limatum* are quite different from those of both *Isopterygium tenerum*, the lectotype species for the genus *Isopterygium*, and *I. albescens* which is widely distributed in Australasia, eastern Asia and Oceania. In the genus *Isopterygium*, erect and almost symmetrical capsules occur only in *I. limatum*. However, erect symmetrical capsules are not rare in Hypnaceae; for example, some species of *Hondaella, Platygyrium, Pylasia*. Species of *Isopterygium* s.s., including *I. albescens* and *I. tenerum*, lack a differentiated annulus and have apiculate or obliquely short-rostrate opercula while *I. limatum* has both a well differentiated and deciduous annulus of 2 or 3 rows of cells and a bluntly conic operculum.

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Some gametophytic characters of *Isopterygium limatum* are also clearly anomalous in the genus *Isopterygium*, according to the criteria set out by Iwatsuki (1987) and cited in Ireland (1991). Species of *Isopterygium* have filamentous pseudoparaphyllia, while *I. limatum* has narrowly foliose pseudoparaphyllia, similar to those of species of *Ectropothecium*. The leaves of *I. limatum* are characteristically strongly secund giving the species something of the appearance of *Hypnum*, while those of *Isopterygium* are usually more or less complanate, erect spreading or only moderately secund. Rhizoids commonly arise on stems between leaf insertions and are smooth in most species of *Isopterygium* whereas they are axillary and papillose in *I. limatum*. These differences are significant enough to require a new genus for this interesting moss, and we propose the name *Austrohondaella*.

The new monotypic genus *Austrohondaella* shares some common characters with *Hondaella*, a genus of Hypnaceae recorded from eastern Asia (Japan, China, Korea, Laos, Myanmar, Thailand, and Russia). Illustrations of the type species of *Hondaella, H. aulacophylla* Dixon & Sakurai (= *H. brachytheciella* (Broth. & Paris) Ando) are available in Sakurai (1938) and Noguchi (1994). Species of *Hondaella* and *Austrohondaella* have erect capsules, similar leaf shape, entire leaf apices, hypnaceous peristomes, etc. However, the pseudoparaphyllia of *Hondaella* are much larger, and wider, than those of *Austrohondaella*. Moreover, the annulus is not differentiated, and leaves are truncate at the base in *Hondaella*.

Austrohondaella Z.Iwats., H.P.Ramsay & Fife, **gen. nov.; fam. Hypnacearum**

Plantae mediocres dioicae; caulis prostratus; stratum corticale e cellulis incrassatis compositum; rhizoidea papillosa axillariaque; folia anguste ovato-lanceolata; nervis binis brevissimus; pseudoparaphyllia anguste foliosa; alae foliorum non decurrentes; cellulae foliorum angustissime prosenchymaticae; thecae ovoideae; annulus distinctus; operculum conicum.

Type species: *Hypnum limatum* Hook.f. & Wilson, *Fl. Antarct. 2* (Suppl.): 545 (1847); *Isopterygium limatum* (Hook.f. & Wilson) Broth., *Nat. Pflanzenfam.* 1(3): 1080 (1908).

Etymology: the generic name reflects the morphological similarities to the Asian genus *Hondaella* and the Australian/New Zealand distribution of the type species.

Plants dioicous. Stems creeping, irregularly branched, epidermal cells small and more or less thick-walled in cross-section; pseudoparaphyllia narrowly foliose, base 2 or 3 cells wide. Rhizoids axillary, red, papillose. Leaves narrowly lanceolate, often falcate to falcate-secund, base rounded, not decurrent; upper portion of leaf gradually narrowed to piliferous apex; costa weak and short, often absent; cells in median portion of lamina linear to subvermicular; basal cells shorter. Perichaetia lateral on stems; perichaetial leaves lanceolate, entire, ecostate with apex narrowly acute. Setae long exserted; capsules cylindrical, erect, mostly symmetrical, sometimes slightly asymmetrical; operculum bluntly conic, apex obtuse; annulus well developed; peristome teeth hypnaceous.

Austrohondaella limata (Hook.f. & Wilson) Z.Iwats., H.P.Ramsay & Fife, **comb. nov.**

Hypnum limatum Hook.f. & Wilson, *Fl. Antarct.* 2 (Suppl.): 545 (1847). Type: Campbell's Island, Antarct. Exp. 1839–1843, *J. D. Hooker*; holotype BM (*n.v.*); isotype: NY. *Isopterygium limatum* (Hook.f. & Wilson) Broth., *Nat. Pflanzen.* 1(3): 1080 (1908).

Hypnum terrae-novae Brid. var. *australe* Hook.f. & Wilson, *Fl. Antarct.* 1: 142 (1845).

Ectropothecium australe (Hook.f. & Wilson) A.Jaeger, *Ber. S. Gall. Naturw. Ges.* 1877–78: 260 (1880) *nom. illeg. incl. spec. prior.*

Leskea amblyocarpa Hampe, *Linnaea* 30: 638 (1860). Type: Victoria, Apollo Bay, *F. Mueller 50*; holotype: BM. *Isopterygium amblyocarpum* (Hampe) Broth., *Nat. Pflanzenfam.* 1(3): 1080 (1908). syn. nov.

Isopterygium acuminatum Bosw., *J. Bot.* 30: 99 (1892). Type: Tasmania, Glen Rae, 1891, *W.A. Weymouth* [555]; holotype: HO 73037; isotype: NY. *syn. nov.*

Illustrations: Hooker (1847, Plate LXI, fig. IV, as *Hypnum terrae-novae*); Sainsbury (1955, Plate 74, fig 3, as *Isopterygium limatum*); Seppelt (2004, fig. 74, as *Isopterygium limatum*).

Plants dioicous, yellow or golden-green, glossy, forming dense mats. Stems creeping, 1–2 cm long, irregularly branched; branches short, usually up to 5 mm long. Cross-sections of stem round to more or less triangular, 0.1–0.2 mm in diam., epidermal cells small and more or less thick-walled, central strand present but often weak. Pseudoparaphyllia narrowly foliose, 2–4 cells wide at base. Rhizoids axillary, restricted to lower stems near base of branches, red, papillose. Leaves narrowly lanceolate to ovate-lanceolate, secund and usually falcate, 1.0–1.5(–1.8) mm long, 0.25–0.75 mm wide at base, base rounded, not decurrent, slightly concave; upper portion of leaf tapering evenly, narrowed to acuminate to piliferous apices; costa weak and double or often absent; margin entire; cells in median portion of lamina linear to subvermicular, 60–120 µm long, 5–8 µm wide, narrow at both ends, moderately thick-walled, not porose; cells at base of leaves wider and shorter, becoming porose; alar cells not differentiated. Propagules, when present, axillary and filamentous or ± fusiform.

Perichaetia lateral on stems; perichaetial leaves lanceolate, narrowly acute at apices, to 1.7 mm long, 0.38 mm wide; ecostate, entire; laminal cells elongate and moderately thick-walled. Calyptra large, cucullate, c. 3 mm long. Setae 1.0–1.5 cm long, reddish brown. Capsules cylindrical, erect, often slightly to clearly asymmetrical, urn about 2 mm long; operculum bluntly conic; annulus well developed, deciduous; exothecial cells rectangular, 25–50 µm long, c. 20 µm wide, moderately thin-walled. Peristome double, hypnaceous; outer teeth c. 1mm long; endostome segments a little shorter than outer teeth; cilia 1 or 2, nodose, equal to the segments or rudimentary. Spores spherical, 10–18 µm in diam., smooth. No chromosome number recorded. Figs 1–4.

Distribution: Australia (New South Wales (alpine), Victoria, Tasmania and Macquarie Is) and New Zealand (North, South, Stewart, Auckland and Campbell Is.). In Australia *Austrohondaella* occurs in scattered pure and dense mats on dolerite karst and also on basalt where it is found on moist exposed rock faces and in crevices. Also, it is occasionally epiphytic on semi-shaded tree trunks (e.g. *Acacia*, *Pomaderris* and tree ferns) and on fallen logs in disturbed *Nothofagus* or wet sclerophyll forest. On the mainland it occurs from 80–1700 m, while on the island of Tasmania is recorded from 20–1000 m. In New Zealand it occurs in scattered or dense mats primarily on mesic or rather dry rock, but in the northern and southern portions of its range it also occurs on tree trunks. It is best developed in montane to alpine vegetation. *Austrohondaella limata* occurs on a wide range of rock types but is most frequent on limestone and marble; it occurs less frequently on greywacke, basalt, conglomerate, granite, diorite and on humus. When epiphytic at the extremities of its range the host species include the gymnosperms *Prumnopitys taxifolia* and *Dacrydium cupressinum*, as well as

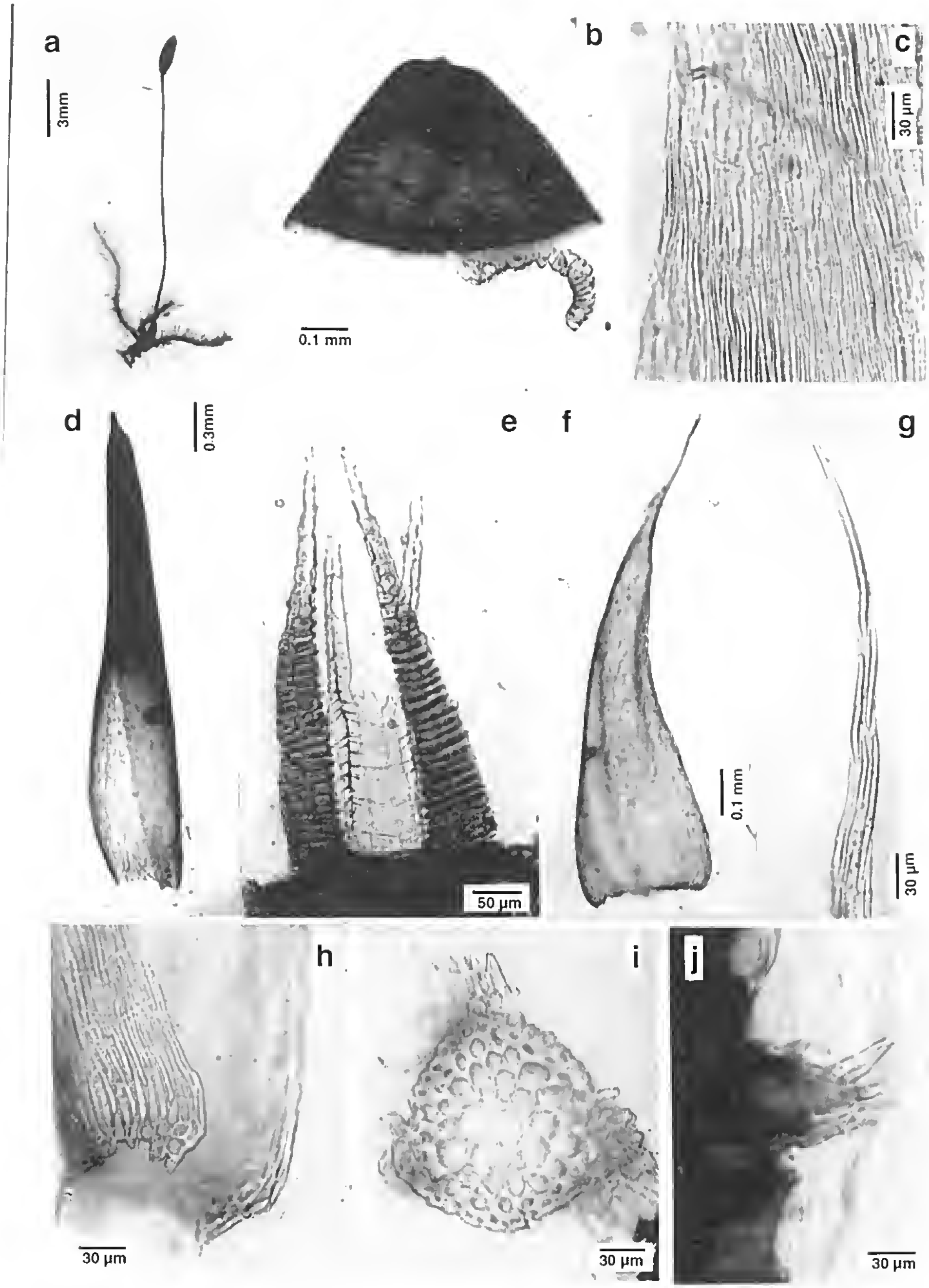

Fig. 1. *Austrohondaella limata.* a, type plant of *Hypnum limatum* with sporophyte; b, operculum with a part of annulus; **c**, median laminal cells of type; **d**, calyptra; **e**, peristome teeth and rudimentary cilia; **f**, a leaf; **g**, apex of leaf; **h**, cells at base of leaf; **i**, cross-section of stem; **j**, pseudoparaphyllia. (a, c, f, g, i and j from the isotype of *Hypnum limatum* in NY; b, d, e and h. from *H. Streimann 58986* in NICH; all photographs by Z. Iwatsuki).

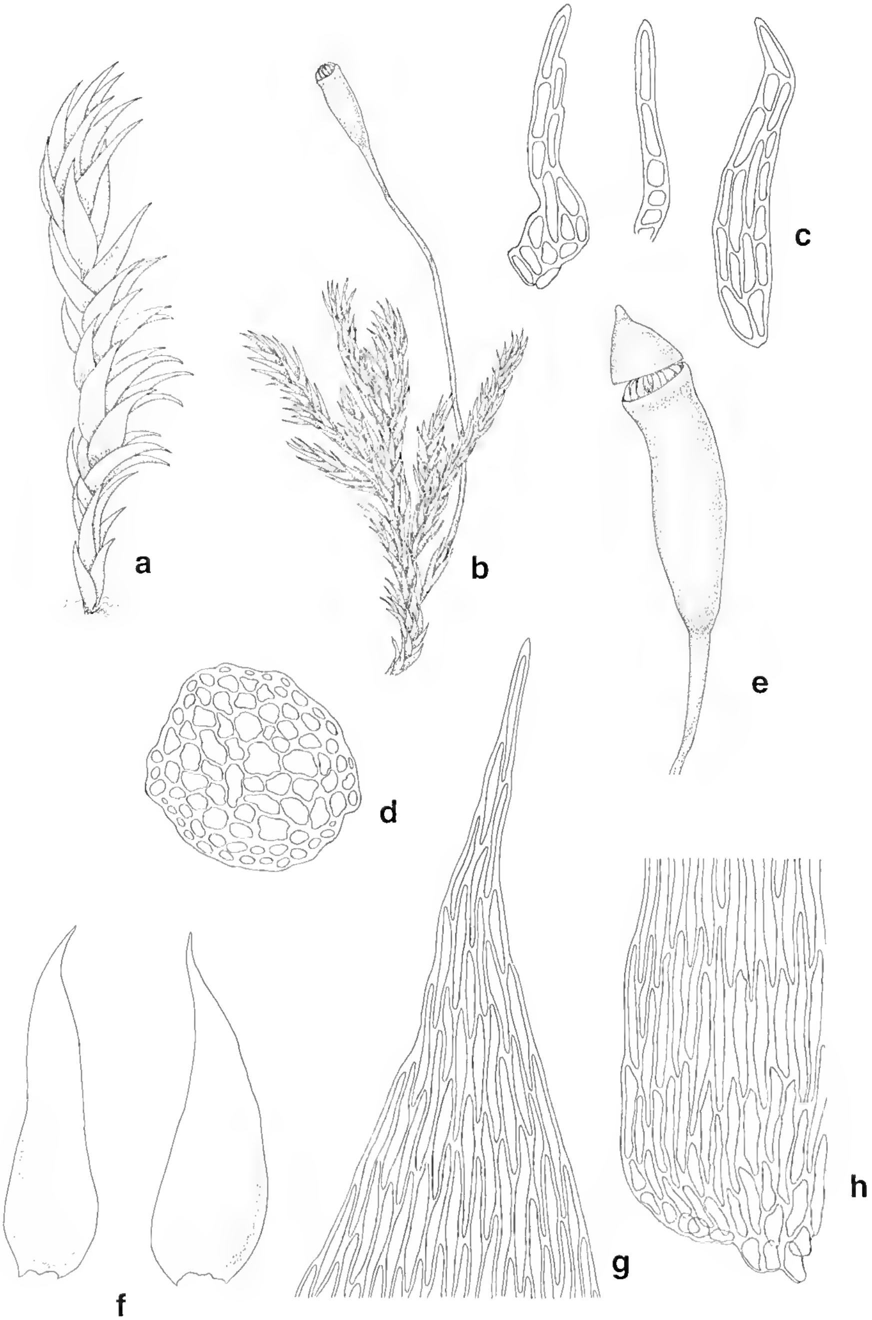

Fig. 2. *Austrohondaella limata.* **a,** sterile shoot; **b,** portion of fertile plant; **c,** pseudoparaphyllia; **d,** stem in cross section; **e,** moist capsule with operculum; **f,** stem leaves; **g,** apex of stem leaf; **h,** alar cells of stem leaf. (a, b, d–h from *J. Child 6212* ex Otago Peninsula, N.Z. (CHR 429281); c from *A.J. Fife 7546* ex Mt Arthur range (CHR 438862); drawn by Rebecca Wagstaff).

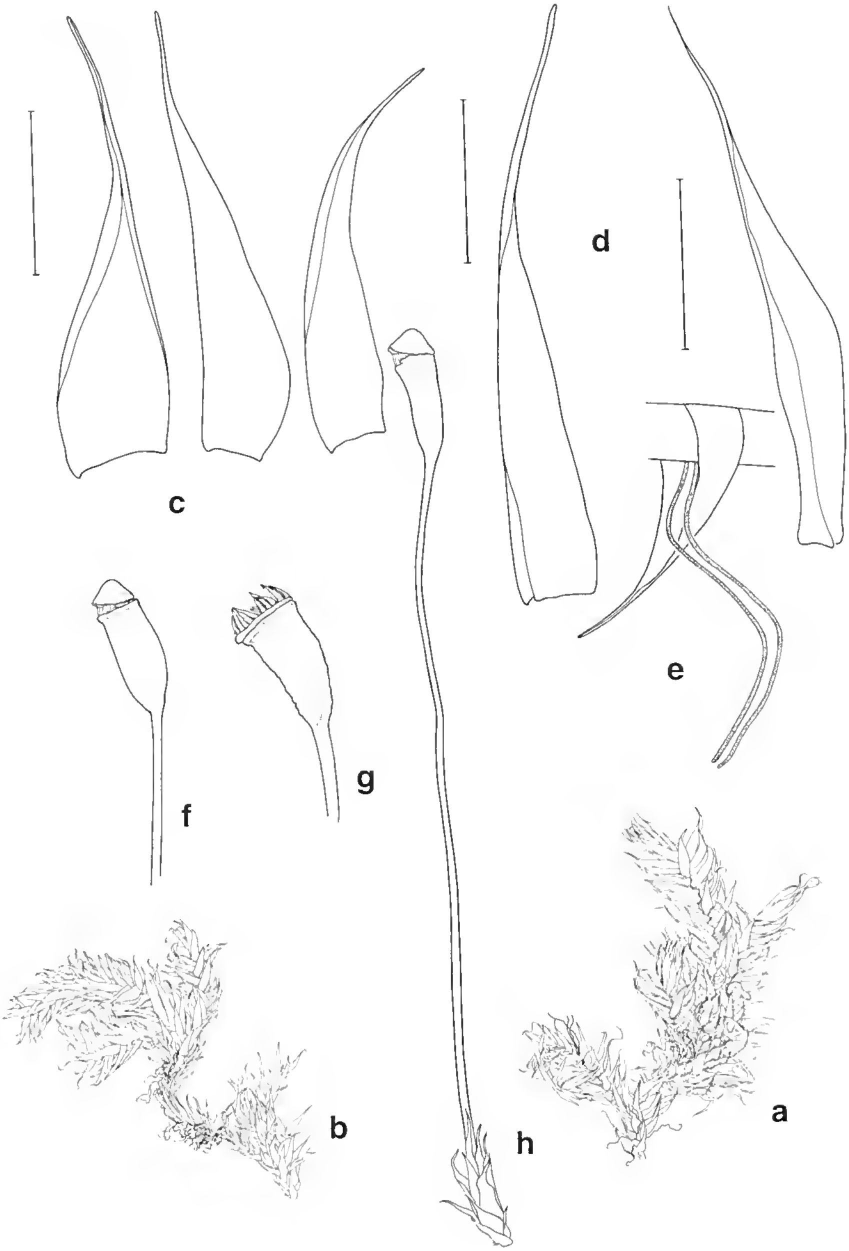

Fig. 3. Drawings of type specimens. **a,** habit of isotype of *Hypnum terrae-novae* var. *australe* (NY); **b,** habit of holotype of *Isopterygium acuminatum* (HO); **c,** branch leaves of *H. terrae-novae* var. *australe*; **d,** branch leaves of *I. acuminatum;* **e,** stem, leaf and axillary rhizoids; **f,** capsule with operculum of *H. terrae-novae* var. *australe;* **g,** capsule showing peristome of *H. terrae-novae* var. *australe* ; **h,** sporophyte showing perichaetial leaves and capsule of isotype of *I. limatum* (NY). (a, b, f, g, h drawn by C. Wardrop, c, d, e by H. Ramsay). Scale bars: 0.5 mm for leaves, 1mm for other drawings.

Beilschmiedia tawa, Carpodetus serratus, Melicytus macrophyllus and Myrsine australis. It is apparently more common on the South Island than the North Island and ranges from near sea level to c. 1650 m (but is common below c. 700 m only from Canterbury southward). Figs 5, 6.

In Scott and Stone (1976), Lewinsky suggested that *Isopterygium acuminatum* from Tasmania was merely a growth form of *Isopterygium limatum.* We have examined type material (Ramsay & Seur 1994) of *I. acuminatum* as well as many Tasmanian collections and we concur with Lewinsky's suggestion.

Fig. 4. *Austrohondaella limata* showing rhizoids in axil of lower stem leaf. (from *R.D. Seppelt 12897* in NICH; photograph by Z. Iwatsuki).

Fig 5. Australian distribution of *Austrohondaella limata.*

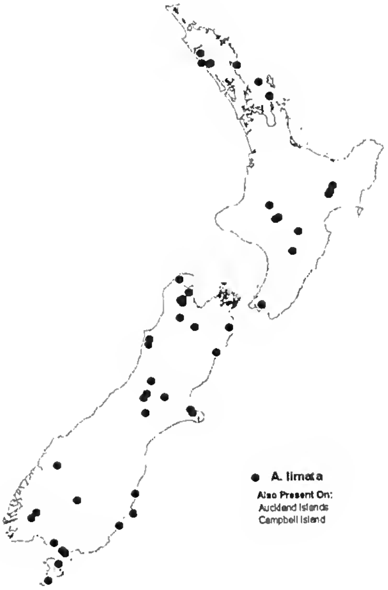

Fig. 6. New Zealand distribution of *Austrohondaella limata*.

Selected Specimens: Australia. New South Wales: Yarrangobilly Caves, *W.W. Watts 8822, 8823, 8807* (NSW). **Victoria:** Sabine Falls track, Angahook-Lorne state forest, 19 km NE of Apollo Bay, *H. Streimann 58986* (NICH, CANB); Bulga National Park, Lyrebird-Ash Tracks, *H. Streimann 51621* (NICH, CANB); Mt Cole State Forest, 27 km E of Ararat, *H. Streimann 54841* (CANB); Maits Rest, Ocean Road 10 km W of Apollo Bay, *H. Streimann 58644* (CANB). **Tasmania:** Williamsford - Montezuma Falls Track, *H. Streimann 59570A* (NICH, CANB, HO); North Dundas, *W.A. Weymouth 3037* (HO); Mt Rumney, *R.A. Bastow 199* (HO); Western Tiers, northern side of Projection Bluff, *R.D. Seppelt 12897* (NICH, HO); Lake Dobson Rd, Mt Field NP, *D.H. Vitt 29139 & H.P. Ramsay,* (CANB, HO); Pipelma track, Mt Wellington, *A.V. Ratkowsky H292* (CANB, HO); Roger River 6 km SW of Trowatta, *A. Moscal 10572* (CANB, HO). **Macquarie Island:** Green Gorge, *R.D. Seppelt 14306* (NICH, CHR 413613); Prion Lake, *R.D. Seppelt 011342* (NICH); Douglas Point, *R.D. Seppelt 12445* (NICH).

New Zealand: North Island: Maunganui Bluff, *A.J. Fife 10705* (CHR 570024); Coromandel Peninsula, Moehau, *L.B. Moore 254* (CHR 593700A, WELT M15107); Gisborne, Lake Waikaremoana, Panekiri Range, *G.O.K. Sainsbury s.n.*, 3 Mar 1940, (WELT M015126); Central Volcanic Plateau, Mt. Hauhungatahi, *J.K. Bartlett A11* (NICH); Tongariro National Park, southwest flank of Mt. Ruapehu, Blyth Hut track, *A.J. Fife 9803* (CHR 512033); NW Ruahine Range, Ohutu Ridge, *B.H. Macmillan 92/8* (CHR 482367). **South Island:** Mt. Burnett, near Collingwood, *A.J. Fife 11734* (CHR 581481); N.W. Nelson, Cobb Valley, *J.K. Bartlett A7* (NICH); N.W. Nelson, Arthur Range, Mt. Hoary Head, *J.K. Bartlett 19388* (NICH); Gouland Downs, Big River, *M.J.A. Simpson 7278* (CHR 106958); Mt Owen, Sanctuary Basin, *A.J. Fife 5061* (CHR 103645); Marlborough, Woodside Creek, *W. Martin 593* (CHR 587227); Canterbury, Arthurs Pass National Park, Bealey River Gorge, *V.O. Heinz 96/29 & B.H. Macmillan* (CHR 510127, NICH); Joyces Creek, tributary of Waimakariri River, *B.H. Macmillan 75/143* (CHR 264840); Westland, Kelly's Hill (=Kelly Range), *S. Berggren 2805* (NICH, WELT M1050); Otago, Otago

Peninsula, near Larnach's [Castle], *J. Child 6212* (CHR 429281, NICH); Dunedin, Tysons Wall, Leith Valley, *J. Child s.n.* (NICH 300228); Dunedin area, Swampy Summit, *W.B. Schofield 49995* (NICH); Akatore Stream, south of Dunedin, *K.W. Allison 1414* (CHR 577752); Tautuku Bay, Lake Wilkie, *W.B. Schofield 49432* (NICH); Southland, Garvie Mountains, above Lake Scott, *D. Glenny 6393* (CHR 509918); Bluff-Invercargill - Winton, *S. Berggren s.n.*, 1874 (NICH 278551). **Stewart Island.** Port Pegasus, *W. Martin 275.3* (CHR 577758); summit of Tin Range, *W. Martin 275.20* (CHR 593701). **Auckland Islands.** Auckland Island, Hanfield Inlet, *D.H. Vitt 10176* (CHR 448072). **Campbell Island.** Perseverance Harbour, *D.H. Vitt 2945* (CHR 577763).

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The genera *Isopterygium* Mitt. (*Bryopsida*, Hypnaceae) and *Isopterygiopsis* (Hedw.) Z.Iwats. (*Bryopsida*, Plagiotheciaceae) in Australia

Zen Iwatsuki[1] & Helen P. Ramsay[2]

[1] *The Hattori Botanical Laboratory, Okazaki Branch 10-3, Okazaki-shi, Aichi-ken 4440846, Japan*
[2]*National Herbarium of New South Wales, Royal Botanic Gardens, Sydney 2000 New South Wales, Australia*

Abstract

A revision of the genus *Isopterygium* in Australia has resulted in recognition of only one species, *I. albescens* in Australia. Of the other species listed for the genus in this country, *Isopterygium minutirameum*, *I. novae-valesiae* and a number of other recorded names have been placed into synonymy with *I. albescens*. *Isopterygium arachnoideum* and *I. subarachnoideum* have been transferred to *Isopterygiopsis pulchella*. The presence of *Isopterygiopsis pulchella* (Schimp.) Z.Iwats. in Australia (considered doubtful by Streimann & Klazenga 2002) is confirmed and the types for Australian species of *Isopterygium arachnoideum*, and *I. subarachnoideum* are placed into synonymy with it. *Isopterygium albescens* is considered to be a member of the family Hypnaceae while *Isopterygiopsis pulchella* is in the Plagiotheciaceae.

Pseudotaxiphyllum pohliicarpum (Hypnaceae) is recorded as a new species for Australia.

Introduction

Prior to Iwatzuki's studies (1970, 1987), the genus *Isopterygium* contained more species, was very heterogeneous and had been placed variously in the Hypnaceae or Plagiotheciaceae. Iwatsuki transferred various species into a number of new genera, e.g., *Pseudotaxiphyllum*, *Isopterygiopsis*, *Herzogiella*, and *Taxiphyllum*, most of which are now included in the family Hypnaceae. The diagnostic characters for these new genera are based on morphological criteria such as absence of pseudoparaphyllia, the location and surface of rhizoids, size and wall of epidermal and cortical stem cells, type of propagules and presence or absence of an annulus (see Iwatsuki 1970: table 3, p. 339; Iwatsuki 1987: fig 1, p. 446 & table 1, p. 450).

Isopterygium was included in the new family Pylasiadelphaceae created by a division of Sematophyllaceae s. l. by Goffinet and Buck (2004) in their recent interpretation of moss classification. As *Isopterygium* does not have a number of the characters that define the Pylasiadelphaceae, e.g., the alar cells enlarged and coloured and rostrate operculum, we do not agree with this placement and have returned *Isopterygium* to the family Hypnaceae.

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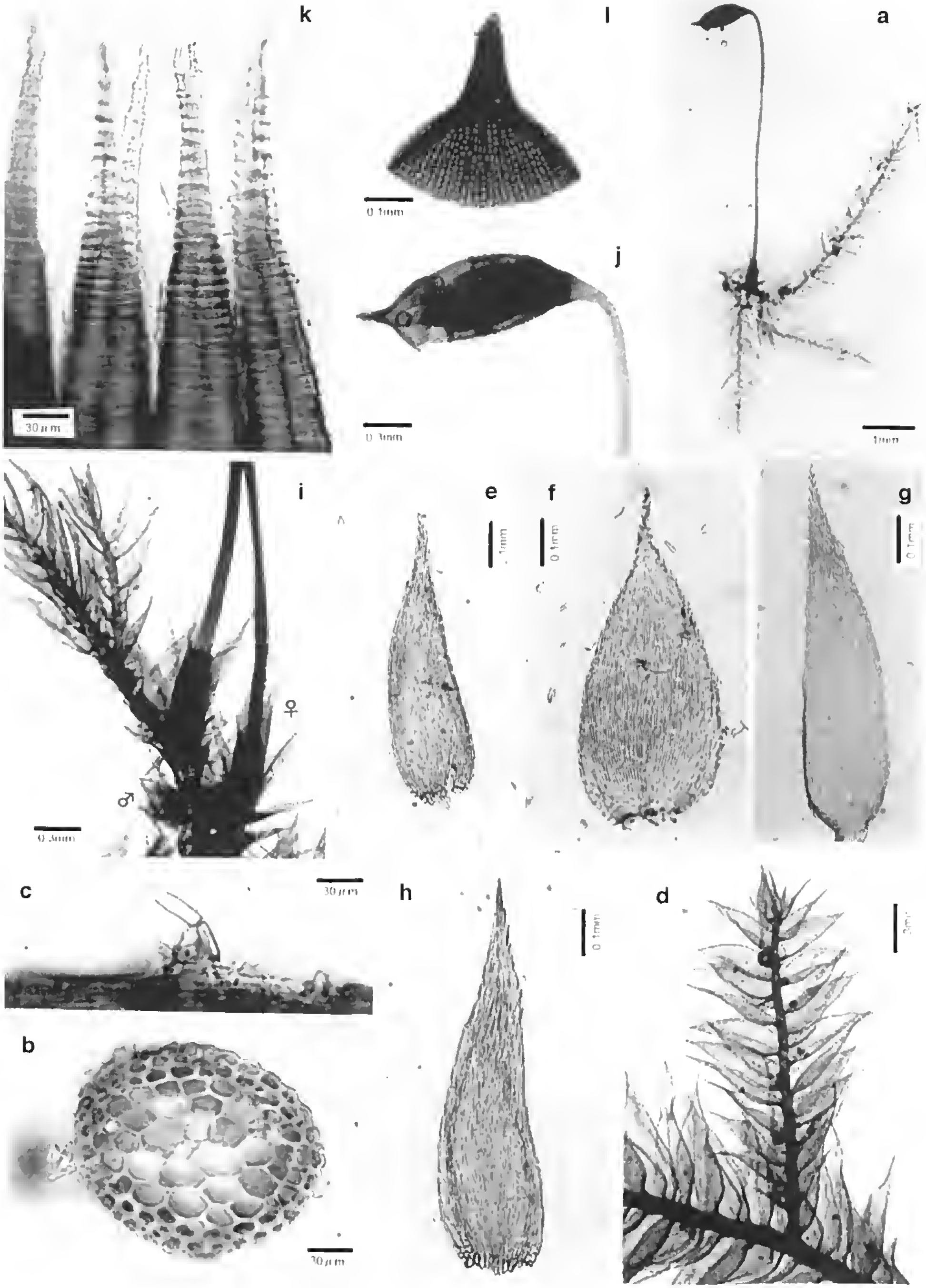

Fig. 1. *Isopterygium albescens*. **a,** plant with a sporophyte; **b,** cross-section of branch; **c,** filamentous pseudoparaphyllia; **d,** branch with leaves; **e–h,** variation of leaves; **i,** sporophytes; **j,** capsule with operculum; **k,** peristome teeth; **l,** operculum. (all figs based on Australian collections; a, j, k & l *Schafer-Verwimp 3862*, CANB; b–d, f *Brock 557*, CANB; g lectotype of *I. novaevalesiae*, *Watts 1902*, NSW; e, h, j *Streimann 45351*, CANB; photographs by Z. Iwatsuki).

The genus *Isopterygium* contains more than 200 taxa of which 11 names are recorded for Australia, including five endemics (Streimann & Klazenga 2002). Present studies have reduced the total species number in Australia for *Isopterygium* to one, and two of the previously listed endemic species known from types or only a few collections, have been determined as *Isopterygiopsis pulchella*.

The other recorded species, *Isopterygium limatum*, found in New Zealand (Fife 1985) and Australia (Streimann & Klazenga 2002), has been under investigation since it lacks the rostrate operculum, has a well-differentiated annulus, different pseudoparaphyllia, as well as characters such as axillary papillose rhizoids that are not present in *Isopterygium*. Based on studies of Australian, New Zealand and subantarctic (including Macquarie Island, Seppelt 2004) material, this taxon has been placed in a new genus *Austrohondaella* (Iwatsuki et al. 2009), which has been placed in the Hypnaceae. *Isopterygium acuminatum* and *I. amblyocarpum* are considered synonymous with it.

Isopterygium

Isopterygium Mitt., *J. Linn. Soc. Bot.* 12: 21 (1869).

Lectotype: *Hypnum tenerum* Sw. = *Isopterygium tenerum* (Sw.) Mitt. selected by Z. Iwatsuki & M. Crosby, *J. Hattori Bot. Lab.* 45: 389–393 (1979).

Etymology: from the Greek *isos* (equal), *pteryx* (wing like) and *ion* (diminutive suffix) in reference to the delicate wing like leaf arrangement.

Defining characters for the identification of *Isopterygium* (Iwatsuki 1987) include leaves ovate to ovate-lanceolate; leaf apices more or less serrulate; costa short and double or absent; rhizoids smooth, rarely scabrous, originating below and between leaf insertions not in leaf axils; epidermis of normal small cells, outer cortical stem cells small and thick-walled forming a sclerodermis, central strand lacking; propagules when present, filamentous or short; sporophytes almost uniform being hypnaceous (diplolepidous) but with absence of annulus, with non-collenchymatous exothecial cells and a short rostrate operculum Several filamentous pseudoparaphyllia are usually seen around a branch primordium in *Isopterygium*. When a branch primordium grows into a branch a few more or less triangular leaves develop first, occurring at the base of young branches, and primordia are also present on the main stems surrounding the triangular leaves.

Chromosome numbers, summarised here and obtained from Fritsch (1991) and Goldblatt and Johnson (1994, 1998, 2003) are available for several species of *Isopterygium* (North America, n = 11, 22, 12 (11+ m); Europe, n=12 (11+m),; Japan, n=11,12 ; India, n=11 (10+m), 12, 22, but none is available for Australian populations.

Isopterygium albescens (Hook.) A.Jaeger, *Ber. Thatigk. St. Gallischen Narwiss.* Ges. 1876–77: 433 (1878). *Hypnum albescens* Hook. in Schwägr., *Sp. Musc. Suppl.* 3(1): 226b,Tab. CCXXV1. b (1828).

Type: In regno Nepal Indiae lectum dedit Pr. Hooker.

Isopterygium latifolium Broth., *Oefv. Finsk. Vetensk. Soc.* 42:114 (1900), *syn. nov.* Type: Australia, New South Wales: Alstonville Road, Ballina, *W.W. Watts 211*, holotype: NSW; isotype: H-BR, MEL 59608).

Isopterygium howeanum Broth. & Watts, *Proc. Linn. Soc. New South Wales* 40: 380–381 (1915) , *syn. nov.* Type: Hillside, back of Johnsons, Lord Howe Island. *W.W. Watts 112,* 8.vii.1911 holotype: (NSW); isotype: (H-BR).

Hypnum candidum Müll.Hal., Linnaea 35: 624 (1868) , *syn. nov.* Type: Australia, New South Wales, Ash Island, Hunter River, *Mrs E. Ford* (MEL 59547). *Isopterygium candidum* (Müll.Hal.) A.Jaeger, *Ber. Thätigk. St. Gallischen Naturwiss. Ges.* 1876–77: 437 (1878) (Gen. Sp. Musc. 2:4503), fide J. H. Willis, *Victorian Naturalist* 71: 161 (1955).

Hypnum molliculum Sull., *Proc. American Academy of Arts and Sciences* 3:78 (1854). Type: Hawaii, Mauna Kea, *Wilkes* (BM). *Isopterygium molliculum* (Sull.) Mitt. in Seem., Fl. Vit. 399 (1873), fide Dixon *Proc. Linn. Soc. New South Wales* 55: 295 (1930).

Isopterygium sublatifolium Broth., *Proc. Linn. Soc. New South Wales* 43: 564 (1918), *nom. nud. in synon.*

Hypnum minutirameum Müll.Hal., *Syn. Musc. Frond.* 2: 689 (1851); *Bryol. Jav.* II, p. 191, Tab. 290 (1808), *syn. nov.* Type: Java: Blume, in Herb. Al. Braun, *syn. nov Isopterygium minutirameum* (Müll.Hal.) A.Jaeger, *Ber. Thätigk. St. Gallischen Naturwiss. Ges.* 1876–77: 434 (1878*). Taxiphyllum minutirameum* (Müll.Hal.) H.A.Mill. & D.R.Smith, *Micronesica* 4: 225 (1968).

Hypnum norfolkianum Müll.Hal., *Linnaea* 37: 160 (1872). Type: Norfolk Insula. Ferd. Muller mixed with *Rhacopilum convolutaceum.* holo: BM (Hampe); isotype: NY. *Isopterygium norfolkianum* (Müll.Hal.) A.Jaeger, *Ber. Thätigk. St. Gallischen Naturwiss. Ges.* 1876–77: 435 (1878), *fide* Streimann (2002), p.100–101.

Isopterygium baileyanum Müll. Hal. *ex* F.M. Bailey, *Syn. Queensland Fl.* Suppl. 2: 71 (1888). *nom. nud. in synon.* Based on: Qld: Kedron Brook and Port Curtis *F.M. Bailey* (BRI).

Isopterygium amoenum Broth., *Oefvers. Finska Vetensk. Soc. Foerh* 42: 112 (1900), *syn. nov.* Type: Australia, New South Wales: Richmond River, *W.W. Watts, n. 802, 888,* lectotype: HBR (*Watts 888*), isolectotype: NSW (*Watts 888*) [selected here]; syn: H-BR(*Watts 802),* isosyntypes: MEL, NSW (*Watts 802*).

Isopterygium neocaledonicum Thér., *Bull. Acad. Int. Géogr. Bot.* 19: 23 (1909), *syn. nov.* Type: New Caledonia, Rivière Carricouyé, *Franc* (BM).

Isopterygium viridepallens Müll.Hal. *ex* Burges, *Proc. Linn. Soc. New South Wales,* 60: 93 (1935). *nom. nud. in synon.* Based on: N.S.W. Gosford *W. Forsyth 442,* 19.ix.1891; Lane Cove *W. Forsyth 497,* National Park *W. Forsyth 492* (NSW).

Isopterygium minutirameum f. *brevifolium* M.Fleisch. *Die Musci der Flora von Buitenzorg* 4: 1427. 1923. *Taxiphyllum minutirameum* (Müll.Hal.) H.A.Mill. & D.R.Smith var. *brevifolium* (M.Fleisch.) H. Whittier, *Florida Scientist* 38: 103 (1975).

Hypnum austropusillum Müll.Hal., *Linnaea* 37: 159 (1872). Type: Qld: Brisbane River, *Dietrich.* (BRI). *Isopterygium austropusillum (*Müll.Hal.) A.Jaeger, *Ber. Thätigk. St. Gallischen Naturwiss. Ges.* 1876–77: 435 (1878). (Gen. Sp. Musc. 2: 501).

Isopterygium austrosubulatum Müll.Hal. *ex* Burges, *Proc. Linn. Soc. New South Wales* 60: 93 (1935), *nom. nud. in synon.* A Watts specimen bearing this name is held at NY (W. Buck, pers. comm.): *W.W. Watts 1586,* Sep 1897 (*n.v.*).

Isopterygium novae-valesiae Broth., *Oefv. Finska Vet. Soc. Foerh.* 42: 113 (1900), *syn. nov.* Type: Australia, New South Wales : Richmond River, Fernleigh, *W.W. Watts 1902,* lectotype [selected here]: H-Br, isolectotype: NSW. From the original list of types the following become *residual syntypes* -. New South Wales, Richmond River, Fernleigh, *W.W. Watts* (n. *1384, 1399, 1403, 1900*); Pearces Creek (*1395, 1408*); Teven (*1430* ex. p.) Alstonville (*470*); Uralba (*1801*), all held H-BR, NSW, except for *Watts 1395* (which at NSW is a poor specimen, not *Isopterygium*).

Illustrations: Dozy & Molkenboer, *Bryologia Javanica*, vol II, p. 193, tab. CCXC, (1868), as *Hypnum*; Bartram, *Mosses of the Philippines*, plate 27, fig. 474 (1939). Gangulee, *Mosses of Eastern India and Adjacent Regions* 7: 1960, fig 1007 (1979). Noguchi, *Illustrated Moss Flora of Japan* 5: 1051, fig. 462A (1994).

Plants autoicous, slender, small to medium-sized, in pale yellow-green, grey-green to green, slightly glossy prostrate mats. Stems creeping, irregularly pinnately branched, to 6.0 cm long. In cross-section, stem without central stand, and the cortex with 2 outer layers of firm-walled cells. Pseudoparaphyllia filamentous. Branches short, ascending, often loosely foliated. Rhizoids smooth, red, sparsely developed on underside of stem between leaves. Branches suberect, simple or with branchlets 1.0–1.5 cm. Leaves ovate,

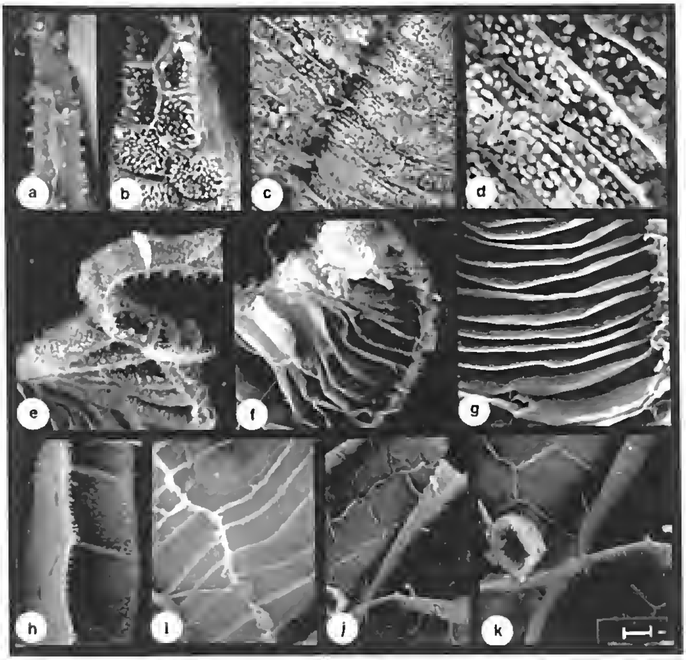

Fig. 2. Scanning electron micrographs of the peristome of *Isopterygium albescens (as I. novaevalesiae.* **a**, close view of apex of exostome tooth; **b**, tooth below apex showing papillose surface; **c & d**, pattern of lamellae and papillae between, on abaxial surface in lower part of tooth; **e**, side view of exostome tooth near apex curled over showing lamellae; **f**, closer view of lamellae in base of mid tooth; **g**, lamellae towards base of tooth, smooth no papillae; **h**, abaxial view of endostome segment near apex; **i**, abaxial view of basal membrane with smooth surface; **j**, cilia curved back over basal membrane; **k**, spore, cilium and basal membrane behind. [*H.P. Ramsay 181115* (NSW).] Scale bar a, b, e, g, h, k = 20 µm; c, f, i = 10 µm; j = 100 µm.[SEM's prepared by Meera Jayachandran at University of New South Wales.]

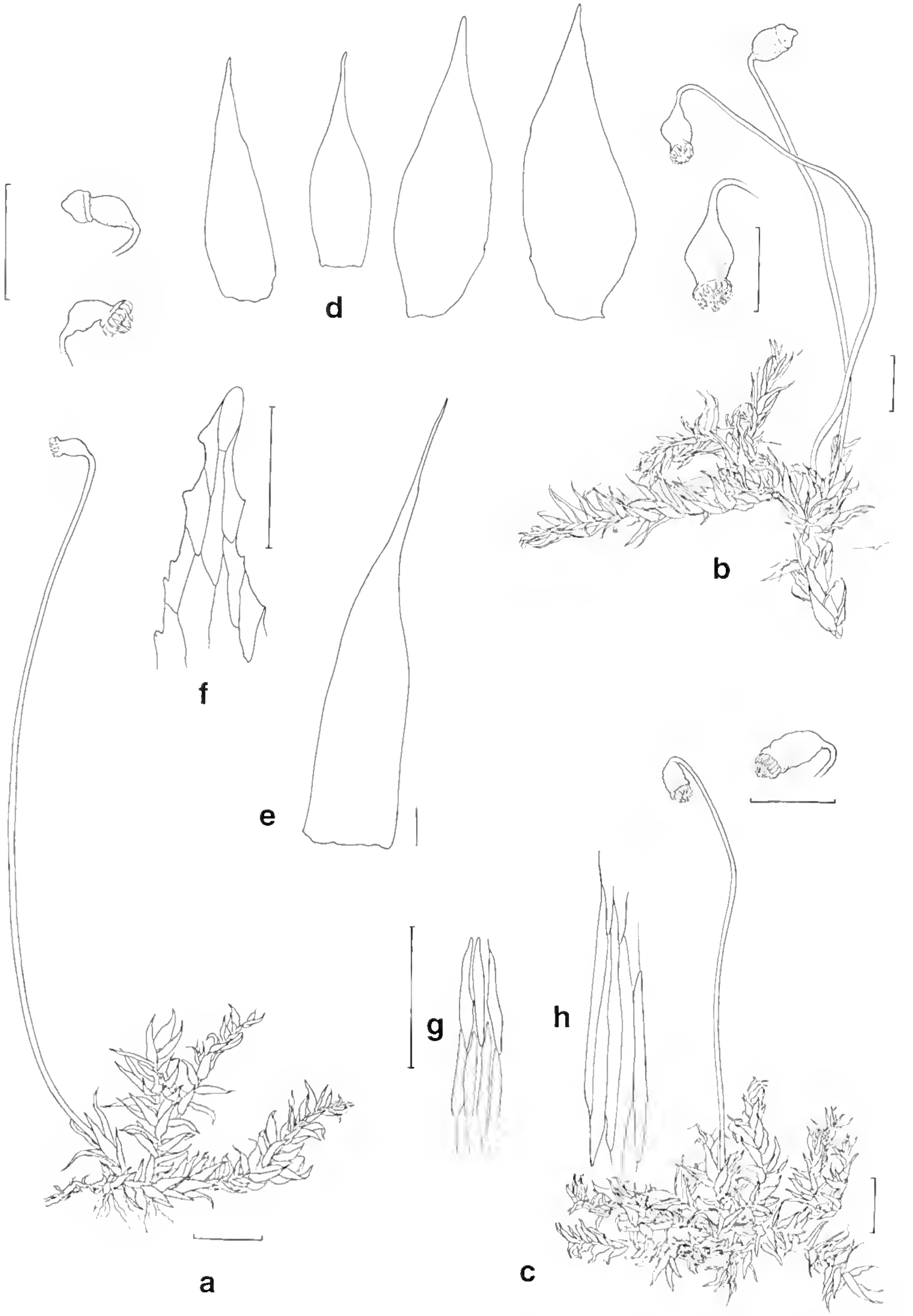

Fig. 3. Illustrations showing variation in *Isopterygium albescens* in Australia. **a,** habit with capsules (as *Isopterygium novaevalesiae*, isolectotype, *Watts 1902*, NSW); **b,** habit with capsules (as *Isopterygium minutirameum*, *Watts 4584*, NSW); **c,** habit with capsules (as *Isopterygium albescens*, *Watts 235*, NSW); **d1–4,** variation in leaves: **d1** stem leaf, **d2–d4** branch leaves; **e,** perichaetial leaf; **f,** apical leaf cells; **g,** upper leaf cells; **h,** midleaf cells. (Drawings by: D. Mackay (habit of *I. novaevalesiae*), C. Wardrop & H.P. Ramsay). Scale bars: 1.0 mm for habits and leaves; 100 µm for cellular drawings.

ovate-lanceolate or lanceolate, usually slightly concave, erect-patent, 0.6–1.2 × 0.28–0.35 mm, asymmetrical, margins entire or obscurely serrate or denticulate above, apex gradually acuminate to a slenderly tapering narrow acumen, slightly falcate towards ends of branches. Laminal cells in midleaf narrow, 70–100 × 4–8 µm, linear to vermicular; apical cells short rhomboid (4:1); cells in alar region consisting of 2–3 small thick walled, shortly rectangular or irregularly shaped hyaline cells, basal row of subrectangular cells. Perigonia on branches and lower parts of stems, rounded budlike. Perichaetia on stems, inner perichaetial leaves gradually long acuminate. Calyptra smooth, cucullate 1.0 mm long. Seta long-exserted, 0.6–1.2 cm, pale red; capsules frequently produced, oblong-ovoid, curved, horizontal or pendulous, operculum bluntly curved-rostrate; peristome double, exostome teeth 16, endostome 16, same length as exostome, with single cilium as long as segments. Spores 9–13 µm, finely papillose. Figs. 1–4

Distributed in Himalayas, Malesia, and tropical and subtropical Asia as far north as Japan, on Pacific Islands, in New Zealand and Australia. Specimens collected by W.W. Watts on Lord Howe Island as *Isopterygium howeanum* or *I. candidum* are *I. albescens.* With the transfer to *Isopterygiopsis* of *Isopterygium pulchellum* and the exclusion of *I. limatum* from the genus (Iwatsuki et al. 2009), distribution of *Isopterygium* in Australia is confined to the mainland chiefly in coastal regions from tropical northern Western Australia, Northern Territory and Queensland south to New South Wales and Victoria.

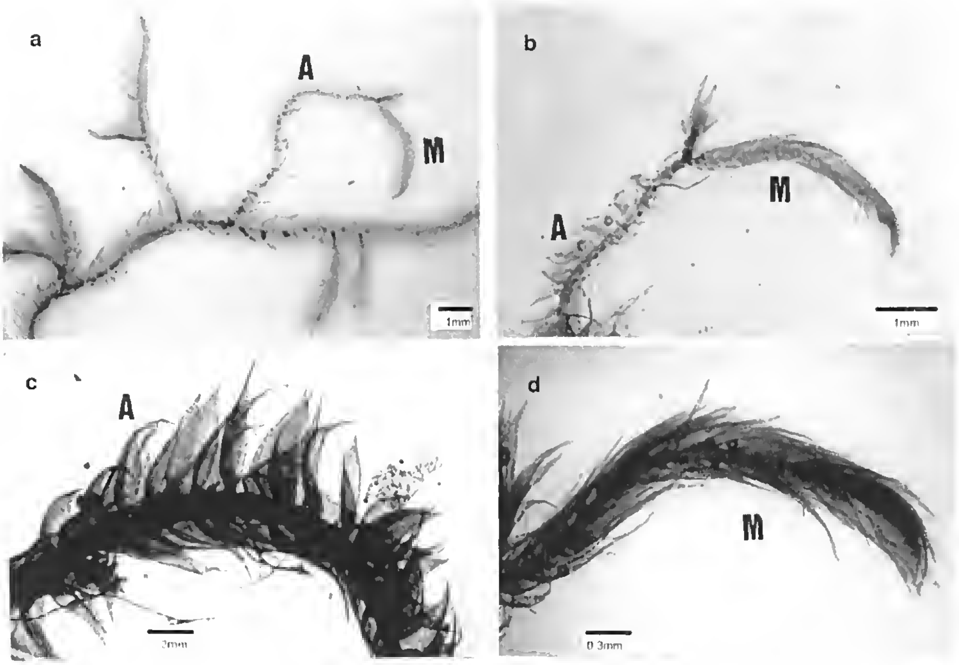

Fig. 4. *Isopterygium albescens*, showing variation of leaves. **a**, **b**, part of plant showing two types of leaves (A shows ovate to ovate-lanceolate leaves, M shows lanceolate leaves); **c**, part of branch with ovate to ovate-lanceolate leaves (plants with this type of leaves have been called *Isopterygium albescens*); **d**, branch with lanceolate leaves (plants with this type leaves have been called *Isopterygium minutirameum*). (all from *Russell-Smith 6200*, CANB; photographs by Z. Iwatsuki).

Dalton et. al. (1991) noted that *I. albescens* had been listed for Tasmania although Scott and Stone (1976) recorded it only from the mainland. Streimann and Klazenga (2002) have listed *I. albescens* for Tasmania but no specimens have been located by us. The genus is thus absent from the temperate regions of southern Western Australia, South Australia and Tasmania. Fig. 5

Selected specimens. Western Australia: Galvin Gorge, *G. Kantak & S.P. Churchill 687* (NY, NSW); **Northern Territory:** Kakadu, *L.A. Craven & G. Whitbread 6801* (CANB); Wangi Road, Walker Creek 68 km SSW of Darwin, *H. Streimann 8814* (CANB); Katherine Gorge, *G.E. Kantak 696* (CANB). **Queensland:** Babinda, *W.W. Watts Q300* (NSW); Malanda, *W.W. Watts 577* (NSW); Cairns, *W.W. Watts 235* (NSW). **New South Wales:** Manning River, *E. Cheel 485* (NSW); Pimlico, Richmond River, *W.W. Watts 432* (NSW); Alstonville Road, Alstonville, *W.W. Watts 612* (NSW); Wardell Road, Richmond River, *W.W. Watts 687* (NSW); Stanwell Park, *W.W. Watts 8267* (NSW); Lord Howe Island, north end of island in closed rainforest, *D.H. Vitt 28327* (NSW). **Victoria:** Dandenongs, East Gippsland, *E. Ronfield s.n.* (MEL).

We had much difficulty in identifying and separating specimens of *I. albescens* and *I. minutirameum*, because these two species are extremely variable in shape and colour of leaves. *Isopterygium albescens* and *I. minutirameum* are usually distinguished as follows:

1. Plants often whitish, leaves ovate to ovate-oblong .... ***I. albescens***
1. Plants not whitish, leaves lanceolate, slenderly tapering to a narrow acumen .... ***I. minutirameum***

However, the above key does not work well for many specimens of *Isopterygium* in Asia or Australia. Recently, we found a very interesting specimen which has two types of leaves on one plant. The specimen had been determined as *I. minutirameum* (Northern Territory, Butterfly Springs, *J. Russell-Smith 6200*, CANB). As shown in Fig. 4 some branches (marked by M) have leaves defined in the key as *I. minutirameum*, and some other branches (marked by A) have leaves defined in the key as *I. albescens.* Identifications of specimens of *I. albescens* and *I. minutirameum* have often been changed from *I. albescens* to *I. minutirameum* or vice versa. For these reasons, we reduce *I. minutirameum* to a synonym of *I. albescens.* In North America, *Isopterygium tenerum*, which is related to our *I. albescens*, is also extremely variable and includes two types of leaves comparable to those of *I. albescens* and *I minutirameum.* These variants

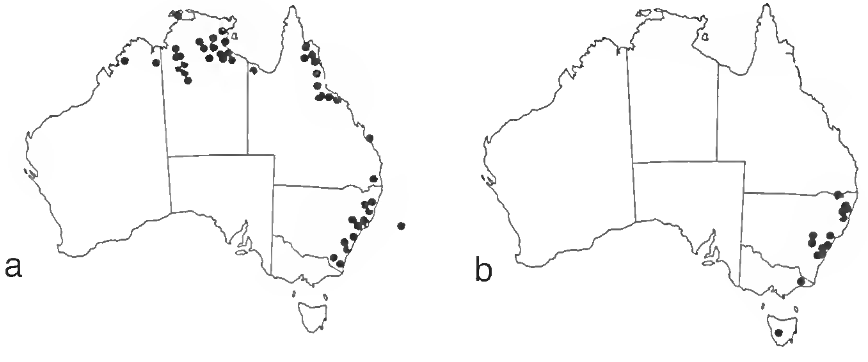

Fig. 5. a, Distribution of *Isopterygium albescens* in Australia; **b,** Distribution of *Isopterygiopsis pulchellum* in Australia.

have been given varietal status, e.g. var. *fulvum*, var. *minus*, var. *grontii*, etc. but Crum and Anderson (1981) note that the species is extremely variable, and that it is useless to segregate such varieties.

There has been confusion in the identity of the species *Isopterygium novae-valesiae* Broth., considered an Australian endemic until these studies, as it has been known as either *Isopterygium* (Broth. 1900) or *Taxithelium* (Broth. 1908). While revising the Australian species of *Taxithelium*, the type collections from H-BR and isotypes from NSW of *Isopterygium* [*Taxithelium*] *novae-valesiae* were examined by Ramsay et al. (2002a) and again recently by Paulo Câmara at the Missouri Botanical Garden, who has been carrying out a world revision of the genus *Taxithelium*. Both confirm that the type specimens listed by W.W. Watts and held at H-BR and NSW do not contain any *Taxithelium* species. *Isopterygium novae-valesiae* has non-papillose cells while *Taxithelium* has pluripapillose cells. Brotherus, however, did allow for non-papillose species in his concept of *Taxithelium*, a view not currently accepted.

The lectotype specimen (*Watts 1902*) of *Isopterygium novae-valesiae* has non-papillose cells, and after careful examination, we have reduced it to synonymy with *I. albescens*. Specimens of this vary somewhat from other collections of *I. albescens* as recognised here. They are often pale yellow-green and have much longer setae and slightly larger more acuminate leaves than the general collection.

Many specimens from north-eastern New South Wales were examined and identified by Brotherus as *Isopterygium candidum* (Müll.Hal.) A.Jaeger in the 1890's. Most of the specimens from New South Wales with this name have been re-determined as *I. minutirameum* (now *I. albescens*). However, those from Lord Howe Island are correctly named as *I. albescens*.

Isoptergiopsis

Isopterygiopsis (Hedw.) Z.Iwats., *J. Hattori Bot. Lab.* 33: 379–380 (1970)

Type: *Plagiothecium muellerianum* Schimp.

Etymology: derived from the name *Isopterygium* (see above) and the Greek *-opsis* (appearance)in reference to the similarity between the two genera.

Plants dioicous or autoicous, medium sized to small, shiny; stems creeping, irregularly pinnately branched; in cross section of stem, epidermal cells large, thin-walled and often hyaline, or small and more or less thick-walled; central strand indistinct,. rhizoids papillose and axillary; pseudoparaphyllia absent; when present, gemmae occur as axillary fascicles of filamentous propagulae 3–7 cells long; annulus differentiated. Leaves erect to wide-spreading and weakly to distinctly complanate; narrowly lanceolate triangular, acuminate, entire. Setae long, capsules suberect, annulus 2 rows of cells, operculum bluntly low-conic. Peristome hypnoid.

Isopterygiopsis was described by Iwatsuki (1970) for species similar in appearance to *Isopterygium* in size, but different in having no pseudoparaphyllia on stems, large hyaline or thin-walled epidermal cells in stem cross-sections and axillary papillose rhizoids instead of smooth rhizoids arising below leaf insertion, filamentous propagules and having a differentiated annulus. It is more similar to *Plagiothecium* in characters of pseudoparaphyllia and propagulae, but differs in having non-decurrent leaf-bases

(Iwatsuki 1987). As part of a revision of the genus *Isopterygium* for the Flora of Australia by us, the specimens for *Isopterygium pulchellum* (Hedw.) A.Jaeger = *Isopterygiopsis pulchella* (Hedw.) Iwats. were examined as its occurrence in Australia has been reported as doubtful' (Streimann & Klazenga 2002). Recent studies of specimens and types of *Isopterygium arachnoideum* and *I. subarachnoideum*, now placed into synonymy with *Isopterygiopsis pulchella* (see below), confirm its presence in Australia.

Isopterygiopsis pulchella (Hedw.) Z.Iwats., *J. Hattori Bot. Lab.* 63: 450 (1987). *Leskea pulchella* Hedw., Sp. Musc. 220 (1801). *Isopterygium pulchellum* (Hedw.) A.Jaeger & Sauerb., Ber. St. Gall. Naturw. Ges. 1876–77: 441 (1878).

Type: In silvis umbrosis Scotiae (Hedwig 1801).

Isopterygium arachnoideum Broth., *Oefvers Finska Vetensk.-Soc. Foerh.* 42: 112 (1900). Type: Australia, New South Wales, Richmond River, Teukombil (=Tuckumbil) Hunter's Scrub, on tree fern trunks. *W.W. Watts 549*, lectotype H-BR, isolectotype (4 specimens in NSW)[selected here]. syntype: Three mile scrub, tree fern trunks *W.W. Watts 879* (NSW, H-BR). [Note *W.W. Watts 587* in MEL is not a type, refer to Ramsay and Seur (1994)]

Isopterygium subarachnoideum Broth. *Oefvers Finska Vetensk.-Soc. Foerh* 42: 113 (1900). Type: Australia, New South Wales, Richmond River, Hunter's Scrub, on tree fern trunk, *W.W. Watts 744*, lectotype: H-BR; isolectotype: NSW [selected here]. No specimen of the syntype *Watts 588* was found in H-BR or NSW.

Illustrations: Crum and Anderson, *Mosses of eastern North America*, vol. 2, fig 582 (1981); Ignatov & Ignatov, *Moss flora of the middle European Russia*, vol. 2: fig 439 (2004); Ireland, *Moss flora of the Maritime Provinces*: fig. 357 (1982); Nyholm, *Illustrated moss flora of Fennoscandia*. II. Musci, fasc. 5: fig. 411 (1965) - all as *Isopterygium pulchellum*. Smith, *The moss flora of Britain and Ireland*, 2nd ed.: fig. 295. 9–11 (2004); Zhang & Si, Hypnaceae. *Moss flora of China*, English Version: pl. 689 (2005) - both as *Isopterygiopsis pulchellum*.

Plants autoicous, small and slender in shiny, bright-green or yellow to greyish-green flat mats. Stems creeping, mostly unbranched with several arising at base of perichaetia, stem in cross section with epidermal cells not so large, with outer wall thin or slightly thickened and with an indistinct central strand. Branches numerous, often ascending; pseudoparaphyllia absent. Leaves usually not crowded, erect to wide-spreading and weakly to distinctly complanate, often secund at tips, 0.7–1.2 mm long, narrowly lanceolate-triangular, slenderly acuminate, not decurrent, less than 0.2 mm wide at base, entire, ecostate. Laminal cells linear in midleaf 35–70 µm x 5 µm , 7–14:1 long as wide, cells scarcely differentiated at basal angles. Propagules occasionally present, axillary fusiform or cylindrical, 2–5 cells long. Perigonia numerous and usually present on lower stems. Perichaetia on stems. Perichaetial leaves erect, similar in size to leaves. Setae 8–16 mm long, orange or yellow, becoming orange-red; capsules suberect and nearly symmetric to inclined and asymmetric, oblong-cylindric, capsules mostly 1.0–1.5 mm., annulus of 2 rows of cells; operculum low-conical with a short rostrum; peristome hypnoid, endostome with non-perforate segments and single (sometimes paired) cilia. Spores 9–13 µm, minutely roughened. Chromosome numbers n=10+m, 10+2m, 22 (none Australian, Fritsch 1991). Fig. 6

Distributed, in North America, Europe, Asia, Africa, New Zealand and Australia (Queensland, New South Wales, Victoria, Tasmania). In N.S.W. most specimens occur

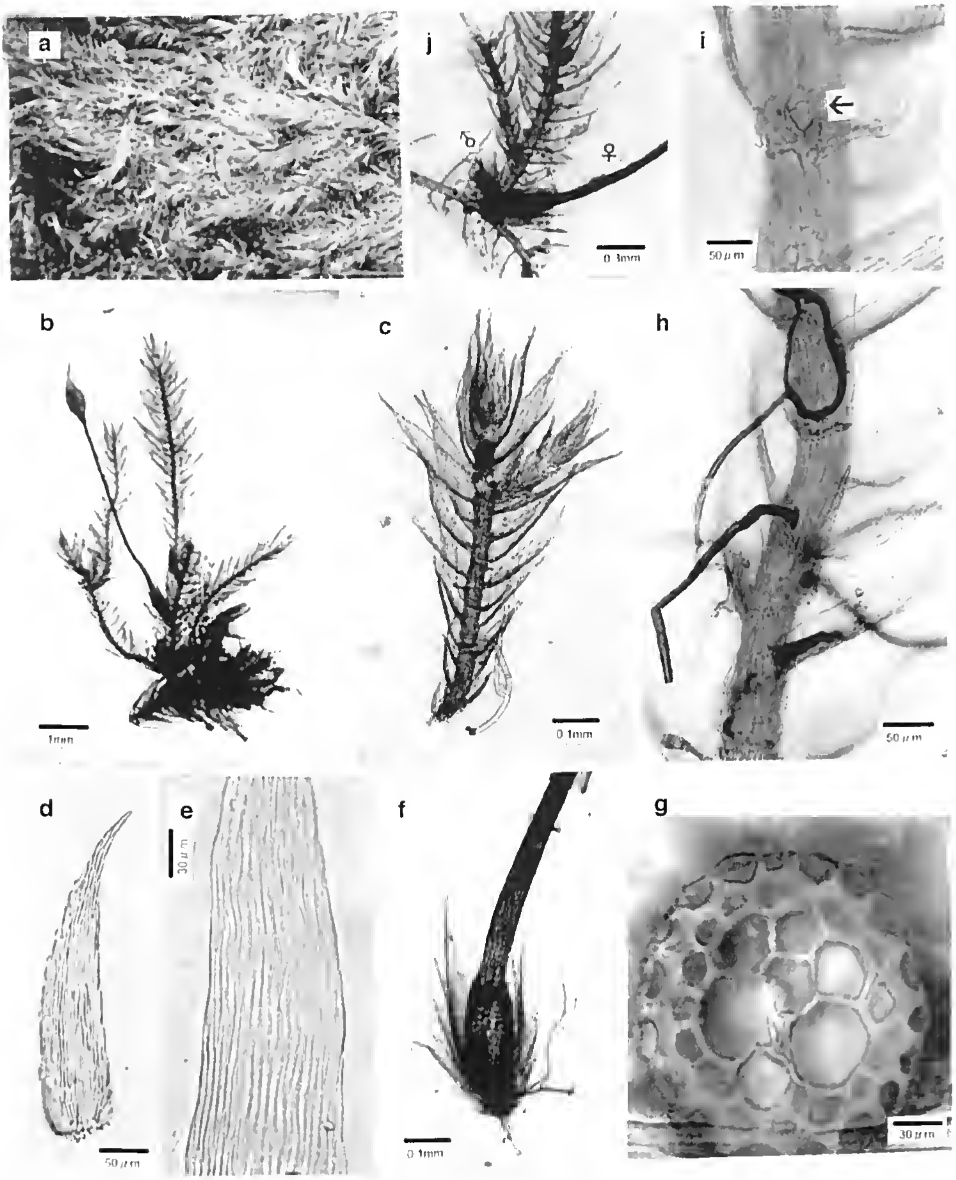

Fig. 6. *Isopterygiopsis pulchella*. **a**, plants; **b**, plant with sporophyte; **c**, branch; **d**, **e**, leaves; **f**, perichaetium; **g**, cross-section of stem; **h**, branch with rhizoids; **i**, branch with branch primordia (arrow); **j**, plant with male and female inflorescences. (all based on Australian material; a, c–e, & g–j *I.R. Telford*, CANB; b & f *W.W. Watts 577*, NSW; photographs by Z. Iwatsuki).

on the trunks of tree ferns from sea level to subalpine in the Blue Mts. and on the coast and coastal ranges as far north as the Richmond River district and the Border Ranges between N.S.W. and Qld possibly as far north as Eungella National Park. In Tasmania it occurs mainly on wood or tree trunks in the west and south-west at altitudes below 300 m. Fig. 5

Selected Specimens: Australia: Queensland: McPherson Range, Coomera Range, *I.R.Telford s.n.* (CANB). **New South Wales:** Valley of Waters, Blue Mts, *W.W. Watts 5434, 5435, 5436, 10471* (NSW); Woodford, Blue Mts, *W.W. Watts 8275* (NSW); Brunswick River, *W.W. Watts 1586, 1591*(NSW), *4195* (MEL); Tuckombil, *W.W. Watts 577 (as I. arachnoideum) 4912, 4913, 4908* (NSW), *W.W. Watts 587 (as I. arachnoideum)* (MEL); Ballina *W.W. Watts 2874, 5849* (NSW); Stanwell Park *W.W. Watts 8277* (NSW); Cambewarra *W.W. Watts 6590, 9930, 9946* (NSW); Bulgong Heights *W.W. Watts s.n.*, May 1916 (NSW 245517); Belmore Falls *W.W. Watts 9822* (NSW); Nowra *W.W. Watts 8268* (NSW); Tomerong *W.W. Watts 6235, 6236* (NSW); "Kingwell", Wyong *W.W. Watts 9604, 9480, 8971, 8972, 9631, 9715, 9532, 9722* (NSW); Gladesville, Sydney *W.W. Watts 9289* (NSW); Manly, Sydney *W.W. Watts 6815, 6820* (NSW), Neutral Bay, Sydney *W.W. Watts 8000* (NSW); Brindle Creek, Wiangarie S.F. *H. Streimann s.n.* (CANB); Dorrigo N.P. *H. Streimann s.n.* (CANB); **Victoria:** Mt Drummer, *N.A.S. Wakefield s.n.* (MEL 1031453); **Tasmania:** West Coast *W.A. Weymouth 2793* (HO); Zeehan Railway, *W.A. Weymouth 630* (HO); Recherche, *W.A. Weymouth 2586, 2587, 2618, 2619* (HO).

The following key is provided to assist in identifying the now recognised Australian taxa that were formerly *Isopterygium*, i.e. *Isopterygium, Isopterygiopsis* and *Austrohondaella.*

1. Leaves acuminate with more or less serrulate apices; rhizoids smooth, arising between leaves on stem; pseudoparaphyllia filamentous; capsule curved, horizontal or pendulous; annulus absent, operculum bluntly apiculate or curved rostrate .... ***Isopterygium albescens***

1. Leaves with entire apices; rhizoids papillose, arising from leaf axils; pseudoparaphyllia absent or foliose; capsule erect or suberect to inclined; annulus present; operculum low conic or blunt

    2. In section, stems with large thin-walled epidermal cells, thick-walled outer cortex, thin-walled inner cells, central strand present; capsule suberect to inclined, operculum low conic; pseudoparaphyllia absent .... ***Isopterygiopsis pulchella***

    2. In section, stem with small epidermal cells, an outer sclerodermis and inner thin walled cortical cells, central strand absent; capsule erect, symmetrical; operculum bluntly conic; pseudoparaphyllia foliose .... ***Austrohondaella limata***

New records for Australia

Among the Australian collections examined during this study, the following specimens of *Pseudotaxiphyllum pohliicarpum* (Hypnaceae) were discovered and are clearly identified by the *Pohlia*-like gemmae (Iwatsuki 1987, Noguchi 1994). The earliest collection is that of Watts in 1916, and a more recent collection is that of H. Streimann in 1991. These are the first records of this species for Australia.

Pseudotaxiphyllum pohliicarpum (Sull. & Lesq.) Z.Iwats., *J. Hattori Bot. Lab.* 63: 449 (1987). *Hypnum pohliaecarpum* Sull. & Lesq., Proc. Am. Ac. Art Sc. 4: 280 (1859). *Isopterygium pohliicarpum* (Sull. & Lesq.) A.Jaeger, *Ber. Thätigk. St. Gallischen Naturwiss. Ges.* 1876–77: 442 (1878).

Specimens examined: Australia: New South Wales: Northern Tablelands: Weeping Rocks, New England National Park, 72 km of Armidale, *Nothofagus–Elaeocarpus* dominated forest, at base of escarpment, on shaded rock face, *H. Streimann 47736* (CANB, NY). Central Coast: Sassafras Gully, Springwood W.W. Watts 10917 Jan 1916 (NSW 245625).

Distribution: Japan, China, Vietnam, Laos, Thailand, Philippines, new to Australia.

Names transferred elsewhere or specimens not found

Isopterygium caespitulosum Paris, *Index Bryol. Suppl.* 218 (1900), *nom. nud.* = *Taxicaulis caespitulosus* Müll.Hal., *nom. nud.* Not found.

Isopterygium nitens E.B.Bartram. A specimen labelled type ('co-type') with this name at NSW collected in Western Australia was redetermined by Bartram as *Sauloma zetterstedtii* (Müll.Hal.) A.Jaeger. Subsequently in a note J. H. Willis says he preferred to treat it as the 'western form of *Sauloma tenella* (Hook.f. & Wilson) Mitt.'

Isopterygium pseudosubulatum (Müll.Hal.) Paris, *Ind. Bryol. Suppl.* 220 (1900) (*Taxicaulis* 1887) is a non Australian taxon (see Streimann & Klazenga, 2002, p. 198). A Whitelegge specimen bearing this name is held at NY (W. Buck, pers. comm.): *T.W. Whitelegge*, 1886 (*n.v.*).

Isopterygium teysmannii Broth. = *Taxiphyllum taxirameum* (Mitt.) M.Fleisch.

Hypnum teysmannii Sande Lac., Bryologia Javanica 2: 192, 290. 1868. *Isopterygium teysmannii* (Sande Lac.) A. Jaeger, *Ber. Thätigk. St. Gallischen Naturwiss. Ges* 1876–1877: 433 (1878).

Isopterygium umbillicatulum Mitt., *Trans. & Proc. Roy. Soc. Victoria* 19:86 (1882), *nom. nud.* = *Ectropothecium* sp.

Isopterygium viridepallidus Müll.Hal. *ex* W.Forsyth, *Proc. Linn. Soc. New South Wales* 24: 683 (1900), *nom. nud.* Not found.

Isopterygium walterianum (Hampe) Mitt., *Trans. Roy. Soc. Victoria* 19:86 (1882). *Hypnum walterianum* (Hampe) A.Jaeger, *Ber. Thätigk. St. Gallischen Naturwiss. Ges.* 1877–78: 320 (1880). (Gen. Sp. Musc. 2: 584). Type: Victoria: Mt. Macedon, *Walter* = *Hypnum cupressiforme* Hedw. var. *mossmannianum* (Müll.Hal.) Ando.

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We wish to acknowledge and thank the various herbaria CANB, H-BR, HO, MEL, NICH, NSW, NY for the loan of many specimens (including type specimens) and access to distribution data. Paulo Câmara at the Missouri Botanical Garden checked the type collections of *Isopterygium novae-valesiae* on loan from H-BR for us. Peter Wilson kindly supplied a translation of the Latin description of *Isopterygium novae-valesiae*. Elizabeth Brown assisted with cutting stem sections. Alison Downing was helpful in checking some specimens for H Ramsay. Allan Fife kindly provided access to unpublished information regarding the species in New Zealand.

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The genus *Cycas* (Cycadaceae) in Indonesia

A.J. Lindstrom[1], K.D. Hill[2] and L.C. Stanberg[2]

[1]*Nong Nooch Tropical Botanical Garden, Sattahip, Chonburi 20250, Thailand*
[2]*National Herbarium of New South Wales, Royal Botanic Gardens, Mrs Macquaries Road, Sydney 2000, Australia*

Abstract

The genus *Cycas* is reviewed for Indonesia. Ten species are enumerated, two of them new (***C. sundaica, C. montana***). Lectotypes are designated for *Cycas* Subsection *Endemicae, C. glauca, C. circinalis* subsp. *riuminiana* var. *curranii* forma *maritima* J.Schust. The species are placed within an infrageneric classification previously outlined. Distribution of all taxa is mapped, and a key to species provided. Extensions into Malaysia (*C. edentata*) and Papua New Guinea (*C. apoa, C. papuana, C. scratchleyana*) are discussed under the species. Previous recordings of *C. circinalis* from Indonesia are discussed.

Introduction

The genus *Cycas* is the single constituent genus of the family Cycadaceae, itself the basal lineage of the living cycads or Cycadophyta (Stevenson 1992). It is also the sole living cycad group occurring in Asia. The only known fossil evidence for this genus is from the Eocene of China and Japan, and this, together with the occurrence of all major lineages in the genus in mainland Asia, supports a long-term presence and probable origin of this genus in that region (Hill 1995b). *Cycas* consists of about 100 species, chiefly Indo-Chinese (about 40 species) and Australian (27 species). The genus also occurs in the Malesian region, Japan and India, extending to Micronesia and Polynesia, Madagascar and East Africa. Plants are commonly understorey shrubs in forest, woodland or savanna habitats. Ten species are known in Indonesia.

The cycad flora of Indonesia is relatively sparse in comparison to Indochina and northern Australia, both of which show extensive local radiations. A similar but smaller radiation, however, appears to have occurred in the Sunda region (Nusa Tenggara) of Indonesia.

Examination of existing herbarium material of the genus *Cycas* L. from Indonesia shows that most specimens are sterile, often incomplete and often hard to assign to any described taxon or even subsection of the genus. This has contributed to the taxonomic confusion, with a number of valid taxa being put into synonymy with unrelated taxa, based upon examination of sterile specimens and inaccurate illustrations. This also highlights the necessity of field studies in this group.

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The present work is the outcome of our separate and combined studies, with a total of three field trips during the period 1999–2000. Herbarium collections held by A, B, BM, BO, E, G, K, L, LAE, NY, P and SING have been examined by at least one author. Terminology is as in previous papers in this series (e.g. Hill 1994a), as are generic and specific concepts applied. Conventions in measurements taken and presented in the following descriptions are as in other papers in this series, and are set out in Lindstrom and Hill (2007). Many of the measurements were made on fresh material; in a few instances these measurements are not given in the descriptions because they were not recorded or fertile material was absent in the field.

Taxonomic history

The genus *Cycas* was first recorded from Indonesia by Rumphius (G.E. Rumpf), with his description of "Olus Calappoides" (1741). The Rumphius plates were then cited by Linnaeus (1753) in his description of *C. circinalis* L., a species in India.

The existence of a distinct Indonesian taxon was first recognised by Roxburgh (1832: 747), who mistakenly applied the name *C. sphaerica* Roxb. to plants from India belonging to the *C. circinalis* alliance (Lindstrom & Hill 2007). The distinct Indonesian taxon he then treated under the name *C. circinalis.*

This Indonesian species was first legitimately recognised by Miquel (1839: 45) as *C. rumphii* Miq., although Miquel was never clear on the specific limits of this taxon. He also described *C. celebica* Miq. (1839: 45), *C. rumphii* var. *timorensis* Miq. (1841: 125) and *C. circinalis* var. *javana* Miq. (1842: 28) but later abandoned all of these (see below). The outcome of Miquel's confusion was a reluctance by many other authors to recognise *C. rumphii* at all, and the name *C. circinalis* has been widely applied to material belonging to the *C. rumphii* alliance up to the present day.

The comprehensive account of the genus by de Candolle (1868) recorded *C. circinalis* var. *javana*, *C. rumphii* and the variety *C. rumphii* var. *timorensis* from Indonesia, and listed *C. celebica* as a species without distinguishing characters. De Candolle had, however, largely followed Miquel's 1851 treatment in developing his account.

Warburg (1900) recognised the presence of a coastal taxon in New Guinea, assigning it to *C. rumphii*. This coastal taxon has also been assigned to *C. circinalis* (White 1923). Koorders (1911) at first used only the name *C. circinalis*, although he later (1913) took up the name *C. rumphii*. Duyster (1927) also used only the name *C. circinalis*. Backer (1925) placed most Javanese material under *C. rumphii*, and Pilger (1926) subsumed all of the Indonesian taxa under *C. rumphii* with no further comment. Ochse (1931) also regarded all Javanese material as *Cycas rumphii.*

Schuster (1932) clearly showed a lack of understanding of most species. He included material of the *C. rumphii* complex in both *C. rumphii* and *C. circinalis* (and in a number of the subspecies and varieties he erected in this species), but also included a range of other sometimes unrelated taxa in his treatments of these two species.

Backer and Bakhuizen van den Brink (1963) recorded only *C. rumphii* from Java.

De Laubenfels and Adema (1998) divided the Indonesian occurrences of the *C. rumphii* complex into *C. rumphii*, *C. celebica* and *C. edentata* de Laub., and applied the names *C. silvestris* K.D.Hill, *C. scratchleyana* F.Muell., *C. javana* (Miq.) de Laub. and *C. riuminiana* Porte ex Regel to material that included some of the *C. rumphii* complex and also the inland forest species. None of these names were wholly correctly applied (see below).

Conservation

Populations of many Asian species appear to have declined, sometimes dramatically, over the past century. However, there is no comparative data to support this impression, and evidence for the decline is largely anecdotal and circumstantial. Several causes for a decline can be observed in action today, however, even though quantitative data on the effects are not available. Two principal threats to cycads exist in Indonesia at present, habitat loss and selective removal of plants from the wild for trade or utilisation. Some, but not all species occur in reserved areas already proclaimed, but enforcement within these areas is sometimes difficult. There is, however, a growing interest in habitat and species conservation within Indonesia, and additional reserved areas are being evaluated and declared.

The notorious Asian cycad scale insect *Aulacaspis yasumatsui*, has been introduced to Timor and is already widespread on Java and Bali. However the wasp that is predatory on the scale seems to be absent from these islands. A similar scenario has occurred in wild cycad populations in Guam and Taiwan (IUCN Cycad Specialist Group 2006) as well as in the U.S.A where the scale is rapidly killing many cultivated cycads (Howard et al. 1999). There is evidence that this pest was introduced many years ago as the once extensive *Cycas* collection in Bogor Botanic Garden, Java, was completely wiped out long ago. The scale is established in West Timor but as yet no scale has been found outside the capital Koupang.

One Indonesian species only (*C. celebica*) was listed in the now out-of-date (for this region) IUCN 1997 Red Book of Threatened Plants (Walter & Gillet 1998). This has now been shown to be conspecific with *C. rumphii* (see below), and is not regarded as seriously threatened. Species treated below are allocated provisional conservation status codes under the new coding system devised by the IUCN (Criteria Version 3.1: IUCN 2001). Conservation status of all species is summarised in Table 1.

Taxonomic treatment

Cycas L., Sp. Pl.: 1188 (1753).

Type: *C. circinalis* L.; lectotype designated by Stevenson in Jarvis et al. (1993).

Dioecious palm-like shrubs with aerial or subterranean, pachycaul, cylindrical stems clad with persistent frond-bases. 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. Leaves with vascular traces girdling stems, girdling traces not present in cataphylls or megasporophlls. Microsporophylls aggregated into determinate cones and bearing numerous microsporangia (pollen-sacs) on abaxial surfaces, with a simple sterile apex, 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 into a pinnatifid, pectinate, toothed or entire lamina. Seeds with a yellow, orange or brown fleshy outer sarcotesta,

Table 1. Conservation status of Indonesian cycads

	Other Countries	1997 Red List Status	Reserved	IUCN Ver 3.1: 2001 Status (Donaldson 2003)	Pop. Size	Present Decline	Range (km²)	Habitat Reduction (%)
C. apoa	Indonesia & PNG	-	N	NT, LC#	>10,000	?	1000	<20
C. edentata	Thailand	-	N	NT**	-	?Low	1000	<30
	Vietnam	-	N	NT**				
	Indonesia	-	N	NT**,NT#	>10, 000			
	Malaysia	-	N	NT**				
	Philippines	-	N	DD				
C. falcata		-	N	DD	?	?	500	-
C. glauca		-	?	VU#	?	?	500	-
C. javana		-	N	DD, NT#	?	?	1000	-
C. montana		-	N	NT#	?	?	200	-
C. papuana	Indonesia	-	N	NT	>10,000	?	200	-
	PNG		Y					
C. rumphii	Indonesia	R*	N	NT	>10,000	?low	1,000	20–50
	PNG	-	Y	-	-	-	-	-
C. scratchleyana	Indonesia & PNG	-	N	NT, LC#	>10,000	low	1,000	<20
C. sundaica		-	Y	LC#	>5000	low	500	<20

* as *C. celebica*

** as *C. litoralis* in Indonesia, Malaysia, Thailand, Vietnam (Donaldson 2003)

\# status recommended by authors

C. apoa, C. papuana and *C. scratchleyana* = combined data for Indonesia & PNG

C. edentata figures = combined data for all countries 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 and a very long, spirally twisted suspensor; seeds platyspermic; germination cryptocotylar.

Six sections are now recognised: four in Hill (1995b), one additional in Hill (2008) and another one in Lindstrom et al.(2008). There has been disagreement on subgeneric division (Wang 1996, de Laubenfels 1998) and, in the light of improved understanding of the genus, none of the proposed systems would appear entirely adequate (Hill 1998, 2004a, b). Two sections occur in Indonesia. One section is represented by species that occur naturally in Indonesia and a second is represented by one widely cultivated species.

Key to sections

1 Ovules tomentose .... Section *Asiorientales*# (*C. revoluta* Thunb.)

1* Ovules glabrous.. Section *Cycas*

Key to the species

1 Seeds with a spongy layer inside the sclerotesta................................. [Subsection *Rumphiae*]

  2 Megasporophyll with distinct lateral spines

    3 Leaves openly keeled (opposing leaflets at c. 150°) .... 5. *C. falcata*
    3* Leaves flat (opposing leaflets at c. 180°) .... 8. *C. sundaica*

  2* Megasporophyll lacking distinct lateral spines

    4 Seeds crested; microsporophylls short-spined .... 6. *C. rumphii*
    4* Seeds not crested; microsporophylls long-spined ....7. *C. edentata*

1* Seeds lacking a spongy layer

  5 Leaves glaucous [Subsection *Endemicae*] .... 9. *C. glauca*
  5* Leaves green, not glaucous

    6 Petiole spinescent; leaflets with margins slightly recurved; new shoots not bluish .... [Subsection Cycas]

      7 Lateral spines on megasporophyll lamina obscure or absent .... 1. *C. apoa*
      7* Lateral spines on megasporophyll lamina present, distinct

        8 Megasporophyll lamina narrow (less than 35 mm wide)

          9 Leaflets broad (> 10 mm wide) .... 3. *C. javana*
          9* Leaflets narrow (<10 mm wide) .... 4. *C. montana*

        8* Megasporophyll lamina broad (more than 35 mm wide)........ 2. *C. scratchleyana*

    6* Petiole smooth, not spinescent; leaflets with margins flat; new shoots bluish [Subsection *Endemicae*] .... 10. *C. papuana*

#widely cultivated in Indonesia, not discussed further in this treatment.

Cycas section *Cycas*

Section *Lemuricae* Schuster, Pflanzenr. 99: 65 (1932), nom. illegit.

Section *Cycas* is defined by the combination of glabrous ovules, a non-pectinate megasporophyll lamina and hard & woody mature male cones. Three subsections are recognised, circumscription following Hill (1995b), with all occurring in Indonesia. The full range of the section is from India and southern Indochina south to Australia, and from East Africa east to Tonga.

Key to the subsections

1 Seeds with a spongy layer inside the sclerotesta .... Subsection *Rumphiae*

1* Seeds lacking a spongy layer

  2 Sarcotesta of seed with fibrous layer present (Indonesian species)......... Subsection *Cycas*

  2* Sarcotesta lacking a fibrous layer.. Subsection *Endemicae*

Cycas subsection *Cycas*

This subsection of about 12 species is defined by the absence of a spongy endotesta, the presence of fibres in the sarcotesta, and the narrow megasporophyll lamina. Seeds have not been seen in *Cycas javana* and *C. montana*, but they fit this section in other ways (leaf and megasporophyll characters), and are assumed to possess the fibrous sclerotesta of the group. The group (subsection) ranges from India and Sri Lanka to Luzon, and south and east to New Guinea. Most representatives are plants of closed forests, usually on ridges away from the coast. Four species occur in Indonesia (Fig. 1).

1. *Cycas apoa* K.D.Hill, Austral. Syst. Bot. 7(6): 553–554 (1994).

Type: Indonesia, Papua, Babrongko, S. coast of Lake Sentani, *G. Iwanggin BW 5245*, 4 Apr 1957 (holo CANB; iso A, BRI, LAE, L).

Literature: de Laubenfels and Adema (1998 as *C. scratchleyana*)

Illustration: Hill (1994a, fig. 9).

Etymology: a rendering of the local vernacular name for this taxon in the Kaka language, as spoken around the Sepik estuary in north-western New Guinea. It is pronounced AP-wah, with the first syllable stressed but short, as in 'cap'.

Vernacular: *handambo* (Sentani language), *apoa* (Kaka language, Kasmin village) (Hill 1994a).

Stems arborescent, to 2.5 m tall. *Leaves* bright green, highly glossy, 180–250 cm long, flat (not keeled) in section (opposing pinnae inserted at 180° on rachis), densely and loosely tomentose with white and orange trichomes shedding as leaf expands; terminated by a spine or paired leaflets to 4 mm long; petiole 35–60 cm long, glabrous, spinescent for 80–100% of length; basal leaflets not gradually reducing to spines, 140 mm long. *Median leaflets* simple, strongly discolorous, 220–320 mm long, 11–15 mm wide, inserted at 70–80° to rachis, decurrent for 7 mm, narrowed to 2.5 mm at base (to 20% of maximum width), 13 mm apart on rachis; section flat; margins slightly recurved, often undulate; apex softly acuminate, not spinescent; midrib raised above, raised below. *Cataphylls* linear, soft, pilose. *Pollen cones* narrowly ovoid, orange; microsporophyll lamina firm, not dorsiventrally thickened, apical spine not prominent, upturned. *Megasporophylls* 20–26 cm long, orange and grey tomemtum; ovules 2–8, glabrous; lamina lanceolate, c. 35 mm long, c. 16 mm wide, lateral spines not developed, apical spine 15–30 mm long. *Seeds* flattened-ovoid, 45–50 mm long, 40 mm wide; sarcotesta orange-brown, not pruinose, 3–5 mm thick; fibrous layer present; sclerotesta smooth; spongy endotesta absent. Fig. 2.

Historical notes: included in *C. scratchleyana* by de Laubenfels and Adema (1998).

Distinguishing features: *Cycas apoa* is distinguished by the thin leaflets with narrow bases and no laminar hypodermis, continuous adaxial and abaxial hypodermis and strongly undulate margins, and the small megasporophyll lamina with reduced or no lateral spines (Fig. 2). *Cycas scratchleyana* from the southern side of New Guinea shares the thin, undulate leaflets, but has a much larger and relatively broader megasporophyll apex with numerous clearly defined lateral spines. The two also share continuous adaxial mesophyll and sometimes continuous abaxial mesophyll. The midrib is also narrow and usually sharply raised in both taxa. This is the species sometimes referred to as *C. circinalis* in northern coastal New Guinea (Borrell 1989).

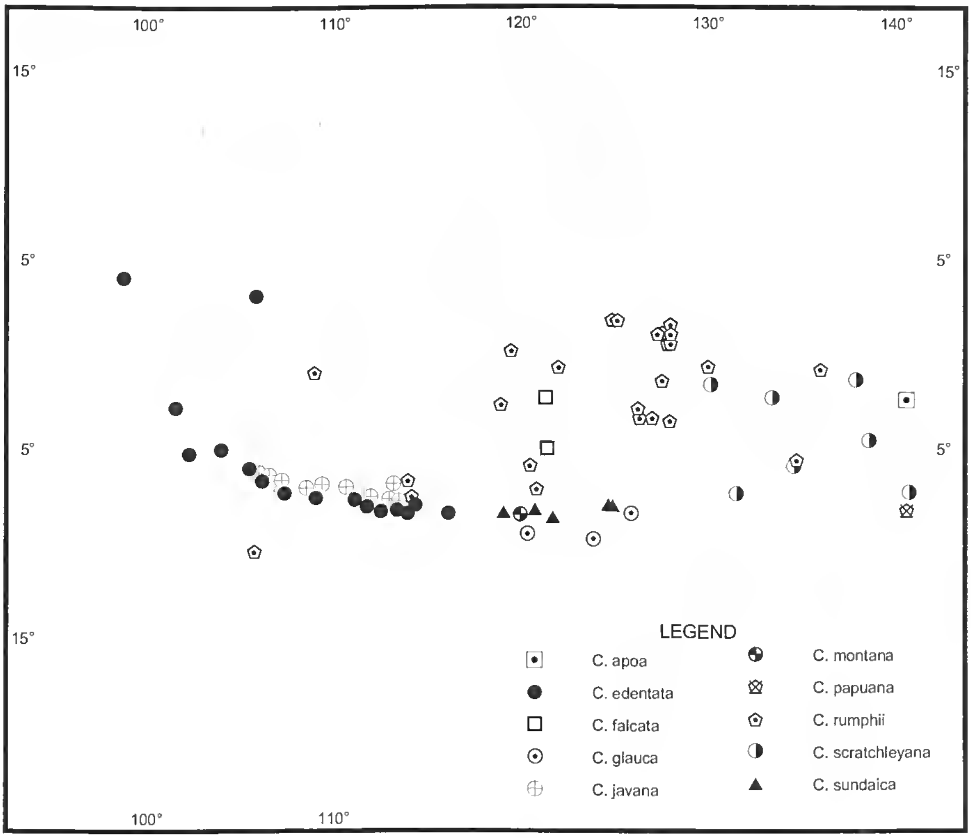

Fig. 1. Distribution of the genus *Cycas* in Indonesia.

Although the reduced lateral spines on the megasporophyll are given as a diagnostic character, some cultivated plants have shown distinct small lateral teeth on the sides of the apical spine on the megasporophyll. However, these teeth are not present on the main part of the lamina.

Distribution and habitat: known from northern coastal New Guinea, from the Huon Peninsula west to the Jayapura Regency (Fig. 1). This species occupies much the same geographic range as *C. rumphii* in this area, and detailed field study would be required to determine the controls on distribution. *Cycas rumphii* is, however, a primarily littoral species, whereas *C. apoa* apparently occurs away from the littoral zone.

This species and *C. scratchleyana* were included in subsection *Rumphiae* by Hill (1994a) on the basis of the limited and apparently mixed seed collections then available. At that time, section *Cycas* was not known to extend beyond Malaysia. More recent, collections and further studies have clearly established placement of these species and *C. javana* in subsection *Cycas* (sensu Hill 1995b), and dramatically extended the known range of this subsection.

Sporadic and scattered, in more or less closed mesophyll forest in wet lowland areas, sometimes in seasonally inundated sites but more often on low ridges.

Conservation status: not considered to be at risk. Recommended status would be **LC.** Ver 3.1:IUCN (2001) status is **NT** (Donaldson 2003) for Indonesia and PNG.

Selected specimens examined: PAPUA NEW GUINEA: West Sepik: Kasiman Village, *Ferrero s.n.*, 1993 (NSW). **Morobe:** Quembung trail, *Clemens 8104*, 2 Apr. 1938 (A[n.v.], BRI, CANB, L); Sattelberg, *Clemens 751*, 31 Oct 1935 (G).

2. *Cycas scratchleyana* F.Muell., Victorian Naturalist 2(2): 18–19 (1885). *Cycas circinalis* subsp. *papuana* var. *scratchleyana* (F.Muell.) J.Schust., Pflanzenr. 99: 70–71 (1932).

Type: Papua New Guinea, Central: "New Guinea, Mt. Bedford, Jala River, Dedouri-Country", *W. Armit s.n.* (holo MEL; iso K).

Literature: Thistleton-Dyer (1888 as a form of *C. rumphii*), Lauterbach (1900 as *C. circinalis* in part), White (1923, as *C. circinalis*), de Laubenfels & Adema (1998), Hill (1994a).

Illustrations: Mueller (1885b), Schuster (1932, fig 10K), Hill (1994a, fig. 13).

Etymology: honouring English military engineer and colonial administrator Sir Peter Henry Scratchley (1835–1885), Special Commissioner for the Territory of New Guinea from 1884–1885.

Vernacular: *bico* (Ekor village, Halmahera), *enge-enge* (Mekeo language, Maipa village), *notuweh* (Medino village), *kataki* (Dsimakani language, Lake Murray area) (Hill 1994a).

Stems arborescent, to 4, rarely 7 m tall, 12–20 cm diam. at narrowest point. *Leaves* bright green or deep green, highly glossy, 170–310 cm long, flat (not keeled) in section (opposing pinnae inserted at 180° on rachis), with 160–300 leaflets, with white tomentum shedding as leaf expands; rachis usually terminated by a spine or paired leaflets; petiole 25–70 cm long (20–30% of total leaf), glabrous, spinescent for 80–100% of length; basal leaflets not gradually reducing to spines. *Median leaflets* simple, strongly discolorous, 220–310 mm long, 10–16 mm wide, inserted at 60° to rachis, decurrent for 1 mm, narrowed to 2.5 mm at base (to 20% of maximum width), 16 mm apart on rachis; section flat; margins slightly recurved and undulate; apex softly acuminate, not spinescent; midrib raised above, raised below. *Cataphylls* linear, pungent, pilose, 50–100 mm long. *Pollen cones* narrowly ovoid or fusiform, yellow to brown (pale), 20–25 cm long, 10–13 cm diam.; microsporophyll lamina firm, not dorsiventrally thickened, c. 35 mm long, c. 20 mm wide, fertile zone c. 27 mm long, sterile apex c. 6 mm long, raised; apical spine prominent or rudimentary, sharply upturned, 2–6 mm long. *Megasporophylls* c. 28 cm long, orange-brown tomentum; ovules 2–8, glabrous; lamina ovate to lanceolate, 45–80 mm long, 38–50 mm wide, regularly dentate; with 28–40 soft lateral spines 5–8 mm long, 1 mm wide; apical spine distinct from lateral spines, 25–30 mm long, 3 mm wide at base. *Seeds* flattened-ovoid, 43–55 mm long, 32–40 mm wide; sarcotesta orange or orange-brown, not pruinose, 5–7 mm thick; fibrous layer present; sclerotesta smooth; spongy endotesta absent. Fig. 2.

Historical notes: described in 1885 by German-born but pre-eminent Australian colonial botanist Sir Ferdinand Jacob Heinrich von Mueller (1825–1896). Collection details cited were "On Mount Bedford, Jala-River, Dedouri-Country; W. Armit." The single specimen known, which can be accepted as the holotype, is MEL 68059 (photo NSW), collected by W.E. Armit on the Argus Expedition into the hinterland of Port Moresby in 1883. The label reads as cited by Mueller, without the "On" preface, although Mount Bedford and Jala River were treated as separate localities by Mueller in a listing of Armit collections appended to the protologue. The label was also written entirely in Mueller's hand. Schuster cited "Mount Bedford, Jala-River (Rev. James Chalmers in Herb. Sidney); Dedouri-Country (W. Armit in Herb. Sidney)." None of these specimens can be found in NSW. An isotype, sent by Mueller, is held by K.

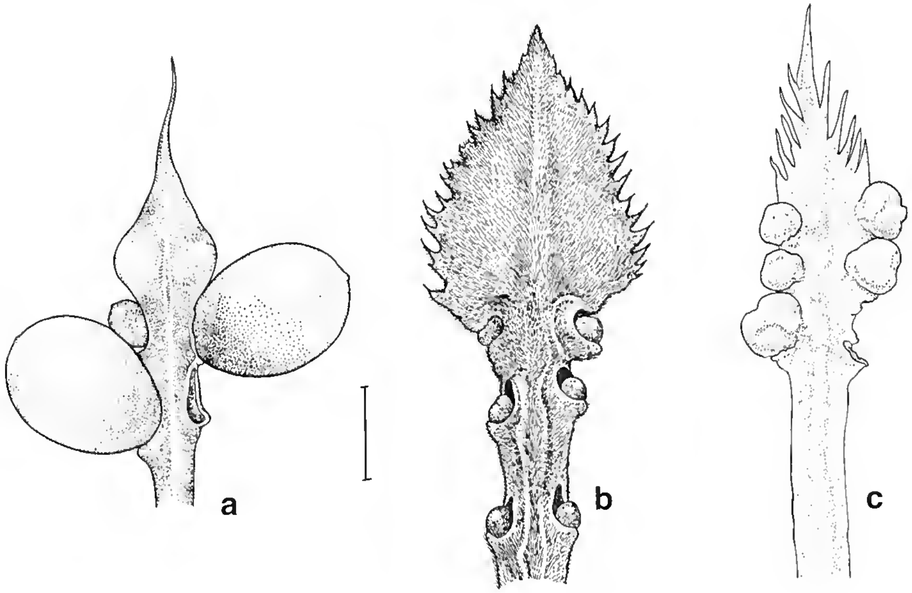

Fig. 2. Comparison of female sporophylls. **a**, *Cycas apoa*. **b**, *Cycas scratchleyana*. **c**, *Cycas javana* (a from *Ferrero s.n.* by N. Oram, b from *Taylor 11* by N. Oram, c from slide, cult. Cibodas Botanic Garden, Java, Indonesia by C. Wardrop). Scale bar = 2 cm.

This species has been poorly understood since it was first described. Subsequent authors have generally ignored the name *C. scratchleyana*, most commonly using the name *C. circinalis* (Lauterbach 1900, White 1923). Thistleton–Dyer (1888) regarded it as a form of *C. rumphii*. The treatment by Schuster (1932) regarded *C. scratchleyana* as a variety of *C. circinalis* within subspecies *papuana* (F.Muell.) Schuster, effectively combining the three subsections of section *Cycas* in a single species.

Schuster's treatment has not been generally followed, although attempts to follow it in the Pacific were made by Smith (1979) and Kanehira (1938). More recently, there has been a tendency to apply the names *C. rumphii*, *C. circinalis* and, to a lesser extent, *C. media* R.Br. somewhat uncritically, including to specimens of *C. scratchleyana* (Paijmans 1976; specimen determinations in LAE, CANB, L, BO). The treatment of *Cycas* by de Laubenfels and Adema (1998) recognises *C. scratchleyana*, but with unclear circumscription and citing material that clearly does not belong (e.g. *Warburg 21129* from New Britain). Mistaken inclusion of *C. scratchleyana* in subsection *Rumphiae* by Hill (1994a) is discussed above under *C. apoa*.

Distinguishing features: nearest to *C. apoa*, from which it is distinguished as discussed above. Distinguished within the genus by the relatively large, ovate megasporophyll lamina with numerous short to medium-length lateral spines, the long, narrow, thin leaflets that lack hypodermis and are frequently very strongly undulate, and the usually wholly spinescent petiole. Adaxial mesophyll is continuous across the usually narrow and strongly raised midrib, and abaxial mesophyll also is sometimes continuous. Some specimens display broader, harder leaflets with scattered laminar hypodermis, probably as an environmental response to higher light conditions. Some specimens from around Port Moresby also show somewhat narrower, harder and slightly keeled leaflets with a harder and glossier cuticle, and are interpreted as the products of hybridism with *C. campestris* K.D.Hill.

Distribution and habitat: widespread in eastern New Guinea, extending from near-coastal sites to foothills, from Milne Bay west to western Irian Jaya and Maluku, apparently mainly on the southern catchments (Fig. 1). Collections from Irian Jaya are limited, and the species is probably more abundant than is suggested. The range also may extend further to the west. Often a species of higher elevations (to over 900 m), usually on slopes or ridges in more or less closed, moist forests, but also extending to similar forests on stabilised calcareous coral-sand dune country and nearby headlands, particularly in the east of the range.

Plants from the far west of the known range (*Buwalda 4622*) from the Tanimbar group) show a somewhat narrower megasporophyll lamina, but still with the distinct dentition of *C. scratchleyana*. These may represent regional variation, some degree of intergradation with *C. javana*, or another taxon. Widespread regional political unrest has rendered this locality off limts for some time now. These plants require further investigation, but are here treated as a regional variant of *C. scratchleyana* until such time as they can be adequately investigated.

Conservation status: not considered to be at risk. Recommended status would be **LC.** Ver 3.1:IUCN (2001) status is **NT** for Indonsesia and PNG. (Donaldson 2003).

Selected specimens examined: PAPUA NEW GUINEA: Milne Bay: Biniguni camp, Gwariu River, *Brass 23830*, 5 Aug 1953 (A[n.v.], CANB, K, L); track between Tutubea and Lake Lavu, Fergusson Island, Esa'ala Subdistrict, *Croft et al. LAE 68785 A*, 12 Nov 1976 (LAE, BRI, CANB, K, L); top of Pini Range, Sagarai, Alor Subprovince, *Gideon LAE76964*, 3 Mar 1984 (LAE, K, L); 2 km inland of Medino, N coast of Cape Vogel Peninsula, *Hoogland 4750*, 15 Sep 1954 (CANB, BM, BO, BRI, K, L, LAE); Sewa Bay, Normanby Island, Ese'ala Sub-district, *Lelean and Streimann LAE 525246*, 21 Oct 1971 (ALE); Biniguni, Raba Raba Subdistrict, *Streimann NGF28556*, 27 Jun 1972 (LAE[n.v.], CANB, K, L); near Kwagira, *Taylor 11*, 26 Sep 1954 (CANB). **Central:** Kubuna, *Brass 5643*, Nov 1943 (BRI, BO); near Maipa airstrip, Maipa village, Kairuku Subdistrict, *Darbyshire 907*, 8 Sep 1962 (CANB, K, L, LAE); on ridge below Boridi Village, Port Moresby Subdistrict, *Foreman and Vinas LAE60256*, 1 Oct 1973 (LAE, CANB, K, L); logging road near Kuriva sawmill, Hiritano Highway road, Moresby Subdistrict, *Larivita and Maru LAE70598*, 1 Sep 1976 (LAE, BRI, K, L, NSW); Mekeo district, *White 794*, Jul–Aug 1918 (BRI); Brown River timber reserve, *Womersley & Van Royen NGF5872*, 24 Jun 1954 (BO). **Gulf:** near Malalaua, *Craven and Schodde 933*, 2 Mar 1966 (CANB, K, L, LAE); above Purari, 63 km at 65 deg. from Baimuru, Baimuru Subdistrict, *Croft et al.LAE 61174*, 27 Mar 1974 (LAE, BRI, CANB, K, L); Mina River, Kikori Subdistrict, *Womersley NGF46475*, 28 Mar 1974 (LAE, BRI, CANB, K, L). **Western:** Fly River, 528 mile camp [Palmer Junction], *Brass 6752*, May 1936 (A, BM, BO, BRI, K, L, LAE); Kiunga, Kiunga Subdistrict, *Streimann and Lelean NGF34119*, 13 Sep 1972 (LAE[n.v.], CANB, L).

INDONESIA: Papua: Mamberamo River nr Albatros bis, *Docters van Leeuwin 9623*, Jul 1926 (BO); Jaba, Wissel Lake region, *Eyma 5451*, 23 Nov 1939 (BO);Merauke District: path from Lake Wam to Wam River, *van Royen 4769*, 21 Aug 1954 (L, CANB, KEP K). Radjah Ampat, Waigeo Island, Siam River on eastern peninsula upstream of Wekasan, *van Royen 5297*, 25 Jan 1955 (L, CANB). **Maluku:** Aru, Kobroor, *Durbaum s.n.*, Aug 1995 (NSW); Halmahera, Ekor, base of Gunung Panjang, *Vogel 3136*, 24 Sep 1974 (L, CANB); Tanimbar, Jamdona Is., Otimmer, *Buwalda 4622*, 5 Apr 1938 (BO, K, L). **West Papua:** Misool Is., Sorong [1° 48'S 130° 08'E], on road to Tip, *Pleyte 978*, 21 Sep 1948 (BO, BRI, K);

3. *Cycas javana* (Miq.) de Laub., in D.Y.Wang, Cycads China: 65 (1996). *Cycas circinalis* var. *javana* Miq., Monogr. Cycad.: 28. Tab. 1, fig. t & u, Tab. II, fig. E1 (1842).

Type: Indonesia, Java, *Blume 1089* (holo L, 2 sheets).

Literature: De Candolle (1868 as *C. circinalis* var. *javana*), Miquel (1868 as *C. rumphii*).

Illustrations: Miquel (1842 as *C. circinalis* var. *javana*) de Laubenfels (in Wang 1996, figs 1-5), de Laubenfels and Adema (1998, fig 2).

Etymology: from the island of Java, with the Latin suffix -ana, a connection, referring to its occurrence on and initial collection from Java.

Stems arborescent, 2–4 m tall, 15–20 cm diam. at narrowest point. *Leaves* dark to mid green, highly glossy, faintly bluish as expanding, to 205 cm long, flat (not keeled) in section (opposing pinnae inserted at 180° on rachis), with c.146 leaflets, with brown or orange-brown tomentum shedding as leaf expands, terminated by a spine to 6 mm long or paired leaflets; petiole 30–60 cm long (15–25% of total leaf length), glabrous, spinescent for 40–90% of length; basal leaflets not gradually reducing to spines. *Median leaflets* simple, strongly discolorous, 240–370 mm long, 10–15 mm wide, inserted at c. 50° to rachis, narrowed to 2.5–6 mm at base (to 20–35% of maximum width); section flat; margins slightly to moderately recurved; apex acute, not spinescent; midrib raised above, raised below. *Cataphylls* linear, soft, rich orange-brown pilose. *Pollen cones* ovoid, orange or brown; microsporophyll lamina firm, not dorsiventrally thickened, apical spine prominent, sharply upturned. *Megasporophylls* 22–36 cm long, brown-tomentose, tomentum persistent; ovules 2–8, glabrous; lamina lanceolate, 60–100 mm long, 11–30 mm wide, regularly dentate; with 12–30 pungent lateral spines 5–20 mm long, 1–2 mm wide; apical spine distinct from lateral spines, 10–65 mm long, 1.5–3 mm wide at base. *Seeds* not seen. Fig. 2.

Historical notes: described in 1842 as a variety of *C. circinalis* by Dutch botanist Miquel. Miquel later subsumed this variety into *C. rumphii*, and no further note was made of it until the present decade when de Laubenfels raised this to species in 1996. The treatment of this species by de Laubenfels and Adema (1998) is essentially correct.

Distinguishing features: the lack of any spongy endotesta and the narrow, regularly-toothed megasporophyll lamina distinguish this species.

Distribution and habitat: *Cycas javana* is apparently a Javan endemic (Fig. 1). Plants occur in closed evergreen forest, inland, often near streams in mountain areas. Populations also persist in disturbed areas.

Conservation status: much of the original habitat of this species has been cleared for agriculture. Although healthy populations remain in some higher areas, the appropriate recommended status would be **NT.** Ver 3.1:IUCN (2001) status is **DD** (Donaldson 2003).

Selected specimens examined: INDONESIA: Jawa Timur: Kangean, [--] Tanbajangan [Tambayangan] 22 m, *Backer 27471*, 1920 (L, BO); Kangean Is., NE of Java, *Hoogerwerf 235*, 1954 (L); Besoeki Poeger [Besuki Puger], [G.] Watangan [8° 25'S 113° 28'E], *Koorders 1564 B*, 21 Aug 1889 (L, BO). **Jawa Tengah:** Prov. Banjoemas, Pringombar, *Koorders 1563*, 20 Nov 1891 (L, BO); Prov. Preangar, Temarang [?Semarang], Kedoengdjati [7° 10'S 110° 38'E], *Koorders 24990 B*, 19 Sep 1896 (L).**Jawa Barat:** Banham Tusschen Malingping [6° 48'S 106° 01'E] en Penjarroengan [Panggarangan 6° 53'S 106° 12'E], *Backer 1476*, 17 Jun 1911 (L); Tjialin a/d Tjitarik [6° 20' S 107° 27' E], Res Oreabgar, 500 m, *Bakhuizen v.d. Brink 5086*, 21 Dec 1920 (L); G. Talagabodas (7° 12'S 108° 28'E), *Ken VH* (L); near Cibaraja village, along stream, 7°22.164'N 107°08.580'E, *Lindstrom 174, 175* (live voucher plants at Nong Nooch Tropical Botanical Gardens); cult. in Cibaraja village, coll. nearby, *Lindstrom 173*, Apr 1999 (NSW, UBC); Res Preangar, Reg Tjabareno estate, by pelaboean Ratoe [Pelabuhan Ratu 6° 59'S 106° 35'E], *Pottinga s.n.*, 1 Oct 1923 (L, BO); Kuripia [? Koeripan - near Bogor], *leg. ign.* (L); Kuripau [? Koeripan - near Bogor], *leg. ign.* (L); Up Kuripian [? Koeripan - near Bogor], *leg. ign. [Blume?] 1079* (L).

Cult.: hort. Bogor, *Stolk 149* (BO, L)

4. *Cycas montana* A.Lindstr. & K.D.Hill, **sp. nov.**

Inter species indonesienses combinatione characterum sequentium distinguitur: folia viridia (non glauca), foliolis rigidis angustis, petiolis tomentosis, fructus non spongiosus.

Type: Indonesia, Flores, Mangarai province, Nggoang district, Ndara, Wae Moto village, 400 m, *Lindstrom 248*, 27 Apr 2000 (Holotype BO, iso UBC).

Etymology: from the montain habitat.

Vernacular: *tulumpu, watai* (unidentified languages).

Stems arborescent, to 1.5 m. tall, 30–35 cm diam. at narrowest point. *Leaves* deep green, glossy, 223–248 cm long, 144–151 leaflets, with persistent brown tomentum; petiole 63–72 cm long (25–30% of total leaf), spinescent for c. 20% of length; basal leaflets not gradually reducing to spines, to 230 mm long. *Median leaflets* simple, strongly discolorous, 230–248 mm long, 8–10 mm wide, decurrent for 7 mm, narrowed to

3–4 mm at base (30–40% of maximum width), 10–15 mm apart on rachis; section slightly keeled; margins distinctly recurved; apex acute or aristate, spinescent; midrib flat above, raised below, narrow. *Cataphylls* narrowly triangular, soft. *Pollen cones* not seen. *Megasporophylls* 20–35 cm long, tomentum orange, persistent; ovules 2–6, glabrous; lamina lanceolate, 45–100 mm long, 20–40 mm wide, shallowly pectinate, with 14–40 pungent lateral spines 9–13 mm long, 1.5 mm wide; apical spine distinct from lateral spines, 25–40 mm long, 5–8 mm wide at base. *Seeds* ovoid, 50–55 mm long, 30–45 mm wide; sarcotesta amber-brown, not pruinose; fibrous layer present; sclerotesta smooth, spongy endotesta absent. Fig. 3.

Distinguishing features: *Cycas montana* is distinguished from other species in the region by the absence of a spongy endotesta, the green (non-glaucous) leaves, the persistent brown tomentum on the petiole, and the stiff, narrow leaflets.

Distribution and habitat: endemic on Flores (Fig. 1), restricted to inland montane forests at higher altitudes.

Conservation status: not thought to be at risk, although not reserved. Recommended Ver 3.1:IUCN(2001) status would be **NT.**

Selected specimens examined: INDONESIA: Nusa Tenggara Timur: Flores: Ngada province, cult. in Bajawa town, said to originate from nearby montain forest, *Lindstrom 253,* 29 Apr 2000 (BO, UBC); Ngada province, cult. in Jerebao village, near Bajawa town, said to come from nearby forest, *Lindstrom 261,* 29 Apr 2000 (BO, UBC); Ngada province, cult. in Wolosambi village, near Bajawa town, said to comefrom nearby forest, *Lindstrom 262,* 30 Apr 2000 (BO, UBC); Ngada province, Nangamboa village, Ondorrea Mountain *Lindstrom 263,* 30 Apr 2000 (BO, UBC); Nunang, 650 m, *Schmutz 0123*, 17 May 1965 (L); Manggarae, Nunang, 650 m, *Schmutz SVD 4717*, 14 Dec 1980 (L).

Cycas* subsection *Rumphiae K.D.Hill, Austral. Syst. Bot. 7: 548 (1994a).

Type species: *Cycas rumphii* Miq., Bull. Sci. Phys. Nat. Neerl. 2: 45 (1839).

This subsection is uniquely defined by the presence of a layer of spongy tissue within the seed. Another potentially synapomorphic character defining this group is the 2-year seed maturation period, although this has been confirmed only for *C. seemannii* A. Br., *C. thouarsii* R. Br. Ex Gaudich.and *C. bougainvilleana* K.D.Hill. All other species of *Cycas* for which data is available have a maturation period of less than one year.

Distribution is very wide, extending from Africa to Fiji and Tonga, and from New Guinea north to southern coastal Indochina. Four species occur in Indonesia.

The spongy endotesta causes seeds to be buoyant, and has been proposed as a dispersal mechanism (Dehgan & Yuen 1983). This dispersal mechanism has been interpreted as a cause of the taxonomic complexity of this group, with successive colonisation events producing the high local variability in some populations and the very different forms sometimes occurring in close proximity (Hill 1994a, Fosberg & Sachet 1975).

5. *Cycas falcata* K.D.Hill, Kew Bull. 54(1): 209 (1999).

Type: Indonesia, Sulawesi, Kabaena, Gunung [Mount] Katopi, 18 km NW of Tangkeno, *McDonald & Ismael 4184*, 7 Aug 1993 (holo K, iso A, BO, E, KEP, L).

Illustrations: Hill (1999).

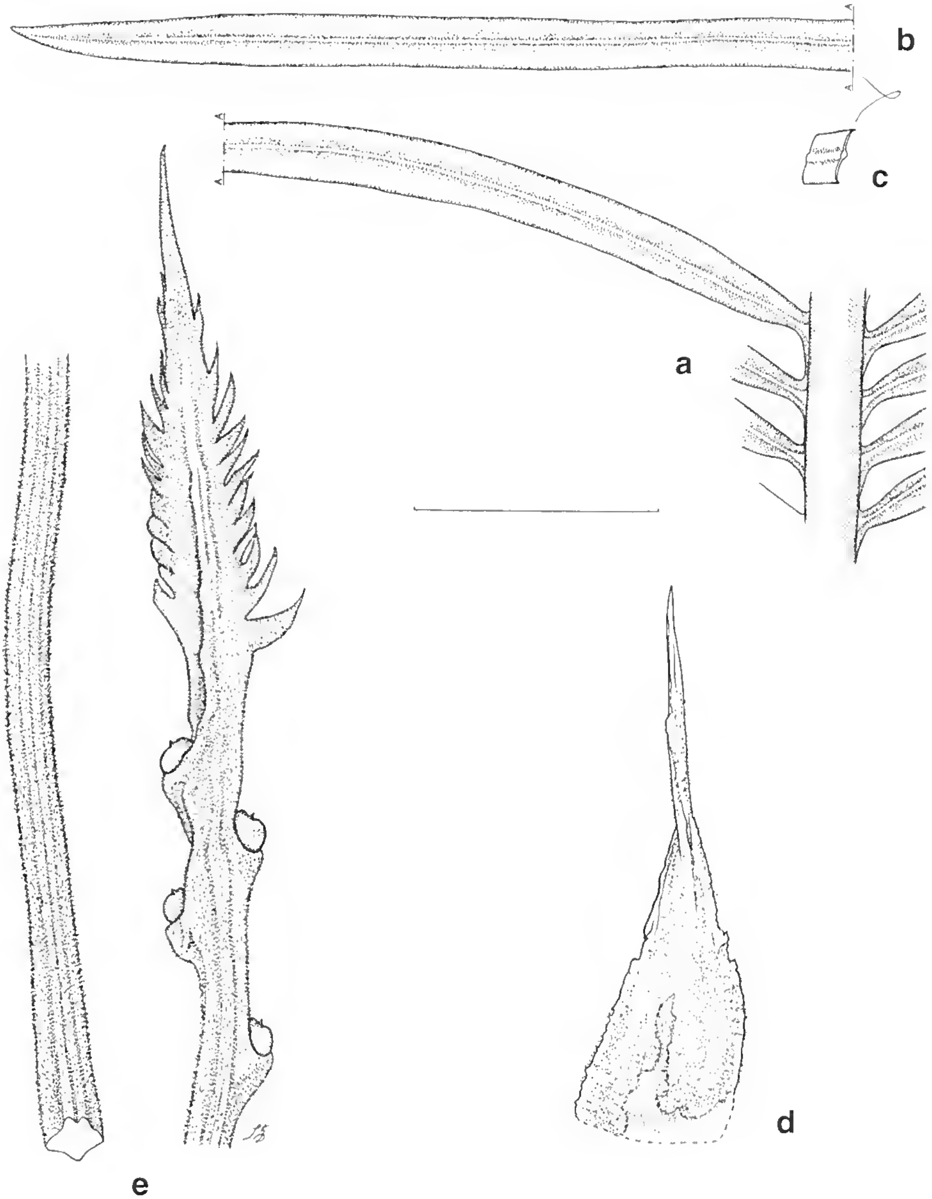

Fig. 3. *Cycas montana*. **a, b,** part of leaf. **c,** cross-section of leaflet. **d,** cataphyll. **e,** female sporophyll (all from *Lindstrom 248*, d, by C. Wardrop). Scale bar = 5 cm.

Etymology: from Latin *falcatus*, falcate or curved in a sickle-shape, from the distinctively curved leaflets.

Stem erect, unbranched or occasionally branching 2 to 3 times at base, to 5 m tall, 12–30 cm diam. at narrowest point. *Leaves* olive-green, glossy, 180–300 cm long, slightly keeled in section (opposing leaflets inserted at c. 150° on rachis), with 100–200 leaflets, glabrous; rachis terminated by paired leaflets or a spine c. 3 mm long; petiole 27–62 cm long (20–35% of total leaf length), glabrous, spinescent for 80–100% of length; basal leaflets not gradually reducing to spines. *Median leaflets* simple, glabrous, moderately discolorous, often strongly falcate, 170–300 mm long, 7.5–13 mm wide, inserted at 60–70° to rachis, decurrent for 5–7 mm, narrowed to 3–4 mm at base (to 45% of maximum width), 11–17 mm apart on rachis; keeled in section; margins slightly recurved; apex acuminate, not spinescent; midrib strongly raised above, green, slightly raised below; leaflets tapering gradually from near midpoint to base; tomentum loose and shed early. *Cataphylls* broadly triangular, soft, 40–70 mm long, with short, erect mid-brown indumentum. *Pollen cones* not seen. *Megasporophylls* 19–27 cm long, mid-brown-tomentose; ovules 4–6, glabrous; lamina narrowly triangular, 60–70 mm long, 22–32 mm wide, shortly pectinate, with 16–28 more or less pungent lateral spines 7–12 mm long; apical spine distinct from lateral spines, 15–28 mm long, 2.5–4 mm wide. *Seeds* flattened-ovoid, 42–46 mm long, 25–34 mm wide; sarcotesta orange-yellow, not pruinose, fibrous layer absent; sclerotesta not or weakly apically crested; thin spongy layer present. Fig. 4.

Distinguishing features: the spongy endotesta places this species unmistakably in the *Cycas rumphii* group (subsection Rumphiae, Hill 1994a), although it differs markedly in many other respects. The small seeds are not typical of this group, and neither are the distinct long lateral spines on the megasporophyll lamina, the keeled leaves or the narrow, falcate pinnae.

Distribution and habitat: *Cycas falcata* is known from two localities on the main island of Sulawesi and from Kabaena Island off the south-eastern coast of Sulawesi (Fig. 1). It occurs in habitats ranging from closed forest to open short tree savanna with grasses dominant, in full sun to heavy shade, over limestone or serpentinite substrates.

The habitat of this species is quite different to the habitats of other species in the *C. rumphii* group, which generally occur in near-coastal situations (Hill 1994a). Aquatic dispersal and the consequent coastal distribution are general features of this group. The departure of this species from the general state can be best regarded as an evolutionary advance, represented by the colonisation of a new and different site. Although many cycads are either calciphiles or serpentiniphiles (Hill 1995b, 1998), such habitat preference can be seen from this example to be derived rather than ancestral conditions, and is a condition that has arisen independently on more than one occasion.

The deeply dentate or shortly pectinate megasporophyll is another feature not known elsewhere in subsection Rumphiae. Similar megasporophylls occur in the forest species *C. macrocarpa* Griff. from Thailand and peninsular Malaysia, and *C. riuminiana* Porte ex Regel from the Philippines. These however lack the spongy endotesta and possess a fibrous sarcotesta not evident in subsection Rumphiae. A hybrid origin between one species of subsection Rumphiae and one of subsection Cycas cannot be demonstrated at this stage, but is not out of the question.

Conservation status: although probably not immediately threatened, this species is of apparently limited distribution and potentially vulnerable in the longer term. On the basis of a preliminary evaluation, the appropriate Ver 3.1:IUCN (2001) status would be **NT**. Further field study is required to fully assess the conservation status of this species and indeed of most Asian cycad species. Current Ver 3.1:IUCN (2001) status is **DD** (Donaldson 2003).

Selected specimens examined: INDONESIA: Sulawesi Selatan: Soroako - Wasuponda road, km 19, *van Balgooy 3930*, 7 Jul 1979 (L, BO); Mt Molinowe, 14 km from Wasuponda between Wasuponda and Soroako, *Hennipman 6133*, 7 Jul 1979 (BO, L, A); S of Wasuponda, SW of Soroako, *de Vogel 6304*, 16 Jul 1979 (L, BO); S. shore of Lake Matano, *de Vogel 5734*, 12 Jun 1979 (L, BO, BRI). **Sulawesi Tenggara:** around Opa Swamp, Mt Makaleo, *Prawiroatmodjo & Soewoko s.n.* and *1757*, 13 Nov 1978 (L ex BO).

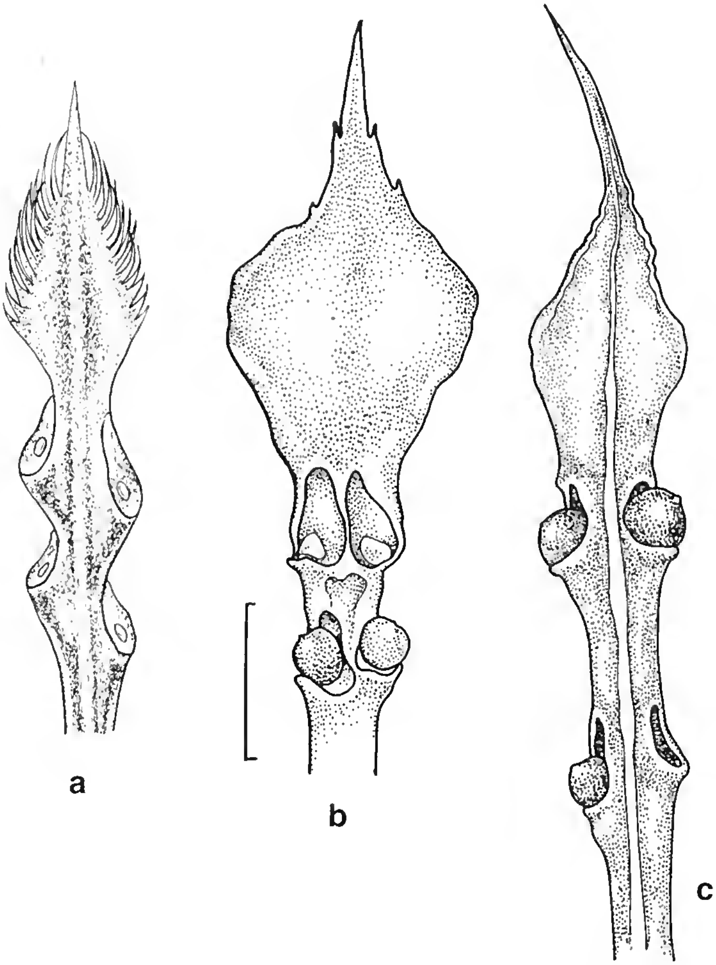

Fig. 4. Comparison of female sporophylls. **a,** *Cycas falcata*. **b,** *Cycas rumphii*. **c,** *Cycas edentata* (a from *McDonald & Ismael 4184* by L.McGurr, b from *van Royen 3300* by N. Oram, c from *Hill 4627* by N. Oram). Scale bar = 2 cm.

6. *Cycas rumphii* Miq., Bull. Sci. Phys. Nat. Néerl. 2: 45 (1839).

Lectotype: Plate 23 in Rumphius (1741), *fide* Lindstrom (2002).

Cycas celebica Miq., Bull.Sci. Phys. Nat. Neerl.2: 45 (1839).
Lectotype: Plate 21 in Rumphius (1741), *fide* Lindstrom (2002).

[*Cycas recurvata* Blume ex. J. Schuster., Pflanzenr. 99:74 (1932); name only, in syn. *Cycas rumphii*]

[*Cycas speciosa* D. Don, Proc.Linn.Soc. 1:53–56 (1840); name only, in syn. *Cycas rumphii*]

[*Cycas sundaica* Miq. ex J. Schust., Pflanzenr. 99: 74 (1932); name only, in syn. *Cycas rumphii*]

Literature: Lemaire (1864 as *C. rumphii* and *C. celebica*), Lauterbach (1900 as *C. circinalis*), Stapf (1916), Backer (1925), Ochse (1931), Schuster (1932), Kanehira (1938), Backer & Bakhuizen van den Brink (1963), Peekel (1984), Hill (1994a), de Laubenfels and Adema (1988, in part).

Illustrations: Miquel (1852), Warburg (1900), Schuster (1932), Kanehira (1938), Peekel (1984), Hill (1994a).

Etymology: honouring German-born Dutch naturalist Rumphius (Georg Eberhard Rumpf, 1628-1702), military officer with the Dutch East India Company in Ambon, 1652–1657, then with the civil merchant service of the Dutch East India Company.

Vernacular: *nufuès* (Biak); queen sago (English); *haji, hajo, intalappana, pakoe laut* (sea fern), *paku gajah, paku laut* (Malay); *sumo* (Wapi); *ftoi* (Weda); *bakutu, djoedjaroet, djudjaru, madjong utu, pekis rady, utta niwel, utta nuer* (unidentified languages) (Hill 1994a, Pant 1962, Schuster 1932, Bonta & Osborne 2007).

Typification: the original description of *C. rumphii* is based on 'Olus Calappoides' or 'Sajor calappa' of Rumphius, Herb. Amboinense., Lib. 1, Cap.XX excl. planta Celebica 1741. Most Rumphius specimens were lost in a ship wreck while en route to Europe (Stafleu & Cowan 1983). This leads to the conclusion that Miquel did not have either live plants or herbarium specimens available and that he relied strictly on the plates in Rumphius's work for his description. However, Hill (1994a) pointed out that one of the illustrations of Rumphius (1741) shows rather distinct lateral teeth on the megasporophyll. This does not entirely accord with other collections from the Moluccas and the larger teeth may be the artist's interpretation. De Laubenfels and Adema (1998) pointed out that recently collected material of *C. rumphii* cited by Hill (1994a) shows variation in the megasporophylls in that some have teeth while others do not. Besides the megasporophyll, other characters in these illustrations are inconsistent with collections from the type locality; specifically the overall shape of the megasporophyll lamina, the short spine on the megasporophyll tip, the clearly visible spines on the petiole and the fact that the seeds do not show any spongy layer. All of these characters could be the artist's interpretation, but it is more probable that the drawing was done from different plants, possibly even different species. Plate 22, overall much more resembles *C. scratchleyana*, a species that is found in the area and on neighboring Ceram. Both plates have been cited as the type (Hill 1994a; de Laubenfels, 1998). Miquel's description of *C. rumphii* initially encompassed Plates 22 and 23 of Rumphius. Later (1839) he placed his *C. celebica* (plates 20 and 21) into synonymy with *C. rumphii*. As Miquel's initial concept of *C. rumphii* was based on plates 22 and 23 these plates should serve as the type. However, recent studies of living specimens and herbarium material indicate that these plates (22, a female plant and 23, a male plant) represent two distinct species. Plate 23 was designated as the lectotype of *C. rumphii* by Lindstrom (2002) for two reasons. First, recently collected material of a male plant from Ambon (*Robinson 563*, Ambon, Wae) matches well with the illustration on Plate 23. Additionally, the current usage of the name *C. rumphii* is in agreement with the illustration on Plate 23 while Plate 22 matches *C. scratchleyana*. Choosing Plate 22 as the type would cause major and unnecessary nomenclatural instability while selecting Plate 23 as the type increases nomenclature stability in the genus. Based upon examination of recently collected material, (see specimens examined), *C. celebica* must correctly stay as a synonym of *C. rumphii*. De Laubenfels' (1998) recognition of *C. celebica* as a distinct taxon was evidently based upon the lack of spines on the petiole in the type illustration. This is correct in the type drawing but not consistent within several populations examined in Sulawesi.

Stems arborescent, to 3(–10) m tall, 11–20 cm diam. at narrowest point. *Leaves* bright green, highly glossy, 150–250 cm long, flat (not keeled) in section (opposing pinnae inserted at 180° on rachis), with 150–200 leaflets, with orange tomentum shedding as leaf expands; rachis consistently terminated by paired leaflets; petiole 35–60 cm long (20–30% of total leaf), glabrous, spinescent for 0–100% of length; basal leaflets not gradually reducing to spines, 190 mm long. *Median leaflets* simple, strongly discolorous, 220–320 mm long, 12–16 mm wide, inserted at 70–85° to rachis, decurrent for 5–8 mm, narrowed to 4.5–7 mm at base (to 35–50% of maximum width), 15–19 mm apart on rachis; section flat; margins slightly recurved; apex acute, not spinescent; midrib flat above, raised below. *Cataphylls* narrowly triangular, soft, shortly pilose. *Pollen cones* fusiform, yellow to brown (pale), 35–55 cm long, 10–15 cm in diameter; microsporophyll lamina firm, dorsiventrally thickened, apical spine rudimentary, sharply upturned, 2–5 mm long. *Megasporophylls* 18–32 cm long, white-tomentose or yellow-tomentose; ovules 2–6, glabrous; lamina lanceolate, 50–75 mm long, 25–35 mm wide, obscurely dentate; with c. 12 soft lateral spines 0–4 mm long, 0–2 mm wide; apical spine distinct from lateral spines, 10–25 mm long. *Seeds* flattened-ovoid, 45 mm long, 30 mm wide; sarcotesta orange-brown, not pruinose; 3–4 mm thick, fibrous layer absent; sclerotesta apically crested; spongy endotesta present. Fig. 4.

Historical notes: although first legitimately described in 1839 by Dutch botanist Miquel, the existence of a distinct Malesian taxon was first recognised by Roxburgh (1832: 747), on the basis of plants in cultivation in the Calcutta Botanic Gardens. He recognised that two taxa were present, treating one as *C. circinalis* and describing the other as a new species *C. sphaerica* Roxb. Roxburgh had, however, mistakenly applied the new name *C. sphaerica* to plants from India belonging to the *C. circinalis* alliance.

The distinct Malesian taxon he then treated under the name *C. circinalis*, although he had also mixed material of the two taxa under each description.

Miquel's *C. rumphii* (1839: 45) was based on part of Olus Calappoides of Rumphius (1741) and he was never clear on the specific limits of this taxon, at first separating material from Sulawesi as *C. celebica* (1839: 45), and later (1868: 232), combining the two. Miquel also separated material from Timor as *C. rumphii* var. *timorensis* (1841: 125), and from Java as *C. circinalis* var. *javana* (1842: 28). In addition, he at first recognised Roxburgh's *C. sphaerica* (1843: 693), apparently on the basis of Roxburgh's published account and without realising the confusion with *C. circinalis*. He later (1851: 32) correctly noted Roxburgh's confusion, and placed *C. sphaerica* in the synonymy of

C. circinalis, although later still (1868: 230), he again recognised *C. sphaerica* at specific rank. At the same time (1868: 232), he placed *C. celebica* and *C. circinalis* var. *javana* in *C. rumphii*, with no mention of *C. rumphii* var. *timorensis*.

Warburg (1900) also recognised the presence of a coastal taxon in New Guinea (including the Province of Papua, Indonesia), assigning it to *C. rumphii*. This taxon has also been assigned to *C. circinalis* (White 1923).

Distinguishing features: distinguished by the broad, falcate, hard, glossy leaflets with relatively broad bases, present but discontinuous laminar hypodermis, the relatively long and usually wholly spinescent petiole, the male sporophyll lacking a distinct terminal spine (Fig. 5.) and the narrowly triangular megasporophyll lamina with a slender apical spine (10–25 mm long) and reduced lateral spines. Adaxial mesophyll is usually continuous across the moderately broad and rounded midrib, but sometimes interrupted by the midrib in the east of the range. This may be due to genetic admixture of *C. bougainvilleana* from further to the east. The condition of reduced lateral spines also occurs in *C. edentata*, and related taxa from Philippines, Malaysia and the Indian Ocean. The latter taxa (not all treated herein) are, however, distinguished as a group by the lack of the apical crest on the seed.

Distribution and habitat: *Cycas rumphii* has been poorly understood in the past. Recent recognition of a number of related species has allowed clarification of its identity, and clear delineation of its distribution (Fig. 1). As now understood, *C. rumphii* has a distribution centred on the Moluccan island group (Maluku, or the Spice Islands) extending east into Indonesian Papua and a short way along the north coast of Papua New Guinea, and north to Sulawesi. In the west, it appears to extend to southern Borneo, north-eastern Java and Christmas Island.

C. rumphii appears to share the ecological preferences of several other taxa in this group, being largely a species of closed woodland or forest on more or less calcareous substrates in near-shore environments.

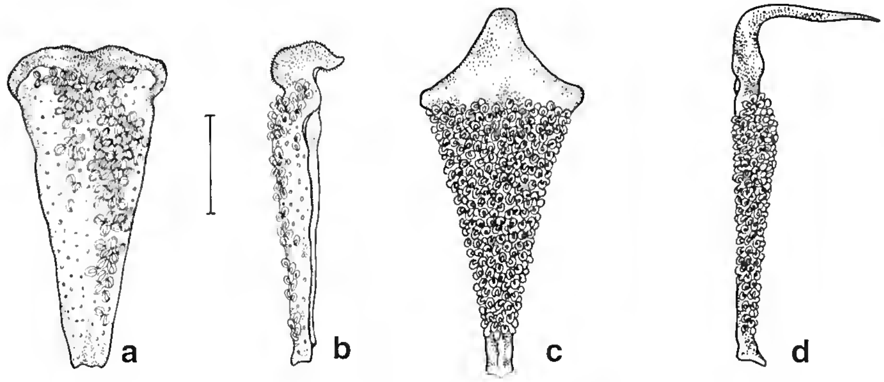

Fig 5. Comparison of male sporophylls. **a, b,** *Cycas rumphii*. **c, d,** *Cycas edentata* (a, b, from *NSW 714722 Claussen s.n.*, c, d, from *Hill 4630* by N. Oram). Scale bar = 1 cm.

Recognition of *C. rumphii* as a distinct species has been widely argued, with early discussion very ably summarised by Stapf (1916). Schuster (1932: 74) provided an essentially correct treatment of this species (with the exception of the varieties and subspecies, and the New Caledonian material cited), in contrast to his confused treatment of most other species. The name has been generally accepted subsequently, although misapplications of the name *C. circinalis* to this and related taxa continue (eg. Jones 1993, corrected in 2nd edition, Jones 2002).

Conservation status: the 1997 IUCN Red List of Threatened Plants lists *C. celebica* as R, although very little is known of this or in fact most occurrences in this region. Once abundant and widespread, this species occurred in coastal sites that have experienced severe pressures from population increase and development. This habitat is also coming under increasing pressure for aquaculture sites. Although probably not immediately threatened, it is potentially vulnerable in the longer term. Ver 3.1:IUCN (2001) status is **NT** (Donaldson 2003).

Selected specimens examined: AUSTRALIA: Western Australia: Christmas Island, Top of escarpment, Tom's Ridge, 1 km south of McPherson Point, near northwest point, *J. Claussen s.n & B. Claussen.,* 07 Mar 2005 (NSW *714734*); Just over the edge of the plateau escarpment, 500 m west of Runaway Cave, North East Point, *J. Claussen s.n.* & *B. Claussen*, 24 Feb 2005 (NSW *714722*); On the edge of the plateau escarpment, c.1.34 km WNW of Wright Point, East Coast, *J. Claussen s.n.* & *B. Claussen*, 18 Feb 2005 (NSW *714713*). **Northern Territory:** Ashmore Reef. 12° 15'S 123° 00'E. Seeds found washed up on beach, probably from Indonesia, *Leach s.n.*, Oct 1996 (NSW).

INDONESIA: [No locality given], *Noblick s.n.* (FTG); [No locality given], *Anon.*, 13 Nov 1993 (NSW). **Jawa Timur:** Srigontjo Sen Z. van Malang aan de Zuidree, strand, *Backer 3825*, 10 Jun 1922 (BO); Kangaean, Soebi, 1.5 m, *Backer 20371*, 12 Apr 1920 (BO); Kangaean P. Mamboerit 1 m, *Backer 27279*, 19 Mar 1919 (BO); Sepandjang [c. 8° 10' S 112° 40' E], *Backer 28875*, 21 Apr 1919 (BO); Zo. Saboentern 0.5 m, *Backer 29746*, 9 May 1919 (BO); Res Soeraharta [Surakarta 7° 32' S 110° 50' E], zuidkust bij Paranggoepita c 20 m, *Burger 5629*, 31 Aug 1922 (BO). **Kalimantan Barat:** Karimata Arch., Poelau Pelapis Giangbalai, *Mondi 136*, 22 Mar 1931 (L, BO). **Maluku:** Ambon, Wae [Waa], *Robinson 563*, 29 Nov 1913 ([M], A, BM, BO, K, L, NSW, NY, P); Wae, Amboina *[Ambon]*, *Robinson s.n.*, Jul 1913 (NSW). Aru, Pulau Wokam, Dosinamaloe, *Buwalda 4971*, 16 May 1938 (BO, BRI); *Lauterbach 259* (BO); Kobroor, *Durbaum s.n.*, Aug 1995 (NSW); "*Amboina*", herb. Maire, *leg. ign.* (P); "Moluccas", *Brogniart* (BM). Buru, NW Wae Dana River N of Bara, 100-300 m, old river bed, limestone, *LBN-L 5269, field no 208*, 25 Nov 1984 (L). Halmahera, Pajehi [Payahe] Road, Weda District, *de Haan 1798*, 2 Nov 1950 (A, BO, K, L, NSW, NY, SING); Halmahera, cult. in kao town, *Lindstrom 151* (NSW, UBC); road between Doro and Pediwang, on coral rock near sea, *Lindstrom 153, 154* (NSW, UBC), *Lindstrom* 155 (UBC); on coral soil along stream near sea, *Lindstrom 156-7* (NSW, UBC). Obi, *Atasrip 60*, 1899 (BO, L). Ternate, Sango, *Beguin 1080*, 1 Nov 1920 (BO); Takome, base of Mt Gamalama less than 50 m from sea, *Lindstrom 158* (NSW, UBC); Sulamedaha, base of Mt Gamalama about 100 m from sea, *Lindstrom 159* (NSW, UBC). Tidore, road between Sidangoli and Tobelo, between km 6 and 7, near roadside, *Lindstrom 148* (NSW, UBC); Cult., in Kao town, *Lindstrom 152* (NSW, UBC); near Bubaneigo, along road, *Lindstrom 150* (NSW, UBC). **Papua:** Diak [? Biak] Bosnik, Schouten Is., *Gibbs 6278*, Dec 1914 (K, BM). **Sulawesi Utara:** Menado, Loewoek, Tobelombang, *Eyma 3727*, 13-16 Sep 1938 (L, BO); Minahassa, Menado, strand, Pandano, *Koorders & Seepit 2868*, 19 Feb 1895 (BO); *Koorders 16646* (L ex BO); "specimen from Forster", *Koorders 16647B* (BO); *Koorders 16648* (L, BO); *Koorders 16648B*, 19 Feb 1895 (B, K, L); N of Manado, Wori town, near beach, *Lindstrom 145* (NSW, UBC); **Sulawesi Tengah:** N central, on coast SW of Donggala, *Meijer 10071*, 11 May 1975 (BO); *Teijsmann s.n.*, 1859-60 (L). **Sulawesi Selatan:** Saleier group[?Salayar]: 2nd

Saleier, zandige kust, *van Leeuwin 1881*, 13-16 Sep 1938 (BO); Saleier groep, Eil Kalao [Kalao Is], strand, *van Leeuwin 1853*, 2 May 1923 (BO); Tapalang, *Noerkas 481*, 4 Aug 1912 (K, L, BO). **West Papua:** Raja Ampat, Marchesa Bay Amdoei on N bank of bay, *van Royen 3300*, 2 Apr 1954 (L, BRI, CANB, K, P).

PAPUA NEW GUINEA: voyage of HMS Sulphur, *Barclay 3540*, Jul-Aug 1840 (BM, L); **West Sepik:** near Yakoi village, 1 mile [1.6 km] W of Aitape, Aitape Subdistrict, *Darbyshire and Hoogland 7855*, 3 June 1961 (CANB, BM, BRI, L, LAE); Yako village, Vanimo Subdistrict, *Streimann LAE53828*, 2 Dec. 1971 (LAE, BRI, K, L, CANB).

Cult. Royal Botanic Gardens, Sydney, *Harwood s.n.*, May 1913 (NSW); *Boorman s.n.*, 1902 (NSW); *Boorman s.n.*, Jun 1915 (NSW); seed from Durbaum 1995, *s.n.* (NSW).

7. ***Cycas edentata*** de Laub., in de Laubenfels & Adema, Blumea 43(2): 372 (1998).

Type: Philippines, Sulu Archipelago, Mt Cabucan, *Kondo & Edaño 38877*, Jan-Feb 1957 (holo L, iso A, BM).

Cycas litoralis K.D. Hill, Brittonia 51(1): 70, fig. 11 (1999).
Type: Thailand. Ao Manao Naol, Narathiwat, *K.D. Hill 4627 & Poonsak Vatcharakorn*, 20 Apr 1994 (holo NSW, iso BKF, K, L, PE)

Cycas circinalis subsp. *riuminiana* var. *curranii* forma *maritima* J. Schust., Pflanzenr. 99: 69 (1932).
Lectotype (here designated): Philippines, Calusa Island, 29 July 1912, *Fenix 15660* (lecto K; isolecto L).

Literature: Lemaire (1864 as *C. circinalis* and *C. rumphii*), Kurz (1877 as *C. rumphii*), Foxworthy (1911 as *C. circinalis*), Merrill (1912 as *C. circinalis*), Merrill (1917 as *C. rumphii*), Merrill (1918 as *C. circinalis*), Merrill (1921 as *C. circinalis*), Merrill (1923 as *C. rumphii*), Backer (1925 as *C. rumphii* p.p.), Ridley (1925 as *C. rumphii*), Leandri (1931 as *C. rumphii*), Ochse (1931 as *C. rumphii* p.p.), Schuster (1932 as *C. rumphii* p.p.), Kanehira (1938 as *C. rumphii* p.p.), Ho and Duong (1960 as *C. rumphii*), Suvatabandhu (1961 as *C. rumphii*), Backer and Bakhuizen van den Brink (1963 as *C. rumphii* p.p.), Smitinand (1971 as *C. rumphii*), Smitinand (1972 as *C. rumphii*), Zamora and Co (1979 as *C. circinalis*), Amoroso (1986 as *C. rumphii*), Hill and Yang (1999 as *C. litoralis*).

Illustrations: Ridley (1925), Schuster (1932 as *C. rumphii* p.p.), Smitinand (1971), Cheng et al. (1975 as *C. rumphii*), Amoroso (1986 as *C. rumphii*), de Laubenfels and Adema (1998), Hill & Yang (1999 as *C. litoralis*)

Etymology: from the Latin *dentata*, toothed, with the Latin prefix *e-*, without, in reference to the megasporophyll apices.

Vernacular: *kwale pahang* (woods on sea shore)(Malay); *prong thale* (sea cycad) (Thai), *sanang, sawang* (Ilocano); *bait, bayit, pitógo* (preferred to *potago, patubo, pitugo* or *bitogo*) (Tagalog); *oliba, oliva* (preferred) (Spanish); *uliba, uliva*; (unidentified language) (Hill & Vatcharakorn 1998, Ridley 1893, Amoroso 1986, Schuster 1932, Zamora & Co 1986, Bonta & Osborne 2007).

Stems arborescent, to 10 m tall, to 20 cm diam. at narrowest point. *Leaves* bright to deep green, highly glossy, 130–230 cm long, flat (not keeled) in section (opposing leaflets inserted at 180° on rachis), with 100–200 leaflets, tomentum shedding as leaf expands; rachis consistently terminated by paired leaflets; petiole 30–90 cm long (20–50% of total leaf), glabrous, spinescent for 5–100% of length; basal leaflets not gradually reducing to spines, 120–280 mm long. *Median leaflets* simple, strongly discolorous, 220–370 mm long, 11–19 mm wide, inserted at 45–80° to rachis, decurrent for 5–13 mm, narrowed to 5–8 mm at base (to 35–50% of maximum width), 12–35 mm apart on rachis; section flat; margins slightly recurved, not undulate; apex acute, not spinescent; midrib flat or raised above, raised below, wide. *Cataphylls* narrowly triangular, soft, pilose, 40–70 mm long. *Pollen cones* narrowly ovoid or fusiform, orange, 35–60 cm long, 11–17 cm diam; microsporophyll lamina firm, not dorsiventrally thickened, 35–44 mm long, 12–23 mm wide, fertile zone 30–35 mm long, sterile apex 5–6 mm long,; level to slightly deflexed; apical spine prominent, sharply upturned, 9–24 mm long. *Megasporophylls* 24–50 cm long, white-, yellow-tomentose or brown-tomentose, tomentum persistent; ovules 2–8, glabrous; lamina lanceolate, 43–120 mm long, 20–40 mm wide, lateral spines short or indistinct; apical spine distinct from lateral spines, 14–40 mm long, 4–12 mm wide at base. *Seeds* flattened-ovoid, 45–66 mm long, 35–50 mm wide; sarcotesta orange-brown, not pruinose, 3–5 mm thick; fibrous layer absent; sclerotesta smooth; spongy endotesta present. Fig. 4.

Historical notes: described by de Laubenfels and Adema in 1998.This taxon has been included in *C. rumphii* by numerous authors, starting with Kurtz (1877), with the exception of Foxworthy (1911), Merrill (1912, 1918, 1921) as *C. circinalis,* Schuster in 1932 described it as *C. circinalis* subsp. *riuminiana* var. *curranii* forma *maritima.* Hill recognised this as a distict taxon in 1995 (Hill 1998) and formally described the taxon as *C. litoralis* in April 1999. De Laubenfels had already described this taxon as *C. edentata,* published in 1998 but with a confused circumscription that included *C. glauca, C. rumphii* and others.

Distinguishing features: the non-pectinate megasporophyll (Fig. 4), the very glossy leaves and the large seed with spongy endotesta place this species unmistakably in the *C. rumphii* group. Within that group, it is distinguished from *C. rumphii* and all related species occurring to the south and east by the distinct, long, stout spines terminating the microsporophylls (Fig. 5.). *C. thouarsii* from the south-western Indian Ocean shares this microsporophyll character, but differs in having narrower leaflets that are distinctly glaucous when developing. *C. zeylanica* (J. Schust.) A.Lindstr. & K.D.Hill from Sri Lanka and The Andamans is characterised by longer, narrower and more attenuate megasporophylls, more widely spaced leaflets and more abundant, longer and distinctly pungent cataphylls with a more rufous tomentum.

Distribution and habitat: *Cycas edentata* occurs in south Vietnam, southern Burma and southern Thailand, extending south into peninsular Malaysia, Sumatra, Java and northern Borneo but apparently not elsewhere in Indonesia (Fig. 1). Once common around the coast of southern Thailand, but now removed from many sites. It also occurs in the western and central parts of the Philippines. This species occurs only along shorelines, in full sun to moderate shade in often dry littoral scrubs on beach sand or rocky headlands, often in very shallow soil and apparently over both granite and limestone substrates.

Conservation status: once abundant and widespread, this species occurred in coastal sites that have experienced severe pressures from population increase and development. This habitat is also coming under increasing pressure for aquaculture sites. Although probably not immediately threatened, it is potentially vulnerable in the longer term. Recommended Ver 3.1:IUCN(2001) status would be **NT** for Indonesia.

Selected specimens examined: INDONESIA: Bali: Gilimanuk, *Forman 176*, 9 Jun 1956 (BO, L). **Jawa Barat:** Oedjoeng Genteng [Ujunggenteng], *Backer 17409*, 25 Nov 1914 (BO); Pulau Panaitan, Tg Manik, beach, *Borssum Waalkes 523*, 13 Sep 1951 (L, BO); Pulau Handenberm [handeuleum], Uejong Kulor[Ujungkulon], W Java, *Wyatt-Smith KEP 93185*, 20 Dec 1958 (KEP, K); Cidaun distr., near Kabun Kopi village, on sand dune less than 50 m from sea, *Lindstrom 166,170* (NSW, UBC); cult in village, coll. nearby, *Lindstrom 171* (NSW, UBC); Pulau Handeulum, Udjong Kulou[n], W. java seashore, *Wyatt-Smith KEP 93185*, 20 Dec 1958 (KEP, K); Res W Preangar, Zuidkust, strand Oedjoeng Genteng bij pasanggrahan 1–2 m, *van Steenis 11286*, 29 Jun 1939 (BO). **Jawa Tengah:** Res Zuidkediri, Baai van Damas bij Prigi, 1 m, *Backer 11956*, 17 Feb 1914 (BO); Res. Preangar, Tjialin a/d Tjitarik, (by Tjisalak, Paroengkoeda) Res Oreabgar, 500 m, *Bakhuizen v.d. Brink 5086*, 21 Dec 1920 (BO); Wirosari dist, Cult Res Semarang Afd. Grobogan Ab Tambiredjo, *Beaumee s.n.*, 25 Sep 1916 (BO); Pasveroean, *Buysman 16*, 14 Aug 1907 (BM); Java Tengah, *Horsfeld 80* (BM, L); Banjumas, Nusa Kambangan Is., SW part betw. Solek Babakan and S. Djeroeh, *Kostermans & van Woerden 188*, 23 Nov 1938 (BO, L); Jimghun, *leg. ign.* (L); Zuidelph deil van Paroela, *leg. ign. 3825*, 1912 (BO); Prov. Banjoemas, Noesa Kambangan, *Koorders 20106 B*, 10 Jun 1895 (L, BO); Noesa Kambangan, *Barbey s.n.*, 23 Nov 1921 (L). **Jawa Timur:** bij Kamalbaai, Nusa Barung [c. 8° 28' S 113° 21' E], vern Soemberdjambe, *Abdoelmachma 202*, 12 Mar 1950 (BO); Res Bondowoa, Radjagwesiebaai, Barringtonia Bosch 0–3 m, *Clason s.n.*, 6 Sep 1936 (BO); Res Mondooman, Radjegweribaai, *Clason s.n.*, 6 Sep 1936 (BO); Res Besoeki, Noeesa Baroeng, Zuid Kandangan, *Hoogerwerf 6*, 4 Jul 1939 (BO); Besoeki [8° 13' S 111° 46' E], Distr. Poeger afd. Djember, Boschterrein Poeger – Watangan [c.8° 05' S 112° 55' E], *Koorders 12727 B*, 10 Dec 1892 (L, BO). **Sumatra:Unknown Province:** *Seemann 2329* (LE). **Bengkulu:** Enggano, Kiorjoh, *Lutjeharms 4691*, 13 Jun 1936 (BO, L, BRI, K, NY, P); Sumatra, *Korthals 901324-28* (L); Batrie Eilanden, *Raap 9*, 3 Sep 1896 (BO, L); Benghoelen, Throei, *van Steenis 3162*, 25 Oct 1929 (L, BO). **Lampung:** Eile Krakatoa, *Backer 50*, 1910 (L); *Backer 1918*, Apr 1906 (B, K); Lang Eiland, Krakatau group, *Backer 34865*, 6 May 1908 (BO, L); Krakatoa, Lampangsche distr, *Backer 34866*, Apr 1906 (BO); Krakatau, *Valeton s.n.*, 1 Mar 1905 (L); N Zirarte Hoeb, *van Leeuwin 3721*, 27 Apr 1919 (BO); N Zurarte Hoeb, *van Leeuwin 3830*, 6 Oct 1929 (BO). **Riau:** Anamba Islands, Padang near Leting Jemaya, *Henderson SF 20338*, 11 Apr 1928 (BO, K). **Sumatra Utara:** Cult., Sibolangit Bot. Gard., N. Sumatra "common in lowlands", *Lorzing 12206*, 20 Oct 1927 (BO, K); Medan, N. Sumatra, *Lorzing 16881*, 1934 (BO, L).

MALAYSIA: Johore: Tg Penawar, coast, *Cockburn FRI 7565*, 8 Feb 1968 (KEP, K); Pulau Tioman, *Lee s.n.*, 28 May 1974 (BKF); Pulau Tinggi, rocky coast, *Ng FRI 5034*, 16 Apr 1967 (KEP); Mersing, Pulau Lima, rocky coast, *Ng FR15062*, 17 Apr 1967 (KEP); Desaru, Tg Penawar, *Ng & Yap FRI 27197*, 25 Aug 1978 (KEP); Pahang Tanjong Gelang, beach forest, *Putz FRI 023617*, 27 Apr 1975 (KEP); SE, Padang Mulut, *Shah & Shukor MS 2480*, 19 Sep 1971 (BKF, BRI); Desaru complex, beach forest, *Yap FRI 27196*, 23 Aug 1978 (KEP). **Langkawi:** P. Dayang Bunting, *Henderson SING 29160*, 27 Nov 1934 (K). **Malacca:** cult, *Maingay 1506*, 1867–68 (K). **Pahang:** Distr. Rompin, near Bevar village, road to Pekan, near edge of beach forest, *Kochummans & Yong KEP 9498*, 30 Jul 1962 (KEP); Kwala Pahan, *Ridley s.n.*, May 1890 (BM). **Perak:** *Ridley 7143*, Mar 1896 (K). **Sabah:** Membakut distr., HS Binsulok, *Amin SAN 126098*, 19 Jan 1991 (KEP); Kudat distr., Pulau Balembangan, midwest just E of Tg Penbatu, *BCS, EFA, LM et al SAN 86813*, 12 Apr 1977 (KEP, L); Mt Silamarea, Lahad Datu distr., *Chai SAN 29392*, 20 Apr 1962 (K ex SAN); Jesselton, *Clemens 11277*, Dec 1916 (B, K); Kota Kinabalu, Sapi Is 200 m W of Gaya Is, *Davidson 1120*, 9 Mar 1970 (L); Pulau Butang, *leg. ign. 15699*, Apr 1911 (K). **Sarawak:** Telok Limau, Bako NP, sandy sea shore, *Ashton S 17927*, 5 Jun 1963 (K); Santubong, 1st div., *Chai et al. S 38561*, 17 May 1980 (KEP, K, L); Kapit, upper Rejang River, *J. & M.S. Clemens 21175*, 1929 (B, K, NY); Usatian Bay nr Keppel, *Gibbs 4337*, 1910 (BM); Datu PF, 1st div., *Lee S 41866*, 16 Apr 1977 (KEP, K, L); Kuching, Setapok FR, in peaty swamp forest near coast, c 100m, vern Paku laut, *Murthy 9576*, 1957 (K, L). **Terengganu:** Kemaman, Rasau Kerteh Ulu Chukai F.R., Hillside forest, *Meijer & F.C. Yong KEP 94932*, 2 Jun 1962 (K); Pulau Redang, Pasir Mah Kepit, *Saw FRI 36473*, 4 Feb 1989 (KEP).

PHILIPPINES: Balabac: Bancalan Is, *Weber s.n.*, Jul 1916 (A). **Basilan:** *Hutchinson FB 3441*, 10 Dec 1905 (K); *Klemme FB 15219*, Aug 1910 (K, L).**Cebu:** Lapu Lapu City, Olango Island, *Madulid et al. PPI 7623*, 20 Mar 1993 (BO). **Masbate:** Hamoraon Island, *Kondo & Edano PNH 36862*, 30 Mar 1957 (L). **Mindanao:** Davao Oriental, Mati district, Mayo Bay, cult. at the House of F.G.R.Dahican (Mayor), Planted 1960's, said to come from nearby now destroyed seaside, *Lindstrom 06/001, 06/002*, 29 Feb 2006 (NSW); Prov. Davao, Caldera, *Wilkes exped. s.n.*, 1832–1842 (GRAY); Santa Cruz, *Williams 2890*, 17 Jun 1905 (NY); between Digas and Santa Cruz, *Williams 3058*, 29 Jun 1905 (GRAY, K, NY). **Mindoro:** Bongabon and Pinamalayan, *Maliwanag 253*, 5 Feb–5 Apr 1941 (A). **Negros:** Negros Oriental, Dumaguete district, Secondary seriously destroyed seaside forest, *Lindstrom 06/005*, 3 Mar 2006 (NSW). **Palawan:** Culion, Alava Island, Halsey Harbour, *Fernando E 1609, 1610*, 22 Jun 2001 (LBC); cult. Puerto Princessa city, coll. from coastal forest near San Vicente, *Fernando E 1616*, 26 Jun 2001 (LBC). **Panay:** Iloilo, fide Amoroso 1986 (no voucher). **Polillo:** fide Amoroso 1986 (no voucher).

SINGAPORE: Changi, *Ridley 4408*, 1892 (BM, K); *Ridley s.n.*, 1893 (BM, K); Kampong Pesek, Pulau Pesek, *Sinclair 5842*, 6 Jun 1949 (E).

THAILAND: "Pulau Mohea, WC Siam" vern. Bogak, *Field 2690*, 2 Feb 19[??] (K). **Chumphon:** collected from Chumphon, cult. Nong Nooch Garden, *Hill 4644*, 30 Apr 1994 (NSW); Ban Thung Maha, *Kerr 11355, 11355A*, 10 Jan 1927 (BM, K); Ko Tao, *Kerr 12768*, 16 Apr 1927 (BM, K); *Kerr 16087*, 25 Sep 1928 (BM, K). **Narathiwat:** Narathiwat, *Charoenphol, Larsen & Warncke 4064*, 20 Oct 1970 (BKF, K, P); Ao Manao Nowl, Narathiwat, *Hill 4627*, 20 Apr 1994 (NSW); near Narathiwat, *Yang 632, Tang & Vatcharakorn*, 27 Jan 1995 (FTG). **Phang Nga:** Takuapa, *Abbe, Smitinand & Rollet 9684*, 19 Mar 1960 (NY); Ko Ngai, *Hansen & Smitinand 12242*, 11 Feb 1966 (BKF, E, K); Ko Kaw Khao, *Larsen, Larsen, Neilsen & Santisuk 30984*, 15 Jul 1972 (BKF, P); **Phu Ket:** cult. Ban Na Si Thon, collected from Phuket, *Hill 4630*, 21 Apr 1994 (NSW); cult. Nong Nooch Garden, *Yang 659, Tang & Vatcharakorn*, 30 Jan 1995 (FTG). **Satun:** Adang, beach, *Congdon 101*, 23 Oct 1979 (A); Tarutas, across Malacca Ck, *Congdon 42*, 17 Oct 1979 (A). **Trang:** "Pulau Mohea, WC Siam", vern. Bogak, *Field 2690*, 2 Feb 19[??] (K); island off coast near Trang, *Robinson s.n.*, Dec 1916 (K). **Trat:** Ko Chang, *Kerr 16569*, 10 Jan 1929 (BM, K); Ko Kut, *Smitinand 5725*, 6 Apr 1959 (BKF).

VIETNAM: Kien Giang: near beach, west part of Phu Quoc island, *leg. ign.* (Botany Dept Univ Ho Chi Minh).

Cult.: hort Bogor, Indonesia, *Stolk 149* (BO, L).

8. *Cycas sundaica* Miq. ex A.Lindstr. & K.D.Hill, **sp. nov.**

A Cycade rumphii et C. edentata megasporophyllis spinis lateralibus prominentibus, foliolis plerumque angustioribus differt.

Type: Flores, Ngada province, foot of Volcano Inerie, along the Eku Ture river, mear Bidhu village, 326 m ASL, *Lindstrom 255*, 29 Apr 2000 (holotype: BO, iso: UBC).

[*Cycas sundaica* Miq. in J.Schust., Pflanzenr. 99: 74 (1932), nom. nud. in synonymy]

Etymology: from the habitat, entirely within the Sunda Island group.

Stems arborescent, to 5 m. tall, 20–35 cm. diam. at narrowest point. *Leaves* bright green or deep green, 120–275 cm long, flat in section (opposing leaflets inserted at 180° on rachis), with 75–114 leaflets, with orange to greyish tomentum shedding as leaf expands; rachis usually terminated by a spine to 13 mm long; petiole 30–67 cm long (20–40% of total leaf), spinescent for 10–100% of length; basal leaflets not gradually reducing to spines. *Median leaflets* simple, strongly discolorous, 230–340 mm long, 9–15 mm wide, narrowed to 3–5 mm at base (25–50% of maximum width), 13–23 mm apart on rachis; section flat; margins slightly recurved; apex spinescent; midrib flat above, raised below. *Cataphylls* linear, pungent, to 10 cm long. *Pollen cones* ovoid, c. 16–30 cm long, 9–15 cm wide; microsporophylls firm, not dorsiventrally thickened, 30–55 mm long, 15–29 mm wide, fertile zone 22–45 mm long, sterile apex 6–10 mm long, apical spine abruptly raised, 12–20 mm long. *Megasporophylls* 30–42 cm long, tomentum persistent; ovules 2–8, glabrous; lamina lanceolate, 30–80 mm long, 20–43 mm wide, shallowly pectinate or regularly dentate, with 4–30 pungent lateral spines 1–12 mm long, 1–1.5 mm

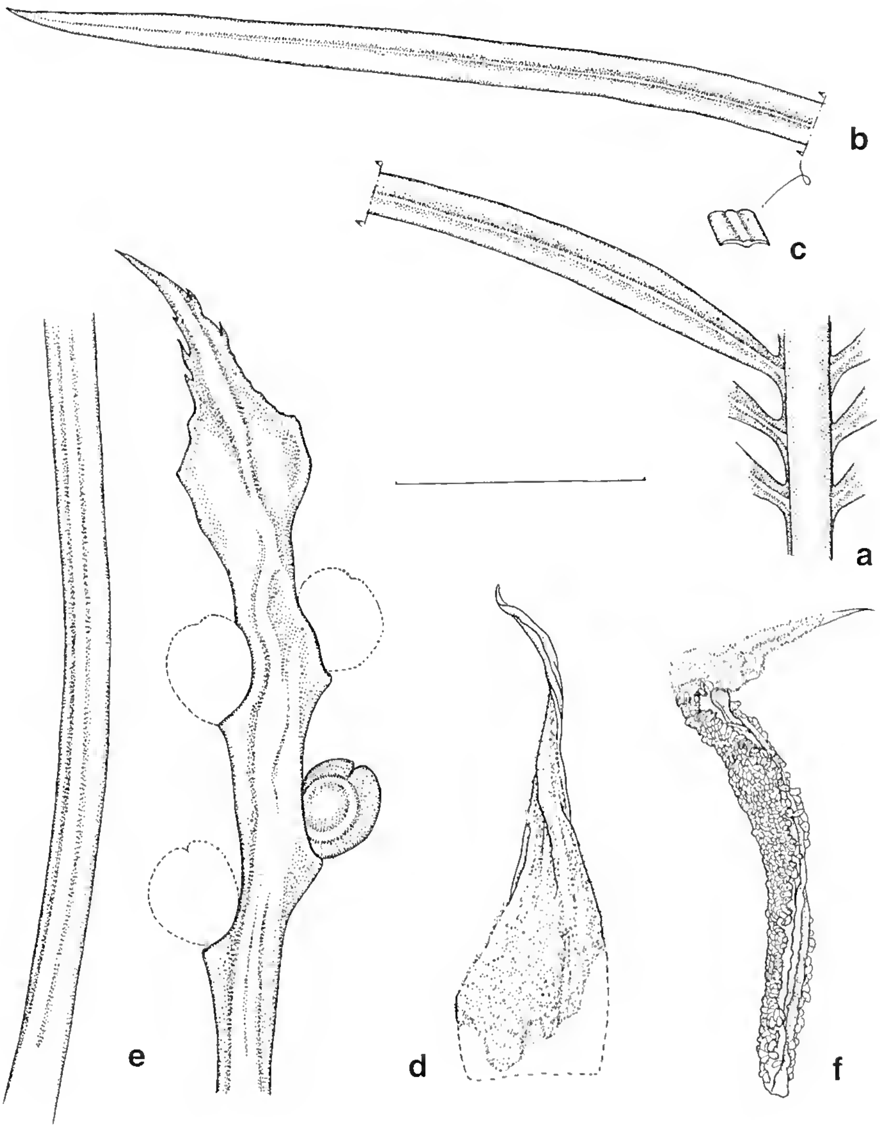

Fig. 6. *Cycas sundaica*. **a, b,** part of leaf. **c,** cross-section of leaflet. **d,** cataphyll. **e,** female sporophyll. **f,** male sporophyll (a, b, c, d, e from *Lindstrom 255*, f from *Lindstrom 258*. d, f, by C. Wardrop). Scale bar: a–e = 5 cm; f = 2.5 cm.

wide; apical spine distinct from lateral spines, 30–50 cm long, 3–7 mm wide at base. *Seeds* ovoid, 45–55 mm long, 35–45 cm wide, sarcotesta orange, c. 8 mm thick, fibrous layer absent; sclerotesta smooth; spongy endotesta present. Fig. 6.

Historical Notes: *C. sundaica* was a name used by Miquel on a herbarium sheet in Utrecht. Schuster (1932) listed Miquel's name in synonomy under *C. rumphii*, although Miquel never published the name.

Distinguishing features: the distinct lateral spines on the megasporophyll lamina distinguish this taxon from the nearby and related *C. rumphii* and *C. edentata*. Leaflets are also on average narrower.

Distribution and habitat: Nusa Tenggara Timur only, on Sumbawa, Komodo, Rinca, and Flores, east to Alor, in near-coastal and lowland forests (Fig. 1).

Conservation status: locally abundant and known to occur in reserved areas set aside for the conservation of the Komodo Dragon, this species is not considered to be at immediate risk. Recommended Ver 3.1:IUCN(2001) status would be **LC.**

Selected specimens examined: INDONESIA: Nusa Tenggara Timur: Alor, Altimelang, 750 m, *du Bois 74*, 26 Jan 1939 (BO); Distr. Krei, Moro-Gendok, 300 m, *Jaag 667*, 7 May 1938 (BM); Taramana, Pisigomo 700 m, *Jaag 893*, 11 May 1938 (BM); Flores, Endeh, 20 m, *Rensch 982*, 9 Jun 1927 (BO); W. Flores, E. Manggarae, Pota, 200 m, *Schmutz 4712*, Dec 1980 (L); Ngada province, foot of Volcano Inerie, along the Eku Ture river, mear Bidhu village, *Lindstrom, 256, 259*, 29 Apr 2000 (BO, UBC).

Subsection Endemicae Schuster (1932: 65).

Lectotype (here designated): *Cycas media* R.Br. Prodr. 1: 348 (1810). Type: Australia, "New Holland, North Coast", *R. Brown s.n.* (holo BM; iso K).

No type species was designated. Schuster included three species in this section, which he defined only on the pungent-acuminate pinnae and the relatively small and slender megasporophylls. *Cycas media* R.Br. is chosen as lectotype of the subsection, being the most well-known and earliest-described of the three species, and also adequately satisfying Schuster's definition.

This subsection is distinguished by the relatively flattened microsporophylls with a short and sharply upturned apical spine, the lack of spongy tissue within the seed, and the lack of a fibrous layer in the sarcotesta. Pinnae are often pungent-acuminate, as stated by Schuster, but not in all species, and often no more so than in other groups. Eight series are recognised (Hill 1995b), six of them endemic in Australia, and two occurring in Australia and New Guinea. About 26 species are endemic in Australia, two endemic in Papua New Guinea, one species ocurring in Papua New Guinea and Irian Jaya, and one on Timor and Sumbawa.

9. *Cycas glauca* hort. ex Miq., Comm. Phytog.: 127 (1840–1841), non Link, Enum. Hort. Berol. Alt. (1821–22), nom. nud., nec Sweet, Hort. Brit. ed. 3: 627 (1839), nom. nud. *Cycas circinalis* forma *glauca* (Miq.) J. Schust., Pflanzenr. 99: 66 (1932).

Lectotype (here designated): Hort. Roterodam. (lecto U). This sheet most closely matches the basally restricted leaflets later described by Miquel (1868).

Cycas rumphii var. *timorensis* Miq., Comm. Phytolog.: 125–126 (1840–1841).
Type: Indonesia, Timor, ex Herb. Mus. Paris (holo L; iso LE, U).

Literature: Miquel (1842, 1843, 1861, 1868,), Lemaire (1864), De Candolle (1868), Regel (1876a, 1876b), Hill (1995a), Hill (1998), de Laubenfels and Adema (1998).

Etymology: from the Greek, *glaucus*, with a bluish waxy bloom, in reference to the bluish glaucous leaves.

Vernacular: *fay* (Amarassi dialect, West Timor).

Stems arborescent, to 3 m tall, 22–35 cm diam. at narrowest point, normally unbranched but occasionally branching 2–4 times at the apex. *Leaves* dark green, semi glossy, with a distinct glaucous blue cast, 174–220 cm long, flat (not keeled) in section (opposing leaflets inserted at 180° on rachis), with 69–118 pinnae, tomentum often present even on mature leaves; petiole 42–58 cm long (20–40% of total length), covered in short orange tomentum, glaucous, spinescent for 20–100 % of its length. *Median leaflets* simple, glabrous, moderately discolorous, 15–30 cm long, 12–16 mm wide, narrowed to 0.2–0.5 cm at base (25–35% of total width), 5–14 mm apart on rachis, section flat, margins recurved, midrib slightly raised above, strongly raised below. *Cataphylls* narrow, elongated, soft, 3–4 cm long. *Pollen cones* c. 49 cm long, c. 10 cm wide, brownish, peduncle 8 cm long; microsporophyll 38–40 mm long, 18–20 mm wide, fertile zone 28–30 mm long, sterile apex c. 10 mm long, apical spine to 20 mm, raised. *Megasporophylls* 30–43 cm long, with persistent orange-brown tomentum; ovules 4–7, glabrous; lamina 25–40 mm long, 23–35 mm wide, shortly pectinate or with rudimentary spines; apical spine distinctfrom lateral spines, 20–40 mm long, 2–5 mm wide. *Seeds* flattened, 4–5 cm long, to 3 cm wide, sarcotesta yellow, ripening to dark brown red, strongly pruinose; fibrous layer absent, sclerotesta weakly ornamented; spongy layer absent. Fig. 7.

Historical notes: described by Miquel in 1840-41 from cultivated material in European collections as *C. glauca*. He also described *C. rumphii* var. *timorensis* in the same publication from a herbarium specimen in the Paris museum. Miquel in 1861 listed *C. glauca* under '*species incertae*' and in 1868 under '*nondum satis certae*' (not yet sufficiently certain). Lemaire in 1864 followed Miquel listing *C. glauca* under doubtful species. De Candolle (1868) listed *C. glauca* under '*species minus notae*' and Regel (1876) treated it as *C. glauca*. Schuster (1932) regarded *C. glauca* as a variety of *C. circinalis*, without really understanding the nature of *C. glauca*.

The types of *Cycas glauca* and *C. rumphii* var. *timorensis* consist solely of sterile leaves, making it extremely hard to relate it to any previously described species. Hill (1995a) first placed *C. glauca* into synonymy with *C. rumphii* but later (Hill 1998) placed the taxon into synonymy with *C. thouarsii*. De Laubenfels (1998) unaware of the type in Utrecht, regarded *C. glauca* as a nomen nudum but placed *C. glauca* into synonymy with *C. rumphii* and *C. rumphii* var. *timorensis* into the synonymy of his newly described *C. edentata*. More recent fieldwork conducted in Indonesia as part of an ongoing study into the systematics of the genus *Cycas* has shown *C. glauca* to be a distinct taxon unrelated to the *C. rumphii* group, widespread and locally abundant on the islands of Sumba and Timor.

Distinguishing characters: *Cycas glauca* is related to the Australian species, probably nearest to *C. silvestris* on the basis of leaflet width but differs in the distinct glaucous blue cast on the emerging leaves. It has a superficial resemblance with and could be confused with *C. thouarsii* (Indian Ocean) due to the bluish cast on the leaves, but differs in having wider pinnae and smaller seeds lacking a spongy layer.

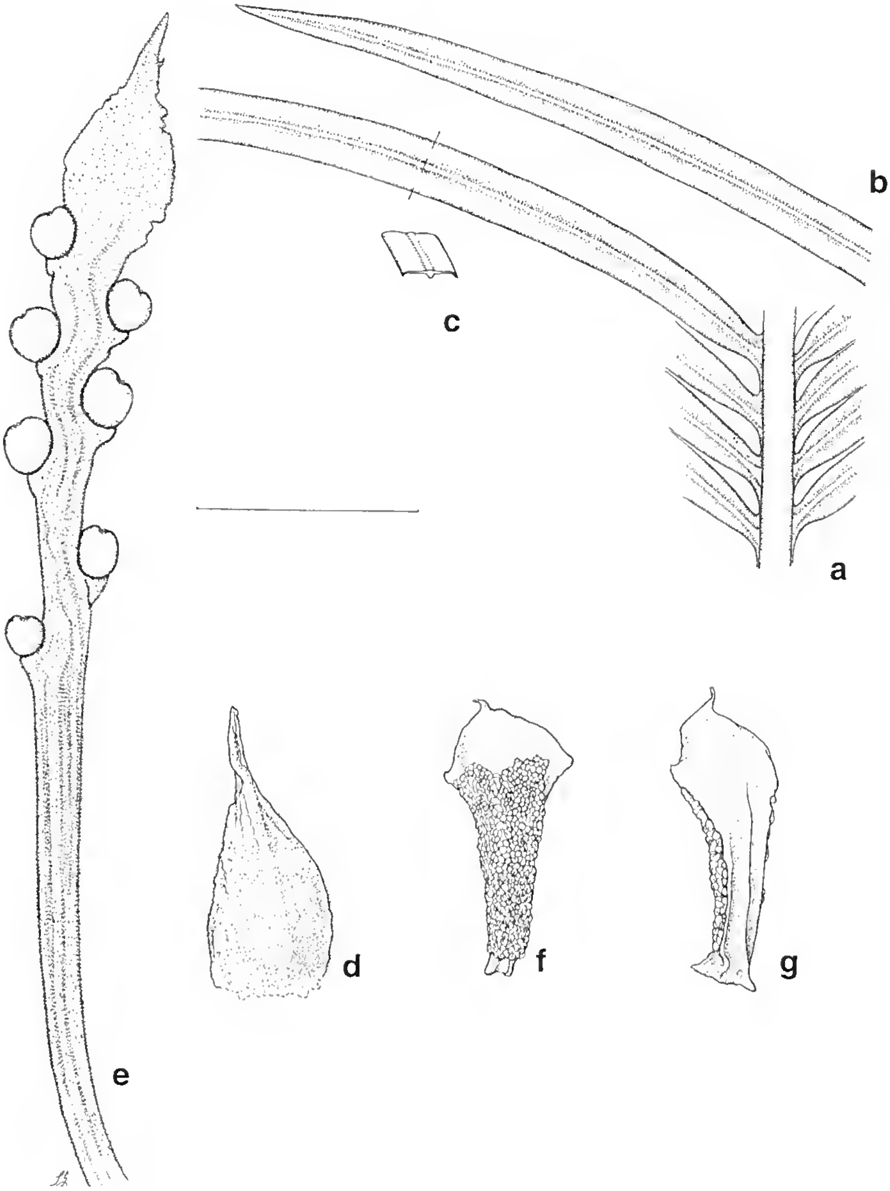

Fig. 7. *Cycas glauca*. **a, b,** part of leaf. **c,** cross-section of leaflet. **d,** cataphyll. **e,** female sporophyll. **f, g,** male sporophyll (a, b, c, d, e from *Lindstrom 274*. f, g from digital image (NSW) from Lindstrom, cult. Nong Nooch Botanic Gardens. d, f, g by C. Wardrop). Scale bar: a–e = 5 cm; f, g = 2.5 cm

Distribution and Habitat: *Cycas glauca* is apparently endemic to the islands of Timor and Sumba (Fig.1). Populations occur in closed evergreen forest, inland, often near streams. Populations also persist in disturbed areas.

Conservation Status: *Cycas glauca* is apparently quite widespread and locally abundant on both Sumba and Timor. It is unknown if there are any populations within protected areas. The present political unrest in Indonesia and Timor in particular, give cause for concern, as effective protective measures would be difficult to implement. Recommended Ver 3.1:IUCN(2001) status would be **VU.**

Selected specimens examined: INDONESIA: Nusa Tenggara Timur: Sumba: Exped. Soemba [*Sumba*], Djore, [Iboet] *237*, 11 Apr 1925 (BO, B, L); **Sumba Timur:** near Paimburu village, 274 m ASL, in sparse open evergreen forest, seasonally dry, clay soil, *Lindstrom 267, 268*, 4 May 2000 (BO, UBC); **Sumba Barat:** northern part, near Tana Righu village, *Lindstrom 273*, 6 May 2000 (BO, UBC); **Cult.** Waingapu town (Sumba Timur), *Lindstrom 274*, 6 May 2000 (BO, UBC). **Timur Barat:** 'Kabupaten Kupang, Amarassi prov.' near Oekabiti village, in closed evergreen forest *Lindstrom 245*, 25 Mar 2000 (BO, UBC); East Amarassi prov. near Baun village, 415 m ASL, *Lindstrom 246*, 25 Mar 2000 (BO, UBC).

TIMOR: *Leschenault s.n.* (P); *ex herb Moricand*, 1827 (P, G).

10. *Cycas papuana* F.Muell., Descr. Notes Papuan Pl. 1,4: 71–72 (1876). *Cycas circinalis* subsp. *papuana* (F.Muell.) J. Schust., Pflanzenr. 99: 70 (1932). *Cycas rumphii* forma *papuana* (F.Muell.) Kaneh., J. Jap. Bot. 14(9): 587 (1938).

Lectotype (fide Hill 1994b): Papua New Guinea, Western, Fly River, *D'Albertis s.n.* (lecto MEL 68056 (photo NSW); isolecto K).

Literature: Beccari (1877 as *C. rumphii*), Lauterbach (1900 as *C. circinalis* in part), Hill (1994b).

Illustrations: Schuster (1932 as *C. circinalis* subsp. *papuana*, figs 10J and 11H), Hill (1994b, fig. 5).

Etymology: from its original collection from the British Territory of Papua.

Vernacular: *Warnara* (Unident language) (Bailey 1909, Bonta & Osborne 2007).

Stems arborescent, to 2.8 m tall. *Leaves* bright green (bluish when new), semiglossy, 100–130 cm long, slightly keeled (opposing pinnae inserted at 130–160° on rachis), with 180–250 leaflets, with white and orange tomentum shedding as leaf expands; rachis usually terminated by a spine; petiole 30–40 cm long (25–35% of total leaf), glabrous, unarmed; basal leaflets not gradually reducing to spines, 30–90 mm long. *Median leaflets* simple, weakly discolorous, 80–130 mm long, 6–9 mm wide, inserted at 60–80° to rachis, decurrent for 1.5–5 mm, narrowed to 3.5–5.5 mm at base (to 55–65% of maximum width), 5.5–14 mm apart on rachis; section flat; margins flat; apex acute, not spinescent; midrib raised above, raised below. *Cataphylls* linear, pungent, pilose, densely orange-tomentose. *Pollen cones* ovoid, orange, 15–20 cm long, 810 cm diam.; microsporophyll lamina firm, not dorsiventrally thickened, c. 24 mm long, c. 10 mm wide, fertile zone c. 17 mm long, sterile apex c. 7 mm long, level, apical spine rudimentary, sharply upturned, 1–5 mm long. *Megasporophylls* 16–20 cm long, brown-tomentose; ovules 2–6, glabrous; lamina lanceolate, 35–50 mm long, 17–25 mm wide, regularly dentate with 14–20 pungent lateral spines, 2–4 mm long; apical spine distinct from lateral spines, 8–15 mm long. *Seeds* flattened to ovoid, 32–35 mm long, 25–29 mm wide; sarcotesta orange-brown, not pruinose, 1.5–2.5 mm thick; fibrous layer absent; sclerotesta smooth; spongy endotesta absent.

Historical notes: the basis of this species was cited only as 'On the Fly-River; D'Albertis. The two sheets MEL68056 and MEL68057 (photos NSW) apparently collected by D'Albertis were annotated only by Mueller, and do not bear D'Albertis' name. A portion of the former was sent to K by Mueller, according to his annotation on the sheet. The sheet MEL68056, annotated by Mueller 'parofolii supera / Fly-River', is more comprehensive, and has been designated the lectotype.

Distinguishing features: *Cycas papuana* is nearest to *C. armstrongii* Miq., differing in the longer leaves with longer petioles and more leaflets (*C. armstrongii* has leaves 55–90 cm long with petioles 10–25 long and 160–220 leaflets). The long, unarmed petiole resembles that of *C. conferta* Chirgwin & Wigston, which differs in the somewhat shorter leaves (70–110 cm long) with more closely crowded leaflets (spaced at 4.0–7.0 mm on rachis), less extended sterile apex on the microsporophylls (6–8 mm long), and larger seeds (36–40 mm long). Both *C. armstrongii* and *C. conferta* are endemic in the Northern Territory of Australia.

Distribution and habitat: Papua New Guinea, Western District, from the flood-plains of the Fly River and around Daru west at least to the Bensbach River. A sporadic but widespread component of savanna woodlands on flat country, sometimes locally abundant. Also present across the border in Indonesian territory (Wasur National Park). Fig. 1.

Conservation status: abundant and apparently not at risk. Although in a national park in Indonesia, there is significant land use pressure in this area, and conservation is somewhat in doubt in this region. Ver 3.1:IUCN (2001) status is **NT** (Donaldson 2003) for Indonesia and PNG.

Selected specimens examined: INDONESIA: Papua: Merauke, Tanah Miring, 10 November 2002, Hambali, Gregory s.n. (NSW).

PAPUA NEW GUINEA: Western: Mabaduan, *Brass 6541*, Apr 1936 ([A], BRI, LAE); Mausa, c. 15 km W of Morehead, on Morehead to Weam road, *Conn 3523 & Jacobs*, 26 Sep 1990 (NSW, LAE); Sibidiri, Morehead Subdistrict, *Foreman et al. LAE60493*, 22 Jul 1974 (LAE, BRI, CANB, A[n.v.], K, L, QRS [n.v.]); 2 km W of Ioka, Daru Subdistrict, *Foreman et al. LAE60454*, 19 July 1974 (LAE, CANB, A [n.v.], L, QRS [n.v.]); Mabaduan Hill, Daru Subdistrict, *Foreman & Stocker LAE59094*, 24 Jul 1974(LAE, BRI, CANB, A [n.v.], BRI [n.v.], L, QRS [n.v.]); 1 km N of Buji, mouth of Mai Kussa River, *Harris 138*, 9 Nov 1974 (DNA); next to Bensbach Wildlife Reserve office, *Rau UPNG6800*, 7 Dec 1982 (LAE, DNA, MEL [n.v.]).

Excluded names

Cycas rumphii var. subinclusa Schuster., Pflanzenr. 99:75 (1932).

Type: the illustration, Schuster, Pflanzenr. 99:75 Fig. 12 Y-Z (1932)

The type drawing appears to have been made from dried material of a plant cultivated at the Botanical garden in Utrecht. The epithet refers to the way the ovules are held on the megasporophyll. However this character appears to be an artifact of the drying process. This drawing lacks the megasporophyll lamina, which is crucial for correct identification. Schuster clearly states 'Laminae macrosporophyllii profunde pinnatifidae'. Judging by Schuster's confused concept of *C. rumphii* and the statement of a "very pinnatifid megasporophyll lamina", this name should not be further associated with *C. rumphii*. Without a complete megasporophyll lamina it will forever be impossible to correctly identify this taxon. No herbarium specimens are known to exist that can be related to this description or the cultivated plant. The cultivated plant can no longer be located.

Cycas corsoniana G.Don, Gard. Mag. & Reg. Rural Domest. Improv. 18: 371 (1842); name only, in syn. (Schuster 1932). *Zamia corsoniana* G. Don, Gard. Mag. & Reg. Rural Domest. Improv. 18: 371 (1842); name only.

Cycas corsoniana G.Don was one of four newly described taxa discovered by Mr. James Corson during his trip to the "South Seas". The locality was said to be Batagoda and (!) Geby. It has not been possible to trace these localities even to country of origin. The description states "scales of strobile cuneated, each with an incurved hook at top, on the upper face". The mention of the spinose tip on the microsporophyll, which is so long that it is curved is interesting as *C. rumphii* has no, or only a rudimentary spinose tip on the microsporophyll. This name should not be associated with *C. rumphii*, although it may be matched with another taxon in the *Rumphiae* subsection. The type specimen has not yet been located and does not exist in the Linnean Society Herbarium but may be in the herbarium of the late Professor Don. The Don collection was auctioned to the Natural History Museum of London (Lot no. 254) in the sale of 10th November 1863.

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New combinations in *Zostera* (Zosteraceae)

S.W.L. Jacobs[1] and D.H. Les[2]

[1]*National Herbarium, Royal Botanic Gardens, Sydney, Australia 2000*
[2] *University of Connecticut, Department of Ecology and Evolutionary Biology, Storrs, CT 06269-3043, USA*
Author for correspondence: Surrey.Jacobs@rbgsyd.nsw.gov.au

Abstract

Systematic studies have clarified interspecific relationships in *Zostera*, but also allow for different but phylogenetically compatible classifications. Recently, several new species have been assigned to the genus *Heterozostera*, which some prefer to retain as a subgenus within *Zostera*; thus, if this taxonomic interpretation is followed, appropriate names do not exist in *Zostera*.To address this problem, we provide three new combinations (***Zostera chilensis, Z. nigricaulis*** and ***Z. polychlamys***) for species from Chile and Australia, that have been described in *Heterozostera*. We also present a brief account of the conflicting classifications available for Zosteraceae.

Introduction

By analysing both molecular and morphological data, Les et al. (2002) demonstrated that *Heterozostera* is nested phylogenetically within *Zostera*. The DNA and morphological cladograms presented by Les et al. (2002) are consistent with a number of options for maintaining monophyletic taxa within Zosteraceae, and there have been at least three ways proposed for resolving the classificatory problem:

(i) recognise one genus, *Zostera* (with two or three subgenera), treating *Heterozostera* as a synonym of the former genus;

(ii) recognise three genera, namely, *Zostera, Heterozostera* and *Nanozostera*; or

(iii) recognise two genera, namely, *Zostera* and *Nanozostera* (including *Heterozostera*).

Tomlinson and Posluszny (2001) adopted option (ii) by elevating the former *Zostera* subgenus *Zosterella* Aschers. to generic rank as *Nanozostera*, an approach that has not yet been widely followed. In our estimation, this option appears to be the least optimal because it introduces a new name for a taxon already widely recognised as a subgenus and would require the unnecessary abandonment of taxonomic names that have been in use for more than a century. Furthermore, the proposed genera would be difficult to delimit morphologically; e.g., a morphological phylogenetic analysis depicted the three taxa as an unresolved polytomy (Les et al. 2002). It also seems excessive to segregate the less than 15 total species as three separate genera with rather weak morphological distinctions.

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Consequently, Les et al. (2002) proposed that only one genus should be recognised, namely *Zostera* (option [i], above). Their recommendation was made because that option provided the highest level of nomenclatural stability and avoided a proliferation of names within this small group of morphologically similar plants.

Phylogenetic analyses by Tanaka et al. (2003) resolved the same basic clades as those found by Les et al. (2002). These authors did not advocate adoption of a specific classification, but suggested yet another option (iii), which was to merge subgenus *Zosterella* and the genus *Heterozostera* under the name of the recently described *Nanozostera*. However, that option would not be valid nomenclaturally, given that such a merger would require the use of the oldest name available at the rank of genus. In this case, that name would be *Heterozostera* (named by Hartog in 1970) rather than *Nanozostera* (named by Tomlinson & Posluszny in 2001).

Phylogenetic analyses by Kato et al. (2003) also mirrored the results of Les et al. (2002), by recovering essentially the same three clades of *Zostera* species. However, those authors advocated the adoption of the 'option (iii)' classification suggested by Tanaka et al. (2003), i.e., two genera (*Zostera*, *Nanozostera*), with *Heterozostera* merged within the latter. Consequently, these authors also failed to recognise the nomenclatural priority of the name *Heterozostera* at the genus level. Further nomenclatural confusion is evidenced by their proposed establishment of only two subgenera within *Nanozostera* (*Heterozostera*, *Zosterella*), neither representing the required autonym (i.e., subgenus *Nanozostera*) which would be established by the presence of the type species of the genus. In any case it is clearly evident that option (iii) should not be considered for classification of *Zostera* species because it is invalid nomenclaturally.

Kuo (2005) published a revision of *Heterozostera*, using morphological and anatomical characters to distinguish four taxa from what originally had been considered a single species (*Heterozostera tasmanica*). This work followed the classification option (ii), retaining *Heterozostera* as one of the four generic segregates advocated by Tomlinson and Posluszny (2001). However, no rationale for following that particular classification was provided. As a result, Kuo (2005) named three new species of *Heterozostera*, that, if they are to be treated as species of *Zostera*, currently lack combinations in that genus.

We make no evaluation of the validity of the new *Heterozostera* species proposed by Kuo (2005); however, we continue to advocate that any species related phylogenetically to the clade containing the former *Heterozostera tasmanica* should be assigned to the genus *Zostera*. A more detailed rationale for our preference is provided in Les et al. 2002), but is summarised here.

The generic distinction of *Zostera* and *Heterozostera* has been disputed, mainly because of the uncertainty of the reliability of apparent diagnostic taxonomic characters. Several taxonomists have remarked on the difficulty of separating the morphologically similar *Zostera* and *Heterozostera* (Aston 1973; Jacobs & Williams 1980). Aston (1973) and Phillips and Meñez (1988) essentially followed Hartog (1970) who distinguished the two genera based on a distinction between monopodial rhizomes as found in *Zostera* compared to sympodial (unbranched) rhizomes in *Heterozostera*. However, Tomlinson (1982) and Soros-Pottruff and Posluszny (1995) have shown that this often-cited sympodial feature is erroneous and should not be used to distinguish the genera. Robertson (1984) followed Tomlinson's (1982) recommendations and considered both *Heterozostera* and *Zostera* as having monopodial, herbaceous rhizomes. Instead, she relied on the difference in cortical vascular bundle number (employed as the secondary key character by Hartog 1970) and retinacule shape to separate the genera. However, Yip (1988) later showed that overlap exists in the number of cortical bundles in *Zostera* (2–4) and *Heterozostera* (2–12). Therefore *Heterozostera*, as circumscribed originally by Hartog (1970), cannot be supported.

Although Soros-Pottruff and Posluszny (1995) clarified the rhizome type in *Heterozostera* and *Zostera* (both monopodial), their clarification provided for a new method of distinguishing between the taxa, namely, an undulating growth pattern that, in the family, is apparently unique to *Heterozostera*. Soros-Pottruff and Posluszny (1995) also included the presence of wiry, erect stems, a tendency toward increased cortical vascular bundles, and lack of vascularisation in retinacules as additional features that separate *Heterozostera* from *Zostera*. Les et al (2002) added retinacule morphology as another useful diagnostic feature, which is described as lanceolate in *Heterozostera* and triangular to suborbicular in *Zostera* (Roberts 1984). Within Zosteraceae, Hartog (1970) described the retinacules as elongate, hence long (2.5–14 mm long) in *Phyllospadix*, moderately long (2–3 mm) in *Heterozostera* and either short (0.5–1.75 mm) or absent in *Zostera*. The longer (>2 mm) retinacules of *Heterozostera* appear to effectively separate it from *Zostera* (<1.75 mm) without overlap.

Even though some of the distinctions made between *Heterozostera* and *Zostera* in past treatments have proven to be flawed, a modified set of characters could be used effectively to separate these taxa taxonomically. In addition to these distinctions, Kuo and McComb (1998) suggest that *Heterozostera* is probably a hexaploid, a unique ploidy level in the family. Hence, the major issue with *Heterozostera* is not whether it is distinct taxonomically, but rather which taxonomic rank is most appropriate given the observed differences. Are undulating rhizomes, additional vascular bundles, and long, unvascularised retinacules sufficient to separate *Heterozostera* and *Zostera* at the generic level?

The circumscription of ranks (genera, sections, species) always involves some subjectivity, but greater objectivity can be achieved by the satisfaction of phylogenetic criteria that taxa should represent monophyletic groups (Judd et al. 1999). Morphological data alone cannot effectively answer this question because of their low resolving power. If the topology of the majority rule consensus tree (Les et al 2002) is used as a guideline, then *Heterozostera* must either be combined with *Zostera*, or four separate genera of Zosteraceae recognised to avoid paraphyletic taxa.

However, the approach taken recently by Tomlinson and Posluszny (2001), seems unnecessarily excessive. Tomlinson and Posluszny (2001) proposed the adoption of a new genus *Nanozostera* to accommodate species in *Zostera* subgenus *Zosterella*. They provided no new data, but essentially echoed the results of Soros-Pottruff and Posluszny (1995) as the basis of their generic segregation. Because neither study analysed phylogenetic relationships, the conclusions were based on perceived morphological incongruities. However, the morphological cladistic analyses of Les et al. (2002) indicate that none of the genera recognised by Tomlinson and Posluszny is particularly well-defined morphologically, especially when compared to the genus *Phyllospadix*. *Nanozostera* is defined by only two morphological synapomorphies, *Zostera* (sensu stricto) by three synapomorphies, and *Heterozostera* by four synapomorphies. In perspective, *Zostera noltii* and *Z. japonica* are differentiated from the other members of *Zostera* subgenus *Zosterella* also by only two synapomorphies, yet have never been considered as separate genera. This level of differentiation is miniscule when compared to *Phyllospadix* which is separated from these taxa by 19 morphological apomorphies. Comparatively, the low level of morphological differentiation would support the merger of *Heterozostera*, plus *Nanozostera*, into a single genus (*Zostera*) and with the family consisting of the latter genus and *Phyllospadix*.

The pattern of nucleotide divergence is similar proportionately; e.g., with *Phyllospadix* differing substantially from all other Zosteraceae (21.8–26.7%) and none of the remaining taxa exhibiting more than 16.8% (mostly <8.0%) nucleotide divergence (Les et al. 2002). Although relative nucleotide divergence can provide interesting evolutionary insights, we believe that major taxonomic distinctions (such as delimitation of genera) should rely principally on morphological characters if any practical utility is to be achieved.

In summary, the phylogenetic analyses of Zosteraceae by Les et al. (2002) resolved the same four clades using molecular or morphological data, either singly or in combination. Although each clade could be recognised as a distinct genus in a cladistic sense, doing so would, in our opinion, create several highly similar and weakly differentiated genera. However, phylogenetic analyses of Zosteraceae by several groups of researchers consistently demonstrate no support for the circumscription of *Heterozostera* as proposed originally by Hartog (1970). If that genus is to be retained, it must also be redefined to include *Zostera* subgenus *Zosterella* if phylogenetic integrity is to be maintained. In such an instance, the generic name *Heterozostera* would have nomenclatural priority.

Our suggestion is to recognise only two genera in Zosteraceae, namely *Zostera* and *Phyllospadix*, which we believe to most usefully depict the major phylogenetic lineages within this family as these two genera are well differentiated at both the morphological and molecular levels. The three subclades within *Zostera* should continue to be recognised as subgenera, namely as *Zostera* subg. *Zostera*, subg. *Heterozostera* and subg. *Zosterella*.

Here we provide the new combinations that are necessary for the implementation of this option (i.e. option i).

New combinations (*Zostera* subgenus *Heterozostera*)

Zostera chilensis (J.Kuo) S.W.L.Jacobs & D.H.Les **comb. nov.**

Basionym: *Heterozostera chilensis* J. Kuo (2005; 126–127).

Type: Chile: Aldea, Puerta, Coquimbo Province, drift, January. 1997, *H. Kirkman and M. Edding* (holo.: US; iso: K, MEL).

This is the name that should be used for all Chilean specimens previously treated as *Heterozostera* (mostly as *H. tasmanica*).

Zostera nigricaulis (J.Kuo) S.W.L.Jacobs & D.H.Les **comb. nov.**

Basionym: *Heterozostera nigricaulis* J. Kuo (2005; 110–124).

Type: Australia: South Australia: Kangaroo Island, site 91, 21 November 1977, *H. Kirkman* (CSIRO 1988) (holo: AD; iso: PERTH).

This is the most widespread and common of the new species and most Australian references to *H. tasmanica* from the eastern States refer to this species.

Zostera polychlamys (J.Kuo) S.W.L.Jacobs & D.H.Les **comb. nov.**

Basionym: *Heterozostera polychlamys* J.Kuo (2005; 124–126)

Type: Australia: Western Australia: Flinders Bay, drift, 11 December 1990, *H. Kirkman* (CSIRO 1751; CMM 260, 261) (holo: CANB; iso L, MEL, PERTH).

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Chromosome numbers in some Mosses from New Zealand

Helen P. Ramsay

National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Mrs Macquaries Rd, New South Wales 2000, Australia
Email: hpramsay@ozemail.com.au

Abstract

Additional chromosome information, based on meiotic studies, is reported here for 27 species (of which eight are endemic) in 22 genera of New Zealand mosses in the following 14 families: Amblystegiaceae, Bartramiaceae, Bruchiaceae, Dicnemonaceae, Ditrichaceae, Funariaceae, Hypnaceae, Hypopterygiaceae, Lembophyllaceae, Leptostomaceae, Pottiaceae, Ptychomniaceae, Racopilaceae, Rhizogoniaceae. When added to the previous chromosome number records for 39 species, data are now available for 66 species.

Introduction

The New Zealand moss flora has proved of great interest for a long time (Dixon 1913–1929, Sainsbury 1945, 1955, Allison 1971, Allison & Child 1971, Bartlett 1984, Beever et al. 1992) and its bryoflora has been well studied taxonomically with the report of at least 525 mosses, 500 hepatics and 15 hornworts (Fife 1985, 1996). However, chromosome studies of New Zealand bryophytes are relatively few as noted by Fife (1996). There have been some further chromosome records published since 1994 e.g. for Bryaceae, *Dicranoloma* (Dicranaceae), *Hypnodendron* in which the low numbers n=4, 5 were recorded, Orthotrichaceae, Polytrichaceae, Sematophyllaceae families for which no additional reports are given here. These are listed in Table 1, together with the references, bringing reports available, prior to these studies, to 39 species in 22 genera of mosses.

Materials and Methods

The techniques used follow those in Ramsay (1974, 1983) with mainly meiotic studies using aceto-orcein or aceto-carmine squashes. Slides were made permanent by freezing with carbon dioxide and mounting in euparal so that many of the slides still remain suitable for study, after more than 30 years. Vouchers for chromosome counts will be deposited at the National Herbarium of New South Wales (NSW).

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Table 1. Previously published chromosome number records for New Zealand mosses

Family and Species	Chromosome number	Reference
Amblystegiaceae		
Sanionia uncinata	2n=20	Przywara et al. 1992
Bartramiaceae		
Breutelia pendula	n=6	Przywara et al. 1992
Philonotis tenuis	n=6	Newton 1973
Bryaceae		
Ochiobryum blandum (as *Bryum blandum*)	n=11	Ramsay & Spence 1996
Gemmabryum sauteri (as *Bryum sauteri*)	n=10	Ramsay & Spence 1996
Dicranaceae		
Dicranoloma billarderi	n=12	Przywara et al. 1992
Dicranoloma billarderi	n=12	Ramsay 2006
Dicranoloma dicarpum	n=7	Ramsay 2006
Dicranoloma plurisetum	n=8	Ramsay 2006
Dicranoloma platycaulon	n=7	Ramsay 2006
Dicranoloma robustum [includes *Dicranoloma cylindropyxis*]	n=7	Ramsay 2006
Dicranoloma menziesii	n=8	Ramsay 2006
Hypnaceae		
Ctenidium pubescens	n= 8	Nishimura & Inoue 1985
Hypnodendraceae		
Hypnodendron arcuatum	n=9	Ramsay 1987
Hypnodendron colensoi	n=5	Ramsay 1987
Hypnodendron comatum	n=4	Ramsay 1987
Hypnodendron comosum	n=4	Ramsay 1987
Hypnodendron kerrii	n=9	Ramsay 1987
Hypnodendron marginatum	n=9	Ramsay 1987
Hypnodendron menziesii	n=5	Newton 1973
Hypnodendron spininervium	n=9	Ramsay 1987
Hypopterygiaceae		
Cyathophorum bulbosum	n=5	Newton 1973
Hypopterygium didictyon (as *H. novae-seelandiae*)	n=6	Newton 1973
Lembophyllaceae		
Acrocladium chlamydophyllum	2n=22	Przywara et al. 1992
Orthotrichaceae		
Orthotrichum calvum	n=6	Ramsay & Lewinsky 1984
Orthotrichum tasmanicum var. *tasmanicum*	n=6	Ramsay & Lewinsky 1984, Ramsay 1993
Orthotrichum graphiomitrium	n=6	Ramsay & Lewinsky 1984
Orthotrichum hortense	n=6	Ramsay & Lewinsky 1984
Ulota lutea	n=11	Ramsay 1993
Ulota viridis	n=11	Ramsay 1993
Zygodon intermedius	n=11	Ramsay 1993
Zygodon minutus	n=16	Ramsay 1993
Macrocoma tenue	n=11	Ramsay & Vitt 1986
Macromitrium gracile	n=9	Ramsay & Vitt 1986
Macromitrium grossirete	n=9	Ramsay & Vitt 1986
Macromitrium submucronifolium	n=10	Ramsay & Vitt 1986

Family and Species	Chromosome number	Reference
Macromitrium longipes	n=9	Ramsay & Vitt 1986
Macromitrium microstomum	n=11	Ramsay & Vitt 1986
Macromitrium gracile	n=9	Ramsay & Vitt 1986
Ptychomniaceae		
Ptychomnium aciculare	n=7	Przywara et al. 1992
Polytrichaceae		
Atrichum androgynum	n=14	Ramsay 1997
Notoligotrichum australe	n=7	Ramsay 1997
Polytrichadelphus magellanicus	n=7	Ramsay 1997
Sematophyllaceae		
Warburgiella leucocyta	n=11	Ramsay et al. 2002

New Chromosome Records

Chromosome numbers already published worldwide have been obtained from indices produced by Fritsch (1991), Kuta et al. (1990) and Goldblatt and Johnson (1994–2006). New counts for 27 species in 22 genera and 14 families, with the collector and collector's specimen number and locality details are listed in Table 2.

Taxa endemic to New Zealand (8 species) are indicated thus *.

Family Amblystegiaceae

The subfamily Campylioideae was raised to the status of family as Campyliaceae by W.R. Buck (Buck & Goffinet 2000) with 18 genera including *Drepanocladus, Warnstorfia* and *Sanionia* which occur in New Zealand. However, more recent studies of the family based on nuclear and chloroplast DNA by Hedenas et al. (2002) and Goffinet and Buck (2004) have returned this family to the Amblystegiaceae

The genus *Drepanocladus* (Müll.Hal.) G.Roth was divided into several genera, e.g. *Sanionia, Warnstorfia* (Goffinet & Buck 2004, Fife 1995) with two species – *Drepanocladus aduncus*, and *D. polygamus* (*Campylium polygamus*) now recognised for New Zealand. The chromosome numbers n=10, 11, 12, 20, 22, 24 have been recorded for *D. aduncus* (Fritsch 1991, Goldblatt & Johnson 1996) from Europe, USSR, USA. Former chromosome number reports for *Sanionia uncinata* (as *Drepanocladus*) include n=10, 11, 12, 20, 30 from Europe, North America and Japan (Fritsch 1991, Goldblatt & Johnson 1996).

Chromosome numbers are determined here for one species of *Drepanocladus*, and one of *Sanionia* in New Zealand. These are the first for *Drepanocladus* while Przywara et al. (1992) recorded 2n=20 for *Sanionia uncinata* from sporophytic mitosis (Table 1) for New Zealand

1. ***Drepanocladus aduncus*** (Hedw.) Warnst. n=10, **Fig. 1.1**

The New Zealand population (Table 2) had the number n=10 which corresponds to one of the numbers reported overseas.

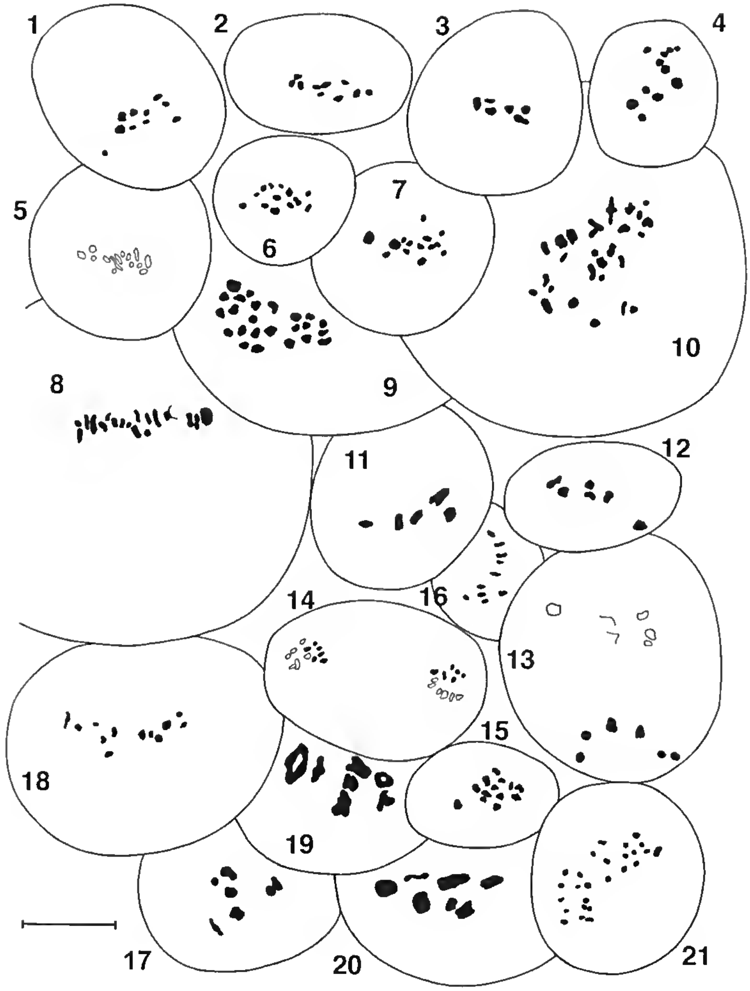

Fig. 1. Meiotic chromosomes in New Zealand mosses. **1.** *Drepanocladus aduncus* (84/84) n=10; **2.** *Sanionia uncinata* (75/84) n=10; **3.** *Philonotis pyriformis* (41/87) n=6; **4.** *Rhynchostegium tenuifolium* (63/84) n=11; **5.** *Trematodon suberectus* (43/87) n=14; **6.** *Ditrichum brachycarpum* (7/84) n=13;. **7.** *Ditrichum brevirostre* (20/87) n=13; **8.** *Entosthodon* species 1 (79/84) n=18; **9.** *Entosthodon laxus* (1/84 n=24; **10.** *Entosthodon* species 2. (97/84) n=26. **11.***Cyathophorum bulbosum* (13/83) n=5; **12.** *Hypopterygium didictyon* (7/80) n=6; **13 & 14** *Leptostomum inclinans* (84/84) n=6. **13.** Anaphase I showing the six half bivalents moving to opposite poles; **14.** Anaphase II showing two Metaphase II plates with 6 chromosomes separating to each end. **15.** *Tortella mooreae* (1/86) n=13; **16.** *Racopilum cuspidigerum var. convolutaceum.* (29/87) n=10; **17.** *Cryptopodon bartramioides* (56/84) n=7; **18.** *Tortula breviseta* (85/84) n=12; **19.** *Dichelodontium nitidum* (101/84) n=7, note smallest bivalent separated early; **20.** *Cladomnion ericoides.* (104/82) n=7; **21.** *Weissia austrocrispa* (58/83) n=26; scale bar 10 µm

Table 2. Additional chromosome records for New Zealand mosses (alphabetical by genus). Unless otherwise stated, collections were made by the author; often with J.E. Beever as my guide on either the North Island (NI) and/or South Island (SI) of New Zealand. JEB – Jessica Beever; AJF Allan J. Fife. Taxa endemic to New Zealand (8 species) are indicated thus *. Vouchers will be deposited at the National Herbarium of New South Wales (NSW).

Taxon	Chromosome number (n)	Voucher specimen & locality data
Acrocladium chlamydophyllum	11	72/84 NI, Mt Ruapehu.
**Cladomnion ericoides*	7	104/84 NI, Mt Ruapehu
**Cryptopodium bartramioides*	7	67/84 NI, Renata track; Akatarawas; 56/84, Kapakapanui track, Akatarawas
Ctenidium pubescens	8	NI, JEB 21-14, Rangitoto Is.; JEB 27-15 Little Barrier Is
Cyathophorum bulbosum	5	13/83 SI, Leith Saddle, Dunedin HPR with J. Child
**Dichelodontium nitidum*	10	62/84 NI, Mt Ruapehu, 101/84 NI, Mt Ruapehu
Dicnemon calycinum	7	102/84 NI, Mt Ruapehu
**Dicnemon semicryptum*	7	107/84 NI, Mt Ruapehu,
**Ditrichum brachycarpum*	13	7/84 SI, Milford Sound L.E. Anderson 65/84 NI, Mt Ruapehu.
Ditrichum brevirostre	13	20/87 SI, Red Hills,
Drepanocladus aduncus	10	84/84, NI, Mt Ruapehu
Entosthodon laxus	24	1/84 SI, AJF
Entosthodon sp. 1	18	79/84 SI, AJF
Entosthodon sp. 2	26	97/84 NI, Mt Ruapehu
Glyphothecium scuiroides	7	61/84 NI Mt Ruapehu
Hypopterygium didictyon	6	7/80 SI, with J. Child
Leptostomum inclinans	6	82/84 NI, Mt Ruapehu
**Philonotis pyriformis*	6	41/87 SI, Lake Rotoroa
Ptychomnion aciculare	7	7/83 NI, Waitakere Ra.
Racopilum cuspidigerum var. *convolutaceum*	10	29/87, SI, Red Hills
Rhynchostegium tenuifolium	11	77/84 NI, Mt Ruapehu 63/84 NI, Mt Ruapehu
Sanionia uncinata	10	75/84 NI, Mt Ruapehu
**Tortella mooreae*	13	1/86, 2/86 NI, Rangitoto Is., JEB 38-27, 38-28
Tortula breviseta	12	83/84, 85/84 NI, Mt Ruapehu
**Trematodon suberectus*	14	8/83, NI, JEB 21-32, Ngaruawahia, S. Auckland 43/87 SI, Lake Rotoroa
Weissia austrocrispa	26	58/83 SI AJF

2. *Sanionia uncinata* (Hedw.) Loeske n=10, Fig. 1.2

The New Zealand population studied here was epiphytic on tree bark in the Wakapapanui alpine garden on Mt Ruapehu (Table 2) and had the meiotic chromosome number n=10. This gametophytic count corresponds to the previous sporophytic count of 2n=20 by Przywara et al. (1992).

Family Bartramiaceae

Beever et al. (1992) report three species of *Philonotis* from New Zealand. The mitotic chromosome number of n=6 was recorded for *Philonotis tenuis* from the South Island by Newton (1973). Previous chromosome records for other species in the genus are n=6, 12 (Fritsch 1991, Goldblatt & Johnson 2000) from Europe, India, Japan, Australia, China and Chile.

***3. *Philonotis pyriformis* (R.Br. bis) Wijk & Margad. *n*=6, *Fig.* 1.3**

The chromosome number of n=6 is reported here for *Philonotis pyriformis* and represents the first record for this species in New Zealand. (Table 2). The number and morphology of the six bivalents at meiosis correspond to those reported for other *Philonotis* species.

Family Brachytheciaceae

The family Brachytheciaceae in New Zealand includes the genera *Brachythecium, Rhynchostegium, Eurhynchium* with several species in each as well as several smaller monospecific genera (Beever et al. 1992). There are no previous chromosome records from New Zealand for this family. The chromosome numbers n=8, 10, 11, 12, 14, 20, 22 have been recorded from India, Europe, Japan and Australia for a number of species of *Rhynchostegium* with some of these including an m-chromosome (Fritsch 1991). Previous studies record the chromosome numbers n=20+2m, 22 and polyploid numbers for specimens of *R. tenuifolium* (including those under *R. laxatum*) from Australia (Ramsay 1974).

4. *Rhynchostegium tenuifolium* (Hedw.) Reichardt n=11, *Fig.* 1.4

In New Zealand (Table 2) the number n=11 was recorded for both populations studied. These had a haploid complement and were not polyploid as were those recorded for Australia so far (Table 1).

Family Bruchiaceae

The genus *Trematodon,* formerly in the Dicranaceae, has been placed in the Bruchiaceae in the recent classification by Goffinet and Buck (2004). Previous chromosome records for *Trematodon* from the Northern Hemisphere (India, U.S.A., Canada, Alaska see Fritsch 1991, Ireland 1991 in Goldblatt & Johnson 1994) are n=11, 13+m, 13+2m, 14, 14+m with polyploids n=28, 28+m, 28+2m, some cytotypes including one or two 'm' chromosomes.

***5. *Trematodon suberectus* Mitt. n=14, Fig 1.5**

T. suberectus is one of three species of *Trematodon* recorded for New Zealand (Beever et al. 1992). The chromosome number n=14 is reported here for *T. suberectus* in two separate collections (Table 2) and is the first record for this genus from New Zealand.

Family Dicranaceae [Dicnemonaceae]

The southern hemisphere family Dicnemonaceae, formerly a subfamily of the Dicranaceae was validated as a family by Brotherus (1924) who recognised five genera. In a later analysis of the family, Allen (1987) retained only *Dicnemon, Eucamptodon* and *Synodontium* while Buck and Goffinet (2000) transferred *Synodontium* elsewhere retaining only *Dicnemon and Eucamptodon.* The genus *Dicnemon* is reported from New Guinea, Vanuatu, New Caledonia, Australia and New Zealand while *Eucamptodon* is distributed in Australia, New Caledonia and South America but is absent from New Zealand (Allen 1987). More recent studies based on DNA analyses (Hedenas et al. 2002, Goffinet & Buck 2004) have returned the Dicnemonaceae to the Dicranaceae.

Observations of sporocytes under light microscopy indicate that the nucleus and cytoplasm are at one end of the sporocyte, while a large vacuolar area exists at the other end. Sporocytes are smaller and rectangular in *D. calycinum* (Fig. 2.1) and larger more oval in *D. semicryptum* (Fig. 2.2). In *Eucamptodon* the sporocytes are spherical with a central nucleus as in other mosses.

The sporocytes in *Dicnemon* are arranged as a single layer around the columella and following meiosis form a ring of 8–12 spores in cross section and 8 columns in rows longitudinally (Allen 1987). At the time of meiosis in these studies the capsule was green and translucent with a coloured annulus in *Dicnemon semicryptum* but in *D. calycinum* the annulus coloured later, after spores were produced. The operculum and peristome became coloured at the young spore stage in both species.

Following meiosis and early spore formation, rapid and simultaneous mitoses lead to the production of large multicellular spores (to 700 µm). In both *D. semicryptum* and *D. calycinum* they are freed from the capsule as tetrahedral protonema.

These are not shed directly but the columella dries out and the multicellular protonemata are dislodged by splashing in heavy rain, i.e. in conditions suitable for germination.

There are no previous chromosome records for *Dicnemon* and none yet for *Eucamptodon*.

6. *Dicnemon calycinum* (Hook.) Schwägr. n=7, **Fig. 2.1**

The chromosome number n=7 was obtained for *Dicnemon calycinum* (Table 2) at anaphase I with seven half bivalents moving to each pole. Meiosis occurs towards one

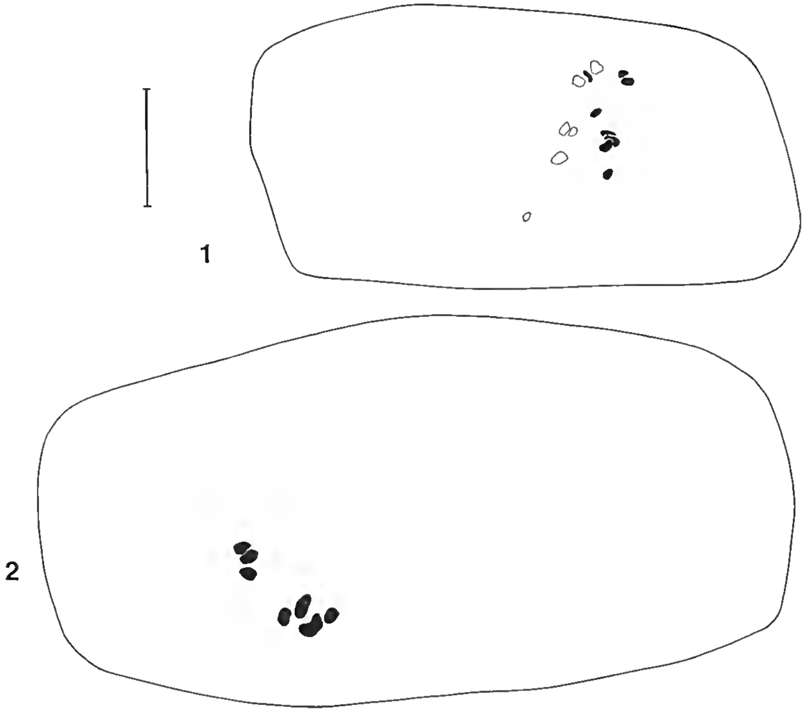

Fig. 2. Chromosome numbers in *Dicnemon* – large sporocytes with meiotic chromosomes towards one end of cell; **1.** *Dicnemon calycinum (107/84)*. Anaphase I of meiosis showing 7 half bivalents moving to each pole in the smaller sporocyte; **2.** *Dicnemon semicryptum* (102/84). Metaphase I of meiosis in larger sporocyte. Scale bar 10 µm

end of the sporocyte, not centrally as in most mosses. The sporocytes are smaller in *D. calycinum* than in *D. semicryptum*.

***7. *Dicnemon semicryptum* Müll.Hal. n=7, Fig. 2.2**

As the nucleus is situated at one end of the very large sporocyte in the specimens of *D. semicryptum* (Table 2), meiosis is also not centrally positioned. At metaphase I of meiosis the seven bivalents were fully contracted with one larger bivalent.

Family Ditrichaceae

The family Ditrichaceae contains some 24 genera (Goffinet & Buck 2004) of which eight genera including *Ditrichum, Ceratodon, Distichium, Eccremidium* and *Pleuridium*, occur in New Zealand. Of these, *Ditrichum* with 12 species (Beever et al. 1992) is the largest. Chromosome data for a number of species of *Ditrichum* from Europe, U.S.A. and India, give the number as predominantly n=13, sometimes with an additional m-chromosome or sometimes polyploids with n=26 (Fritsch 1991, Goldblatt & Johnson 1994, 1996, 2003). Chromosome numbers have been recorded for the single species *D. difficile* from Australia n=13, 13+m (Ramsay 1974) but there are no previous records from New Zealand.

***8. *Ditrichum brachycarpum* Hampe n=13, Fig. 1.6**

9. *Ditrichum brevirostre* (R.Br.bis.) Broth. n=13, Fig. 1.7

Both species of *Ditrichum* studied (Table 2), had the chromosome number n=13. The two collections of *Ditrichum brachycarpum* examined were collected at different times and in different localities on the South Island (Table 2).

Family Funariaceae

Fife (1982, 1985, 1985a, 1986, 1996) and Fife and Seppelt (2001) have revised the various taxa in the Funariaceae for Australasia. They recognise six species of *Entosthodon* (smooth capsules) and two species of *Funaria* (grooved capsules) for New Zealand.

Chromosome data are available for a number of taxa as *Entosthodon* or *Funaria* from North America, Europe, India and Australia (see Fritsch 1991, Goldblatt & Johnson 1994). A recent count (Goldblatt & Johnson 2000) for *Entosthodon wichurae* from India is n=7 representing the probable basic number of the family. Numbers for other species include n=14, 21, 24, 26, 27, 28, 42, 52, 54, 56. Information is provided here for 3 species.

10. *Entosthodon laxus* (Hook.f. & Wilson) Mitt n=24, Fig 1.9

Formerly *Funaria apophysata*, now known as *Entosthodon laxus*, has the chromosome number n=24, the first for this species for a collection from the South Island by A.J. Fife (Table 2).

11. *Entosthodon* species 1, n=18, Fig. 1.8

The chromosome number of n=18 determined here for a New Zealand collection of *Entosthodon* for an as yet unidentified species from the South Island made by A.J. Fife (Table 2) is the first with the chromosome number n=18.

12. *Entosthodon* species 2, n=26, **Fig. 1.10**

This as yet unidentified species has the chromosome number n=26 for a collection from Mt Ruapehu (Table 2).

Family Hypnaceae

The Hypnaceae is a large family of mosses with some 62 genera (Buck & Goffinet 2000). The family is not well represented in Australasia and in New Zealand only the four genera *Hypnum* (two species), *Ctenidium*, *Fallaciella* (formerly *Camptochaete gracilis*) and *Ectropothecium*, each with a single species, are present.

Chromosome numbers for the family of n=11 (five species) and n=8 (four species) have been reported for nine species from Europe, North America, New Zealand and Japan mainly by Nishimura et al. (see Fritsch 1991) based on mitotic studies. These included n=8 for *Ctenidium pubescens* in New Zealand (Nishimura & Inoue 1985).

13. *Ctenidium pubescens* (Hook.f. & Wilson) Broth. n=8.

Ctenidium is a small genus with 21 species worldwide (Nishimura 1985). In these studies of meiosis, the chromosome number for *C. pubescens* in New Zealand is confirmed as n=8. but no illustrations are included here. The collections were obtained from localities near Auckland (Table 2) close to that from which J.E. Beever obtained the specimens sent to Nishimura.

Family Hypopterygiaceae

A recent revision of the family Hypopterygiaceae by Kruijer (2002) has renamed a number of former *Hypopterygium* species. Newton (1973) reported n=6 for *Hypopterygium didictyon* (formerly *H. novae-seelandiae*) while Ramsay (1967) reported studies on a population from Australia of *H. tamarisci* (as *H. rotulatum*) with various cytotypes and the numbers n=9, 18, 27, 36. The chromosome number for *Cyathophorum bulbosum* from New Zealand examined mitotically by Newton (1973) is n=5 and is the same for Australia examined meiotically (Ramsay 1974).

14. *Cyathophorum bulbosum* (Hedw.) Müll.Hal. n=5, **Fig. 1.11**

The meiotic chromosome number recorded here for *Cyathophorum bulbosum* from Dunedin (Table 2) had the same chromosome number n=5 and similar bivalents to the Australian collections examined previously.

15. *Hypopterygium didictyon* Müll.Hal. n=6, **Fig. 1.12**

These studies provided the meiotic chromosome number of n=6 for *H. didictyon* (Table 2) confirming that determined by Newton (1973) (as *H. novaeseelandiae*) based on gametophytic mitosis.

Family Lembophyllaceae

The family Lembophyllaceae was revised by Tangney (1997) and includes eight genera of which five have representatives in New Zealand. Przywara et al. (1992) recorded the chromosome number 2n=22 based on sporophytic mitotic studies for *Acrocladium chlamydophyllum* from New Zealand. This corresponds to a meiotic count of n=11. Australian studies have previously reported the chromosome number for *Acrocladium chlamydophyllum* (Hook.f. & Wilson) Müll.Hal. & Broth. as n=11 (10+m), [as *A.*

auriculatum (Mont.) Mitt.] at meiosis (Ramsay 1974). Chromosome numbers for *Lembophyllum divulsum* (Hook.f. & Wilson) Lindb. n=10, and *Camptochaete deflexa* (Wilson) A.Jaeger [as *C. ramulosa* (Mitt.) A.Jaeger] n=10, 11, 22 and n=11 for *C. excavata* (Taylor) A.Jaeger [as *C. vaga* (Hornsch. ex Müll.Hal.) Broth.] have been recorded for Australian species (Fritsch 1991).

16. *Acrocladium chlamydophyllum* (Hook.f. & Wilson) Müll.Hal. & Broth., n=11.

The meiotic chromosome number was verified as n=11 for a population from New Zealand (Table 2) and corresponds to the sporophytic mitotic count of n=22 made by Przywara et al. (1992). No illustration is included here.

Family Leptostomaceae

The Leptostomaceae is a southern hemisphere family distributed in Australia, New Zealand and Papua New Guinea. It contains a single genus *Leptostomum* with two species in New Zealand (Beever et al. 1992). The chromosome numbers n=6, 12 have been reported previously for *L. inclinans* in Australia (Ramsay 1967, 1974).

17. *Leptostomum inclinans* R.Br. n=6, Figs. 1.13 & 1.14

This is the first chromosome count for *Leptostomum inclinans* in New Zealand (Table 2). The number n=6, (Fig. 1.13) at anaphase I corresponds to that found for Australian specimens. Many sporocytes were at metaphase II where the count could be confirmed, Fig. 1.14.

Family Pottiaceae

The family Pottiaceae contains a very large number of taxa with a high range of chromosome numbers within individual species for a number of genera such as *Tortula* (some species now recorded as *Syntrichia* by Zander (1993)), *Tortella, Trichostomum* and *Weissia.*

***18. *Tortella mooreae* Sainsbury n=13, Fig. 1.15**

Tortella mooreae is a New Zealand endemic species and the specimens examined here, collected by J.E. Beever, came from islands near Auckland, North Island (Table 2). The chromosome number, the first report for the species, was determined as n=13 in both collections.

The genus *Tortula* is a large genus of colonising mosses with many species and a wide range of chromosome numbers. There are numbers available for more than 50 species worldwide; n=7 (6+m), 12, 13, 24, 26, 28, 36, 48, 50, 52, 66 which include high intraspecific and interspecific polyploids (Fritsch 1991).

19. *Tortula brevisetacea* (F.Muell.) Thér. n=12, Fig. 1.18

There are no previous chromosome records for this New Zealand species. The number reported here (Table 2) is n=12.

Weissia is another widespread colonising genus in the Potticaceae with many species. Chromosome numbers for some species reported in Fritsch (1991) from North America, Europe, India, Japan and Australia are n=13, 14, 26.

20. *Weissia austrocrispa* (Beckett) I.G.Stone n=26, **Fig. 1.21**

This species (in Beever et. al. 1992 as *Astomum austrocrispum* (Beckett) Broth.) is present in New Zealand and Australia (Streimann & Klazenga 2002). The chromosome number of n=26 was obtained from specimens collected by Allan Fife (Table 2) and is the first for the species.

Family Ptychomniaceae

The family Ptychomniaceae is a southern hemisphere pleurocarpous family. There are 6 recognised genera (Buck & Goffinet 2004) including *Dichelodontium, Ptychomnion, Cladomnion, Hampeella* and *Glyphothecium. Cladomnion* is monotypic and endemic to New Zealand. The genus *Ptychomnion* has one species, *P. aciculare*, in New Zealand and Australia and another species, *P. densifolium*, found in New Zealand at high altitudes and on subantarctic islands. The chromosome number n=7 has been recorded previously for Australian species of *Glyphothecium* and *Ptychomnion* (Ramsay 1967, 1974).

***21. *Dichelodontium nitidum* (Hook.f. & Wilson) Broth. n=7,** **Fig. 1.19**

Both collections of *D. nitidum* examined here (Table 2) had the chromosome number of n=7, with comparatively large chromosomes. These are the first records for this genus and species. The number supports its relationship to other taxa in the family.

***22. *Cladomnion ericoides* (Hook.) Hook. f. & Wilson n=7,** **Fig. 1.20**

There are no previous chromosome number records for the genus *Cladomnion*. The number n=7 (Table 2), is reported here and includes a small bivalent (not an m-bivalent) which disjoins early. This is the same number as for the related genus *Ptychomnion* both here and in Australia and the other genera in the family studied here.

23. *Ptychomnion aciculare* (Brid.) Mitt., n=7.

The chromosome number n=7 was reported for *P. aciculare* in Australia (Ramsay 1974). This number is confirmed here for a New Zealand population (Table 2) with bivalents similar to those for Australian collections. The bivalents included one smaller one that disjoined early but was not an m-chromosome. No illustration is included here.

24. *Glyphothecium sciuroides* (Hook.) Hampe n=7.

In this study the chromosome number n=7 was reliably confirmed for two New Zealand populations (Table 2). This corresponds with the number n=7 determined previously for an Australian population (Ramsay 1974). No illustration is included here.

Family Rhizogoniaceae

The family Rhizogoniaceae is represented in New Zealand by the genera *Pyrrhobryum, Rhizogonium, Cryptopodium, Goniobryum* and *Hymenodon*. There have been a number of chromosome studies for various genera in the family, including counts of n=6, for two different species of *Pyrrhobryum* (one as *Rhizogonium paramattense*), n=12 for *Pyrrhobryum mnioides* and n=5 for *Rhizogonium novaehollandiae* in Australia (Ramsay 1974) [for photographs see figs 22–31 in Ramsay 1983] as well as n=6 and or n=12 for *P. spiniforme* (as *Rhizogonium*) from America, Japan (Fritsch 1991) and Papua New Guinea (Ramsay 2008).

Cryptopodium is a monotypic New Zealand endemic moss (Fife 1995) commonly found on the lower trunks of tree ferns.

***25. *Cryptopodium bartramioides* (Hook.) Brid. n=7,** **Fig. 1.17**

This is the first chromosome report for *Cryptopodium bartramioides*, determined from collections from two different localities (Table 2). The chromosomes are large and the meiotic chromosome number n=7 corresponds well with those recorded for other taxa in the family.

Family Racopilaceae

The family Racopilaceae contains two genera, *Powellia* with two species occurring in tropical regions and *Racopilum* a primarily southern hemisphere genus of 20 species occurring in South America, Africa, south-eastern Asia Australia and New Zealand. Chromosome counts of n=10 have been published for six species of *Racopilum* (Fritsch 1991) with the polyploid number n=20 for *R. tomentosum* from South America. In Australia the number n=10 was published for *R. cuspidigerum* var. *convolutaceum* as *R. convolutaceum* and also includes a collection incorrectly named as *R. strumiferum* (Ramsay 1974). *R. strumiferum*, present in New Zealand and Australia, has the number n=10 (de Vries et al. 1989, Zanten 2006) in New Zealand.

26. *Racopilum cuspidigerum* (Schwägr.) Ångstr. var. *convolutaceum* (Müll.Hal.) Zanten & Dijkstra. n=10, **Fig. 1.16**

This report (Table 2) confirms the number as n=10 for this taxon and is the first record from New Zealand.

Discussion

These additional studies bring the total chromosome data to 12% of the species present in New Zealand. Many taxa, including endemic species, have not been investigated There is therefore an obvious need for more cytological studies on New Zealand mosses. Such studies may highlight extra characters for the species and, where aneuploidy or polyploidy occurs, give some information on the evolution occurring both intra- and inter- specifically that may not be available from molecular studies.

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A new species of *Solanum* (Solanaceae) from the mid north coast of New South Wales

A.R. Bean

Queensland Herbarium, Brisbane Botanic Gardens, Mt Coot-tha Road, Toowong 4066 Queensland

Abstract

Solanum sulphureum A.R.Bean sp. nov. is described and illustrated. It is related to *S. brownii* and other species in the informal *S. macoorai* group, and is apparently confined to lowland rainforest in the Taree district on the mid north coast of New South Wales. Its conservation status and relationships are discussed.

Introduction

While examining a loan of *Solanum* specimens from the National Herbarium of New South Wales, I was puzzled by an unidentified specimen collected in 1983 from Killibakh Creek near Taree. At first I took it to be an introduced species, but later concluded that it was native, in view of the many character states shared with the indigenous *Solanum brownii* and its allies. Subsequent field studies have confirmed its native status.

The new species belongs in the *Solanum brownii* group, which is in turn a part of the informal *S. macoorai* group, i.e. Group 27B of Bean (2004). The *S. brownii* group now excludes *S. cinereum*. *S. cinereum* has previously been considered closely related to *S. brownii* (Symon 1981, Bean 2001) and was placed in the *S. macoorai* group by Bean (2004), but I now recognise that *S. cinereum* fits much more readily into the informal *S. hystrix* group (Group 25 of Bean 2004).

Nomenclature in relation to the indumentum follows Bean (2004).

Taxonomy

Solanum sulphureum A.R.Bean, **sp. nov.**

Solano brownii affinis sed foliis ovatis basi obtusis vel cordatis, pilis stellatis majoribus in partibus vegetativis, antheris brevioribus, ovario pilis stellatis carente et seminibus parvis differens.

Type: New South Wales: North Coast: 4.3 km along Somerset road, WSW of Wingham, *A.R. Bean 23356*, 29 December 2004 (holo BRI; iso NSW, MEL).

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Erect, rhizomatous perennial shrub 0.9–2.5 m high. *Adult branchlets* yellow, rusty or brown; prickles 2–15 per decimetre, straight, acicular, 5–11 mm long, 8–14 times longer than wide, glabrous; stellate hairs dense or very dense, 0.6–1 mm diameter, stalks 0.2–1.2 mm long; lateral rays 7 or 8, porrect or ascending, central ray 0.7–1 times as long as laterals, not gland-tipped; type 2 hairs dense. *Juvenile leaves* 9–12 cm long, 6–8.5 cm wide, with 2 or 3 pairs of lateral lobes, apex acute, base obtuse to cordate; prickles present on midvein and lateral veins. *Adult leaves* ovate, entire, lamina 6.5–12.3 cm long, 2.3–5.8 cm wide, 2.1–2.8 times longer than broad, apex acute, base obtuse or cordate, oblique part 0–4 mm long, obliqueness index 0–5 percent; petioles 0.8–3.1 cm long, 12–27 % length of lamina, prickles absent or present. *Upper leaf surface* green, prickles absent or present on midvein only, or occasionally on lateral veins also, prickles 0–7, straight, acicular, 8–12 mm long; stellate hairs distributed throughout, protostellae present, density sparse to moderate. Upper leaf surface ordinary stellae 0.2–0.6 mm apart, 0.4–0.7 mm across, stalks 0.1–0.8 mm long, lateral rays 4–8, porrect or ascending, central ray 0.8–1.5 times as long as laterals, central ray not gland-tipped; simple hairs absent; type 2 hairs present throughout, 0.05–0.1 mm apart. *Lower leaf surface* greenish white, white or grey; prickles absent or present on midvein only, 0–3, straight, acicular; stellate hairs dense or very dense; stellae 0.1–0.25 mm apart, 0.6–1.2 mm diameter, stalks 0.2–1.2 mm long; lateral rays 7 or 8, rays porrect; central ray 0.7–1.3 times as long as laterals, not gland-tipped; simple hairs absent; type 2 hairs present throughout, 0.05–0.2 mm apart. *Inflorescence* supra-axillary, cymose (pseudo-racemose), common peduncle absent or present, 0–7 mm long, rachis prickles absent or present, 7–11-flowered, with some bisexual and some male flowers. *Flowers* 5-merous; pedicels at anthesis 10–13 mm long, same thickness throughout, prickles absent or present. *Calyx* tube at anthesis 3–4 mm long; calyx lobes at anthesis deltate, 2.5–4 mm long; calyx prickles at anthesis absent or present, 0–5 per flower; stellate hairs very dense, yellow or brown or rusty, 0.6–0.7 mm across, stalks 0.1–0.5 mm long, lateral rays 7 or 8, central ray 0.8–1.2 times as long as laterals, not gland-tipped; simple hairs absent. *Corolla* purple, c. 14 mm long, shallowly lobed, inner surface glabrous. *Anthers* 4.0–4.3 mm long. *Ovary* with type 2 hairs only; functional style c. 8 mm long, protruding between anthers, with type 2 hairs only. *Fruiting calyx* lobes less than half length of mature fruit; prickles absent or present, 2–7 mm long. *Mature fruits* 1–4 per inflorescence, globular, 14–19 mm diameter, yellow or yellowish green, 1-locular (septum absent or incomplete); placenta stalked, anvil-shaped; mesocarp juicy, succulent; exocarp 0.7–1.1 mm thick; pedicels at fruiting stage 19–22 mm long, 1.1–1.5 mm thick at mid-point. *Seeds* pale yellow, 2.2–2.5 mm long. (Fig. 1).

Specimens examined: New South Wales. Port Macquarie, *collector unknown*, Oct 1892 (NSW); Killibakh Ck via Wingham, *T. Launders 16*, Oct 1983 (BRI, NSW); Woodside, Manning River, *Cameron s.n.*, Oct 1911 (NSW); 3.4 km along Mulligans Lane, near Burrell Creek, WSW of Taree, *A.R. Bean 23376*, Dec 2004 (BRI, MO, NSW).

Derivation of name: from the Latin *sulphureus* – sulphur yellow, in reference to the colour of the mature fruits.

Distribution: known from the Taree-Wingham area on the mid north coast of New South Wales. The 1892 specimen cited above gives the location merely as 'Port Macquarie', but the collection was probably made many kilometres from the town, as no suitable habitats are apparent close to Port Macquarie.

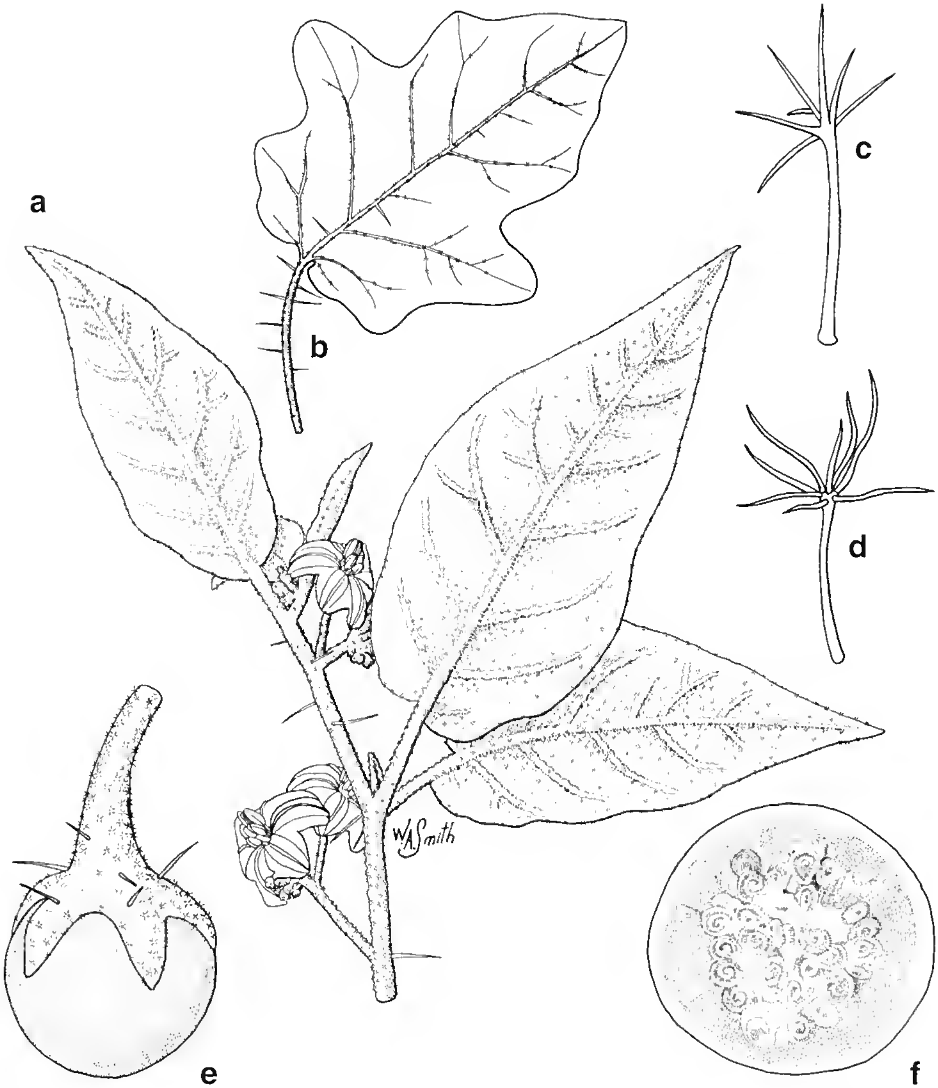

Fig. 1. ***Solanum sulphureum.*** **a,** flowering branchlet × 0.8; **b,** juvenile leaf × 0.6; **c,** a stellate hair from the upper leaf surface × 40; **d,** a stellate hair from the lower leaf surface × 40; **e,** a mature fruit with attached calyx × 1.5; **f,** transverse section of fruit × 2 (a, c, d from *Bean 23356*; b, e, f from *Bean 23376*).

Habitat: it inhabits sunny breaks in rainforest, rainforest regrowth on pasture land, or eucalypt forest with rainforest understorey. The soils are loams or clay-loams, shallow or deep. All collections have been from low altitudes (< 200 metres).

Conservation status: for the populations where the land use is cattle grazing, *S. sulphureum* is threatened by competition from aggressive pasture grasses, inevitably leading to a decline in population for the Solanum. My encounters with some local graziers indicated that they perceive any prickly plant to be a noxious weed, and that all 'native tomatoes' are poisonous and will result in the death of cattle. Hence the species is threatened by active destruction by humans. It not known from any Nature reserves or State Forests. A conservation status of Vulnerable (VU B2ab(iii,v); C1) is recommended, based on the Red List criteria (IUCN 2001).

Affinities: *S. sulphureum* is distinguishable from other Australian species by the entire ovate adult leaves (2.1–2.8 cm times longer than wide), the dense to very dense stellate hairs with stalks up to 1.2 mm long, the few-flowered cymose inflorescence, the calyx with few or no prickles and with stellate hairs 0.6–0.7 mm diameter, and the globose yellow fruits 14–19 mm diameter.

S. sulphureum is related to *S. brownii*, but differs by the adult leaves 2.3–5.8 cm broad with obtuse or cordate bases (1.4–2.9 cm broad, base cuneate or attenuate for *S. brownii*), the much larger stellate hairs on all vegetative parts of the plant, the presence of type 2 hairs on the branchlets and leaves, the anthers 4–4.3 mm long (5–6 mm for *S. brownii*), the yellow fruits (green or yellowish-green for *S. brownii*), and the seeds 2.2–2.5 mm long (2.6–3.1 mm long for *S. brownii*).

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Short Communication

Oryza nivara in Australia?

P.G. Kodela

National Herbarium of New South Wales, Botanic Gardens Trust, Mrs Macquaries Road, Sydney NSW 2000, Australia.

This paper expands on notes provided on *Oryza nivara* S.D.Sharma & Shastry (1965) in the *Flora of Australia* Poaceae Volume 44A (Kodela 2009), where this species is treated as an excluded taxon.

Oryza nivara is part of the *O. sativa* L. complex and is related to *O. rufipogon* Griff. and *O. meridionalis* N.Q.Ng (in the AA genome group of wild rice). Sharma and Shastry (1965) describe how *O. nivara* differs from the closely related species *O. sativa* and *O. rufipogon*, but in a revision of the genus Duistermaat (1987) placed it in synonymy with *O. sativa*, whilst others have possibly confused *O. nivara* with *O. meridionalis*. There is also the possibility of the existence of intermediate forms between the various species.

Lu and Jackson (2004) distinguish *O. meridionalis* from *O. nivara* mainly on the basis of the spikelets, i.e. usually less than 2 mm wide in *O. meridionalis* and usually greater than 2 mm wide in *O. nivara*. The awn can also be distinctly longer in *O. meridionalis* (D. Vaughan, pers. comm.). However, where characteristics overlap there appear to be few other reliable morphological features to separate the species (P.G. Kodela, pers. obs., B.K. Simon, pers. obs. & comm.). There are also issues relating to the habit of the species where *O. rufipogon* (usually perennial), *O. meridionalis* (usually annual) and *O. nivara* (usually annual) may be influenced by a range of habitat factors such as wetter to drier conditions or deeper to shallower water.

Oryza nivara is reported to occur in India, Sri Lanka, Nepal, Bangladesh, Myanmar, Laos, Thailand, Cambodia, Vietnam, Malaysia and introduced into the U.S.A. and Australia (Vaughan 1994, Lu & Jackson 2004). The basis for a cited Northern Territory distribution of *O. nivara* (Sharma & Shastry 1965) is unknown, while a record of *O. nivara* from Queensland (Vaughan 1994, Anon. 2005) is based on *J.R.Clarkson 7320* from Red Lily Lagoon, Lakefield National Park (BRI, K, L, NSW) (D. Vaughan & B.K. Simon, pers. comm.). However, the Clarkson specimen and others from Australia with similar spikelet dimensions (i.e. > 2 mm wide) have been identified by most Australian experts as *O. meridionalis*. Further investigation, including study of Type material, is required to determine whether *O. nivara* occurs in Australia.

As well as the holotype of *Oryza nivara* (i.e. near Kandagarh, 16 km S of Raigarh, Madhya Pradesh, India, 15 Oct 1960, *S.D.Sharma 69*; CAL), Sharma and Shastry (1965) cite a number of paratypes, including *Pullen 1941* (LAE) from Papua New Guinea. Further investigation strongly suggests this is a typographical error for *Pullen 1641* (CANB71016, L, LAE), a specimen determined at CANB as *O. rufipogon* and described by Duistermaat (1987), who did not realise it was a paratype of *O. nivara*, as a possible local East Sepik form of *O. rufipogon* that has large spikelets with long sterile lemmas. This form has subsequently been referred to as a perennial *O. rufipogon* ecotype with

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similarities to *O. meridionalis* (Vaughan et al. 2008). Material of *Pullen 1941* was not located at LAE (R. Banka, pers. comm.); however, *Pullen 1941* held at CANB is a specimen of *Microtis* sp. (Orchidaceae) from Australia.

In conclusion, the status and placement of *O. nivara* is uncertain, especially in the Australian context where specimens appear to be difficult to distinguish from other AA genome *Oryza* species. There may well be introduced AA genome wild rice from Asia in Australia (brought in by birds or humans) and there appear to be intermediates and the possibility for hybrids that would complicate the current understanding of the taxa present (e.g. the status of *O. nivara*). The complex nature of *Oryza* in Australia warrants detailed study (D. Vaughan, pers. comm.).

Acknowledgments

I am very grateful for assistance and information provided by Australian Biological Resources Study (Canberra), Jenny Tonkin (Australian Botanical Liaison Officer at Kew 2006–2007), Bryan Simon (BRI), Peter Wilson (NSW) and Duncan Vaughan (FAO Regional Office for Asia and the Pacific, Bangkok, Thailand). Roy Banka (LAE) kindly checked the presence of relevant Pullen specimens held at LAE.

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Telopea 12(3) 445–446

Short Communication

Lectotypification of *Neckera hymenodonta* Müll. Hal. (Neckeraceae, Bryophyta)

Johannes Enroth

Department of Biological and Environmental Sciences, and Botanical Museum
P.O. Box 7, FI-00014 University of Helsinki, Finland
Email: johannes.enroth@helsinki.fi

Müller (1851) described *Neckera hymenodonta* from Tasmania ("Van Diemen's Land"). In the protologue it was compared with "*N. pinnata*", which is here regarded as an orthographic error for *N. pennata* Hedw., since there is no taxon known with the former name. The name *N. hymenodonta* was synonymised with *N. pennata* by Sainsbury (1952), and it remained in taxonomic oblivion (cf. Beever et al. 1992, Fife 1995, Streimann & Klazenga 2002) until reinstated as a distinct species and described in detail as well as illustrated in line drawings by Ji & Enroth (2008). Some of the morphological distinctions between the two species are found in the peristome, as indeed noted by Müller (1851), but there are also more easily observed ones, such as the presence of paraphyllia in *N. hymenodonta* and their absence in *N. pennata* (Ji & Enroth 2008).

Carl Müller's personal herbarium was destroyed in Berlin in 1943 (e.g. Isoviita & Ochyra 1990). In connection with M.-C. Ji's PhD-thesis, which is a revision of *Neckera* in Asia and Australasia, type material of Müller's *N. hymenodonta* was sought in numerous herbaria worldwide, but unsuccessfully. In late 2008, two duplicates of the syntype material of *N. hymenodonta*, as cited in the protologue, were examined. As far as is known, they are the only remaining duplicates of the type material, so one of them is here designated as the lectotype. It should be noted that, nevertheless, both these specimens remain isotypes.

Neckera hymenodonta Müll. Hal., *Botanische Zeitung (Berlin)* 9: 564 (1851).

Type citation: [Australia, Tasmania] Van Diemen's Land, ad truncos arborum fruticeti densi infra Bek-river [sic!] prope Launceston. Coll. No. 746 [all specimens reported in Müller's (1851) work were collected in 1850 by Samuel Mossman].

Lectotype (designated here): "Neckera hymenodonta C. Muller On trees in a brushwood. S°. Esk River. Van Dieman's Land. Collected by Samuel Mossman. No. 746. 1850" (NY-Mitten!; Fig. 1).

Isotype: "Neckera hymenodonta C. Muller Bot. Zeit. 1851, p. 564. On trees amongst brushwood S. Esk River, Tasmania. Mossman 746" (NY-Mitten!; Fig. 2).

The duplicate selected as the lectotype has somewhat more material and has an original label of Samuel Mossman's herbarium. Both duplicates have William Mitten's herbarium stamp on the label. Clearly, the name "Bek-river" in the protologue is a misreading by Carl Müller of the hand-written name Esk, which is a river in NE Tasmania.

The newly discovered type material, although in good condition, does not add any new information of the morphological variation of *N. hymenodonta*, because it is quite a common species especially in New Zealand. Over thirty representative specimens were cited by Ji & Enroth (2008).

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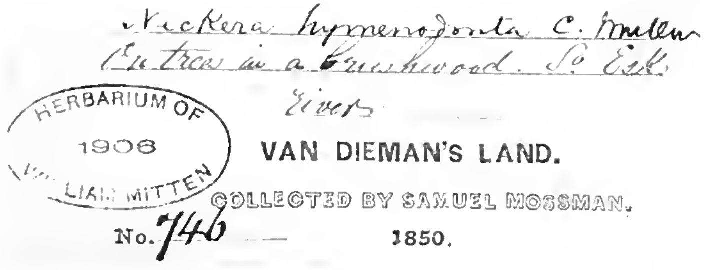
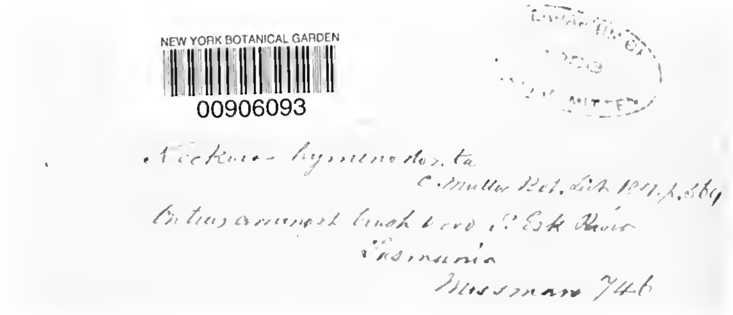


Neckera hymenodonta C. Muller
On trees in a brushwood. S° Esk
Rivers
VAN DIEMAN'S LAND.
COLLECTED BY SAMUEL MOSSMAN.
No. 746 1850.

HERBARIUM OF
1906
WILLIAM MITTEN

Fig. 1. Packet label of lectotype of *Neckera hymenodonta* Müll. Hal.



NEW YORK BOTANICAL GARDEN
00906093

Neckera hymenodonta
C. Muller Bot. Zeit. 1851, p. 564
On trees amongst brushwood, S° Esk River
Tasmania
Mossman 746

Fig. 2. Packet label of isotype of *Neckera hymenodonta* Müll. Hal.

Acknowledgments

I thank William R. Buck (NY) who informed me of the presence of two duplicates of syntype material of *Neckera hymenodonta* and I thank the Director and staff of NY for making these materials available for study.

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Short Communication

Notes on *Cycas truncata* de Laub. and related matters.

K.D. Hill and L.C. Stanberg

National Herbarium of New South Wales, Royal Botanic Gardens, Mrs Macquaries Road, Sydney 2000, Australia.

In December 2007, de Laubenfels published a new species of *Cycas* from the Philippines: *C. truncata*. He placed several *Cycas* names in synonomy under this new species: *C. inermis* Lour. ('nomen illeg., given in syn. *C. revoluta*'); *C. circinales* [sic] auct. non L; *C. rumphii* auct. non Miq.; *C. media* auct. non R. Br.; *C. silvestris* auct. non Hill and *C. riuminiana* auct. non Porte. In our opinion this paper did not deal adequately with a number of issues, the most significant of which was de Laubenfels' interpretation of de Loureiro's Latin description of *C. inermis*. We believe that de Laubenfels was in error when he stated that de Loureiro considered *C. inermis* to be a synonym of *C. revoluta*. This and several other matters arising from his 2007 publication are discussed briefly below.

Validity of the name *C. inermis* Lour., Fl. Cochinch., ed. 1, 2: 632 (1790).

C. inermis Lour. is a validly and legitimately published name in Edition 1 of Flora Cochinchinensis (1790) with an extant specimen housed by the BM that could reasonably be taken to be the Holotype (see Hill et al. 2004). Following the description of *C. inermis*, de Loureiro states:

"*Cycas circinalis. Jacq. Ac. Helver. tom. 8. pag. 59. tab. 2. Cycas revoluta. Thunb. Jap. pag 229. Olus Calapoides. Rumph. Amb. l. 1. cap. 20. tab. 20, 21, 22, 23, 24. Quamvis figurae Rumphianae aliquantulum differant, sicut etiam descriptiones Jacquini, & Thunbergii, puto pro diversis speciebus non habendas : nec etiam nostram, licet semper inermem inveuerim, in quo ab illis dissidet. Ramosam nunquam vida, nec Monoicam.*"[1]

We contend that Loureiro's mention of *C. revoluta*, along with the two other species of *Cycas* known at the time (*C. circinalis* and Rumphius' "Olus Calapoides", now known as *C. rumphii*), was to compare and contrast the already-published cycads with his new species. In fact, Loureiro's Latin comments indicate that he considered that these three were not sufficiently distinct to justify them being separate species. He clearly states that his new taxon, *C. inermis*, differs from all of them by being consistently unarmed but does not specify the unarmed organs. The citation of the name *C. inermis* in synonymy with *C. truncata* by de Laubenfels renders the latter name illegitimate (Article 52.2, Ex. 2, McNeill et. al. 2006), even though the author of *C. truncata* considers the name *C. inermis* to be invalid.

Hill et al. (2004) applied the name *C. inermis* to a taxon occurring in the foothills of southern and central Vietnam. This is a widespread taxon in Vietnam, related most

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[1] Translation from the Latin: "Although the Rumphian figures [there are 5 cited] may differ by only a little, similarly I do not think the descriptions of Jacquin and Thunberg should be considered as separate species; not so ours [i.e., *C. inermis*], granted that I have always found it unarmed, in which [feature] it disagrees with them. I have never seen it branching, nor monoecious."

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closely to *C. macrocarpa* from Thailand and peninsular Malaysia. It is not considered to be part of or related to *C. silvestris* (regarded as an Australian endemic), or to occur in the Philippines. The illegitimacy of the name *C. truncata* thus leaves *C. inermis* (sensu Hill et al. 2004), *C. macrocarpa* (Hill & Yang 1999) and *C. silvestris* (Hill 1992, 1996) as valid taxa.

Does an undescribed taxon exist in Northern Luzon?

The description of *Cycas truncata* by de Laubenfels (2007) is problematic in a number of respects.

In the Latin description of *C. truncata*, de Laubenfels states "*Margines apicum microsporophyllorum dendatum* [sic] *ad 5 mm longum*". This does not fit with the dimensions given in the English description: "*Microsporophylls 15-22 mm wide, sharply truncated at the apex but raised slightly towards the center with a narrow sterile zone and with a spike10-23 mm long*". Furthermore, the previously published illustrations referred to by de Laubenfels do not adequately illustrate *C. truncata*. The Amoroso (1986) illustrations are apparently from a range of material (Amoroso 1986, table1), and the individual illustrations (Figs. 7-9, 27-30) are not linked to herbarium specimens. The Hill et. al. (2004) Fig. 17 refers to *C. inermis* sens. strict.

Apart from the designated type (*Merrill 3257*), no naturally occurring specimens are formally cited by de Laubenfels (2007), although one cultivated specimen is mentioned (*E.D. Merrill Species Blancoanae 855*). As a result, the logical conclusion one is forced to draw from de Laubenfels (2007) is that all of the previously cited material of *C. silvestris* (de Laubenfels & Adema 1998) falling within the geographic range now quoted for *C. truncata*, actually belongs to the concept of *C. truncata* presented. The majority of material cited as belonging to *C. silvestris* by de Laubenfels and Adema (1998) is here thought to represent several taxa from a number of countries (Table 1). Some specimens could not be located (Table 2). This leaves a 'core' of remaining specimens (Table 3), including the designated type of the name *C. truncata* (*Merrill 3257*). These specimens are from populations occurring in northern Luzon, a region where specimens cited and plants seen (Lindstrom et al. 2008) can be placed in either *C. riuminiana* or the recently described *C. zambalensis*. Our assessment of this core of remaining specimens (Table 3) is that they all fall into the character range of *C. riuminiana*.

This highlights the need for further taxonomic study, particularly in The Philippines. Although several new species have recently been enumerated (Madulid and Agoo 2005, Lindstrom et al. 2008), novelties may be anticipated, especially from the south-eastern Philippines (Mindoro and southern Luzon through to and including Mindanao). This area suffers considerable political unrest and substantial human impact (through clearing and farming), making the field work which would be required difficult.

Acknowledgments

Dennis Stevenson is gratefully thanked for his constructive comments on the manuscript, his translation of the Latin descriptions in Flora Cochinchinensis eds. 1 & 2 and for images of Merrill specimens held at NY. Peter Wilson is thanked for his helpful comments and his translation of the Latin description in Fl. Cochinch. Karen Wilson is also thanked for her Latin translation. We would also like to thank the following people for images of specimens: Jeremy Bruhl (while Australian Botanical

Table 1. Collections cited by de Laubenfels & Adema (1998) as *C. silvestris* but here thought to belong to other taxa.

Collection cited by de Laubenfels & Adema (1998)	K.D. Hill determinavit	Collection Locality	Herbarium duplicates viewed by K.D. Hill
Backer 50	*C. edentata*	Eile Krakatoa, Indonesia	L
v.BorssumWaalkes 523	*C. edentata*	Pulau Panaitan, Tg Manik, beach, West Java, Indonesia	BO, L
Chai SAN 29392	*C. edentata*	Mt Silamarea, Lahad Datu distr., Sabah, Malaysia	K ex SAN
Curran 3842	*C. curranii*	[type], Molinao River, on river bank, Palawan, Philippines	K, P
d.v.Leeuwin 1881	*C. rumphii*	Saleier group[?Salayar]: 2nd Saleier, zandige kust, South Sulawesi, Indonesia	BO
Edano 76373	*C. vespertilio*	Panagan River, Camarines Sur, southern Luzon, Philippines	BO, G, NY
Eyma 3727	*C. rumphii*	Tobelombang, Loewoek, Menado North Sulawesi, Indonesia	BO, L
Fosberg 32376	*C. rumphii* group?	E. coast of Babeldaob Isl., Palau Group, Palau	L
Kondo & Edano 36768	*C. vespertilio*	Gigantangan, Leyte, Philippines	L
Noerkas 481	*C. rumphii*	Tapalang, Celebes [South Sulawesi], Indonesia	BO, K, L,
Podzorski SMHI 2119	*C. curranii*	Narra, Mt Victoria, Trident Mining Co area, alluvial fan at base of ultrabasic mountain, Palawan, Philippines	L
Ramos & Edano 48953	*C. lacrimans*	[type] Davao, Mati, Mindanao, Philippines	BM, BO, NY, P

Table 2. Collections cited by de Laubenfels & Adema (1998) as *C. silvestris* but authors (KDH & LCS) unable to locate.

Cardona 23870
Curran 7381
Gressit 21 p.p.
Ramos 3281

Table 3. Collections cited by de Laubenfels & Adema (1998) as *C. silvestris* from the now designated type locality of *C. truncata*.

Collection cited by de Laubenfels & Adema (1998)	K.D. Hill determinavit	Collection Locality	Herbarium duplicates viewed by K.D. Hill
Curran 7513	*C. riuminiana*	Lamas [?Lamao], Luzon. Philippines	K
Merrill [Species Blancoanae] 855	*C. riuminiana*	cult Manila, Philippines	A, BM, BO, K, L, NSW, NY
Merrill 3257	*C. riuminiana*	Lamao R., Mt Mariveles, Luzon, Philippines (designated type of *C. truncata*)	BM, K, NY, P, US
Whitford 1235	*C. riuminiana*	Lamao River, Luzon, Philippines	K, NY

Liason Officer at K), Ciarán Moloney (NY), John Boggan (US) John Hunnex (BM) and Luc Willemse (L). Anders Lindstom is thanked for drawing our attention to the Encephalartos publication and Wynand van Eeden is also thanked for his assistance in sending us the pdf file of this article at short notice.

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Corrigenda - Telopea 12(1)

Lindstrom AJ, Hill KD and Stanberg LC. The genus *Cycas* (Cycadaceae) in The Philippines.

Page 136: selected specimens under *Cycas vespertilio* should read as follows.

Selected specimens: PHILIPPINES: Leyte: Gigantangan (? Hingatungan), *Kondo & Edaño PNH 36768*, 26 Mar 1957 (L).

Telopea 11(4)

Lindstrom AJ and Hill KD. The genus *Cycas* (Cycadaceae) in India.

Page 476:

Cycas sphaerica replaces *Cycas spherica.* Both spellings are acceptable, however, Roxburgh used the former in the protologue.

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- Cite no more than 20 (except for very widely distributed species) and arrange by Botanical Divisions. Use accepted format: locality, collector & number, date (herbarium code plus institutional number if there is no collector's number) Only latitudes and longitudes on the original labels should be included. Give dates in the following format: 12 Jan 1987, 2 Jun, 30 Jul, 10 Dec etc.

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