

SHORT COMMUNICATION**Corrigendum to: Two new and rare species of *Ptilotus* (Amaranthaceae) from the Eneabba sandplains, Western Australia**

See *Nuytsia* 24: 123–129 (2014).

The epithet *cliviculus*, which has an adjectival ending, should be changed to a noun in apposition, i.e. *clivicola* (see Stearn 1992: 387).

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Two new and rare species of *Ptilotus* (Amaranthaceae) from the Eneabba sandplains, Western Australia**Robert W. Davis^{1,3}, Timothy A. Hammer² and Kevin R. Thiele¹**¹Western Australian Herbarium, Department of Parks and Wildlife,
Locked Bag 104, Bentley Delivery Centre, Western Australia 6983²Department of Biological Sciences, Old Dominion University, Norfolk, VA, 23529 USA³Corresponding author, email: Robert.Davis @dpaw.wa.gov.au**Abstract**

Davis, R.W., Hammer, T.A. & Thiele, K.R. Two new and rare species of *Ptilotus* (Amaranthaceae) from the Eneabba sandplains, Western Australia. *Nuytsia* 24: 123–129 (2014). *Ptilotus cliviculus* R.W.Davis & T.Hammer and *P. falcatus* R.W.Davis & T.Hammer, are described as new. The two species are very closely related to each other and are relatively distantly related to other *Ptilotus* R.Br. taxa. They have identical ITS and *matK* molecular sequences, but are morphologically distinctive. Both species are rare and endemic to sandplains near Eneabba in south-west Western Australia.

Introduction

Ptilotus R.Br. (Amaranthaceae) is a large genus of shrubs and annual or perennial herbs, almost all endemic to arid to semi-arid temperate and tropical Australia. In Western Australia, the genus is poorly represented in sand-heath (kwongan) habitats in the south-west, with only *P. manglesii* (Lindl.) F.Muell. and *P. stirlingii* (Lindl.) F.Muell. common in such habitats. Most species of *Ptilotus* are widely distributed, with relatively few that are narrowly endemic. The two new species described here are thus unusual, as both occur in kwongan habitats and are narrowly endemic in the Eneabba-Warradarge-Mount Lesueur area, a region unusually rich in such species (Hopper & Gioia 2004). *Ptilotus cliviculus* R.W.Davis & T.Hammer is currently known from two populations, one on a sand-mining lease south-east of Eneabba and the other in Lesueur National Park east of Jurien Bay. *Ptilotus falcatus* R.W.Davis & T.Hammer is known from a single population on private property east of Warradarge.

Methods

Morphological assessments are based on specimens held at the Western Australian Herbarium (PERTH). Vegetative parts were measured from dried material, while floral parts were measured using material reconstituted in hot water. The distribution map is based on all known specimens.

DNA was extracted from leaf material of specimens held at PERTH using DNeasy Plant Mini Kits (Qiagen, Valencia, California, USA) following the manufacturer's protocol. The nuclear ribosomal DNA (nrDNA) internal transcribed spacer region (ITS) and chloroplast DNA (cpDNA) *matK* region were amplified by PCR on an ABI 2720 thermal cycler and purified using the AMPure PCR purification protocol (Agencourt, Beverly, Massachusetts, USA). Sanger sequencing was performed by Macrogen

(Seoul, Korea) on an ABI 3730XL DNA analyser. Sequences were edited, low-quality ends of strands deleted, and final sequences aligned using Geneious 6.0 (Biomatters 2005–2014).

Results

Ptilotus cliviculus and *P. falcatus* are morphologically distinct from all other species of *Ptilotus* and from each other. They have a combination of characters—five fertile stamens, sub-verticillate hairs on floral parts, and an eccentric, curved style—that is unusual in the genus. Only two other species, *P. pyramidatus* (Moq.) F.Muell. and *P. grandiflorus* F.Muell., share this character combination; these, however, differ in many other respects from the new taxa and appear to be distantly related. The two taxa differ from each other in both vegetative and floral characters (Table 1). These differences would be sufficient to segregate taxa at species rank elsewhere in the genus. The two populations of *P. cliviculus* are morphologically similar.

Trimmed sequences for both taxa had a quality percentage (HQ%) at or above 98%, and no sequence had base call ambiguities. No nucleotide differences were found between the two taxa in either molecular marker, and they form a strongly supported clade in unpublished Bayesian and Maximum Likelihood analyses based on ITS and *matK* sequence data (Hammer *et al.*, in prep.), with a posterior probability (PP) of 1.0 and maximum likelihood bootstrap support (BS) of 100. No other known pairs of taxa in *Ptilotus* are sequence-identical in this analysis. The closest taxa to the *P. cliviculus*-*P. falcatus* clade, *P. procumbens* Benl and *P. holosericeus* (Moq.) F.Muell., differ in 30 ITS and 18 *matK* base positions, and in 46 ITS and 10 *matK* base positions, respectively. The morphologically similar *P. pyramidatus* and *P. grandiflorus* are more distant, and differ in 52 ITS and 23 *matK* base positions, and 79 ITS and 22 *matK* base positions respectively.

Discussion

The new species *Ptilotus cliviculus* and *P. falcatus* present a conundrum. There is a lack of sequence variation between them in both the nuclear and chloroplast markers but a significant morphological difference, and hence a conflict between the molecular and morphological evidence. The former may support an interpretation that they comprise a single species, especially since all other recognised taxa in *Ptilotus* have sequence differences. The morphological differentiation (Table 1), however, is noteworthy. Six characters, all regarded as taxonomically informative in the genus, differ between the taxa, either qualitatively (habit, bract shape, inflorescence colour) or quantitatively (inflorescence, bract, bracteole, stamen and style dimensions) and with no apparent overlap. The limited amount of material available means that the ranges given in Table 1 may be too narrow. However, if further material were to extend the ranges so that they overlap, the total range over all material would be unusually large for any known single *Ptilotus* species, particularly one with such a narrow geographic range.

We regard that both these observations may be explained by recent divergence of these two rare and locally endemic species, perhaps from a rare and locally endemic shared ancestor. Given the rarity and close proximity of all three known populations of the two species (the two populations of *P. cliviculus* are separated by 28 km, while 17 km and 36 km separate each of these from *P. falcatus*), the ancestor may also have had a limited range and limited genetic variation in the neutral markers assessed, this and a limited time since divergence accounting for the lack of sequence variation. Conversely, morphological changes under selection or drift in the species' small, genetically isolated populations may have been rapid, accounting for the morphological distinctiveness of the two taxa. In this scenario the two species comprise discrete lineages diagnosable under a morphological species concept and the

general lineage concept of de Queiroz (2007), but are cryptic using molecular methods. Similar cases of morphologically distinct species that are sequence-identical for ITS and *matK* have been found in North American *Ceanothus* (Hardig *et al.* 2000) and the widely distributed Northern Hemisphere genus *Paeonia* (Sang *et al.* 1997).

We acknowledge that it could be regarded as premature to describe these species at this time, given the very limited amount of material currently available. However, we regard that describing and naming rare species is an important task of taxonomy; undescribed species are likely to remain undetected in biological surveys, leaving them poorly known and at greater risk of extinction through inadequate protection. Surveys undertaken in the course of preparing this paper failed to locate further populations in areas of apparently suitable habitat, leading us to believe that these species are amongst the rarest in the genus. Two of the populations (one of *P. cliviculus* and one of *P. falcatus*) are in areas that are not adequately conserved. It is clear that one species at least may be adequately described now; we have chosen on the basis of the morphological variation to delimit here two taxa rather than merge all material into a single, unusually morphologically variable one.

Taxonomy

***Ptilotus cliviculus* R.W.Davis & T.Hammer, sp. nov.**

Type: south of Eneabba, Western Australia [precise locality withheld for conservation reasons], 4 November 2013, C. Payne s.n. (*holo*: PERTH 08486433).

Ptilotus sp. Eneabba (K. Kershaw & D. Leach 07-02-01), Western Australian Herbarium, in *FloraBase*, <http://florabase.dpaw.wa.gov.au/> [accessed February 2013].

Prostrate to ascending, perennial *herbs* to 10 cm high, with stems arising singly and scattered from a hairy rhizome c. 2–3 mm in diam. *Stems* terete, slightly ribbed, sparsely hairy with crisped, nodose hairs. *Basal leaves* absent. *Cauline leaves* 10–35 mm long, 2–4 mm wide, alternate, flat, oblanceolate, glabrous or sparsely hairy with crisped, nodose hairs. *Inflorescences* 15–25 mm long, 20–25 mm diam., ovoid-spiciform, solitary, terminal, magenta; *bracts* 5.6–6.2 mm long, narrowly ovate, straight, reddish brown along medial section becoming translucent towards margins, pilose with sub-verticillate hairs becoming sparsely hairy to glabrous towards margins; *bracteoles* 6.2–7.0 mm long, ovate, reddish brown along medial section becoming translucent towards margins, with indumentum as for bracts. *Flowers* pedicellate; *outer tepals* 14–16 mm long, linear with a rounded, serrate apex, slightly concave with inrolled margins, reddish purple becoming white on the upper margins and apex, with long, silky, sub-verticillate hairs to 6 mm long, glabrous at apex, the inner surface glabrous; *inner tepals* 13–15 mm long, narrowly lanceolate with a rounded, serrate, longitudinally folded apex, reddish purple becoming white on the upper margins and apex, with indumentum as for outer tepals, inner surface glabrous except for tuft of basal hairs on margins; *staminal cup* symmetrical, 2.4–3.0 mm long, sometimes with minute appendages between the stamens, glabrous; *fertile stamens* 5 (staminodes absent), the filaments 2.2–3.1 mm long, glabrous, slightly incurved, dilated towards base; *anthers* 1.1–1.3 mm long; *ovary* ovoid, 1.8–4.5 mm long, 1.5–1.8 mm wide, glabrous, with a stipe 1.1–1.8 mm long; *style* slightly curved, 1.7–2.1 mm long, eccentrically fixed to ovary. *Seeds* not seen.

Diagnostic features. *Ptilotus cliviculus* is uniquely diagnosable from all other taxa by the combination of rhizomatous habit with scattered, arched, usually single, flowering branches, sub-verticillate floral hairs, five fertile stamens, eccentric, curved style and straight, ovate bracts 5.6–6.2 mm long.

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 13 Nov. 2009, K. Kershaw & D. Leach 07-02-01 (PERTH); 28 Oct. 2011, V. Westcott & B. Todd 14-16 (PERTH).

Distribution and habitat. Currently known from two populations each of limited extent, one near a sand-mine south-east of Eneabba, the other in Lesueur National Park. *Ptilotus cliviculus* occurs in kwongan heath on gently sloping gravelly rises with a shallow covering of coarse sand, at the transition zone between deep sand and laterite uplands. Associated species include *Xanthorrhoea drummondii*, *Allocasuarina microstachya*, *Melaleuca trichophylla*, *Caustis dioica* and *Daviesia epiphyllum* (Figure 1).

Conservation status. *Ptilotus cliviculus* is listed by Smith (2013) as Priority One under Department of Parks and Wildlife Conservation Codes for Western Australian Flora, under the name *Ptilotus* sp. Eneabba (K. Kershaw & D. Leach 07-02-01); however, it has recently been downgraded to Priority Two (Western Australian Herbarium 1998–) since one of its two known populations is in a national park. It is highly likely that *P. cliviculus* is an uncommon and restricted taxon. Further surveys should be conducted to ascertain its distribution and population and plant numbers.

Phenology. Flowers in late October and early November. The flowering period for this species appears to be relatively short; plants in the Eneabba population had only a few leaves visible in early November 2010, but three weeks later were in late flower. This may be partly due to an extremely dry winter and short spring in that year.

Etymology. From the Latin *clivis* (a slope) and *-colus* (inhabiting) referring to the gentle rises which this species seems to prefer.

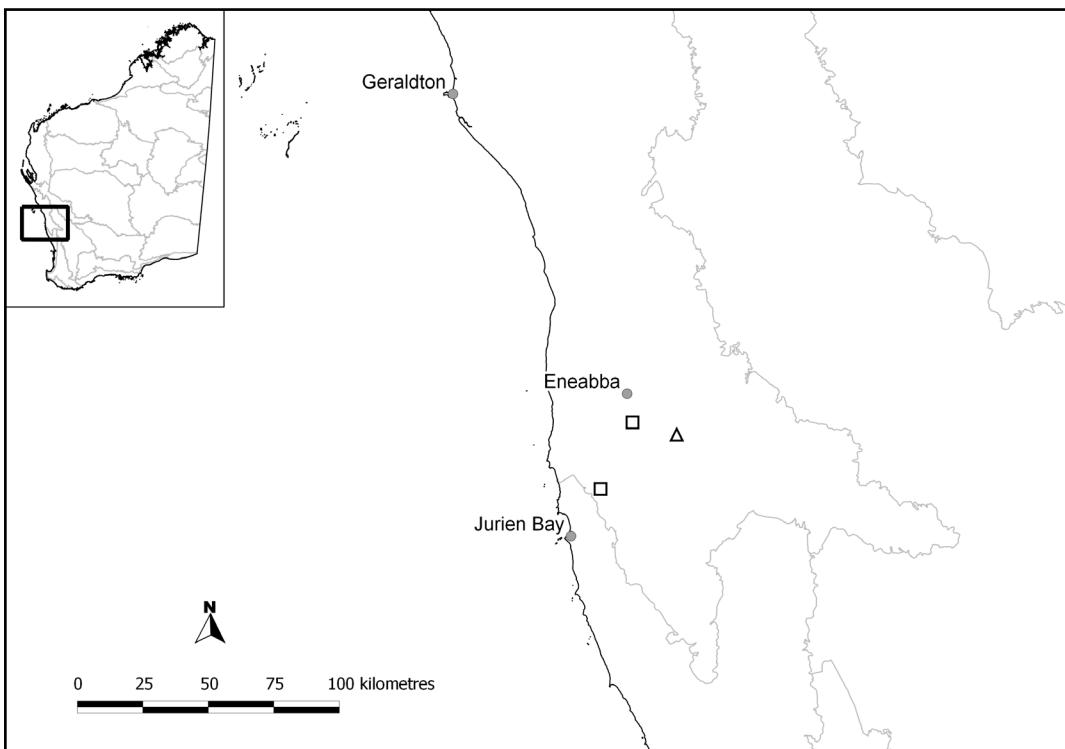


Figure 1. Distribution of *Ptilotus cliviculus* (□) and *P. falcatus* (Δ), Western Australia.

Notes. Although *P. pyramidatus* and *P. grandiflorus* share a number of floral and indumentum characters with *P. cliviculus* and *P. falcatus*, they differ greatly in their overall appearance. *Ptilotus pyramidatus* is a rare and diminutive species, only several centimetres in height and is locally restricted to the Swan Coastal Plain. It has narrower, cylindrical spikes, spathulate basal leaves and is restricted to a single known population. *Ptilotus grandiflorus* is an annual species with mostly glabrous tepals that occurs north and east of Geraldton.

While *P. procumbens* and *P. holosericeus* are genetically closely related to *P. cliviculus* and *P. falcatus*, they differ significantly in their morphology. *Ptilotus procumbens* has four stamens and much narrower spikes (8–10 mm wide *cf.* *P. cliviculus* 20–25 mm and *P. falcatus* 35–40 mm) while *P. holosericeus* has three fertile stamens and spikes 12–20 mm wide.

Locally, *P. cliviculus* could be confused in the field with *P. stirlingii*, but differs in having a rhizomatous habit with single, scattered branches, five fertile stamens and a short style to 2.1 mm long (*P. stirlingii* has multiple branches arising from a woody rootstock, two fertile stamens and three staminodes, and a prominently curved style 3–5.4 mm long). It differs from the closely related *P. falcatus* in the features given in Table 1.

***Ptilotus falcatus* R.W.Davis & T.Hammer, sp. nov.**

Type: Warradarge, Western Australia [precise locality withheld for conservation reasons], 24 October 2011, R. Warner & S. Werner WWF 12-14 (*holo*: PERTH 08341117).

Ptilotus sp. Warradarge (R. Warner & S. Werner WWF 12-14), Western Australian Herbarium, in *FloraBase*, <http://florabase.dpaw.wa.gov.au/> [accessed February 2013].

Prostrate to ascending, perennial herbs to 10 cm high, with annual stems from a perennial woody rootstock. Stems slightly flattened, lacking ribs, with moderately hairy, crisped, nodose hairs. Basal leaves absent or not seen. Cauline leaves 28–45 mm long, 1–4 mm wide, alternate, flat, oblanceolate, sparsely hairy with crisped, nodose hairs mostly on margins and midrib. Inflorescences 23–30 mm long, 34–40 mm diam., ovoid-spiciform, solitary, terminal, greenish white; bracts 8.9–10.0 mm long, narrowly ovate, falcate, reddish brown along medial section becoming translucent towards margins, sparsely pilose with scattered, sub-vorticillate hairs mostly on the medial section; bracteoles 8.5–9.1 mm long, lanceolate to narrowly ovate, mostly translucent but with a narrow, reddish brown strip along midrib, with indumentum as for bracts. Flowers pedicellate; outer tepals 18–20 mm long, lanceolate, constricted at 4/5th of their length then expanding to a rounded, serrate apex, concave with in-rolled margins, greenish brown becoming white on the upper margins and apex, with long, silky, sub-vorticillate hairs to 8 mm long, glabrous at the apex, the inner surface glabrous; inner tepals 17–19 mm long, narrowly lanceolate, constricted as for outer tepals expanding to a rounded, serrate, longitudinally folded apex, greenish brown becoming white towards apex, with indumentum as for outer tepals, inner surface glabrous except for lower margins and at the base; staminal cup symmetrical, 1.8–2.3 mm long, glabrous; fertile stamens 5 (staminodes absent), the filaments 3.5–3.8 mm long, glabrous, straight, dilated towards base; anthers 1.3–1.4 mm long; ovary ovoid, 3.2–3.3 mm long, 1.7–1.9 mm wide, glabrous, with a stipe 0.9–1.2 mm long; style curved, 2.5–2.8 mm long, eccentrically fixed to ovary. Seeds not seen.

Diagnostic features. *Ptilotus falcatus* is uniquely diagnosable from all other taxa by the combination of sub-vorticillate floral hairs, five fertile stamens, eccentric, curved style and falcate, narrowly ovate bracts 8.9–10.0 mm long.

Table 1. Morphological differences between *Ptilotus cliviculus* and *P. falcatus*.

Characters	<i>Ptilotus cliviculus</i>	<i>Ptilotus falcatus</i>
Habit	Rhizomatous with scattered, single stems	Non-rhizomatous with several stems arising from a woody rootstock
Inflorescence colour	Magenta	Greenish white
Inflorescence width (mm)	20–25	34–40
Bract shape	Narrowly ovate, straight	Narrowly ovate, falcate
Bract length (mm)	5.6–6.2	8.9–10.0
Bracteole length (mm)	6.2–7.0	8.5–9.1
Outer tepal length (mm)	14–16	18–20
Staminal cup height (mm)	2.4–3.0	1.8–2.3
Filament length (mm)	2.2–3.1	3.5–3.8
Style length (mm)	1.7–2.1	2.5–2.8

Distribution and habitat. Only known from one small population on private property near Warradarge, where it was growing on an exposed north-east facing slope in low heath on gravelly, grey to light brown, sandy loam soils. Associated species are *Hakea anadenia*, *H. auriculata*, *Petrophile shuttleworthiana*, *Melaleuca trichophylla* and *Beaufortia bracteosa* (Figure 1).

Conservation status. *Ptilotus falcatus* is listed by Smith (2013) as Priority One under Department of Parks and Wildlife Conservation Codes for Western Australian Flora, under the name *Ptilotus* sp. Warradarge (R. Warner & S. Werner WWF 12-14). It was discovered during a survey for prospective wind-farm sites. A search by the first author at the type locality in 2013 failed to locate any plants. It is highly likely that *P. falcatus* is a rare and restricted taxon. Further surveys should be conducted to ascertain its distribution and population and plant numbers.

Phenology. The only collection of *P. falcatus* was flowering in mid- to late October; it is likely to continue flowering to early November.

Etymology. From the Latin *falcatus* (sickle-shaped) in reference to the unusual, gently curved bracts of this species.

Notes. *Ptilotus falcatus* could be confused with *P. manglesii*; however, it can be readily distinguished from that species by its greenish white inflorescences, five fertile stamens and falcate bracts (*P. manglesii* has pink inflorescences, 3(–4) fertile stamens, and straight bracts). It differs from the closely related *P. cliviculus* in the features given in Table 1.

Acknowledgements

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