

## *Paranotis halfordii* (Rubiaceae: Spermacoceae), a new species from the Kimberley region of Western Australia, in a recently described Australian genus

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### Abstract

*Paranotis halfordii* K.L.Gibbons & S.J.Dillon, a new species from the Dampierland and Central Kimberley bioregions of Western Australia, is here described. *Paranotis* Pedley ex K.L.Gibbons was recently described to include some Australian species previously included in *Oldenlandia* L. A key to the species of *Paranotis* is provided.

### Introduction

In their treatment of *Hedyotis* L. for the *Flora of the Kimberley Region*, Koch and Halford (1992) recognised the phrase name *Hedyotis* sp. B., with four included collections. Halford (1992) subsequently recognised *Hedyotis* and *Oldenlandia* L. as separate genera, placing *Hedyotis* sp. B in *O. mitrasacmoides* (F.Muell.) F.Muell. subsp. *mitrasacmoides* based on its relatively short corolla tubes, but noting that additional collections were needed to assess its status. A recent molecular phylogenetic study aimed at resolving generic limits in the Australian members of *Hedyotis*, *Oldenlandia* and related genera (Gibbons 2020) found this variant to be genetically distinct from allied species. Subsequent morphological examination of collections held at CANB, NSW and PERTH supported the recognition of this taxon as a distinct species, described below as *Paranotis halfordii* K.L.Gibbons & S.J.Dillon. *Paranotis* Pedley ex K.L.Gibbons is one of two endemic Australian genera newly recognised to accommodate species formerly included in *Oldenlandia*, with new combinations for Australian taxa also having been made in *Scleromitron* (Wight & Arn.) Meisn. (Gibbons 2020). A key to the species of *Paranotis* is provided. For a key to the genera of Spermacoceae (Rubiaceae) in Australia (excluding *Spermacoce* and related naturalised genera) see Gibbons (2020).

## Methods

All measurements are based on dry material from specimens at CANB or PERTH, except for measurements of stamens, stigma and styles, which were taken from spirit collections at PERTH. Seeds of *P. halfordii* and *P. mitrasacmoides* (F.Muell.) K.L.Gibbons subsp. *mitrasacmoides* were coated with gold using a JEOL Smart Coater and imaged with a JEOL JCM 5000 NeoScope desktop SEM. For molecular, sequence alignment and phylogenetic methods, see Gibbons (2020).

## Key to the species of *Paranotis*

1. Stigma narrowly conical and included within corolla tube; stamens included within or partly exerted beyond corolla tube..... 2
- 1: Stigma bifid, exerted beyond corolla tube; stamens partly or completely exerted beyond corolla tube..... 3
2. Corolla lobes 1.0–1.5 mm long; capsule 2.0–2.5 mm wide; seeds depressed obconic..... *P. kochiae*
- 2: Corolla lobes 1.5–3.0 mm long; capsule 2.5–3.5 mm wide; seeds scutelliform..... *P. halfordii*
3. Pedicels stout, unequal in length within an inflorescence; capsule depressed obovoid, deeply furrowed along dissepiment, beak emarginate; ovules 2–6 per locule..... *P. pterospora*
- 3: Pedicels slender, ± equal in length within an inflorescence; capsule subglobose, ovoid-globose or depressed obovoid, slightly furrowed at dissepiment, beak rounded or truncate; ovules > 10 per locule..... *P. mitrasacmoides*

Note. Modified, in part, from Halford (1992), which includes a key to the subspecies of *P. mitrasacmoides* (*O. mitrasacmoides*). The ‘beak’ refers to the portion of the capsule beyond the insertion of the persistent calyx lobes.

## Taxonomy

*Paranotis halfordii* K.L.Gibbons. & S.J.Dillon, *sp. nov.*

Type: One Arm Point, N Dampier Peninsula, Kimberley Coast, Western Australia, 25 March 1989, B.J. Carter 365 (*holo*: PERTH 03841553, including associated spirit material; *iso*: CANB).

*Hedyotis* sp. B, Koch BL, Halford DA in Wheeler JR (ed.) *Flora of the Kimberley Region* p. 919 (1992)

*Hedyotis* sp. B Kimberley Flora, Western Australian Herbarium, in *FloraBase* <https://florabase.dpaw.wa.gov.au/> (Accessed 17 Nov. 2020)

*Oldenlandia* sp. B Kimb. Flora, Kenneally KF *et al.*, *Broome and Beyond* p. 175 (1996)

*Oldenlandia* sp. E One Arm Point (B.J. Carter 445), Western Australian Herbarium, in *FloraBase* <https://florabase.dpaw.wa.gov.au/> (Accessed 17 Nov. 2020)

*Oldenlandia* sp. F Barred Creek (P.R. Foulkes 79), Western Australian Herbarium, in *FloraBase* <https://florabase.dpaw.wa.gov.au/> (Accessed 17 Nov. 2020)

*Oldenlandia mitrasacmoides* (F.Muell.) F.Muell. subsp. *mitrasacmoides pro parte, sensu* Halford, *Austrobaileya* 3: 704 (1992)

**Illustrations:** Koch BL, Halford DA in Wheeler JR (ed.) *Flora of the Kimberley region* p. 917, Fig. 282 (M<sub>1</sub>–M<sub>3</sub>), as *Hedyotis* sp. B (1992); Kenneally KF *et al.*, *Broome and Beyond* p. 175, as *Oldenlandia* sp. B Kimb. Flora (1996).

Erect annual herbs to 50 cm high, mostly little-branched from base. Branchlets terete or weakly ribbed, hispidulous on ribs near base of plant, glabrous above. Stipules interfoliar, adnate to leaf bases, membranous, 1–3 mm long, glabrous; margins entire or with 2 or 3 lacinate or lacerate lobes to 0.2 mm long. Leaves opposite, sessile, linear, 10–50 mm long, up to 1 mm wide, glabrous; apex acute; margins entire, recurved. Inflorescences lax, terminal, paniculiform cymes; peduncles unbranched or irregularly dichasially branched, reduced to a single lateral at the ultimate branchlets; flowers paired (rarely 1 or 3) at nodes; bracts leaf-like, triangular or ovate, 0.5–1.0(–2.0) mm long, glabrous. Pedicels 5–15 mm long, ± equal in length within an inflorescence, glabrous. Flowers homostylous; perianth and androecium 4-merous. Hypanthium hemispherical, 0.7–1.8 mm long, 1.0–1.5 mm wide, glabrous. Calyx persistent, glabrous; lobes triangular, 0.5–1.5 mm long; margins smooth or scabridulous; colleters not observed. Corolla salverform, pink-mauve; abaxial surface glabrous; adaxial surface glabrous apart from a dense line of hairs just inside throat, trichomes *c.* 0.7–1.0 mm long; tube

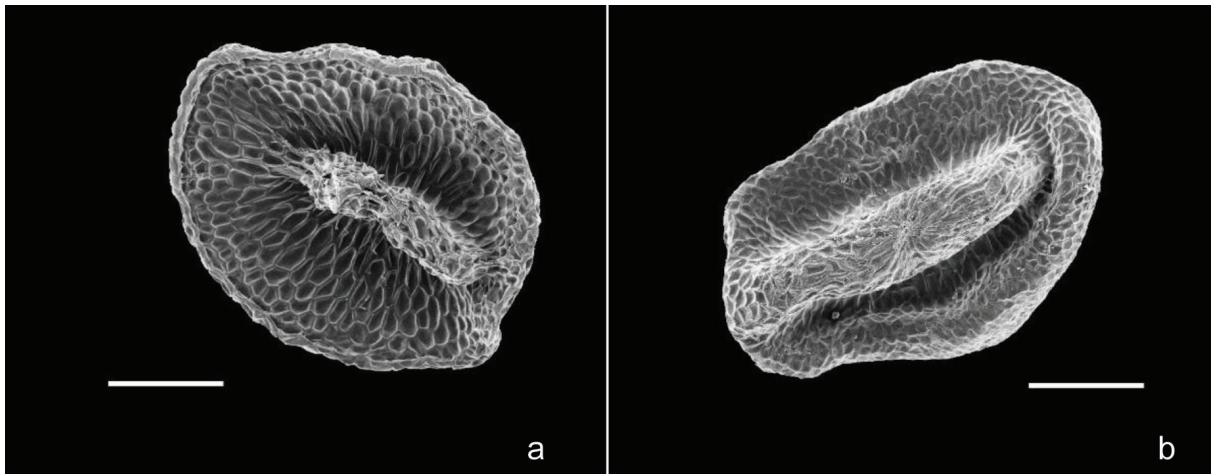
*c.* 0.6–1.0 mm long, *c.* 1–2 mm wide; lobes ovate or elliptical, 1.5–3.0 mm long, aestivation valvate. Stamens adnate to corolla tube, inserted at or below sinuses, ± included within or partly exerted beyond corolla tube; filaments 0.4–0.7 mm long; anthers dorsifixed, linear-oblong, 0.6–0.8 mm long. Ovary bilocular, 4/5 inferior, subglobose; placenta globose, peltately attached towards base of septum; ovules many. Style *c.* 0.2–0.3 mm long; stigma narrowly conical, *c.* 0.8–1.0 mm long, included within corolla tube. Capsule crustaceous, depressed obovoid, somewhat laterally compressed, slightly furrowed at septum, 1.5–2.5 mm long, 2.5–3.5 mm wide, glabrous with a loculicidally dehiscent beak; beak broad, rounded or slightly emarginate, 0.5–1.0 mm long, usually equal to or protruding beyond calyx lobes. Seeds many, scutelliform, with hilum on prominent ventral ridge, broadly elliptic in outline, light brown, 0.7–0.9 mm long, 0.5–0.6 mm wide, with a thinned rim; margin sometimes slightly incurved; testa reticulate-areolate or slightly reticulate-foveolate. (Figs 1, 2, 3a).



**Fig. 1.** *Paranotis halfordii* **a.** habit (sketch); **b.** habit (in three sections); **c.** flower, one corolla lobe removed; **d.** conical stigma and triangular sepals; **e.** immature capsule. Scale: a = 15.1 cm; b = 50mm; c = 3.33mm; d = 1.6 mm; e = 2.5mm. From A.A. Mitchell 6093, CANB (a, b) and B.J. Carter 615, PERTH 2886030 spirit material (c, d, e). Illustration by C. Wardrop.



**Fig. 2.** *Paranotis halfordii*, showing flowers, immature capsules and inflorescence branching. Image by R.L. Barrett, from R.L. Barrett 7828, M.D. Barrett & B. Anderson.



**Fig. 3.** **a.** *Paranotis halfordii* seed, adaxial surface, showing the prominent ventral ridge and thinned rim. **b.** *Paranotis mitrasacmoides* seed, adaxial surface, showing the prominent ventral ridge and thickened, incurved rim. Scale bars = 0.2 mm. Images by S.J. Dillon, from K.F. Kenneally 11870 (A) and P.R. Foulkes 409 (B).

**Diagnostic features:** *Paranotis halfordii* may be distinguished from all other species of *Paranotis* by the following combination of characters: corolla tube up to 1 mm long; corolla lobes 1.5–3.0 mm long; stigma included within corolla tube and narrowly conical; capsule depressed obovoid; seed scutelliform with hilum on a prominent ventral ridge and a thinned rim.

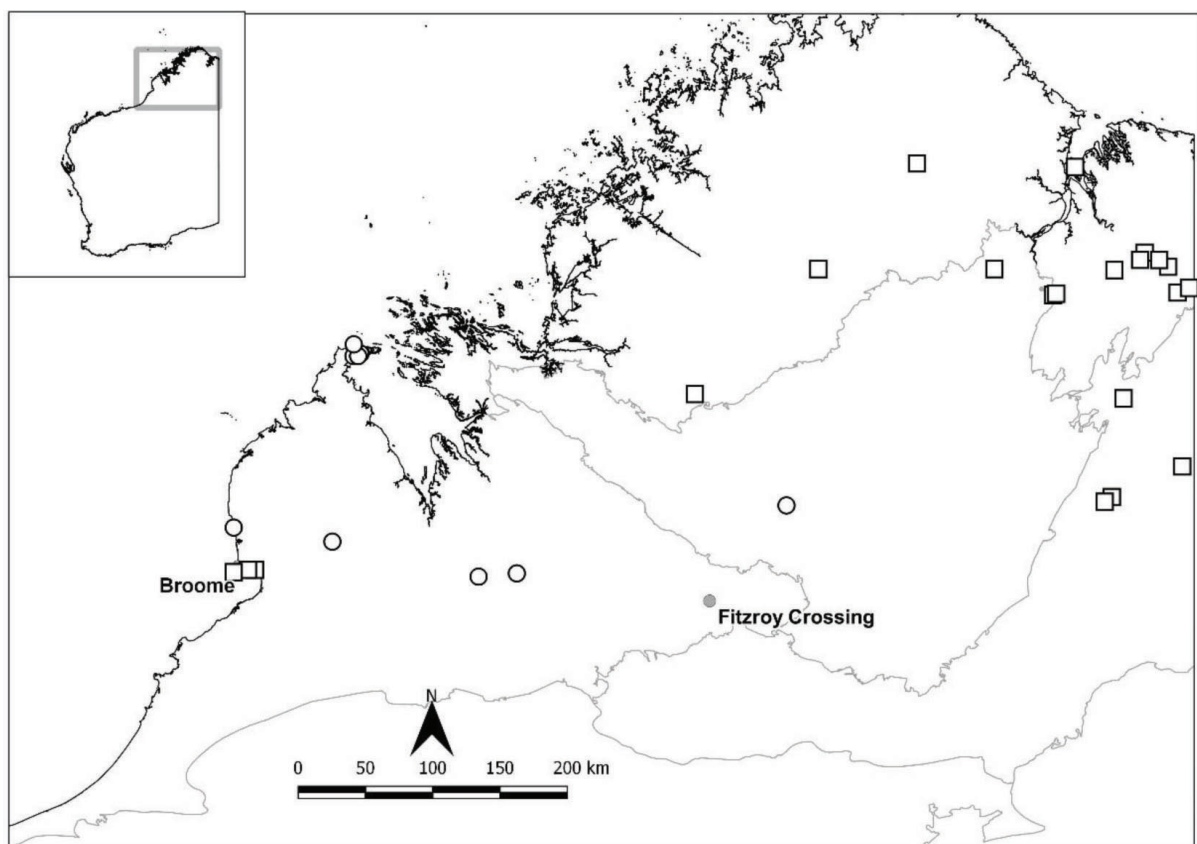
**Other specimens examined:** WESTERN AUSTRALIA: [Precise localities withheld] ENE of Broome, 4 Apr. 2013, R.L. Barrett 7828, M.D. Barrett & B. Anderson (PERTH); Mount Anderson, 12 Feb. 1953, H.F. Broadbent 658 (PERTH); One Arm Point, N Dampier Peninsula, 29 Mar. 1991, B.J. Carter 445 (PERTH); One Arm Point, 28 Feb. 1993, B.J. Carter 615 (PERTH); One Arm Point, Dampier Peninsula, W Kimberley, 24 Apr. 1993, B.J. Carter 640 (PERTH); 27 May 2007, G. Dowden GD 074 (PERTH); Dampierland Peninsula,



West Kimberley, 24 Feb. 1985, *P.R. Foulkes* 79 (PERTH); E of Broome, 26 Jun. 1997, *K.F. Kenneally* 11870 (PERTH); near One Arm Point, 4 Apr. 2000, *A.A. Mitchell* 6093 (CANB, DNA); Camballin, May 1970, *Y. Power* 872 (PERTH, one element on left of sheet, mixed collection with *P. mitrasacmoides* subsp. *mitrasacmoides*).

**Phenology:** Flowering from February to May. Fruiting from February to June.

**Distribution and habitat:** Most collections of *P. halfordii* are from Western Australia's Dampier Peninsula and surrounds (Pindanland subregion, Dampierland bioregion; Department of the Environment and Energy 2013) (Fig. 4). The species has also been collected from the Central Kimberley bioregion (*G. Dowden* GD 074). Two Fitzgerald collections also from the Central Kimberley bioregion (*Fitzgerald* 836, PERTH; *Fitzgerald* 949, PERTH) are doubtfully attributable to *P. halfordii* because they lack flowers. The distribution of *P. halfordii* is generally south-west of that of *P. mitrasacmoides* subsp. *mitrasacmoides* in Western Australia. Three PERTH collections of *P. mitrasacmoides* subsp. *mitrasacmoides* from Broome and nearby (24 Mar. 1985, *P.R. Foulkes* 188; 23 Mar. 1986, *P.R. Foulkes* 409; Feb. 1890, *J.W.O. Tepper* 345), and a mixed collection of *P. halfordii* and *P. mitrasacmoides* subsp. *mitrasacmoides* from Camballin (*Y. Power* 872, cited above) are exceptions to that pattern.



**Fig. 4.** Known geographic distribution of *Paranotis halfordii* (circles). Western Australian distribution of *P. mitrasacmoides* subsp. *mitrasacmoides* (squares) shown for comparison.

The habitat of *P. halfordii* is incompletely known but collection notes suggest that it occurs in moist, sandy soils in herbfields, including sandflats near waterways (Fig. 5), and on rocky sandstone clifftops. Observed in herb fields dominated by tall annual grasses and scattered shrubs, with mixed perennial grasses, in association with *Acacia tumida* var. *kulparn*, *Alloteropsis semialata*, *Aphyllodium parvifolium*, *Byblis guehoi*, *Calandrinia quadrivalvis*, *Calandrinia strophiolata*, *Chrysopogon fallax*, *Dolichandrone occidentalis*, *Drosera broomensis*, *Eriachne obtusa*, *Eriachne pindanica*, *Goodenia lamprosperma*, *Lindernia cleistandra*, *Hibiscus apodus*, *Murdannia graminea*, *Phyllanthus minutiflorus*, *Sorghum plumosum*, *Trianthema pilosum*, *Tribulopsis angustifolia* and *Xerochloa imberbis* (R. Barrett pers. comm.).



Fig. 5. Habitat of *P. halfordii*, site of the collection by R.L. Barrett 7828, M.D. Barrett & B. Anderson. Photograph R.L. Barrett.

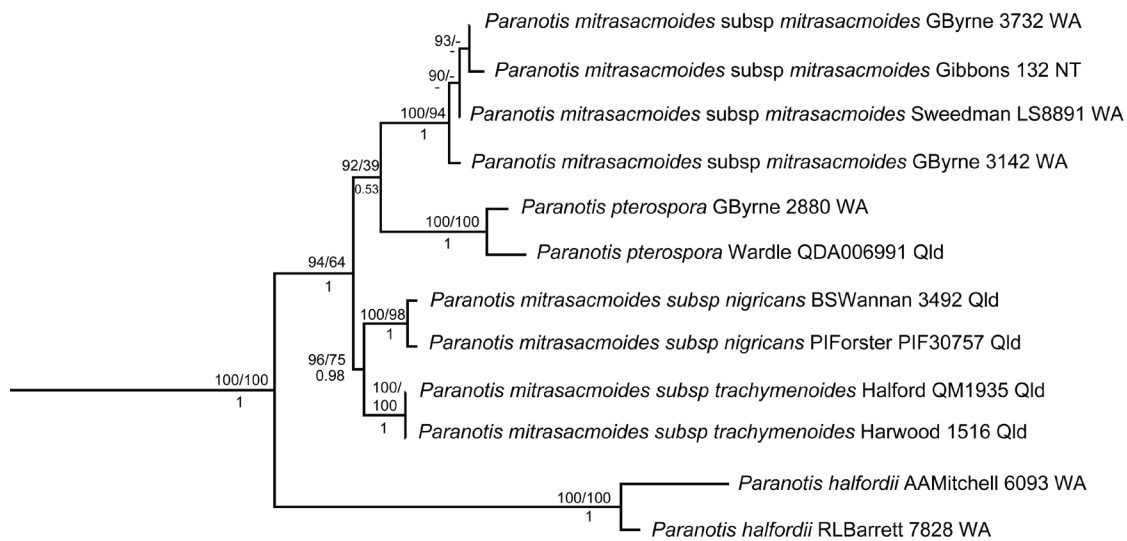
**Conservation status:** *Paranotis halfordii* is known from 10 collections from around seven locations. Three collections, spanning much of the known geographic range of the species, have been within the last 20 years. While *P. halfordii* is not known to be under threat, the species is poorly known and is recommended for listing as Priority Three under Conservation Codes for Western Australian Flora and Fauna (Department of Biodiversity, Conservation and Attractions 2019).

**Etymology:** The epithet is in honour of botanist David Halford (BRI), who revised *Oldenlandia* and related genera in Australia in the 1990's.

**Affinities:** Molecular phylogenetic analyses (Gibbons 2020) place *P. halfordii* in *Paranotis* with strong bootstrap support (Fig. 6). There was no phylogenetic support for the inclusion of *P. halfordii* in *P. mitrasacmoides* subsp. *mitrasacmoides*. *Paranotis halfordii* was, instead, placed sister to the rest of *Paranotis* [excluding *P. kochiae* (Halford) K.L.Gibbons, for which material was not available], separated from the remaining taxa by a relatively long branch length.

In revising Australian *Oldenlandia*, Halford (1992) recognised three subspecies in *P. mitrasacmoides* (as *O. mitrasacmoides*). For much of their geographic range, these subspecies are geographically isolated and morphologically distinct. However, morphological intermediates exist between all three subspecies in north-eastern Queensland (Burke and Cook districts; Halford 1992). In contrast, although *P. halfordii* and *P. mitrasacmoides* subsp. *mitrasacmoides* (the only subspecies occurring in Western Australia) overlap in geographic range, no morphologically intermediate specimens have been observed. This lack of morphological intermediacy, together with the genetic distinctiveness of *P. halfordii*, justifies its recognition as a distinct species.

*Paranotis halfordii* differs from *P. mitrasacmoides* subsp. *mitrasacmoides* in its capsule shape (depressed obovoid, compared with subglobose in *P. mitrasacmoides* subsp. *mitrasacmoides*) and its seeds, the rim of which is thinned and, if incurved, then only slightly so (seed rim thickened and incurved in *P. mitrasacmoides* subsp. *mitrasacmoides*; Fig. 3a and b). In these characters, *P. halfordii* more closely resembles *P. mitrasacmoides* subsp. *trachymenoides* (Halford) K.L.Gibbons (Halford 1992, Fig. 1c and 6f), but differs from that taxon, and from *P. mitrasacmoides* subsp. *nigricans* (Halford) K.L.Gibbons in its shorter corolla tube (0.6–1.0 mm long, compared with 3–6(–9) mm long in subsp. *trachymenoides* and 2.5–6.0 mm long in subsp. *nigricans*). In addition, the leaves of *P. halfordii* are glabrous, whereas those of all subspecies of *P. mitrasacmoides* are generally sparsely hispidulous, at least near the base. The branchlets of *P. halfordii* are hispidulous only on the ribs, whereas those of *P. mitrasacmoides* are generally hispidulous between the ribs as well. However, some Queensland specimens of *P. mitrasacmoides* subsp. *mitrasacmoides* and some specimens of *P. mitrasacmoides* subsp. *trachymenoides* from the Gulf and Burke districts, Queensland, have glabrous leaves and branchlets with hairs only on the ribs.



**Fig. 6.** Phylogenetic relationships in *Paranotis*. Maximum likelihood subtree (ETS, ITS, *petD*) from Gibbons (2020). Support values above the line are ultrafast bootstrap approximations (UFboot2) followed by standard non-parametric bootstrap. Note that the ultrafast bootstrap approximations are not equivalent to the standard non-parametric bootstrap;  $\geq 95$  indicates support. Support values below the line are posterior probabilities from the corresponding Bayesian analysis. Although *P. pterospora* (F.Muell.) Pedley ex K.L.Gibbons was nested within the *P. mitrasacmoides* complex, this relationship was not well supported and should be considered uncertain.

Morphologically, *P. halfordii* also closely resembles *P. kochiae*. *Paranotis halfordii* and *P. kochiae* are unique in *Paranotis* in having both a narrowly conical stigma that is 0.5–1.0 mm long and included within the corolla tube, and a stout style that is c. 0.2–0.3 mm long (stigma bifid or capitate, c. 0.1 mm long, exerted beyond the corolla tube, and slender style 1.5–7.0 mm long in the remainder of *Paranotis*). *Paranotis halfordii* differs from *P. kochiae* in its longer corolla lobes and larger capsules, as well as in seed shape (scutelliform with hilum on prominent ventral ridge in *P. halfordii* (Fig. 3a), compared with depressed obconic in *P. kochiae*).

**Notes:** Some specimens of *P. halfordii* held at PERTH were incorrectly identified as *P. kochiae*. Previous inclusion of a part of *B.J. Carter* 365 (the type of *P. halfordii*) in the reference collection at PERTH, as *P. kochiae*, might have led to this confusion.

The taxonomic treatment of phrase named entities referable to *P. halfordii* has also been confused (Western Australian Herbarium 1998–). Although *O. sp.* F Barred Creek (P.R. Foulkes 79) was correctly attributed to *O. mitrasacmoides* subsp. *mitrasacmoides*, (following Halford 1992), *O. sp.* One Arm Point (*B.J. Carter* 445) has been mistakenly attributed to *P. kochiae*. *Hedyotis sp.* B Kimberley Flora has also been incorrectly attributed to *O. corymbosa* L. A specimen of *O. corymbosa* (*R. Cranfield* 6664), originally mislabelled *O. sp.* B Kimberley Flora (*R.J. Cranfield* 6664), has clearly led to this error, together with the incorrect citation of *H. sp.* B Kimberley Flora as *Oldenlandia sp.* B Kimb. Flora by Kenneally *et al.* (1996).

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