

Redescription of the suspended aquatic *Utricularia aurea* Lour. (sect. *Utricularia*) and a new species *U. adamsii* for northern Australia

Richard W. Jobson¹ and Taylor Davies-Colley²

¹National Herbarium of New South Wales, Royal Botanic Gardens and Domain Trust,
Mrs Macquaries Road, Sydney, NSW 2000, Australia.

²Department of Botany, University of Otago, Dunedin 9016, New Zealand
Author for correspondence: richard.jobson@rbgsyd.nsw.gov.au

Abstract

Australia has seven species in *Utricularia* L. section *Utricularia*, with the habit for all members of either affixed or suspended aquatic. Of the six recognised Australian species, one is endemic, one is pantropical, three are also distributed across Asia or Papua New Guinea - with *U. australis* R.Br. extending into Europe, and one other, *U. stellaris* L.f. into Africa. We present a molecular phylogeny based on two plastid and the nuclear ITS sequences for members of the subgenus *Utricularia* representing *U. aurea* Lour. and closely allied species from across each of their distributions. The molecular phylogeny provides strong support for recognition of a new species *Utricularia adamsii* R.W.Jobson & Davies-Colley (Lentibulariaceae), here described as new member of section *Utricularia*. This taxon was previously included within *U. aurea*, however, our molecular phylogeny and morphology supports a sister relationship with *U. muelleri* Kamienski. We provide a revised concept of *U. aurea*, and a description of the new species. The morphological differences between *U. adamsii*, *U. muelleri*, *U. aurea* and closely related species are here discussed, and an identification key provided. Distributions and habitat preferences of these taxa are discussed.

Introduction

There are six Australian species of *Utricularia* L. section *Utricularia* (subgen. *Utricularia* sensu Müller and Borsch 2005) (Jobson *et al.* 2003), with the habit for all members of the section either affixed or suspended aquatic. Of these six species, *U. corneliana* R.W.Jobson is endemic, *U. gibba* L. is pantropical, *U. aurea* Lour. and *U. muelleri* Kamienski extend across Asia or Papua New Guinea respectively, *U. australis* R.Br. is distributed across Asia and into Europe, while *U. stellaris* L.f. is distributed across southern Asia and into Africa (Taylor 1989; Jobson 2012; Jobson *et al.* 2018). The three species *U. aurea*, *U. muelleri* and *U. stellaris* develop spongy float-like rhizoids; in the latter two species they arise near the middle of the peduncle, while in the former they arise at or near the base of the peduncle (Taylor 1989; Jobson 2012).

We here present a molecular phylogeny based on two plastid and the nuclear ITS sequences of subgenus *Utricularia* representing multiple accessions from across the distributions of the three Australian float-bearing, and closely allied, species. The current study provides strong molecular phylogenetic support for recognition

of a new species, *U. adamsii* R.W.Jobson & Davies-Colley, which is restricted to northern Australia, on Cape York Peninsula and south of Darwin in the Top End.

Utricularia adamsii was previously considered a minute form of *U. aurea*, based mainly on their similar deflexed fruit capsules at maturity (Taylor 1989). However, our molecular phylogeny supports recognition as a distinct species due to the well-supported sister relationship with *U. muelleri*, rather than other *U. aurea*. We provide a revised concept of *U. aurea*, and a description of the new species. The morphological differences between *U. adamsii*, *U. muelleri*, *U. aurea* and closely related species are here discussed, an identification key provided, and the distribution and habitat preferences of these taxa discussed.

Methods and Materials

Taxon sampling and DNA extraction

DNA isolations were performed as for Jobson *et al.* (2017). We sampled 46 accessions from silica dried and herbarium specimens, including 13 outgroup taxa (Table 1). We obtained previously published sequences from GenBank, and outgroup taxa were selected based on the phylogenetic hypothesis of Jobson *et al.* (2018) (Table 1). Our data matrix includes three Asian accessions of *U. aurea* (one from Cambodia and two from Vietnam) (Fig. 1).

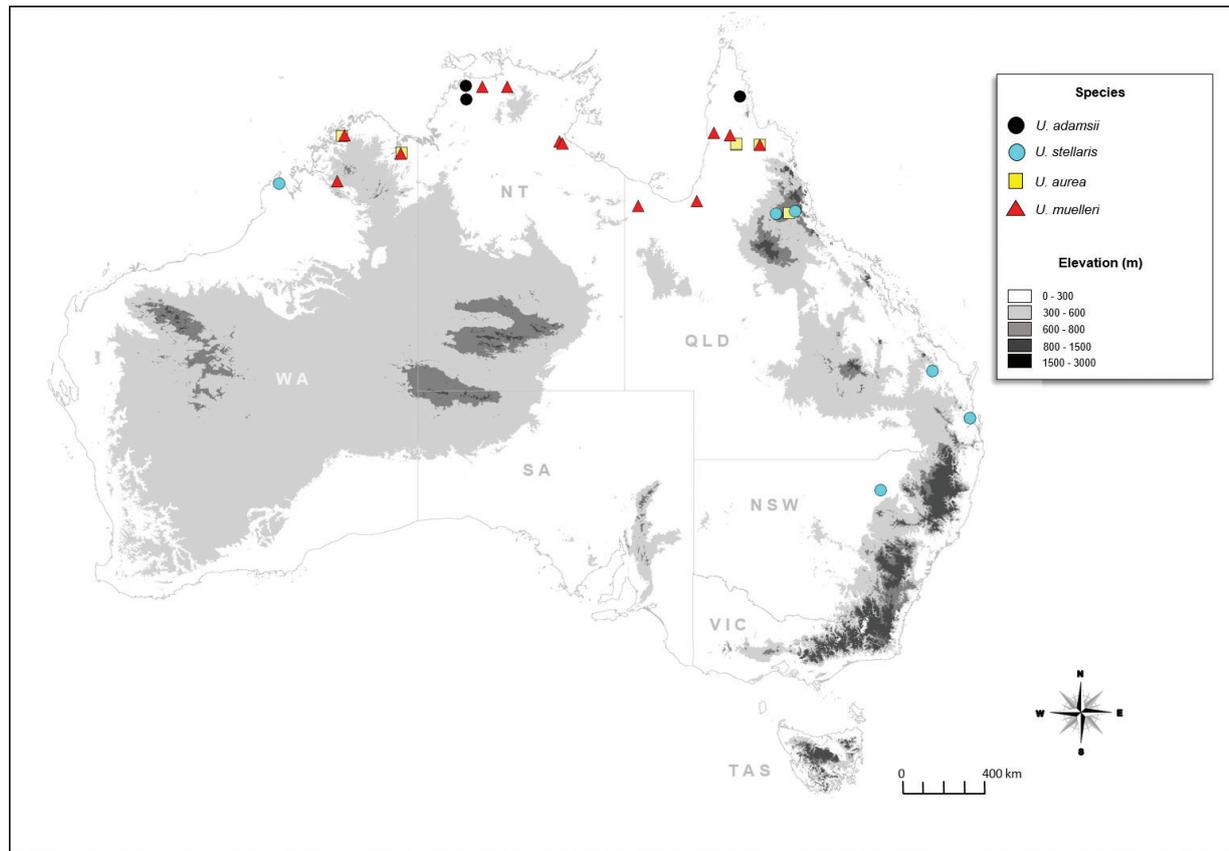


Fig. 1. Distribution map showing accessions of *Utricularia aurea* and allied species: *Utricularia adamsii* (black circle), *U. aurea* (yellow square), *U. muelleri* (red triangle), *U. stellaris* (blue circle). Asian accessions not included (refer to Table 1).

Table 1. Accessions used in the ITS and cpDNA matrices. Secondary collectors are not included. Locality abbreviations: NSW, New South Wales; NT, Northern Territory; Qld, Queensland; WA, Western Australia. GenBank accession numbers for each sequence are shown. NS indicates a sequence that either failed or was not included in the study.

Group	Section	Taxon	Voucher	Locality	ITS	rps16	trnDT
Outgroup	<i>Australes</i>	<i>U. minutissima</i> Vahl	R.W. Jobson 2676 (NSW)	Mitchell plateau, WA	NS	KY243558	NS
	<i>Lasiocaulis</i>	<i>U. antennifera</i> F.Lloyd	M. Barrett 2213 (PERTH)	North Kimberley, WA	NS	KY243462	KY243755
	<i>Lecticula</i>	<i>U. resupinata</i> Greene ex Bigelow	B. Keener 1948 (UNA)	Alabama, USA	MT248965	AF488527	MT278832
	<i>Nelipus</i>	<i>U. leptoplectra</i> F.Muell.	R.W. Jobson 1256 (NSW)	Mt Garnet, Qld	NS	KY243546	KY243842
	<i>Nigrescentes</i>	<i>U. caerulea</i> L.	R.W. Jobson 1257 (NSW)	Mt Garnet, Qld	NS	KY243543	KY243840
	<i>Oligocista</i>	<i>U. bifida</i> L.	R.W. Jobson 3293 (NSW)	Girraween, NT	NS	KY243548	NS
	<i>Pleiochasia</i>	<i>U. ameliae</i> R.W.Jobson	R.W. Jobson 2188 (NSW)	E of Boulia, Qld	MK259674	KY243405	KY243695
	<i>Pleiochasia</i>	<i>U. byrneana</i> R.W.Jobson & Baleeiro	R.W. Jobson 2323 (NSW)	Dampier Peninsula, WA	MK259940	KY243520	KY243818
	<i>Polypomphyloxy</i>	<i>U. multifida</i> R.Br.	B.G. Briggs 10126 (NSW)	Walpole, WA	NS	KY243502	KY243796
	<i>Utricularia</i>	<i>U. australis</i> R.Br.	R.W. Jobson 1391 (NSW)	Minnamoolka, Qld	MT248972	MT278867	NS
Ingroup		<i>U. geminiscapa</i> Benj.	R.W. Jobson UQ197 (BRI)	New Jersey, USA	MT248956	MT278856	MT278823
		<i>U. gibba</i> L.	R.W. Jobson 1861 (NSW)	Doongmabulla, Qld	MT248957	NS	MT278824
		<i>U. striata</i> Le Conte ex Torrey	R.W. Jobson 1372 (NSW)	Florida, USA (L. Adamec)	MT248967	MT278863	MT278834
		<i>U. adamsii</i> R.W.Jobson & Davies-Colley	R.W. Jobson 1761 (NSW)	Portland Road, Qld	MT248951	MT278852	MT278819
		<i>U. adamsii</i> R.W.Jobson & Davies-Colley	R.W. Jobson 2249 (NSW)	Humpty Doo, NT	MT248966	MT278862	MT278833
		<i>U. adamsii</i> R.W.Jobson & Davies-Colley	R.W. Jobson 3184 (NSW)	Adelaide River, NT	MT248976	MT278871	MT278842
		<i>U. adamsii</i> R.W.Jobson & Davies-Colley	L.G. Adams 1741 (CANB)	Pine Creek, NT	MT248946	NS	NS
		<i>U. aurea</i> Lour.	R.W. Jobson 1265 (NSW)	Hann River, Qld	MT248952	MT278853	MT278820
		<i>U. aurea</i> Lour.	R.W. Jobson 1381 (NSW)	Minnamoolka, Qld	MT248953	MT278854	MT278821
		<i>U. aurea</i> Lour.	A.A. Mitchell 3704 (CANB)	S of Wyndham, WA	MT248955	NS	MT278822
		<i>U. aurea</i> Lour.	R.W. Jobson 3861 (NSW)	ex. Cambodia (L. Adamec)	MT248980	MT278875	MT278846
		<i>U. aurea</i> Lour.	R.W. Jobson 2887 (NSW)	Crosbie Creek, Qld	MT248981	NS	MT278847
		<i>U. aurea</i> Lour.	L. Adamec s.n. (SPF)	ex. Vietnam (L. Adamec)	MG027742	NS	NS
		<i>U. benjaminiana</i> Oliver	C.J. Ward 9779 (HO)	Natal, South Africa	MT248944	NS	NS
		<i>U. inflexa</i> Forsskål	R.W. Jobson 1425 (NSW)	ex. Africa (L. Adamec)	MT248958	MT278857	MT278825
		<i>U. muelleri</i> Kamiński	L.A. Craven 5535 (CANB)	Jim Jim Creek, NT	MT248947	NS	NS
		<i>U. muelleri</i> Kamiński	R.W. Jobson 1264 (NSW)	Hann River, Qld	MT248959	MT278858	MT278826
		<i>U. muelleri</i> Kamiński	R.W. Jobson 2215 (NSW)	Jabiru, NT	MT248960	MT278859	MT278827

Group	Section	Taxon	Voucher	Locality	ITS	<i>rps16</i>	<i>trnDT</i>
		<i>U. muelleri</i> Kamiński	R.W. Jobson 2233 (NSW)	Point Stuart, NT	MT248961	MT278860	MT278828
		<i>U. muelleri</i> Kamiński	R.W. Jobson 2266 (NSW)	Mitchell Plateau, WA	MT248962	NS	MT278829
		<i>U. muelleri</i> Kamiński	R.W. Jobson 2391 (NSW)	Corinda, Qld	MT248963	MT278861	MT278830
		<i>U. muelleri</i> Kamiński	I. Cowie 4395 (CANB)	Derby, WA	MT248964	NS	MT278831
		<i>U. muelleri</i> Kamiński	R.W. Jobson 2652 (NSW)	Parry Lagoon, WA	MT248973	MT278868	MT278839
		<i>U. muelleri</i> Kamiński	R.W. Jobson 2737 (NSW)	Towns River, NT	MT248974	KY243569	MT278840
		<i>U. muelleri</i> Kamiński	R.W. Jobson 2809 (NSW)	Coleman River, Qld	MT248978	MT278873	MT278844
		<i>U. muelleri</i> Kamiński	R.W. Jobson 2793 (NSW)	Edward River, Qld	MT248979	MT278874	MT278845
		<i>U. muelleri</i> Kamiński	R.W. Jobson 3395 (NSW)	Limmen, NT	MT248982	NS	MT278848
		<i>U. muelleri</i> Kamiński	S.W.L. Jacobs 5037 (NSW)	Magela Creek, NT	MT248945	NS	NS
		<i>U. muelleri</i> Kamiński	R.W. Jobson 3692 (NSW)	Normanton, Qld	MT248948	MT278849	MT278816
		<i>U. stellaris</i> L.f.	R.W. Jobson UQ190 (BRI)	Caboolture, Qld	MT248954	MT278855	NS
		<i>U. stellaris</i> L.f.	R.W. Jobson 1405 (NSW)	Monto, Qld	MT248968	MT278864	MT278835
		<i>U. stellaris</i> L.f.	R.W. Jobson 1255 (NSW)	Undara, Qld	MT248969	MT278865	MT278836
		<i>U. stellaris</i> L.f.	R. Dowling WP128 (NSW)	Goondiwindi, Qld	MT248970	NS	NS
		<i>U. stellaris</i> L.f.	R.W. Jobson 1842 (NSW)	Buffalo Swamp, Qld	NS	MT278866	MT278837
		<i>U. stellaris</i> L.f.	R.W. Jobson 2324 (NSW)	Dampier Peninsula, WA	MT248971	NS	MT278838
		<i>U. stellaris</i> L.f.	R.W. Jobson 3109 (NSW)	Cuttabri, NSW	MT248975	MT278870	MT278841
		<i>U. stellaris</i> L.f.	R.W. Jobson 3702 (NSW)	Taffy's Swamp, Qld	MT248949	MT278850	MT278817
	Hybrids -	<i>U. aurea x muelleri</i>	R.W. Jobson 2784 (NSW)	Crosbie Creek, Qld	MT248977	MT278872	MT278843
	(excluded)	<i>U. aurea x muelleri</i>	R.W. Jobson 3588 (NSW)	Merton Falls, WA	MT248950	MT278851	MT278818

Amplification and sequencing

Amplifications were performed as for Jobson *et al.* (2017) using two noncoding plastid (cpDNA) and nuclear ITS ribosomal gene marker. The cpDNA markers included the *rps16* intron amplified according to the primers (*rps16F* 5'-TGGTAGAAAGCAACGTGCGACTT; *rps16R2R* 5'-TCGGGATCGAACATCAATTGCAAC) and program described in Oxelman *et al.* (1997), while the *trnD-trnT* intron spacer (*trnD-T*) was amplified using primers (*trnD*^{GUCF} 5'-ACC AAT TGA ACT ACA ATC CC; *trnT*^{CGU} 5'-CTA CCA CTG AGT TAA AAG GG) and parameters described in Shaw *et al.* (2005). These cpDNA markers have been shown to provide enough information to resolve relationships at the species and intraspecific level across *Utricularia* (Jobson *et al.* 2017). The nuclear ribosomal Internal Transcribed Spacer region (ITS) was amplified using primers (ITS5A 5'-CCT TAT CAT TTA GAG GAA GGA G ; ITS4 5'-TCC TCC GCT TAT TGA TA TGC) described in White *et al.* (1990), and Stanford *et al.* (2000). Forward and reverse sequences were assembled, edited and aligned as for Jobson *et al.* (2017).

Phylogenetic analyses

Phylogenetic analyses were performed on 1) the nuclear ITS, and 2) the two individual and combined cpDNA. Topologies obtained from individual *rps16* and *trnDT* analyses were congruent and were concatenated and

analysed together. The ITS and combined *rps16/trnDT* datasets were not concatenated even though an examination of the topologies showed the same branching order across each topology (Fig. 2).

Two accessions (*R. W. Jobson* 2784, 3588) were found to be incongruent between cpDNA and ITS tree topologies and were removed from the final datasets. Analysis of these accessions revealed a potential hybridization event between *U. muelleri* and *U. aurea*.

For the Bayesian phylogenetic analyses, we investigated the most suitable nucleotide substitution model for each of the datasets using the Akaike information criterion (AIC) implemented in the program jMODELTEST, ver. 2.1.7 (Guindon and Gascuel 2003; Posada 2008). The best-fit model was GTR+I+G and GTR+G for the cpDNA and nuDNA datasets respectively. Using MrBayes 3.2.7a (Ronquist *et al.* 2012; <https://github.com/NBISweden/MrBayes/tree/v3.2.7a>) we estimated Bayesian posterior probability with five independent runs of 20 million generations, using four chains, sampling of trees every 1000 generations. The first 25% of trees were discarded as burn-in. All parameters were set as Dirichlet; with all other priors for the analysis unlinked and set flat for the multinomial distribution. Stationarity was investigated by examining plots of the $-\ln L$ across generations in Tracer, ver. 1.6 (see <http://http://beast.community/tracer>, accessed 20 August 2019). The parameters of the effective sample size (ESS) were > 1000 , and remaining trees were used to construct a 50% majority-rule consensus trees (Fig. 1). The results were visualised using FigTree version 1.4.0 (see <http://tree.bio.ed.ac.uk/software/figtree/>, accessed 20 August 2019).

Results

Sequences and alignment

The *rps16* matrix was 1080 bp long of which 283 characters (26%) were parsimony informative, *trnDT* matrix was 1490 long of which 284 characters (19%) were parsimony informative, and the ITS matrix was 1003 bp long of which 506 characters (50%) were parsimony informative.

Phylogenetic relationships

The ITS and the combined *rps16/trnDT* trees strongly supported monophyletic clades (posterior probability (PP) = 1.00) representing *U. stellaris*, *U. inflexa* and *U. muelleri*, however, we find that *U. aurea* is paraphyletic with *U. adamsii* accessions possessing small stature (inflorescence >50 mm tall) and three basally positioned peduncle floats sister to *U. muelleri* (Fig. 2). *Utricularia aurea* was found to be sister to *U. adamsii* and *U. muelleri* in a well-supported clade containing both Asian (Cambodia, Vietnam) and Australian accessions (Fig. 1). The molecular phylogenetic result supports the morphological character differences between *U. adamsii* and *U. aurea* and we here recognise *U. adamsii* at species level.

Taxonomy

Utricularia aurea Lour., *Fl. Cochinch.* 1: 26 (1790), non Ridley (1916).

Type: Vietnam, C   Roang, *J. Loureiro*; not located.

=*Utricularia flexuosa* Vahl, *Enum. Pl.* 1: 198 (1804).

Type: India, *D. Banks s.n.* [*J.G. K  nig* collection] ex herb. Schumacker (holo: C 10013885, image!; iso W).

=*Utricularia fasciculata* Roxb., *Fl. Ind.* 1: 143 (1820).

Type: India, Calcutta, Wallich Catalogue No. 1499H (syn: K 001113250, image!); Roxburgh's *Flora Indica* Icon 1203 (syn: K).

According to Forman (1997), the original material consists of Wallich Catalogue No. 1499H and Roxburgh's *Flora Indica* Icon 1203 at K.

=*Utricularia confervifolia* Jacks. ex D. Don, *Prodr. Fl. Nepal.*: 84 (1825).

Type: Nepal, Narainhetty, *F. Buchanan-Hamilton s.n.*, Sept. 1802 (holo: BM 000521796!).

=*Utricularia flexuosa* var. *blumei* A.DC. in DC., *Prodr.* 8: 24 (1844). *Utricularia blumei* (A.DC.) Miq., *Fl. Ned. Ind.* 2: 997 (1859).

Type: Java, Batavia, *Blume s.n.* (holo L L.282768, image!).

Notes: De Condolle (1844) cites the description of *Utricularia flexuosa* in Blume (1826) as the basis for his *Utricularia flexuosa* var. *blumei* A.DC. The specimen cited above appears to be the only collection that can be specifically attributed to Blume's concept, though it should be noted that it has never been annotated with the varietal name.

=*Utricularia inaequalis* Benj., *Linnaea* 20: 304 (1847), *nom. illeg., non A.DC.* (1844).
 Type: Sri Lanka, *Hügel 3747* (holo W; not located).

=*Utricularia calumpitensis* Llanos, *Fragm. Pl. Filip.*: 11 (1851).
 Type: Philippines, Calumpit, *s. coll. s.n.* (holo: ?PNH, not seen).

=*Utricularia extensa* Hance in Walp., *Ann. Bot. Syst.* 3: 3 (1852).
 Type citation: Hong Kong (not seen).

=*Utricularia reclinata* Hassk. in Versl., *Med. Kon. Ak. Wet. Amsterdam* 4: 161 (1855).
 Type citation: Java, Mt. Gedé, 4–5000 ft, *Hasskarl s.n.* (not seen).

=*Utricularia flexuosa f. gracilis* Oliv., *J. Linn. Soc. Bot.* 3: 175 (1859). *Utricularia aurea* Lour. *var. gracilis* (Oliv.)
 Phuong, *Danh luc cac loai thuc vat viet nam* 3: 248 (2005), *nom. inval.*
 Type: Sri Lanka (holo: K).

=*Utricularia vulgaris var. pilosa* Makino, *Bot. Mag. Tokyo* 9: 111 (1895).
 =*Utricularia pilosa* (Makino) Makino, *Bot. Mag. Tokyo* 11: 70 (1897).
 Type citation: Japan, *T.Makino s.n.* (holo: ?MAK, not located).

=*Utricularia aurea f. immaculata* M.Tamura, *Acta Phytotax. Geobot.* 15: 32 (1953).
 Type: Japan, Ohtsu near lake Biwa, Honshu, *M.Tamura 149*, 26 Oct 1952 (holo KYO; not seen).

Medium to large perennial, suspended aquatic herb. *Rhizoids* sometimes present at or near the peduncle base as either a cluster of short papillose branches (1–3 mm long), or in a whorl of 4–5 inflated, spongy, narrowly fusiform appendages (floats) 50–100 mm long, bearing dichotomously divided, capillary leaf segments. *Stolons* filiform, terete, branched, papillose, up to 1 m long, 0.5–2 mm diam., internodes 5–20 mm long, sometime bearing cylindrical airshoots. *Leaves* very numerous, 1–8 cm long, divided from the base into 3 to 5 primary, filiform or sometimes inflated segments, the secondary segments alternate, pinnately divided; ultimate segments numerous, capillary, setulose. *Traps* few, inserted along the segments, stalked, dimorphic, 1–4 mm long, ovoid-subglobose mouth basal, appendages branched, setiform; internal glands 2- and 4-armed, arms subulate, up to 70 μ long, ~5 μ m in diameter. *Inflorescence* erect, simple, emergent; peduncle glabrous, filiform, terete, 50–270 mm long, 1–1.5 mm thick. *Scales* and *bracteoles* absent. *Bracts* basifixed, broadly ovate to orbicular, convex, 1–2 mm long, apex rounded. *Flowers* 5–10; pedicels filiform, erect at anthesis, deflexed in fruit, 4–20 mm long. *Calyx* lobes subequal, ovate, accrescent, reflexed and up to 9 mm long in fruit. *Corolla* 10–15 mm long, externally pubescent, pale yellow, few reddish nerves on the basal portion of the lower lip; upper lip ovate with apex rounded; lower lip limb transversely elliptic, bilobed swelling at the base, apex mostly emarginate, sometimes rounded; spur cylindrical from a conical base, constricted near the middle, shorter or equal in length to the lower lip. *Ovary* ovoid. *Capsule* globose, walls fleshy, circumscissile dehiscence, up to 5 mm long (excluding style), ~5 mm in diam., with a long, persistent style. *Seeds* disk shaped, 1.5–2 mm wide, angular, the angles winged. Pollen 13–23-colporate, dimensions range from 29 \times 39 μ m to ~30 \times 46 μ m (*sensu* Taylor 1989).

Selected specimens examined: INDIA: “Peninsula Ind. Orientalis”, *s. coll.*, #809, 1836 (NSW). JAPAN: Mitagaya in Musashi, *N. Maruyama s.n.*, Sep 1950 (NSW). MYANMAR: Yangon (“Rangoon”), *H.S. McKee 5815*, 8 Jul. 1957 (NSW). SINGAPORE: Jalan Nordin, *I. Ali & K.S. Lioe 2010-934*, 29 Sep 2010 (SING). MALAYSIA: Sabak Bernam, *M.Y. Chew FRI63406 & E.H.S. Chin*, 10 Jan 2009 (SING). PAPUA NEW GUINEA: c. 20 km W of Morehead, *B.J. Conn 3495*, 22 Sep 1990 (NSW). AUSTRALIA: WESTERN AUSTRALIA: S of Wyndham, Parry Lagoons, *A.A. Mitchell 3704*, 27 Jul 1994 (CANB); QUEENSLAND: Crosbie Creek, *R.W. Jobson 2887*, 20 Jul 2015 (NSW); NORTHERN TERRITORY: Arafura Swamp, *I.D.Cowie 1247*, 20 May 1990 (DNA); Beatrice Lagoon, Humpty Doo, *H.S. McKee 8343*, 10 Feb 1961 (NSW); NEW SOUTH WALES: Lake Minnie Waters, Grafton, *B.V. Timms s.n.*, 12 Jul 1968 (NSW).

Distribution and ecology: Widespread across tropical Asia, from western India to South-east Asia from Malaysia, China, Japan, and New Guinea. In Australia, occurs in north-western Western Australia through to the Northern Territory and Cape York Peninsula, Queensland south to north-eastern New South Wales (Fig. 1). Grows in shallow or deep water in pools and swamps (Taylor 1989). Flowers February–October.

Notes: The *Utricularia aurea* type specimen was collected at Cáy Roang, Vietnam by Portuguese Botanist João de Loureiro (1717–1791) and the protolog was published in the *Flora Cochinchinensis* in 1790. As with many of Loureiro’s other Asian collections, the type seems not to have been successfully deposited in any herbarium (Merrill 1935). In Taylor’s (1989) monograph of *Utricularia*, he notes ‘Loureiro – no specimen located, see Merrill (1935)’. Even so, Taylor was reluctant to assign a neotype, instead relying on the observations of Merrill (1935) who, under that binomial, stated ‘Loureiro’s description is definite and unmistakably applies to the common Asiatic species currently known as *Utricularia flexuosa* Vahl.’ This latter taxon is a synonym of

U. aurea (see above and Taylor 1989). The authors of the current study are also reluctant to assign a neotype, instead we suggest that workers in the vicinity of the type location are better positioned to undertake this task. Our phylogenetic trees (Fig. 1 a, b) include three Asian accessions of *U. aurea* (Cambodia, Vietnam) that are well-supported within a monophyly that includes those distributed across northern Australia (Fig. 1).

Utricularia adamsii R.W.Jobson & Davies-Colley, *sp. nov.*

Diagnosis: Similar to *U. aurea* in possessing a deflexed pedicel at fruit maturity, but differs in shape and length of rhizoid float appendages (20–30 mm *v.* 50–100 mm long), corolla spur always glabrous and longer than the corolla lower lip *v.* spur hairy and shorter or equal in length to the corolla lower lip.

Type: AUSTRALIA: QUEENSLAND: Cook: Portland Road, NE of Wenlock River Crossing [precise location withheld], R. W. Jobson 1761 & W. Cherry, 20 April 2013 (holo: NSW 972856; iso: BRI, NSW 922658 - spirit).

Small perennial, suspended or affixed aquatic herb. *Rhizoids* always present at or near the base of the peduncle, in a whorl of 3 inflated, spongy, narrowly fusiform appendages (floats), each subulate or zig-zag shaped, 20–30 mm long, 2 mm diam., narrowing to a fine cylinder, 0.1 mm at apex, each node bearing dichotomously divided, capillary leaf segments. *absent.* *Stolons* filiform 5–20 mm long, 0.3–0.5 mm thick, unbranched, terete, sparsely hairy, internodes 6–8 mm long. *Leaves* numerous, 2 primary segments at each node, 12 mm long, often with a third smaller segment, slightly flattened, divided at the base into 2 primary segments, with 6 further dichotomously divided segments, laterally setulose. *Traps* inserted along segments, shortly stalked, ovoid 0.7–1.3 mm long, mouth lateral with two small, dorsal, setiform, appendages 0.1–0.2 mm long; internal glands 4-armed, narrowly ovate, up to 40 μ long, ~15 μ m in diameter. *Inflorescence* erect, simple, emergent; peduncle filiform, 30–50 mm long, 0.4–0.9 mm thick, terete, minutely glandular; *Scales* and *bracteoles* *absent.* *Bracts* basifixed, narrowly ovate when flattened, convex, 0.5–1.2 mm long, 0.1–0.3 mm diam., apex acute. *Flowers* 1–3, on an elongated raceme axis; *pedicels* filiform, surface sparsely glandular, erect at anthesis, deflexed in fruit, 3–5 mm long. *Calyx* lobes subequal, upper lobe slightly longer, broadly ovate, 1.4–2.2 mm long, 0.6–1.1 mm in diam. *Corolla* 2.8–3.2 mm long, pale (cream–yellow) or bright yellow, with few brownish red nerves on the basal portion of the upper lip; *upper lip* ovate with apex rounded 2–2.5 mm long, 1.4–1.8 mm in diameter; *lower lip limb* lower surface sparsely hairy, entire or slightly trilobed, with a single prominent, swelling at the base; *spur* mostly glabrous, few glands, 4–4.5 mm long, longer than the lower lip, slightly compressed, conical near base, tapering to a narrowly rounded apex. *Filaments* curved, *c.* 1.0 mm long. *Ovary* globose. *Capsule* *c.* 3.2 mm long (excluding style), 3.1 mm in diam., walls fleshy, circumscissile dehiscence, style short, persistent. *Seeds* prismatic, 0.35–0.4 mm in diameter, 0.09–0.1 mm high, gently angled. *Pollen* 12–13-colporate, 15 \times 15 μ m, from Jobson 1761 (NSW). Figures 3 and 4.

Additional specimens examined: AUSTRALIA: NORTHERN TERRITORY: Noonamah, SE of Darwin [precise location withheld], 22 Apr 2014, R. W. Jobson 2249 & P. C. Baleeiro (NSW 924511); NNE of Adelaide River, [precise location withheld], 18 Apr 2016, R. W. Jobson 3184 & P. C. Baleeiro (NSW 927193); NE of Pine Creek, [precise location withheld], 27 Mar 1967, L. G. Adams 1741 (CANB); [precise location withheld], 20 Apr 1980, I. R. Telford 7843 (CANB).

Etymology: The specific epithet honours the late Laurence (Laurie) George Adams (1929–2014) who in March 1967 collected, and recognised as distinct from *U. aurea*, the first known specimen of *U. adamsii* near Darwin, NT (*Utricularia* sp., Adams 1741). Laurie Adams worked as a researcher at the Australian National Herbarium identifying and collecting plants from Australia.

Distribution and ecology: Known only from four locations; a single site on Cape York in a shallow tributary of the Wenlock River (type site), with *U. caerulea*, *U. chrysantha*, *U. uliginosa*, *Carex* sp., and *Najas malesiana*, and three sites near Darwin, NT (Fig. 1). One of these is a wetland on sloping ground in pasture-land SE of Darwin (Jobson 2249) with sedges, grasses, *U. capilliflora*, *U. leptoplectra* and *Eriocaulon* sp., while the second site was a shallow pool on a swampy track through previously disturbed grassland north of Adelaide River (Jobson 3184), with *Drosera indica* s.l., *U. kimberleyensis*, *U. limosa*, sedges and grasses. The most southern known site is just NE of Pine Creek occurring in shallow water on a swampy flat with sedges (Fig. 5). Flowers and fruits observed in March–April.

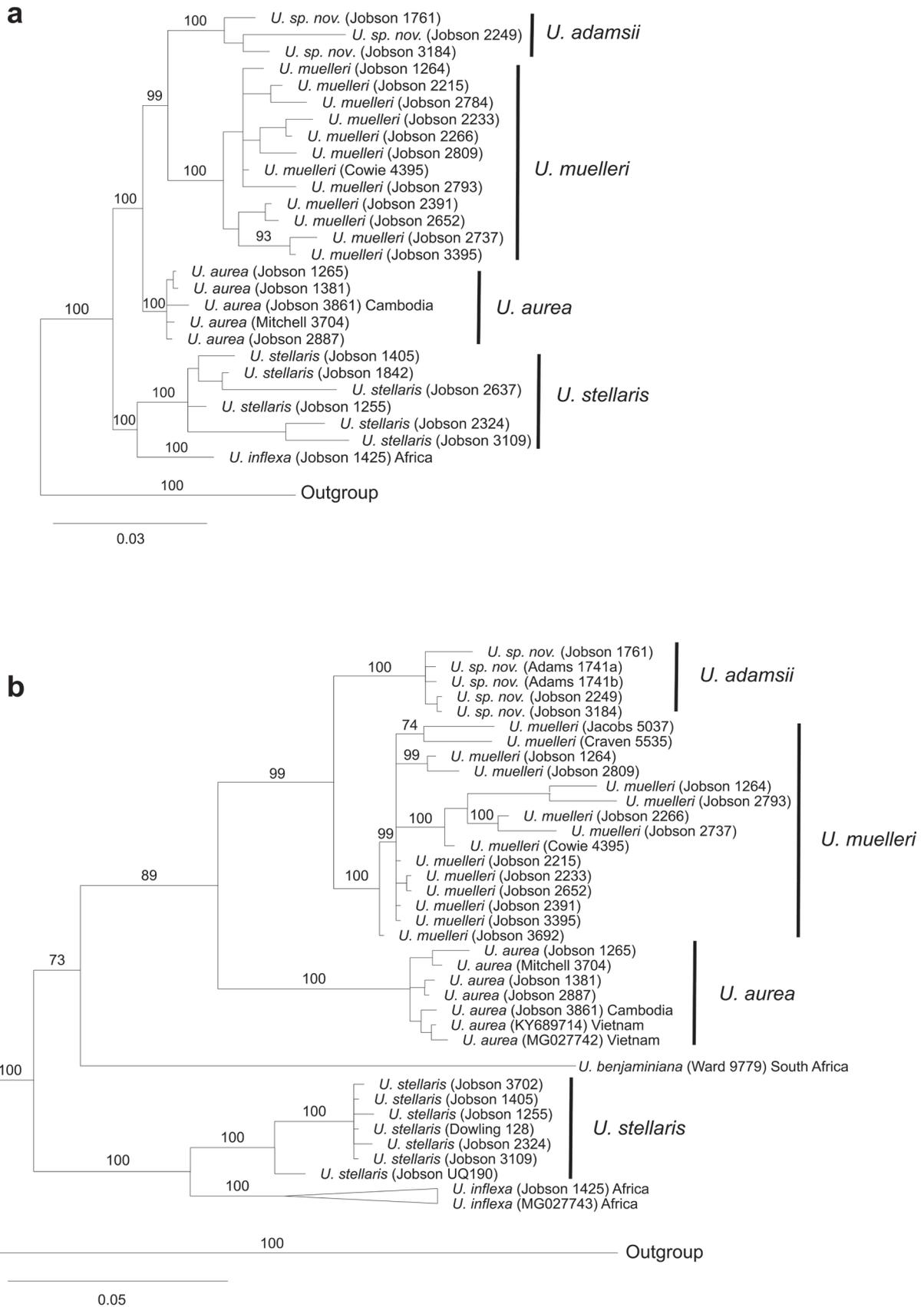


Fig. 2. 50% majority-rule Bayesian inference consensus tree for data sets: a, concatenated cpDNA; b, nDNA. Posterior probability (PP) support values are shown above branches. PP = 1.0–0.95: strong support; 0.94–0.84: weak support; <0.84: not supported.

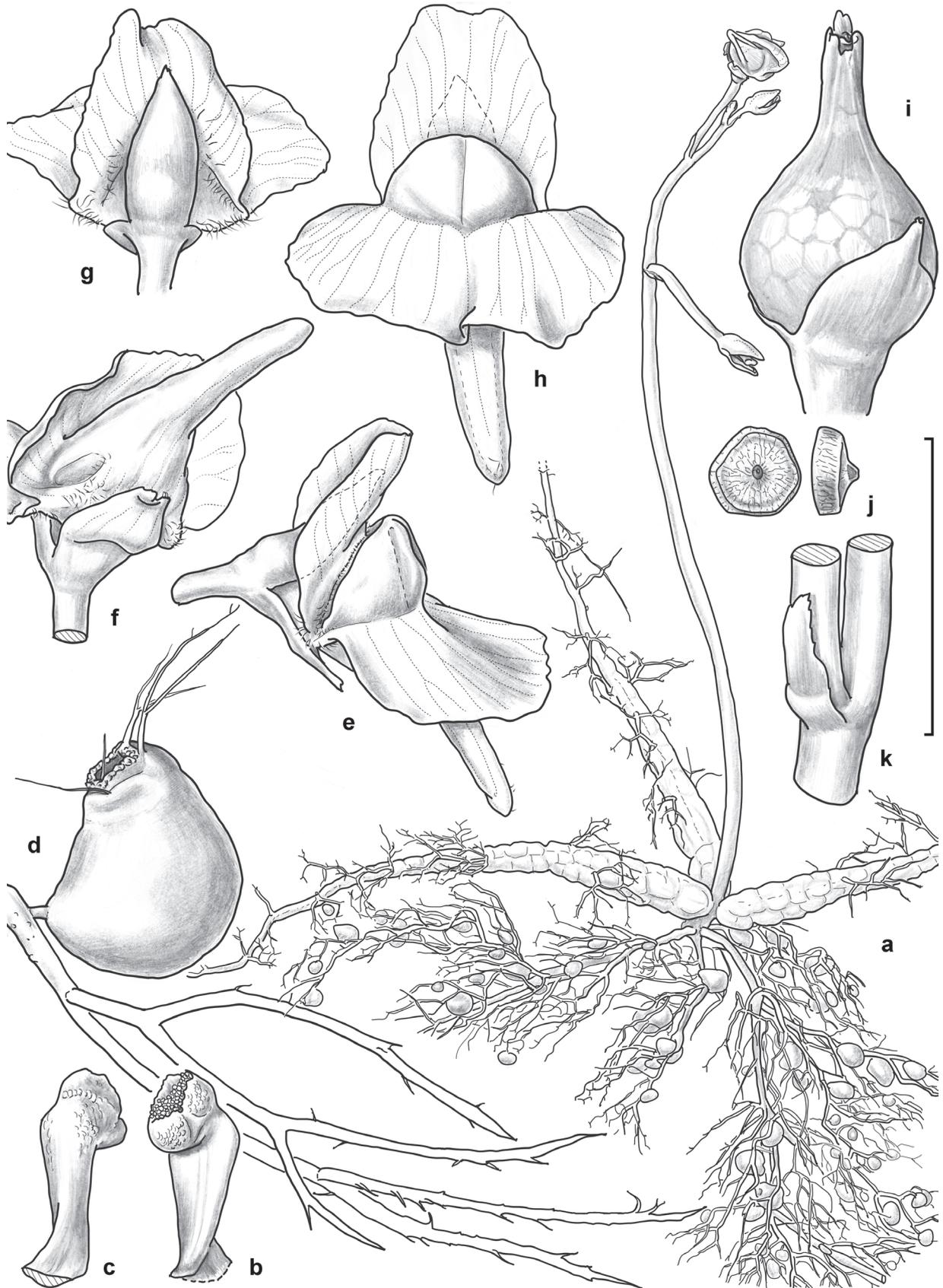


Fig. 3. *Utricularia adamsii*: **a**, habit; **b**, stamen front view; **c**, stamens rear view; **d**, bladder-trap and leaf segments; **e**, flower lateral view; **f**, flower ventral view; **g**, flower rear view; **h**, flower frontal view; **i**, fruit capsule; **j**, seed dorsal and lateral view; **k**, pedicel-peduncle junction showing bract. Scale bar: **a** = 15 mm; **b**–**d** & **j** = 2 mm; **e**–**h** = 4 mm; **i** = 5 mm; **k** = 2.5 mm. All from R. W. Jobson 1761 & W. Cherry (NSW 922658).

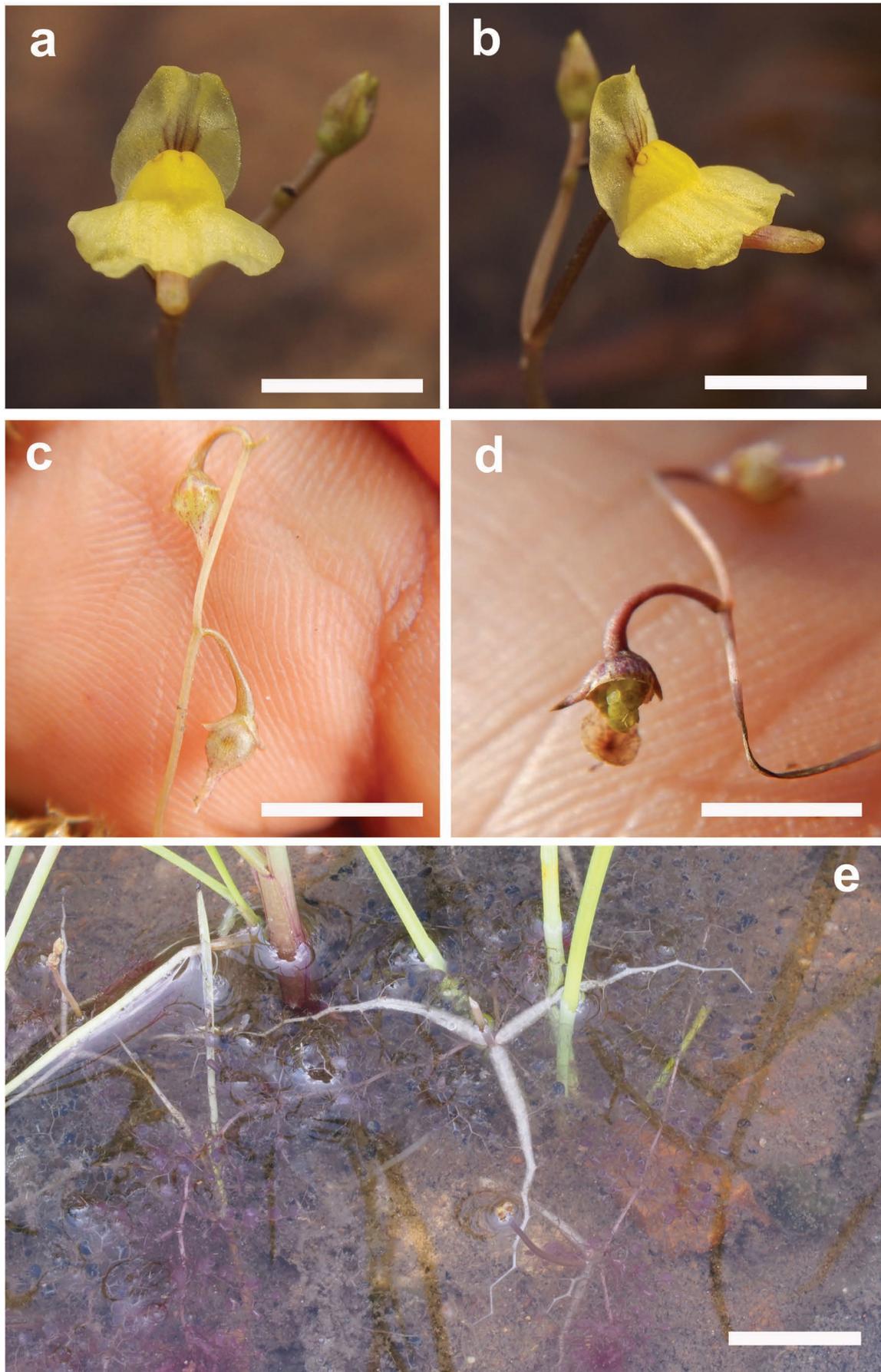


Fig. 4. *Utricularia adamsii*: **a**, flower frontal view; **b**, flower lateral view; **c**, mature seed capsules; **d**, capsule showing circumscissile dehiscence with few seed attached to placenta; **e**, habit showing floating organs near the base of peduncle. Scale bars: a & b = 4 mm; c–e = 10 mm. Images: a, b & e = Wayne Cherry (type site); c & d = R.W. Jobson (Jobson 2249 & Baleeiro).

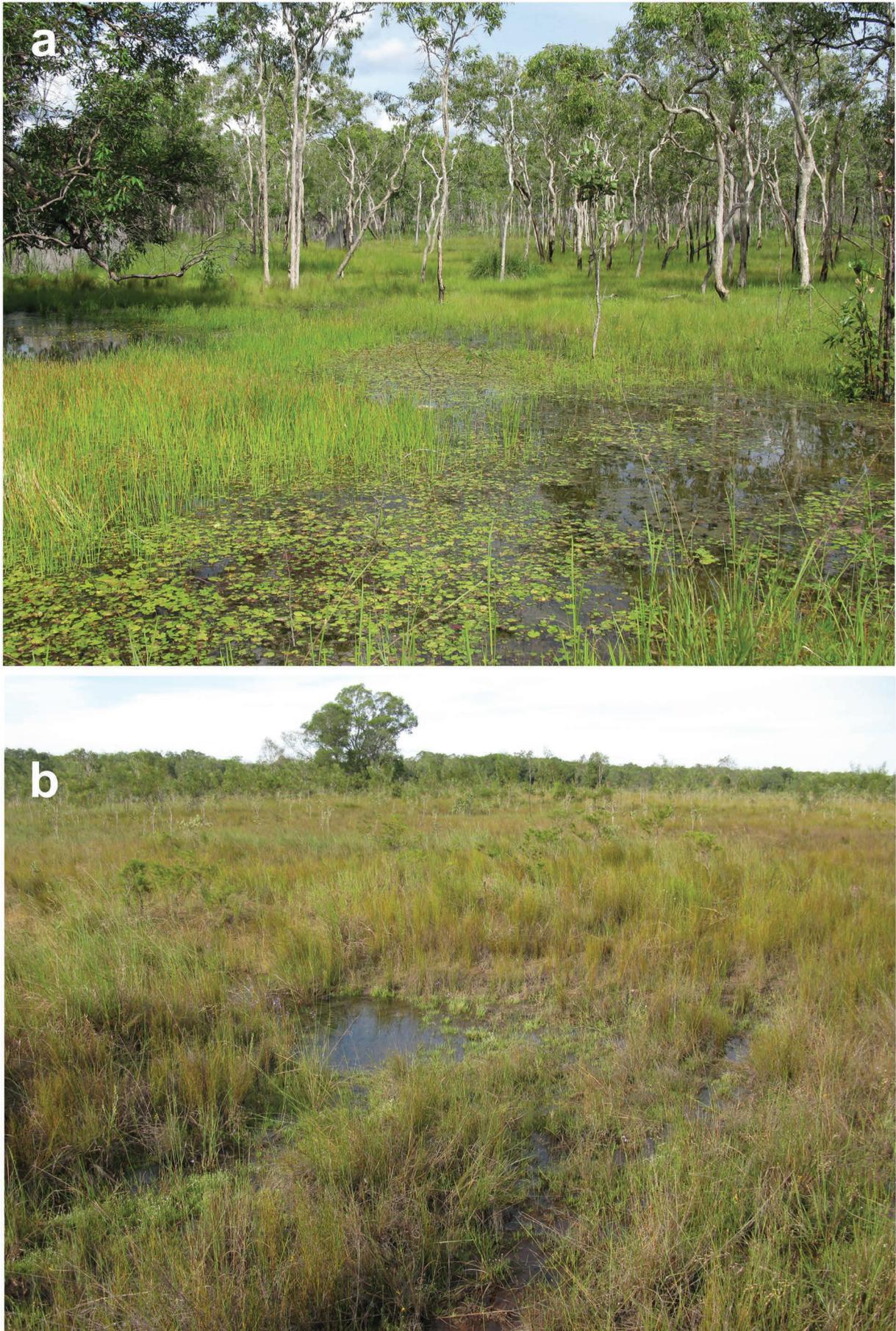


Fig. 5. Habitat of *U. adamsii*: **a**, Shallow creek wetland on Cape York Peninsula, Queensland (type site); **b**, sloping wetland near Darwin, Northern Territory. Images by R.W. Jobson.

Conservation status: Although *U. adamsii* is only known from a few sites, it does have a wide distribution, found on Cape York, Qld and Darwin, NT with all four accessions supported as monophyletic and sister to a clade containing *U. muelleri* (Fig. 2). This apparent disjunction may reflect the rarity of the species, but it may also be due to confusion in the field with other small, yellow-flowered *Utricularia* such as the common *U. gibba*, which are also known to frequent shallow pools (R.W. Jobson, *pers. obs.*). None of the known sites are within conservation protected areas, with two of the sites located in disturbed wet grassland. Future surveys are required to determine conservation status, and in the mean-time, based on the available data, this species should be considered data deficient.

Notes: Although the known distribution of *U. adamsii* is limited to northern Australia, there is the possibility that one of the synonyms of *U. aurea* represents an Asian population of the taxon *U. adamsii*. We have tried our best to eliminate this possibility by examining protologues and images of extant sheets for characters that diagnose *U. adamsii*. In all cases, the descriptions and images included characters best fitting *U. aurea*; e.g., spur and underside of corolla covered in pilose hairs, and spur nearly as long as the lower corolla lip. These characters are at odds with those of *U. adamsii*. Superficially, the rhizoid floats of *U. adamsii* resemble those occasionally found on *U. aurea*, with the main difference involving their position on the peduncle; those of *U. aurea* are positioned at the very base of the peduncle. This was the primary reason Taylor (1989) suggested the term rhizoid was a better morphological definition for the flotation organs in *U. aurea*. Our phylogeny shows a well-supported sister relationship between *U. adamsii* and *U. muelleri* (Fig. 2 a, b). The latter species possess flotation organs that are positioned near the middle of the peduncle (see Taylor 1989, fig. 193). The hybrid *U. aurea* × *U. muelleri* often resembles the *U. aurea* parent for most morphological features except the position of floats; as these are usually positioned well above the base. This characteristic has caused confusion in the field (R.W. Jobson *pers. obs.*). A study of the evolution of rhizoids and peduncle floats, and hybridization in section *Utricularia* is in progress.

Key to Australian and related suspended aquatic species of section *Utricularia*.

- 1a. Peduncle with whorl of usually inflated leaf-like structures at or above the base; primary segments of leaves three to six 2
- 1b. Peduncle without a whorl of inflated leaf-like organs; primary segments of leaves two 5
- 2a. Inflated leaf-like organs fusiform, arising at, or near the base of the peduncle 3
- 2b. Inflated leaf-like organs ellipsoid, arising some distance above the base of the peduncle 4
- 3a. Corolla spur pilose, shorter or equal in length to the corolla lower lip *U. aurea* (NSW, Qld, NT, WA, Asia)
- 3b. Corolla spur glabrous, longer than the corolla lower lip *U. adamsii* (Qld, NT)
- 4a. Inflated leaf-like organs sessile with capillary segments arising from the distal half only; seeds disk shaped, angular; calyx about equal in length to the capsule *U. stellaris* (NSW, Qld, NT, WA, Asia, Africa)
- 4b. Inflated leaf-like organs stipitate with capillary segments arising from the distal half and from the base; seeds lenticular, narrowly winged; calyx much shorter than the capsule *U. muelleri* (Qld, NT, WA, PNG)
- 5a. Corolla externally pubescent; traps always inserted at the angle between leaf segments..... 6
- 5b. Corolla externally glabrous; traps lateral on leaf segments 7
- 6a. Corolla upper lip longer than the lower; seed flat, lenticular *U. corneliana* (Qld)
- 6b. Corolla upper lip equal or shorter than the lower; seed thick, disk-shaped *U. reflexa* (tropical Africa, Madagascar)
- 7a. Leaves with ultimate segments few (2–8); upper corolla lip larger than lower..... *U. gibba* (Pantropical)
- 7b. Leaves with ultimate segments numerous (20–80); upper corolla lip smaller than lower *U. australis* (All Australian states, Asia, Europe)

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