

Proposed plant host test list for assessing risk of biological control agents for Navua sedge, *Cyperus aromaticus*

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1 Background

The following is a draft test list for potential weed biological control agents for Navua sedge, *Cyperus aromaticus* (Ridl.) Mattf. & Kukenthal (formerly *Kyllinga aromatica* Ridl. or *K. polyphylla* Willd. Ex. Kunth).

Navua sedge is a perennial grass-like plant with a creeping rhizome and densely set culms. It was first detected in Australia in Cairns in 1979 and has since spread along the coast of northern Queensland between Bamaga and Langdon (west of Mackay) and west to the Atherton Tablelands (DAF 2020). In 2011, it was recorded in south-eastern Queensland (AVH 2020). Navua sedge is particularly prevalent in areas with more than 2500mm rainfall per year and no distinct dry season (Figure 2; Parsons and Cuthbertson, 2001). In lower rainfall areas it is restricted to wetter low-lying areas.

In higher rainfall areas of northern Australia, Navua sedge has become a serious pasture weed (DAF 2020). It is an aggressive competitor for nutrients, light, and moisture and can form dense monospecific stands (Vitelli et al. 2010). Reproduction and spread occurs vegetatively by rhizomes and by seed, which are produced in abundance (Parsons and Cuthbertson 2001). Navua sedge has low nutritional value and is avoided by grazing animals (Vitelli et al. 2010).



Figure 1. Navua sedge in Northern Queensland.

2 Phylogeny and relatives in Australia

Order: Poales
Family: Cyperaceae
Subfamily: Cyperoideae
Tribe: Cypereae
Genus: *Cyperus*
Clade: C4 *Cyperus*
Species: *aromaticus* (Ridl.) Mattf. & Kukenthal

Cyperus is a large genus in the Cyperaceae family and consists of around 700 species worldwide. Molecular studies have demonstrated that the *Cyperus* genus includes a number of segregate genera (*Alinula*, *Ascolepis*, *Courtoisina*,

Kyllinga, *Kyllingiella*, *Lipocarpha*, *Oxycaryum*, *Pycreus*, *Queenslandiella*, *Remirea*, *Sphaerocyperus* and *Volkiella*; Figure 4) and these are now included in an expanded *Cyperus sensu lato*. (Reid et al. 2017; Bauters et al. 2014; Reynders et al. 2013). There are about 125 native *Cyperus* species in Australia, including one former *Kyllinga* species, two former *Lipocarpha* species, one former *Pycreus* species and one former *Queenslandiella* species, plus numerous naturalised species. (Zich et al. 2018).

Within the *Cyperus s.l.* genus, C3 taxa form a grade, within which the C4 *Cyperus* (subgenus *Cyperus*) clade is nested (Figure 2; Reid et al. 2017, Larridon et al. 2013). Many of the relationships within the C4 *Cyperus* are unresolved due to rapid radiation following the origin of C4 photosynthesis (Reid et al. 2017; Bauters et al. 2014; Reynders et al. 2013). That said, a number of groups are strongly supported, including section *Kyllinga*. *Cyperus aromaticus* (formerly known as *Kyllinga aromatica*), is part of this section. Other representatives include introduced species such as *C. brevifolius* (Rottb.) Endl. ex Hassk. (syn. *Kyllinga brevifolia* Rottb.) and *C. sesquiflorus* (Torr.) Mattf. & Kuek. (syn. *Kyllinga odorata* Vahl) and one native species, *C. sphaeroideus* L.A.S. Johnson & O.D. Evans (syn. *Kyllinga intermedia* R.Br.). The *Kyllinga* group is characterised by a head-like inflorescence, deciduous spikelets and laterally flattened gynoecea (Larridon et al. 2013).

Closely related to the *Kyllinga* clade is another well supported clade, *Cyperus s.s.* group 4, which consists of sections *Papyrus* and *Rotundi* species (Larridon et al. 2013). There is weak support for the *Kyllinga* clade as sister to a subclade including *C. iria* L. Another well supported group is the *Ascolepis*, *Lipocarpha* and *Volkiella* clade. All up there are at least 85 native C4 *Cyperus* species in Australia, including two former *Lipocarpha* spp., one former *Pycreus* sp. and one former *Queenslandiella* species. There are also at least 28 C3 *Cyperus* species.

The *Cyperus* genus is in the tribe Cyperae. The tribe consists of two major clades: the *Ficinia* clade and the *Cyperus* clade (Figure 3). The *Ficinia* clade (which is characterised by a mostly spiral glume arrangement and C3 anatomy) contains six genera, and the *Cyperus* clade (which is characterised by predominantly distichous glume arrangement and C3 or C4 anatomy) consists of *Cyperus s.l.* (Garcia-Madrid et al. 2015). Outside of the *Cyperus* genus but within Cyperae, there is one *Ficinia* species found in Australia and around 30 *Isolepis* species (15 endemic). Cyperae is within the subfamily Cyperoideae. Eight other tribes within Cyperoideae are represented in Australia (Table 1). Some of the larger genera include *Fimbristylis* (85 species (c. 25 spp. endemic)), *Carex* (86 spp. (c. 30 spp. endemic)), *Lepidosperma* (65 spp. (60 endemic)), *Schoenus* (90 spp. (85 spp. endemic)). Cyperaceae contains two subfamilies and the second, subfamily Mapanioideae, is represented in Australia by 14 species in nine genera (Table 1).

The Angiosperm Phylogeny Group system of plant classification has assigned Cyperaceae to the order Poales (Chase et al. 2016; Stevens 2001 onwards). In other systems such as the Cronquist system, Cyperaceae was assigned to the order Cyperales with Poaceae. The Cyperaceae family is most closely related to the rush family Juncaceae (Figure 6).

2.1 Test list

The following test list was compiled using a modernised centrifugal phylogenetic method (Wapshere 1974, Briese 2005). Species were selected based on the currently accepted phylogenetic relationships in the literature (e.g. Reid et al. 2017, Garcia-Madrid et al. 2015; Bauters et al. 2014; Larridon et al. 2013; Reynders et al. 2013; Muasya et al. 2009) and following the familial classification of the Angiosperm Phylogeny Group IV (Stevens 2001 onwards, Chase et al. 2016). Within the phylogenetic framework, an emphasis was placed on native and economically important species with a biogeographic overlap with *Navua* sedge in Australia. The list was developed in consultation with Cyperaceae experts Karen Wilson (National Herbarium of NSW), Jeremy Bruhl (University of New England) and Ron Booth (Queensland Herbarium).

The draft host test list for *Navua* sedge agents is 38 species in length, of which 21 are from the *Cyperus* genus and 34 are from the sedge family Cyperaceae (Table 2). Four representatives from other families have been included as outlier species, including rice and sugar cane. The final list will likely contain around 40 species.

Any suggestions for plant species substitutions or additions are welcomed but we request that they be justified within the phylogenetic/evolutionary framework approach taken to develop test lists. Feedback and comments on this proposed host plant test list can be addressed to Di Taylor (di.taylor@daf.qld.gov.au).

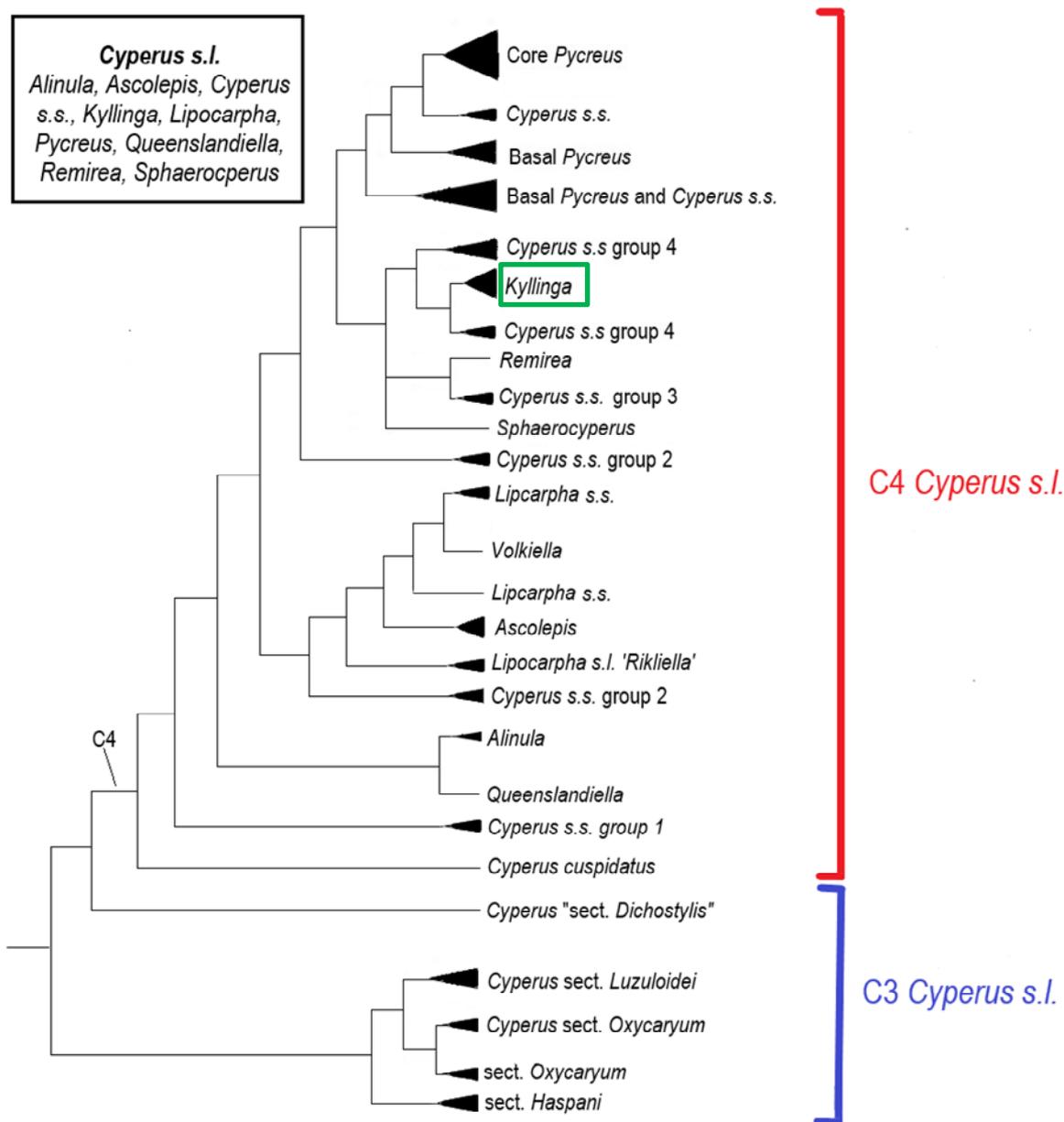


Figure 2. Schematic representation of phylogenetic relationships within *Cyperus sensu lato* (Reid et al. 2017; Bauters et al. 2014; Larridon et al. 2013). Note that relationships within C4 *Cyperus* remain largely unresolved. Segregate genera are listed as their former names. This is a draft figure and the size of the triangles do not necessarily represent the number of species. The group including *Navua* sedge is highlighted.

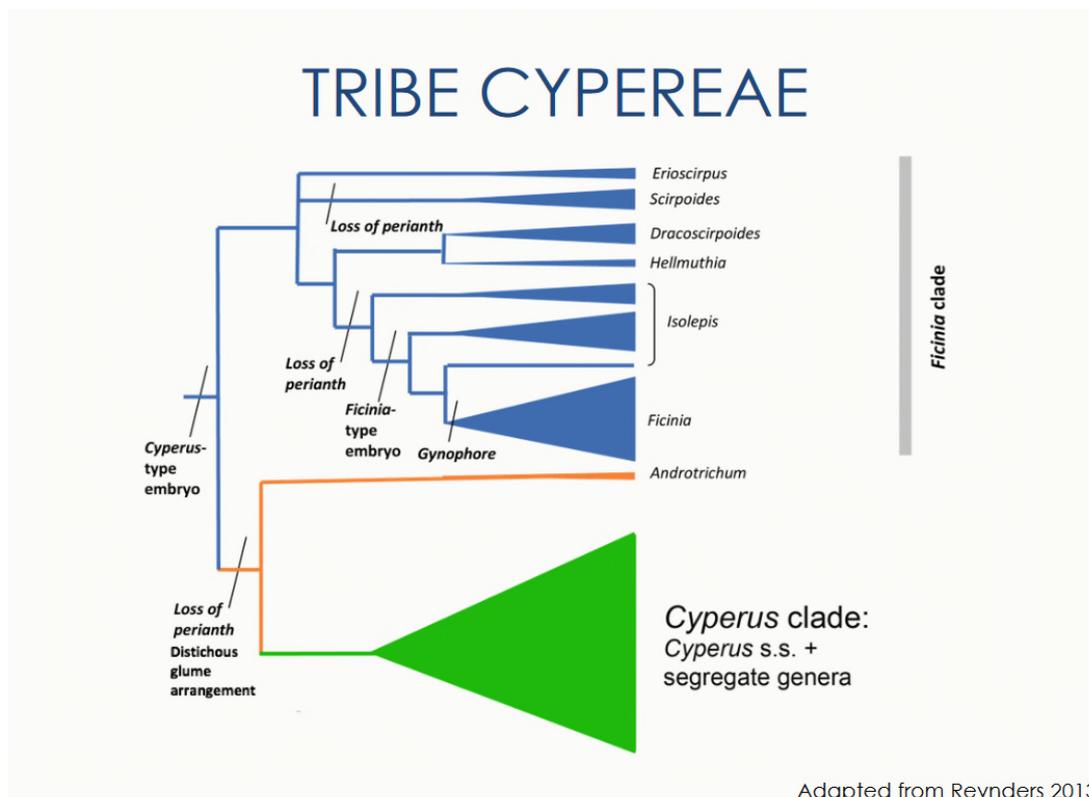


Figure 3. Relationships within the Cyperaceae tribe (source unknown).

Table 1. Australian Cyperaceae species.

Subfamily	Tribe	Genera	Species
Cyperoideae	Cypereae	3	180
Cyperoideae	Fuireneae	3	12
Cyperoideae	Abildgaarieae	5	117
Cyperoideae	Eleocharideae	1	10
Cyperoideae	Scirpeae	2	2
Cyperoideae	Cariceae	3	86
Cyperoideae	Rhynchosporeae	2	22
Cyperoideae	Sclerieae	2	24
Cyperoideae	Schoeneae	18	210
Mapanioideae	Hypolytreae	6	7
Mapanioideae	Chrysitricheae	3	7

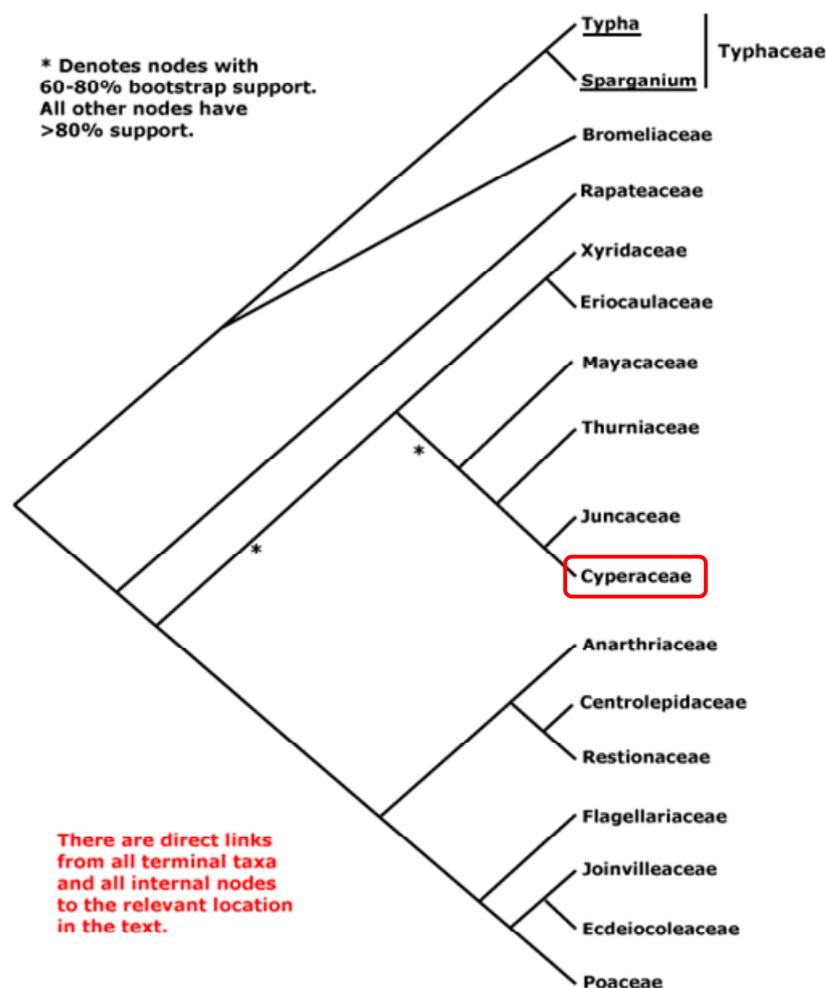


Figure 4. A phylogenetic tree showing the relationships of the families within the order Poales (<http://www.mobot.org/MOBOT/research/APweb/>).

Table 2. Proposed host plant test list for *Navua sedge*.

Species	Status	Distribution
Order Poales		
Family Cyperaceae		
Subfamily Cyperoideae		
Tribe Cyperus (Cyperus clade)		
Genus <i>Cyperus</i>		
Subgenus <i>Cyperus</i>		
Section <i>Kyllinga</i>		
<i>Cyperus aromaticus</i> (Ridl.) Mattf. & Kukenthal.	TW	North coastal Queensland
<i>Cyperus melanospermus</i> (Nees) Valck.Sur.	I	Inland around Townsville and Cairns
<i>Cyperus sphaeroideus</i> L.A.S.Johnson & O.D.Evans	N	Eastern seaboard to Rockhampton
<i>Cyperus sesquiflorus</i> (Torr.)Mattf. & Kük.	I	Eastern seaboard
<i>Cyperus mindorensis</i> (Steud.) Huygh (syn. <i>C. kyllingia</i> Endl.)	I	Coastal far north Queensland
Other sections		
<i>Cyperus iria</i> L.	N	Widespread in north, esp. coastal
<i>Cyperus papyrus</i> L.	I	East coast to Rockhampton
<i>Cyperus bifax</i> C.B. Clarke	N	Widespread in north on floodplains
<i>Cyperus pedunculatus</i> (R.Br.) J.Kern	N	East coast north of Gladstone
<i>Cyperus polystachyos</i> Rottb	N	Widespread
<i>Cyperus sanguinolentus</i> Vahl	N	Widespread - east coast and tablelands
<i>Cyperus exaltatus</i> Retz	N	Widespread
<i>Cyperus cyperoides</i> (L.) Kuntze	N	East coast - woodlands
<i>Cyperus conicus</i> (R.Br.) Boeckeler	N	Northern Australia - open woodland

<i>Cyperus pilosus</i> Vahl.	N	East coast, north from northern NSW
<i>Cyperus lucidus</i> R.Br.	N	Eastern seaboard
<i>Cyperus fulvus</i> R.Br.	N	Widespread
<i>Cyperus leptocarpus</i> (F.Muell.) Bauters, comb. nov. (<i>Lipocarpa microcephala</i>)	N	Widespread
Subgenus <i>Anosporum</i>		
<i>Cyperus puchellus</i> R.Br.	N	Northern Australia
<i>Cyperus gracilis</i> R.Br.	N	East coast; west to Lightning Ridge
<i>Cyperus trinervis</i> R.Br.	N	East coast.
<i>Cyperus difformis</i> L.	N	Widespread
Tribe Cyperus (Ficinia clade)		
<i>Ficinia nodosa</i> (Rottb.) Goetgh. et al.	N	East coast south of Maryborough
<i>Isolepis inundata</i> R.Br.	N	East coast
Tribe Fuireneae		
<i>Schoenoplectiella laevis</i> (S.T.Blake) Lye	N	Northern Australia - open woodland & grassland
<i>Fuirena ciliaris</i> (L.) Roxb.	N	Northern Australia - woodland
Tribe Abidgaarieae		
<i>Fimbristylis ferruginea</i> (L.) Vah	N	Coastal, north of Wollongong
Tribe Eleocharideae		
<i>Eleocharis dulcis</i> (Burm. f.) Trin. ex Hensch	NC	Northeast coast - still fresh water
Tribe Cariceae		
<i>Carex brunnea</i> Thunb.	N	East coast - rainforest
Tribe Rhynchosporeae		
<i>Rhynchospora corymbosa</i> (L.) Britton	N	Coastal Queensland
Tribe Schoeneae		
<i>Gahnia aspera</i> (R.Br.) Spreng.	N	East coast
<i>Machaerina rubiginosa</i> (Spreng.) T.Koyama	N	East coast - swamps
<i>Schoenus brevifolius</i> R.Br.	N	East coast to Rockhampton
Subfamily Mapiioideae		
Tribe Hypolytreae		
<i>Hypolytrum nemorum</i> (Vahl) Spreng.	N	North of Townsville
Tribe Chrysitricheae		
<i>Chorizandra cymbaria</i> R.Br.	N	Coastal – east and south-west
Family Juncaceae		
<i>Juncus continuus</i> L.A.S.Johnson/ <i>Juncus usitatus</i> L.A.S.Johnson	N	East coast
Family Eriocaulaceae		
<i>Eriocaulon australe</i> R.Br.	N	East coast and Northern Territory
Family Poaceae		
<i>Oryza sativa</i> L.	IC	
<i>Saccharum</i> sp.	IC	Northeast coast

Status: C - crop; I - introduced; N - native; O - ornamental; TW - target weed.

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