Identification of *Tecticornia* voucher specimens for Toro Energy Ltd

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Scope

The purpose of this project was to confirm identifications of *Tecticornia* specimens collected from the Lake Way region in 2014–15 by *Ecologia*/*Engenium* on behalf of Toro Energy Limited.

Specimens

It is my understanding from Melissa Hay at *Engenium* (via an email on 27th May 2015) that the 169 specimens listed in *Appendix A Tecticornia Specimen Data* that were supplied to the Western Australian Herbarium in April, and the initial subset of taxa accessioned by Andrew Craigie in late 2014 "represent the 3 x 3 m quadrats from the *Tecticornia* vegetation community specific transects". Further, the additional 86 specimens also included for identification were collected from "...'standard' 30 x 30 m quadrats and opportunistic collections".

A total of 254 specimens was examined and identified. These are listed in the amended spread sheet *Appendix A Tecticornia Specimen Data_KAShepherd Identifications_3June15_taxa* under **KAShepherd identifications** (**KAS notes** include some additional comments).

These included:

- 155 of the 175 specimens listed in *Appendix A Tecticornia Specimen Data*.
- 8 specimens from the earlier accession submitted by *Engenium* not included in *Appendix A*.
- 78 of the 89 additional 30 x 30 m quadrats and opportunistic specimens.
- An additional 13 specimens that could not be linked to any listed collections (but presumably match the missing specimens in *Appendix A* etc.).

It should be noted that a number of instances occurred where two specimens were listed together as a single collection hence the total of 175 rather than the 169 specimens quoted in *Appendix A*.

Specimen issues

- 9 instances of duplicate numbers (representing 18 specimens) were found (highlighted in olive green in the data sheet).
- 29 specimens were found to be sterile and could not be identified.

A number of field names listed in the *Appendix A* data sheet were observed to be slightly different from those provided on the watch tags attached to specimens. These are noted in red in the data sheet next to the field name in square brackets.

Results

The original identifications by *Engenium* included 21 taxa, of which 12 were named species or subspecies while a further nine had informal tag-names indicating a hypothesised affiliation to recognised species (Table 1).

In 11 of the 12 named species identified by *Engenium* (all except *Tecticornia undulata*), the majority of identifications were usually correct although some of the subspecies identifications were incorrect e.g. 10 specimens of *Tecticornia indica* were identified as the wrong subspecies.

Some known species (e.g. *T. pergranulata* and *T. tenuis*) and phrase-named taxa were not recognised as such and were included under a tag-named entity. Also, in a number of instances more than one taxon had been included under a single tag-name.

Table 1. Identification of *Tecticornia* specimens from the Lake Way area

	***Engenium* identifications**	**KAS Identifications**	**Conservation Code**
1	*Tecticornia calyptrata*	*Tecticornia calyptrata*	
2	*Tecticornia cymbiformis*	*Tecticornia cymbiformis*	Priority 3
3	*Tecticornia doleiformis*	*Tecticornia doleiformis*	
4	*Tecticornia disarticulata*	*Tecticornia disarticulata*	
5	*Tecticornia indica* subsp. *bidens*	*Tecticornia indica* subsp. *bidens*	
6	*Tecticornia indica* subsp. *leiostachya*	*Tecticornia indica* subsp. *leiostachya*	
7	*Tecticornia laevigata*	*Tecticornia laevigata*	
8	*Tecticornia peltata*	*Tecticornia peltata*	
9	*Tecticornia pruinosa*	*Tecticornia pruinosa*	
10	*Tecticornia pterygosperma* subsp. *denticulata*	*Tecticornia pterygosperma* subsp. *denticulata*	
11	*Tecticornia pterygosperma* subsp. *pterygosperma*	*Tecticornia pterygosperma* subsp. *pterygosperma*	
12	*Tecticornia undulata*	***Tecticornia* sp. aff *laevigata* (non-rotated fruitlets)**	
13		***Tecticornia* sp. aff *pruinosa* (inflated bracts)**	
14	*Tecticornia halocnemoides* s.l. sp. A	***Tecticornia* aff *halocnemoides* s.l. 'large ovate seed aggregate'**	
15		***Tecticornia* aff *halocnemoides* s.l. 'tuberculate seed'**	
16		**?*Tecticornia* sp. aff *globulifera* (small) [vegetative articles not like the collections under *'Tecticornia halocnemoides* s.l. sp. D' below, seed possibly larger than usual]**	(note typical *T. globulifera* is Priority 1)
17	*Tecticornia halocnemoides* s.l. sp. B	*Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	Priority 3
18	*Tecticornia halocnemoides* s.l. sp. C	*Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	
19		**sterile (unusual epidermis aff *halocnemoides*)**	
20	*Tecticornia halocnemoides* s.l. sp. D	***Tecticornia* sp. aff *globulifera* (small)**	(note typical *T. globulifera* is

			Priority 1)
21	*Tecticornia halocnemoides* s.l. sp. E	*Tecticornia pergranulata* (poor specimen)	
22	*Tecticornia* sp. aff. *moniliformis*	*Tecticornia tenuis*	
23	*Tecticornia* sp. aff. *undulata* (broad articles)	***Tecticornia* sp. aff. *undulata* (broad articles)**	
24	*Tecticornia* sp. aff. *undulata* (inflated fruitlets)	*Tecticornia* sp. Burnerbinmah (D. Edinger et al. 101)	
25 26	*Tecticornia* sp. aff. *undulata* B	*Tecticornia undulata* ***Tecticornia* sp. aff. *undulata* (broad articles)**	
27	*Tecticornia* sp. aff *undulata* (enlarged bracts)	***Tecticornia* sp. aff. Burnerbinmah (inflated fruit)**	

In all, I identified 25 taxa. These comprised 14 known species or subspecies, three phrase-named species (*Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al. KS 867); *Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) and *Tecticornia* sp. Burnerbinmah (D. Edinger et al. 101)) and a further seven entities that could not be attributed to any known species or subspecies (Table 1).

Tecticornia undulata senso lato

There is considerable variation, likely representing a number of distinct taxa, currently included within *Tecticornia undulata* that is yet to be resolved (Shepherd 2007).

Two taxa that cannot be matched to typical *Tecticornia undulata* were included under *Engenium's* concept of that species (***Tecticornia* sp. aff *laevigata* (non-rotated fruitlets)** and ***Tecticornia* sp. aff *pruinosa* (inflated bracts)**), while typical *T. undulata* specimens were included under *Engenium's* ***Tecticornia* sp. aff. *undulata* B** along with some specimens of the potentially new ***Tecticornia* sp. aff. *undulata* (broad articles)**.

Also within this complex is *Engenium's* ***Tecticornia* sp. aff. *undulata* (inflated fruitlets)**, which represents the phrase-named taxon *Tecticornia* sp. Burnerbinmah (D. Edinger et al. 101). A taxon with affinity to this phrase-named taxon identified by *Engenium* as ***Tecticornia* sp. aff *undulata* (enlarged bracts)** was designated as ***Tecticornia* sp. aff. Burnerbinmah (inflated fruit)** to highlight this affinity.

Tecticornia halocnemoides senso lato

The *Tecticornia halocnemoides* complex is one of the most difficult and complicated of all the samphire groups as their highly reduced vegetative and floral morphology (they include taxa with the smallest flowers and seeds in the genus) hinders accurate identification (further information about the challenges of samphire taxonomy are provided in the **Background** section below). Found across the saline regions of Australia, this group contains innumerable variants, evidenced by differences in seed morphology. The status of five subspecies, five phrase-named taxa and more than 30 morphotypes currently included in three informal 'aggregates' are yet to be resolved.

Engenium identified five groups within *Tecticornia halocnemoides* s.l. (designated as sp. A to sp. E) (Table 1). Three unknown, potentially new taxa were included under *Engenium's* ***Tecticornia***

***halocnemoides* s.l. sp. A**, identified as ***Tecticornia* aff *halocnemoides* s.l. 'large ovate seed aggregate'**, ***Tecticornia* aff *halocnemoides* s.l. 'tuberculate seed'** and **?*Tecticornia* sp. aff *globulifera* (small)**. The latter is tentatively included under ***Tecticornia* sp. aff *globulifera* (small)** as it has a number of features in common with these collections; however, the seeds are possibly slightly larger.

***Tecticornia halocnemoides* s.l. sp. B** and **sp. C** represent the phrase-named taxa *Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al. KS 867) and *Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552) respectively. A few sterile specimens with a distinctive papillate epidermis were also included under ***Tecticornia halocnemoides* s.l. sp. C**.

***Tecticornia halocnemoides* s.l. sp D** was supported as a distinct, potentially new taxon that I designated as ***Tecticornia* sp. aff *globulifera* (small)** to highlight's its proposed closer affinity to *T. globulifera* rather than *T. halocnemoides s.l.* (although it should be noted that *T. globulifera* does have affinity to the *T. halocnemoides* complex and *Tecticornia pergranulata* as stated in Shepherd & van Leeuwen 2011).

A single collection designated as ***Tecticornia halocnemoides* s.l. sp. E** was in poor condition and was identified as *T. pergranulata* by the characteristic seeds but it could not be identified to subspecies level due to the poor quality of the specimen.

Sterile specimens

Engenium attributed a number of sterile specimens to named taxa (or tentatively to a named taxon as indicated by a '?'). Sterile specimens are particularly challenging to accurately identify as many taxa appear superficially similar. Consequently, specimens without fruits and seeds should be recorded as sterile, as the identifications (by myself or others) are a guess at best. Any identification that I have given as a tentative name should not be included in subsequent vegetation data analyses.

Conservation status

Two taxa with a Priority 3 conservation status were confirmed (*T. cymbiformis* and *Tecticornia* sp. Sunshine Lake (K.A. Shepherd et al. KS 867)); however, it should also be noted that the unknown entity ***Tecticornia* sp. aff *globulifera* (small)** has some similarity to the Priority 1 species *Tecticornia globulifera* recently described in 2011 from the Pilbara region. Furthermore, there is some further variation evident within ***Tecticornia* sp. aff *globulifera* (small)**, as specimens attributed to this entity were included by *Engenium* under two different tag names (***Tecticornia halocnemoides* s.l. sp. D** and ***Tecticornia halocnemoides* s.l. sp. A**) and I note some of the specimens in the latter group possibly have larger seeds.

Field tag-names

A detailed assessment of field tag-names has not been undertaken; however, a preliminary assessment has been completed. In nine instances, duplicate collecting numbers were given to

different specimens. It is not clear if the correct name can be assigned to the appropriate quadrat or transect data point so *Engenium* may need to clarify this.

It is evident that very few taxa were correctly and consistently identified in the field (Table 2: highlighted in yellow) and there are no cases where every specimen of a taxon was consistently given the same field tag-name.

Table 2. Field tag-names for the 24 taxa identified (not including sterile specimens); yellow highlight = correct (or at least similar) field determination. Note text given in square brackets in red is scribed directly from the field tag by KAS.

KAS Identifications	
Tecticornia calyptrata	Dead tect tect Tect Tecticornia low dense Tecticornia tecticornia? hal
Tecticornia cymbiformis	Tect dark green
Tecticornia disarticulata	Narrow Tecta Tecticornia und A Tecticornia und B small
Tecticornia doleiformis	Tect other Tect 5pc Tect #10 Tect #9
Tecticornia indica* subsp. *bidens	Tect blue gren Tect umb fat Tecticornia indica Tec ?ind Dominant tect Tecticornia green Tect um B Tect light green Tect Jutty [?] 2 c. 70 cm high Tec ind Tect umb A Tec ind Tec ind Tec ?ind ?dis Tecticornia indica [Tec ind] Tecticornia indica Tecticornia indica Tecticornia indica [Tec ind]
Tecticornia indica* subsp. *leiostachya	Tecticornia spike flower Tect bands Tec und

	Tec ind bid Tect fatty Tec ? IND 2 Tecticornia sp 2 Tec ? Ind 2 Tecticornia fat Dominant tect
Tecticornia laevigata	tect green round segments Tect halo green bee Tecticornia laevigata [Tect ?laev?] Tect halo green 2 Tect halo green Tect halo Tect green blue Tect halo green Tect blue green Tecticornia ?laevigata Tect prun Tect blue Tect green 2 Tect bee Tec ?laev
Tecticornia peltata	Tect funny fruit Tect hal B tect round green Tect mid green Tect halo brown Tecticornia peltata Tecticornia peltata [Tect pelt] Tect Tect green club Tecticornia 3 Tect fatty
Tecticornia pergarnulata	Tect glab
Tecticornia pruinosa	Tecticornia ?pruinosa [Tect pru?] Tec ?indica ?undulata
Tecticornia pterygosperma* subsp. *denticulata	Tect green Tect green Tect A/ALS.L Tecticornia halocnemoides (green) [Tec hal green]
Tecticornia pterygosperma* subsp. *pterygosperma	tect green
Tecticornia tenuis	tect no overlap Tect pale
Tecticornia undulata	Tect cymbi Tect indi
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	Tecticornia ?undulata [Tec und] tect hollow segments

	tect duplicate? Tecticornia undulata [Tec und] Tecticornia ?indica [Tec ?ind] Tecticornia ?indica 2 [Tec ?ind ?2] Tect red green Tecticornia ?undulata not fat [Tec ?und not fat] Tec ? und Tec dark Tec und not fat
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	Tect #2 Tecticornia halocnemoides 2 [Tec hal 2] Tecticornia halo Tecticornia halocnemoides [Tect halo] Tect halo green Tecticornia halocnemoides (green) Tect halo mess Tect green blue [Tect green] Tectincornia halo Tecticornia halo [Tect hal] Tecticornia halo tall Tecticornia halo [Tec hal] Tecticornia halo Tecticornia halo 2 Tecticornia halocnemoides Tecticornia halocnemoides (red) Tecti red Tecti green Tecticornia 2 Tecticornia 4 Tecticornia sp1 Tecticornia halo Tecticornia red Tecticornia red Tecticornia sp 2 Tecticornia red Tecticornia small segments small bulb segments Tecticornia small balls Tecticornia red balls Tecticornia 8 T. hal sp. C tect tiny ball segments Tect halo A Tect hal A
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	Tect halo fringe G Tecticornia halocnemoides ?catenulata [Tec hal ?cat] Tectocornia halo 2

	Tect mid red Tecticornia halocnemoides ?catenulata [Tect red ?cat] Tecticornia red [Tect red] Tecticornia red [Tect red] tect red/green balls [tect red/green] tect halo red [Tect bulb red] tect swollen ball red tect cluster segments tect red tip tect only tect tapered [Tect halo fringe R]
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	Tec hal Tect green Tecticornia halo 1 Tecticornia halocnemoides Tect yellow tall Tect halo green Tecticornia green Tecticornia halo Tecticornia green Tect green Tect hal A tect small
Tecticornia aff halocnemoides s.l. 'tuberculate seed'	Tec hal green Tect halo yellow tect red
?Tecticornia sp. aff globulifera (small)	Tecticornia halocnemoides (green)
Tecticornia sp. aff globulifera (small)	Tect red Tect red Tect red Tect halo fringe Tecticornia halocnemoides (green) [Tec hal green] Tect halo [Tecticornia halo] Tecticornia halo Tecticornia halocnemoides (red) [Tect hal red] Tect halo red Tect halo red Tec hal red Tect red tect red
Tecticornia sp. aff laevigata (non-rotated fruitlets)	Tecticornia fatty Tect fat blue Tect long cones tect fat short segemts tect und

	tect tall fat Tecticornia ?undulata [Tect und] Tecticornia undulata not so fat [Tect und not so fat] Tect ?und Tecticornia blue [Tec blue] Tecticornia fatty [Tect fatty] Tec 3 blue
Tecticornia sp. aff pruinosa (inflated bracts)	Tecticornia undulata [Tect und]
Tecticornia sp. aff. Burnerbinmah (inflated fruit)	Tect point out
Tecticornia sp. aff. undulata (broad articles)	tect fat wide segments Tect umb trans Tect umb A Tect hal trans Tect hal A Tec und Tecticornia 1 Tecticornia? indica [Tec ?ind] Tecticornia fatty Tecticornia fatty [Tect fatty] Tecticornia fatty Tecticornia sp 1 Tecticornia fatty Tecticronia fat Tect indi Tect indi Tect fat Tect fat blue out Tecticornia undulata 2 [Tec ?und2] Tect [blue] fat out tip Tecticornia ?undulata 2 [Tec ?und2] Tect indi Tecticornia undulata fat [Tect und fat] Tecticornia undulata fat [Tect und fat] Tect indi

In many instances it is also evident that the same field tag-name was given to a number of different taxa (Table 3). It should be noted that in a significant number of cases morphologically distinct species were given the same field tag-name. For example the field tag-name 'green' was given to 13 collections representing six different taxa including the robust shrub *Tecticornia indica* subsp. *bidens*, which has hard woody fruits retained for a year or more, as well as collections of *Tecticornia* sp. Dennys Crossing (K.A. Shepherd & J. English KS 552), which is a potentially new species distinguished by its tiny vegetative articles, fine branches and soft fruits that fall away at maturity. Other examples include the field tag-name 'halo', which was given to 17 collections representing six different taxa, while 'halo green/halocnemoides (green)/hal green' was used to identify 11 collections that represented eight different taxa and so on.

This highlights a significant potential issue with the accuracy of any unvouchered transect and quadrat records. If there is not a specimen for every recorded taxon along a transect or in a quadrat, then the recorded field tag-name is unlikely to be correct and one must conclude that unvouchered records are likely to be almost meaningless.

Table 3. Identifications sorted by Field tag-names ('Tect/Tecticornia removed), with groups that have similar tag-names highlighted in grey; total number of taxa with the same field tag-name and total number of collections with same tag-name.

KAS Identification	Field tag-name	Number of taxa with a similar field tag-name	Total number of collections with a similar tag-name
Tecticornia sp. aff. undulata (broad articles)	1		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	2	1	2
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	#2		
Tecticornia peltata	3		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	4		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	8		
Tecticornia doleiformis	#9		
Tecticornia doleiformis	#10		
Tecticornia laevigata	?laev	1	3
Tecticornia laevigata	?laev?		
Tecticornia laevigata	?laevigata		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	3 blue		
Tecticornia doleiformis	5pc		
Tecticornia pterygosperma subsp. *denticulata*	A/ALS.L		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	ball red		
Tecticornia indica subsp. *leiostachya*	bands		
Tecticornia laevigata	bee		
Tecticornia laevigata	blue	2	2
Tecticornia sp. aff laevigata (non-rotated fruitlets)	blue		
Tecticornia sp. aff. undulata (broad articles)	blue fat out tip		
Tecticornia laevigata	blue green	2	2
Tecticornia indica subsp. *bidens*	blue gren		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	bulb red		
Tecticornia indica subsp. *bidens*	c. 70 cm high		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	cluster segments		
Tecticornia undulata	cymbi	2	2
Sterile	cymbiformis		
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	dark		
Tecticornia cymbiformis	dark green		
Tecticornia indica subsp. *bidens*	dominant	2	2
Tecticornia indica subsp. *leiostachya*	dominant		
Tecticornia indica subsp. *leiostachya*	fat	2	3
Tecticornia sp. aff. undulata (broad articles)	fat		

Tecticornia sp. aff. undulata (broad articles)	fat		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	fat blue	2	2
Tecticornia sp. aff. undulata (broad articles)	fat blue out		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	fat short segemts		
Tecticornia sp. aff. undulata (broad articles)	fat wide segments		
Tecticornia sp. aff. undulata (broad articles)	fatty	4	8
Tecticornia sp. aff. undulata (broad articles)	fatty		
Tecticornia sp. aff. undulata (broad articles)	fatty		
Tecticornia sp. aff. undulata (broad articles)	fatty		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	fatty		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	fatty		
Tecticornia peltata	fatty		
Tecticornia indica subsp. *leiostachya*	fatty		
Tecticornia peltata	funny fruit		
Tecticornia pergarnulata	glab		
Sterile	Gnulla Gnulla		
Tecticornia indica subsp. *bidens*	green	6	13
Tecticornia pterygosperma subsp. *denticulata*	green		
Tecticornia pterygosperma subsp. *denticulata*	green		
Tecticornia pterygosperma subsp. *pterygosperma*	green		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	green		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	green		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	green		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	green		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	green		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	green		
Sterile	green		
Sterile	green		
Sterile	green		
Tecticornia laevigata	green 2	2	2
Sterile	green 2		
Tecticornia laevigata	green blue		
Tecticornia peltata	green club		
Tecticornia laevigata	green round segments		
Sterile	grey divided segments		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	hal ?cat	6	17
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	hal		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	hal		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halo		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halo		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halo		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halo		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halo		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halocnemoides		
Tecticornia sp. aff globulifera (small)	halo		
Tecticornia sp. aff globulifera (small)	halo		
Tecticornia laevigata	halo		
Tecticornia calyptrata	hal		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	hal		

Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	halo		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	halocnemoides		
Sterile	halo s.l.		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	hal A	4	7
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halo A		
Tecticornia sp. aff. undulata (broad articles)	hal A		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	hal A		
Sterile	hal A		
Sterile	hal A		
Sterile	halo A		
Tecticornia peltata	hal B		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	hal sp. C		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halo green	8	11
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halocnemoides (green)		
Tecticornia sp. aff globulifera (small)	hal green		
Tecticornia pterygosperma subsp. *denticulata*	hal green		
Tecticornia laevigata	halo green		
Tecticornia laevigata	halo green		
Tecticornia aff halocnemoides s.l. 'tuberculate seed'	hal green		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	halo green		
Sterile	halocnemoides (green)		
?Tecticornia sp. aff globulifera (small)	halocnemoides (green)		
Sterile	?halocnemoides (green)		
Sterile	halocnemoides (green) 2	2	2
Tecticornia laevigata	halo green 2		
Tecticornia laevigata	halo green bee		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halocnemoides (red)	3	7
Tecticornia sp. aff globulifera (small)	hal red		
Tecticornia sp. aff globulifera (small)	hal red		
Tecticornia sp. aff globulifera (small)	halo red		
Tecticornia sp. aff globulifera (small)	halo red		
Sterile	hal red		
Sterile	halo red		
Tecticornia aff halocnemoides s.l. 'tuberculate seed'	halo yellow		
Tecticornia peltata	halo brown		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	halo 1		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	halo 2	2	3
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halo 2		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	hal 2		
Tecticornia sp. aff. undulata (broad articles)	hal trans		
Tecticornia sp. aff globulifera (small)	halo fringe	2	3
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	halo fringe G		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	halo fringe R		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halo mess		
Sterile	halo mid		
Sterile	halo small	na	na
Sterile	hal sml		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	halo tall		

Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	hollow segments		
Tecticornia undulata	indi	4	16
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	?ind		
Tecticornia sp. aff. undulata (broad articles)	indi		
Tecticornia sp. aff. undulata (broad articles)	indi		
Tecticornia sp. aff. undulata (broad articles)	indi		
Tecticornia sp. aff. undulata (broad articles)	indi		
Tecticornia sp. aff. undulata (broad articles)	?ind		
Tecticornia indica subsp. *bidens*	ind		
Tecticornia indica subsp. *bidens*	ind		
Tecticornia indica subsp. *bidens*	ind		
Tecticornia indica subsp. *bidens*	ind		
Tecticornia indica subsp. *bidens*	ind		
Tecticornia indica subsp. *bidens*	indica		
Tecticornia indica subsp. *bidens*	indica		
Tecticornia indica subsp. *bidens*	indica		
Tecticornia indica subsp. *bidens*	?ind		
Tecticornia indica subsp. *leiostachya*	ind 2	2	3
Tecticornia indica subsp. *leiostachya*	ind 2		
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	?ind ?2		
Tecticornia indica subsp. *bidens*	?ind ?dis		
Tecticornia pruinosa	?indica ?undulata		
Tecticornia indica subsp. *leiostachya*	ind bid		
Tecticornia indica subsp. *bidens*	jutty [?] 2		
Tecticornia indica subsp. *bidens*	light green		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	long cones		
Tecticornia calyptrata	low dense		
Tecticornia peltata	mid green		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	mid red		
Sterile	mini FB		
Tecticornia disarticulata	narrow		
Tecticornia tenuis	no overlap		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	only		
Tecticornia doleiformis	other		
Tecticornia tenuis	pale		
Tecticornia peltata	pelt	1	2
Tecticornia peltata	peltata		
Tecticornia sp. aff. Burnerbinmah (inflated fruit)	point out		
Sterile	postal fade gr/red		
Tecticornia pruinosa	pru?	3	3
Tecticornia laevigata	prun		
Sterile	prui		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	red	5	13
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	red		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	red		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	red		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	red		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	red		
Tecticornia sp. aff globulifera (small)	red		

Tecticornia sp. aff globulifera (small)	red		
Tecticornia sp. aff globulifera (small)	red		
Tecticornia sp. aff globulifera (small)	red		
Tecticornia sp. aff globulifera (small)	red		
Tecticornia aff halocnemoides s.l. 'tuberculate seed'	red		
Sterile	red		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	red ?cat		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	red balls		
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	red green		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	red tip		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	red/green	2	2
Sterile	red/green		
Sterile	round		
Tecticornia peltata	round green		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	small		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	small bulb segments		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	small balls	1	2
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	small segments		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	sp 1	2	2
Tecticornia sp. aff. undulata (broad articles)	sp 1		
Tecticornia indica subsp. *leiostachya*	sp 2	2	2
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	sp 2		
Tecticornia indica subsp. *leiostachya*	spike flower		
Sterile	swollen ball green		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	tall fat		
Tecticornia sp. Sunshine Lake (K.A. Shepherd et al. KS 867)	tapered		
Tecticornia calyptrata	thin dark		
Tecticornia sp. Dennys Crossing (K.A. Shepherd & J. English KS 552)	tiny ball segments		
Tecticornia calyptrata	turquoise		
Tecticornia indica subsp. *bidens*	um B		
Tecticornia indica subsp. *bidens*	umb A	2	2
Tecticornia sp. aff. undulata (broad articles)	umb A		
Tecticornia indica subsp. *bidens*	umb fat		
Sterile	umb green	na	na
Sterile	umb green		
Sterile	umb red		
Tecticornia sp. aff. undulata (broad articles)	umb trans	2	2
Sterile	umb trans		
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	und	5	9
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	und		
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	? und		
Tecticornia sp. aff. undulata (broad articles)	und		
Tecticornia sp. aff pruinosa (inflated bracts)	und		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	und		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	und		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	?und		
Tecticornia indica subsp. *leiostachya*	und		
Tecticornia sp. aff. undulata (broad articles)	?und2	1	2
Tecticornia sp. aff. undulata (broad articles)	?und2		

Tecticornia disarticulata	und A		
Tecticornia disarticulata	und B small		
Sterile	und dk stem		
Tecticornia sp. aff. undulata (broad articles)	und fat	1	2
Tecticornia sp. aff. undulata (broad articles)	und fat		
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	und not fat	2	3
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)	?und not fat		
Tecticornia sp. aff laevigata (non-rotated fruitlets)	und not so fat		
Tecticornia aff halocnemoides s.l. 'large ovate seed aggregate'	yellow tall		
Tecticornia peltata			
Tecticornia sp. Burnerbinmah (D. Edinger et al. 101)			
Sterile			

Background

Samphires are among the most salt tolerant land plants known and are considered a 'key-stone' group as they usually comprise the dominant vegetation in habitats along coastlines, estuaries and inland salt lakes. Until recently the Australian samphires represented six genera; however, molecular and morphological data now support the recognition of only two genera in Australia namely *Sarcocornia* and an expanded *Tecticornia* which includes the former genera *Halosarcia, Pachycornia, Sclerostegia* and *Tegicornia* (Shepherd *et al*. 2004; Shepherd & Wilson 2007).

These plants have a highly modified and reduced morphology with no true leaves but succulent articles. They also have tiny flowers comprising a single anther and ovary. They are considered to be one of the most taxonomically challenging groups in Australia for the following reasons.

1. Morphologically cryptic and variable.

   The characteristic reduced morphology typical of samphires limits the availability of diagnostic characters that are easy to see with the naked eye. Because of this reduced morphology many species appear superficially similar (evidenced by the same field tag-name being applied to multiple species in Table 3). Fruits and seeds in particular are useful for delimiting taxa but they are so small (the majority of seeds are < 1.5 mm long) it is difficult to observe critical differences without a microscope.

   Their succulent form can also radically change when dried, so field knowledge is often lost when looking at herbarium specimens. Moreover, plants exhibit morphological plasticity, whereby young seedlings or new seasonal growth can appear quite different in size and colour to adult plants or older branches. Therefore specimens collected from different parts of the same plant, and from the same taxon growing in different parts of the same marsh, can appear quite different. This is one of the factors that contributes to the difficulty in gaining a sound understanding of what constitutes 'typical' morphology for any given taxon.

2. Biologically complicated

Molecular evidence suggests the genus *Tecticornia* likely underwent a recent and rapid radiation in Australia and species are genetically closely related (Shepherd *et al.* 2004). It is hypothesised (and is somewhat confirmed by chromosome data) that this relatedness ensures that many taxa may readily hybridise when they co-occur. Thus at times it is difficult to determine what comprises a taxon, as opposed to variation that may be due to the presence of hybrids and intergrades.

A chromosome study of Australian samphires (Shepherd & Yan 2003) revealed that many species are polyploids, in that they have multiple sets of chromosomes. Moreover, the ploidy level may vary even within a single species as specimens of *Tecticornia indica* subsp. *bidens* were found to be diploid, triploid or tetraploid (i.e. have 18, 27 or 36 chromosomes). It is unclear if ploidy variation within a taxon has a corresponding impact on morphology. For example do plants with larger numbers of chromosomes have larger seeds (as reported in other plant groups)? Or does the variation in seed size etc. in any given group represent taxonomically meaningful differences?

3. Taxonomic knowledge is not complete

Even though samphires dominate saline landscapes detailed information about their basic biology is lacking and a significant number of potentially new taxa require resolution. There are a number of potentially new phrase-named taxa currently listed on the WA Census (as seen on FloraBase) but little information is available to the general public about these taxa or what features delineate them or how to identify them. Moreover, there are considerably more potential entities that do not match the type specimens of known species and are considered to be new; most of these have not been taxonomically assessed in any detail.

All of these unknowns represent significant challenges to both stakeholders and land managers as little information can be determined about the distribution or conservation status of many taxa.

Summary

It is clear from the identifications provided by *Engenium* that in many instances species of *Tecticornia* were correctly identified in the laboratory. This generally occurred when a species was taxonomically well delineated, there is good descriptive information available and the taxon does not include significant morphological variation. This clearly supports the fact that if there are good (fertile) collections and a sound taxonomic framework available, skilled identification botanists can identify species of *Tecticornia* with a good degree of accuracy.

However, in taxonomically problematic groups, particularly where there are potentially new entities (e.g. phrase-named species) or groups that are variable and have not been adequately assessed and quantified (i.e. include multiple potential new taxa, as seen in the *T. halocnemoides* and *T. undulata* groups), multiple entities have been included under the same identification.

It is also clear that there may be more taxa than expected in these saline habitats as there were some sterile specimens present. While some of these specimens may simply represent non-flowering material of taxa already sampled, there were a few specimens included under the *T. halocnemoides* group that had a distinctively different epidermis. As none of these were fertile at

the time of collection when all other species had flowers and or seeds, this entity may flower at a different time of the year and may well be new. Moreover, the less well-defined groups that have not been investigated in any detail may comprise more than one taxon (e.g. two possible forms of ***Tecticornia* sp. aff *globulifera* (small)**). Therefore the current identification of 25 taxa may represent an underestimate of the number of samphire species in the study area.

It is also evident that different species of *Tecticornia* cannot be accurately and consistently identified in the field and that voucher specimens should be collected for all data points. It should also be noted that voucher specimens need to be collected at the appropriate times, as fertile specimens with mature fruits and seeds are required for identification and sterile specimens cannot be accurately identified in most cases.

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