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. mtrtasacmoides (F.Muell.) F.Muell. subsp. mtrtasacmoides 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 Scleromitrion (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 exserted beyond corolla tube ................................................................................................................................................. 2
   1: Stigma bifid, exserted beyond corolla tube; stamens partly or completely exserted 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 locale....................... *P. pterospora*
3: Pedicels slender, ± equal in length within an inflorescence; capsule subglobose, ovoid-globose or depressed ovoid, slightly furrowed at dissepiment, beak rounded or truncate; ovules > 10 per locale....................... *P. mitrasacmoides*

Note. Modified, in part, from Halford (1992), which includes a key to the subspecies of *P. mitrasacmoides* (as *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 (M₁–M₉), 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 laciniate 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 exserted 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.
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,
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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 cliff tops. 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 straphiolata, Chrysopogon fallax, Dolichandrone occidentalis, Drosera broomensis, Eriachne obtusa, Eriachne pindanica, Goodenia lamproserma, Lindernia cleistandra, Hibiscus apodus, Murdannia graminea, Phyllanthus minutiflorus, Sorghum plumosum, Trianthema pilosum, Tribulopsis angustifolia and Xerochloa imberbis (R. Barrett pers. comm.).
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; ≥ 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, exserted 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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