NUYTSIA
WESTERN AUSTRALIA'S JOURNAL OF SYSTEMATIC BOTANY

ISSN 0085-4417

Shepherd, K.A. & van Leeuwen, S.J.
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Nuytsia 16(2): 383–391 (2007)

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Tecticornia bibenda (Chenopodiaceae: Salicornioideae), a new C_4 samphire from the Little Sandy Desert, Western Australia

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Abstract

Shepherd, K.A. & van Leeuwen, S.J. *Tecticornia bibenda* (Chenopodiaceae: Salicornioideae), a new C_4 samphire from the Little Sandy Desert, Western Australia. *Nuytsia* 16(2): 383–391 (2007). *Tecticornia bibenda* K.A. Sheph. & S.J. van Leeuwen, a new species of conservation significance is described and illustrated. Previously *Tecticornia indica* (Willd.) K.A. Sheph. & Paul G. Wilson (formerly *Halosarcia indica* (Willd.) Paul G. Wilson) was the only member of the Salicornioideae that was known to have a modified Kranz anatomy indicative of the C_4 photosynthetic pathway. Anatomical evidence indicates that *T. bibenda* shares a similar modified anatomy. While *T. bibenda* is related to *T. indica*, it is distinguished by the presence of unusually large vegetative and fertile articles and having paired cymes of (4)5–7 flowers rather than the more typical 3-flowered cymes. This species is restricted to the flood zones and fringing spinifex/samphire heath of several gypsiferous playa and salt lake systems in the Little Sandy Desert of Western Australia. Due to its restricted distribution this species has a Priority three conservation status.

Introduction

The newly expanded *Tecticornia* Hook.f., which includes all of the Australian genera of the Salicornioideae Kostel. (Chenopodiaceae Venet.) except *Sarcocornia* Scott, is the largest genus of this subfamily (Shepherd & Wilson 2007). Commonly known as samphires, these unique plants are among the most salt tolerant land plants (Short & Colmer 1999; English 2004) and predominate in the vegetation around the margins of Australian inland salt lakes.

The Little Sandy Desert is one of the most recently recognised natural regions but also the least understood and appreciated areas in Western Australia with respect to its biota and natural history. The Desert was not formally recognised until 1969 (Keartland Botanical District, Beard 1970) and until recently received little attention with respect to its biodiversity values. The first biological work undertaken in the Desert was by Earnest Giles in 1876 (Giles 1889). During this expedition Giles collected several plant specimens, the most noteworthy (and subsequently legendary) of these being *Eucalyptus rameliana* F. Muell., which until its rediscovery in the Little Sandy Desert in July 1991 was presumed to be the only extinct *Eucalyptus* (Hopper 1992). This rediscovery, together with initiatives designed to conserve biodiversity through the establishment of a comprehensive, adequate and representative reserve network fostered a sustained period of interest in this bioregion that culminated in a biological survey of the south-western Little Sandy Desert (National Reserve System Project N706) in the late 1990s (van Leeuwen 2002).

In 1996, while undertaking field sampling for this biological survey, a morphologically distinct samphire was encountered on the fringes of Yanneri Lake. Over the subsequent six years several additional populations were located within a radius of 35 km. All populations fringe gypsiferous playa or salt lakes with well developed fringing samphire and samphire/spinifex heaths. As this species is geographically and edaphically restricted, it was considered to be a priority for naming and *Tecticornia bibenda* K.A. Sheph. & S.J. van Leeuwen is here described.

Methods

This study is based on the examination of herbarium specimens lodged at PERTH and from fresh or spirit material preserved in 70% ethanol collected in the field. Images of the seed were produced using an Environmental Scanning Electron Microscope (Danilastos 1993).

A detailed description of the morphological variation in the Australian Salicornioideae is outlined in Shepherd (2004), Shepherd *et. al.* 2005b (see Table 5) and Shepherd and Wilson (2007) (see Appendix 1). Due to the highly reduced morphology typical of samphires the terminology used to describe the inflorescence structure is further clarified here. Inflorescences are comprised of opposite pairs of bracts in a decussate arrangement. Each bract pair may be free or fused. The shape of each bract and the degree of curvature of the upper edge is firstly described from the face or front-on view, where the bract is at its widest. The side view is then described where the bract is at its narrowest and may fuse with the opposite bract. The degree of protrusion of the outer face in the front-on view may range from flat to strongly protruding. The apex of the bract may be truncate to acuminate and the margin entire or dissected. Subtending bracts may also overlap the bract pair above.

Anatomical sections were made from fresh material fixed in 2.5–5% glutaraldehyde in 0.05 M phosphate buffer (pH 7.0) and then embedded in Glycol Methacrylate (GMA) resin following the methods of O'Brien and McCully (1981). The fixed material was washed in buffer and dehydrated through a series of alcohol solutions (methoxyethanol, ethanol, 1-n-propanol and 1-n-butanol) for a period of 24 hours each. The material was transferred through two changes of GMA and then polymerised at 60° for 8 hours under oxygen free conditions. A Sorvall semi-automatic microtome with a glass knife was used to make ultra-thin sections (2–4 μm) in the transverse (TS) plane. Sections were mounted and fixed on a glass slide using a hotplate and subsequently stained using Toluidine Blue (pH 4.4). Images were taken using the Zeiss Axiocam system on a Zeiss Optical Microscope.

The species distribution map was created using MapInfo software. The distribution map inset is based on Version 5.1 of the Interim Biogeographic Regionalisation for Australia categories (Thackway & Cresswell 1995; Environment Australia 2000). Due to conservation concerns the precise localities for Priority species are withheld.

Results and Discussion

The Salicornioideae are distinguished by their articulated photosynthetic stems. These stems consist of vegetative articles that typically have a uniseriate epidermis and a simple cuticle layer. In the majority of samphires the epidermis is subtended by a thin layer (1–3 cells thick) of photosynthetic palisade. These palisade cells may merge either abruptly or gradually into an 'aqueous' tissue layer of thin-walled, fluid filled parenchyma that surrounds the central stele (Wilson 1980; Carolin *et al*. 1982; Shepherd 2004). The shape of epidermal cells is variable among samphires (Shepherd 2004) and the epidermal cells of *T. bibenda* are irregular (Figure 1) rather than even, giving the outer epidermis a dull appearance. The stomata of *T. bibenda* are orientated perpendicular to the main stem axis and are slightly sunken below the outer surface of the epidermis. The vascular bundles are present in the central stele. Within each vegetative article two large strands branch from the central stele and traverse each side of the node, branching and forming a network throughout the article. In *T. bibenda* the photosynthetic palisade is comprised of two distinct forms of cells: an upper layer of palisade cells clustered below each stomate interspersed with larger cylindrical clear cells; and a subtending layer of tightly packed isodiametric chlorenchyma cells (Figure 1). This unusual palisade anatomy was first discovered by Wilson (1980) who noted that *Halosarcia indica* (now *Tecticornia indica*) was the only representative of the Salicornioideae with a modified Kranz anatomy which is typical of plants that utilise the C_4 rather than C_3 photosynthetic pathway. Carolin *et al*. (1982) later confirmed that *T. indica* was indeed a C_4 species using labelled $\delta^{13}C$.

Tecticornia bibenda is allied to *T. indica* through similar floral and fruit characters and the modified Kranz stem anatomy however, the distinct habit (Figure 2), unusually large vegetative and fertile articles (Figure 3) and paired cymes of (4)5–7 flowers (Figure 4E) clearly set it apart. Moreover, molecular sequence evidence shows that *T. bibenda* is related to *T. indica* but is supported as distinct (Shepherd *et al*. 2004; Shepherd *et al*. 2005b).

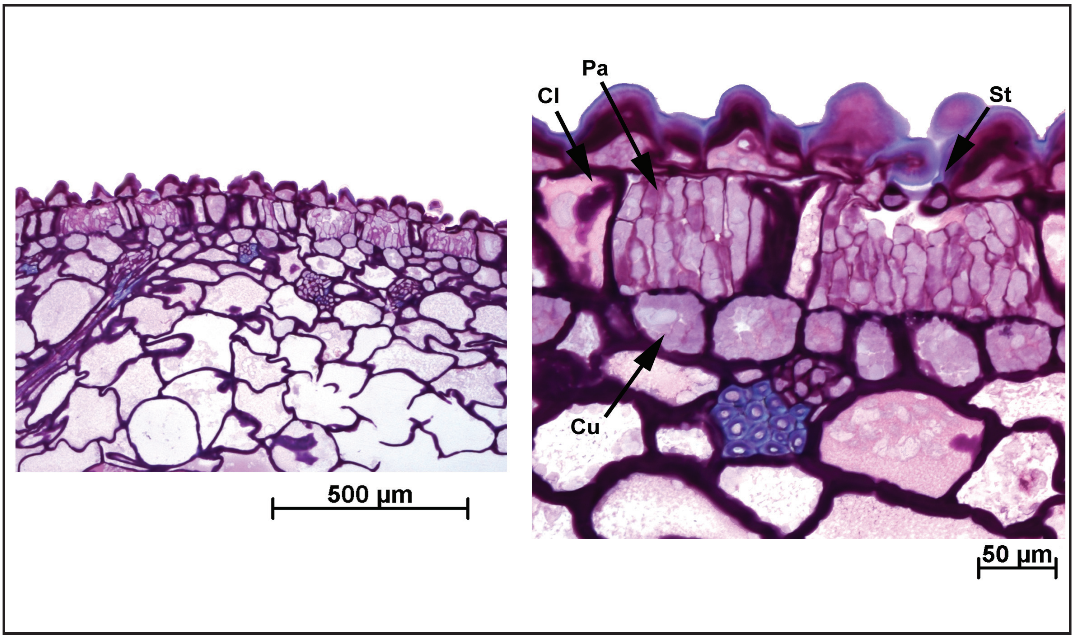

Figure 1. Transverse anatomical sections of a vegetative article of *Tecticornia bibenda* highlighting the irregular epidermal cells and the modified Kranz anatomy; pa – palisade, cu – cuboid cells, cl – clear cells and st – stomata (*K.A. Shepherd & C.F. Wilkins* KS 836).

Figure 2. Large spreading shrubs of *Tecticornia bibenda* growing in the typical swale habitat in the floodzone of salt lakes in the Little Sandy Desert, Western Australia.

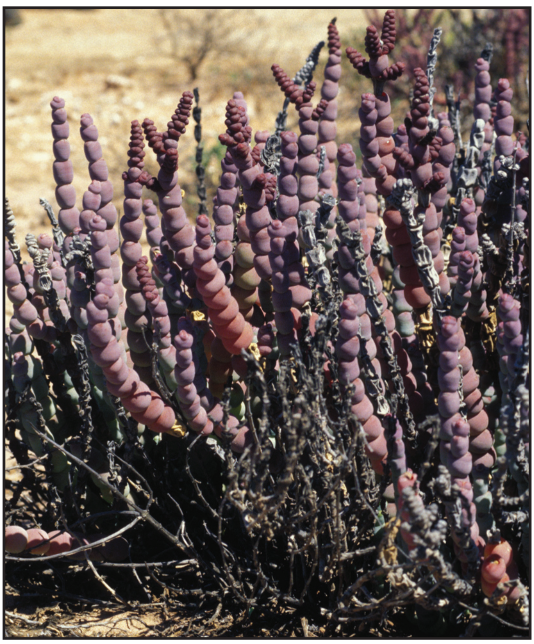

Figure 3. *Tecticornia bibenda* is distinguished by the presence of very large articles which are up to 12.5–24 mm long and the (4)5–7 flowers in each paired cyme of the inflorescence.

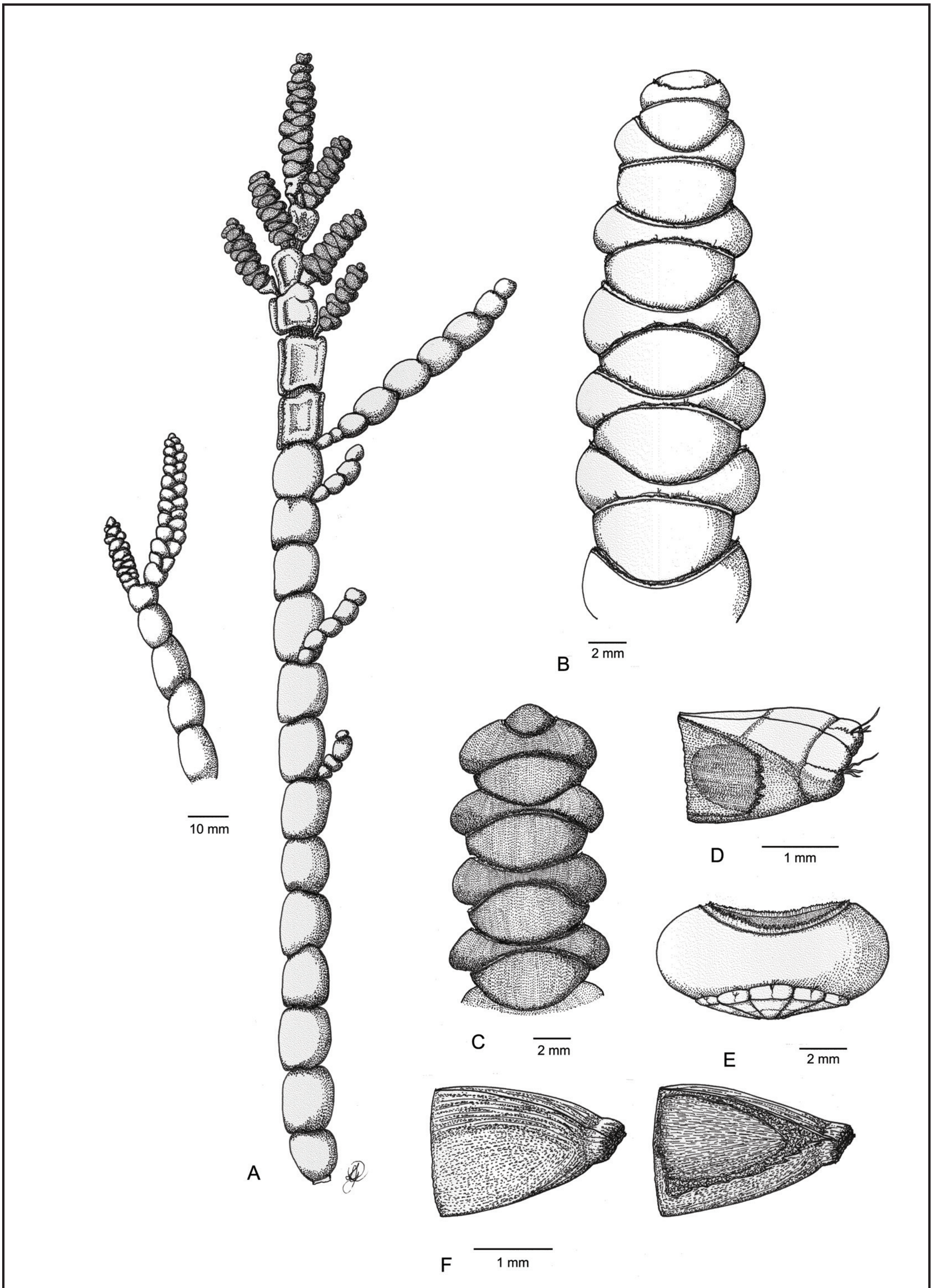

Figure 4. *Tecticornia bibenda* (*K.A. Shepherd & C.F. Wilkins* KS 836). A – flowering branches; B – inflorescence; C – persistent fruiting spike; D – lateral view of two adjacent florets with the ovary exposed at the torn base; E – fertile article with the five florets exposed at the base; F – lateral view of a fruitlet and L.S. showing the firm woody pericarp enclosing the seed.

Taxonomy

Tecticornia bibenda K.A. Sheph. & S.J. van Leeuwen *sp. nov.*

A *Halosarciae indicae* articulis marginibus grandioribus, 'Kranz' anatomia mutata, et cymis paribus (4)5–7 floribus continentibus statim dignoscenda.

Typus: Yanneri Lake, Little Sandy Desert, Western Australia [precise locality withheld], 17 August 2001, *K.A. Shepherd & C.F. Wilkins* KS 836 (*holo*: PERTH 07462786; *iso*: CANB).

Halosarcia sp. Yanneri Lake (S. van Leeuwen 3002), G. Paczkowska & A.R. Chapman, WA Fl. Descr. Cat.: p. 205 (2000).

Illustration: Nikulinsky, P. & Hopper, S.D. (2005). *Soul of the Desert.* p. 125 pl. 44 (as *Haloscarcia* sp.).

Perennial, erect or spreading shrub, 0.5–1.2 m tall and 2–4 m wide. *Vegetative articles* cylindrical or barrel-shaped, circular in cross section, dull green or deep red to burgundy, 12.5–24 mm long, 11–22 mm wide, apex rounded or truncate, margin ciliate; palisade modified Kranz anatomy. *Inflorescence* 18–45.5 mm long, 8–10 mm wide, of (4)5–7-flowered cymes forming a spike of 9–25 nodes, with a very strongly undulating, cylindrical outline; terminal to main or lateral branches. *Bracts* fused, convex in face view with the upper edge gently curved, concave in side view with the upper edge curved to strongly curved, outer face of bract protruding, apex truncate, margin entire or ciliolate to denticulate; with strongly overlapping subtending bracts. *Flowers* hermaphrodite, fully covered or partially exposed by subtending bracts, fused to bracts above and with adjacent flowers, free from opposite flowers. *Perianth* fused and laterally square, with the adaxial and abaxial surfaces horizontal, apex truncate; lobes 3 with 2 lateral and a small inner, central abaxial lobe, margins entire. *Stamen* 1, the anther elliptic and abaxial to the ovary. *Ovary* free from the stem cortex; style bifid, membranous. *Fruiting spikes* scarcely expanded, pithy and firm, persisting on dead branches, apical vegetative growth absent; seed released only after the eventual decay of the bracts and perianth. *Fruitlets* partially obscured by the subtending bract, fused to bracts above, fused to adjacent fruitlets and free from opposite fruitlets; fruiting perianth soft and spongy or pithy and firm, enclosing the seed, dehiscing ± in the medial plane. *Pericarp* hard and horn-like, fused with the perianth, free from the seed. *Seed* horizontal relative to the stem axis, ovate or orbicular, slightly beaked, 1.0–1.5 mm long, opaque, gold-brown without ornamentation. *Embryo* straight, perisperm present. (Figures 1–5)

Specimens examined. WESTERN AUSTRALIA: 17 Oct. 1997, *K. Kershaw s.n*. (PERTH 05287154); 24 Aug. 1997, *L. Sweedman* 4546 (PERTH 04920678); 23 Oct. 1996, *S. van Leeuwen* 3002 (PERTH 04868765, 07013906); 23 Oct. 1996, *S. van Leeuwen* 2972 (PERTH 04868757, 07013256); 24 Oct. 1996, *S. van Leeuwen* 3010 (PERTH 07014880, 04608402); 17 Aug. 2001, *S. van Leeuwen* 4958 (PERTH 06765181); 6 Sep. 2002, *S. van Leeuwen* 5138 (PERTH 07478631); 8 Sep. 2002, *S. van Leeuwen* 5176 (PERTH 07478623).

Distribution. Currently known from only five populations fringing wetlands in the Little Sandy Desert. These populations are restricted to an area of approximately 530 sq km with 35 km between the most distant populations (Figure 6). The wetlands include Terminal and Yanneri Lakes on Ilgarari Creek and Beyondie Lakes on Nanyerinni Creek. These creeks and lakes are part of the Ilgarari Palaeoriver which joins the Disappointment Palaeoriver and forms part of the Lake Disappointment catchment (Beard 2005).

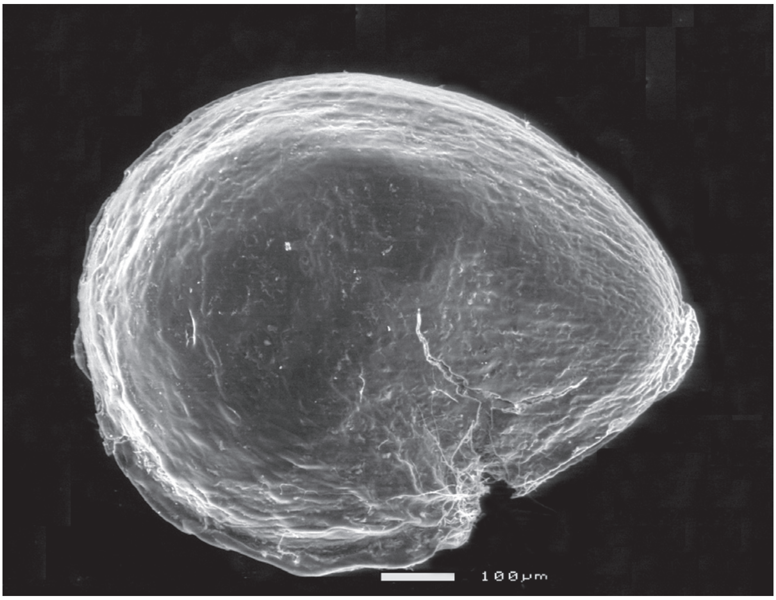

Figure 5: Environmental Scanning Electron Micrograph of a seed of *Tecticornia bibenda* (*K.A. Shepherd & C.F. Wilkins* KS 836). White scale bar = 100 µm.

Habitat. Low in the landscape near the edge of gypsiferous playas and salt lakes on flat to gently undulating terrain or on elevated gypsiferous and calcareous rims above playa basement. Soils red-brown saline sand with some clay over calcrete and gypsum (kopi) at depth. Growing in low heath to open dwarf scrub of *Melaleuca glomerata* and *M. xerophila* with *Lawrencia helmsii*, *Senna artemisioides, Eremophila glabra*, *Tecticornia* spp., *Scaevola collaris, Goodenia gypsicola*, over open low grass of *Eragrostis* spp. and *Aristida* spp. (Figure 2). Occasionally growing in deep red sand over gypsum forming an open heath over open hummock grasses of *Triodia schinzii* and *T. lanigera* with open tussock grass of *A. holathera*.

Phenology. Flowers from August to October. Fruits are retained on the plant for a year or more.

Conservation status. Conservation Codes for Western Australian Flora: Priority Three. Currently there are five known populations represented by several thousand individuals, especially in the Terminal and Yanneri Lakes populations. Current threats to populations are mainly from trampling by camels and burning, especially for those plants growing in a sandy situation amongst spinifex hummocks. Future mineral exploration activity and the potential for the mining of gypsum may pose an increased threat to this species.

Chromosome numbers. Diploid counts of 2n = 18, 36 were previously published for this species under *Halosarcia*. sp Yanneri Lake (S. van Leeuwen 3002) (Shepherd & Yan 2003).

Etymology. This species was nicknamed 'Michelin Man' because its large bulbous articles are reminiscent of the iconic 'Michelin Man' logo of Michelin Tyres. Michelin Tyres have given this character the Latin name Bibendum from the saying "Ad bibendum" (for drinking). The epithet for this species is derived from the name given to this character and is treated as an adjective.

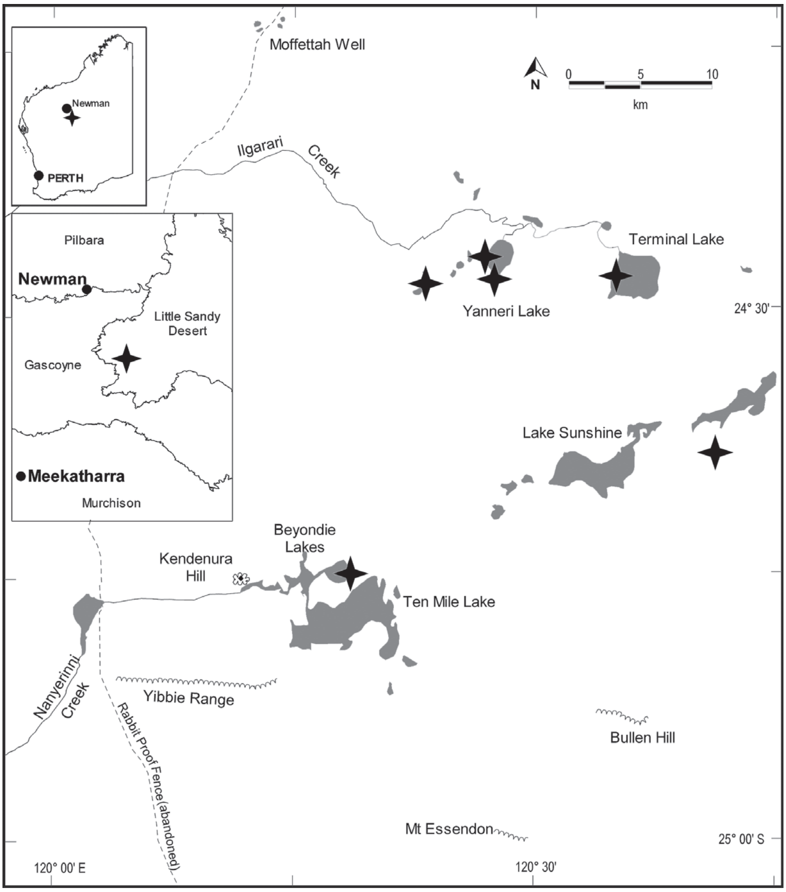

Figure 6: Distribution of *Tecticornia bibenda* with large inset showing the Interim Biogeographic Regionalisation for Australia (IBRA) categories.

Affinity. Molecular and morphological phylogenetic analyses indicate that *Tecticornia bibenda* is related to *T. indica* (Shepherd *et al*. 2004; Shepherd *et al*. 2005b). These species have similar flower and fruit morphology and a C_4 modified Kranz anatomy. *T. bibenda* is distinguished by the presence of very large and distinctive vegetative and fertile articles and having (4)5–7 flowers in each paired cyme rather than 3 which is typical for *T. indica* and almost all other species.

Notes. A possible hybrid between *T. indica* × *T. bibenda* was collected near Yanneri Lake (*K.A. Shepherd* & *C.F. Wilkins* KS 841) which has the same modified Kranz anatomy but smaller vegetative articles 5–12 mm long, 3–6.5 mm wide, shorter flowering spikes 10–21 mm long, 5.5–6.5 mm wide and only 3–4 flowers in each paired cyme. A phylogenetic analysis of molecular sequence data showed that this putative hybrid positioned between the parent species based on nuclear sequence data and placed sister to *T. bibenda* (as *H*. sp Yanneri Lake (S. van Leeuwen 3002)) in the chloroplast sequence analysis (Shepherd *et al*. 2004). This latter branch was supported with 69% Bootstrap support suggesting that while closely related, these two taxa were not identical. This supports the idea that this taxon is most likely a hybrid rather than a smaller form of *T. bibenda*.

The seeds of *Tecticornia bibenda* are gold brown in colour, smooth, and similar in shape to *T. indica* (Shepherd *et al*. 2005a) (Figure 5).

Acknowledgements

This research was funded in part through the Western Australian Government's 'Saving our Species' Project and an ARC linkage grant with the University of Western Australia with support from MERIWA, Normandy Mining Limited, Placer (Granny Smith), Acacia Resources, KCGM and the Western Australian Herbarium. Funding of the biological survey of the south-western Little Sandy Desert was provided by Environment Australia under the auspices of the National Reserve System Scheme (Project N709). Sincere thanks to Carol Wilkins and Bob Bromilow for field support, Lorraine Cobb for her excellent illustrations, Paul Wilson for providing the Latin diagnosis, advice on the epithet name and for providing comments, John Murphy and the Centre for Microscopy and Microanalysis UWA for providing support and use of the Sorvall Microtome and Environmental Scanning Electron Microscope.

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