


## Reassessment of the taxonomic status of Cyperaceae on Rapa Iti, Austral Islands, French Polynesia, with a new combination, *Morelotia involuta*

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### Abstract

We reassess the current taxonomic status and distribution of Cyperaceae on Rapa Iti, Austral Islands, French Polynesia. This includes the poorly known *Machaerina involuta* H.St John (Cyperaceae, tribe Schoeneae), 86 years after it was first collected. Detailed morphological examination revealed that *M. involuta* belongs in *Morelotia* Gaudich., and the new combination, *Morelotia involuta* (H.St John) J.J.Bruhl & R.L.Barrett, is made here. Nineteen species of Cyperaceae are reported for Rapa Iti (10% of the vascular flora). The high diversity of Cyperaceae invites further discussion of the biogeographic connections and environmental conditions of Rapa Iti and a summary is provided. Notes on additional Cyperaceae named from Rapa Iti (*Carex rapaensis* (H.St John) K.L.Wilson, *Carex stokesii* F.Br., *C. stokesii* var. *aristata* F.Br., *Cyperus rapensis* F.Br., *Eleocharis caribaea* var. *stokesii* F.Br., *Gahnia stokesii* F.Br. and *Rhynchospora stokesii* F.Br.) are presented and a presently unidentified *Carex* is noted.

**Keywords:** Cyperaceae; *Machaerina*; *Morelotia*; Schoeneae; Hawaii; New Zealand; Pacific.

### Introduction

A collaboration between Australia and French Polynesia has led to the reassessment of *Machaerina involuta* H.St John (Cyperaceae), 86 years after it was first collected on the remote island of Rapa Iti, Austral Islands. Surprisingly, the species remained unnamed for fifty years before being named by the collector of the type specimen, Harold St John (St John 1984). Jeremy Bruhl suspected that *M. involuta* was misplaced in that genus after examination of material at K. While reviewing generic relationships in the *Tricostularia* Nees ex Lehm. group of genera, we confirmed that *Machaerina involuta* is actually a species of *Morelotia* Gaudich. *Machaerina involuta* appeared to be only known from three collections made on a single expedition to Rapa Iti

(Austral Islands, French Polynesia) in July 1934 by US botanists Harold St-John and F. Raymond Fosberg during the “Mangarevan expedition” funded by the Bernice Pauahi Bishop Museum of Honolulu, Hawai‘i.

An enquiry was made by Russell Barrett to Jean-Yves Meyer as to whether any recent collections might have been made during more recent botanical expeditions. These include expeditions conducted by French botanists Jacques Florence (IRD, formerly known as ORSTOM) and Nicolas Hallé (Muséum national d’Histoire naturelle, Paris) in January–February 1984, and by a team of French Polynesian and US botanists (Délégation à la Recherche de la Polynésie française, New York Botanical Garden and National Tropical Botanical Garden, Kaua‘i) in March–May and during a multidisciplinary scientific expedition to assess the terrestrial biodiversity of the Austral Islands led by Jean-Yves Meyer in December 2002 (see Meyer *et al.* 2014; Motley *et al.* 2014). While none was apparently known, Ravahere Taputuarai was recently undertaking botanical research on Rapa Iti, with no defined boat departure date due to COVID-19 travel restrictions.

Ravahere Taputuarai spent over three months on the island, February–June 2020. A targeted search for the species was therefore initiated, and at least seven populations were located. Subsequent searches of PAP and PTBG revealed that four collections had in fact been made during the 2002 expedition noted above, but they had initially been identified as Cyperaceae sp., *Carex* sp., or *Carex stokesii* F.Br., largely due to their dissimilarity to any *Machaerina* species (Chevillotte *et al.* 2019). The specimens, at PTBG, were later determined as the poorly known *Machaerina involuta* by Mark Strong (US; 2006), and confirmed by Tetsuo Koyama (MBK; 2010), but the specimens at PAP remained under their original determinations.

Rapa Iti (literally Little Rapa, to distinguish it from Easter Island or Rapa Nui, i.e. Big Rapa) is a small volcanic island (40 km<sup>2</sup>) in the far south-east of the Austral Islands chain, some 1250 km south-southeast of Tahiti in the Pacific Ocean. The highest peak, Mont Perau or Perahu, is c. 650 m high. The island of Rapa Iti formed progressively between c. 4.1 and 4.8 Ma (Meyer and Claridge 2014a, 2014b). Annual rainfall is 2500–3800 mm, and year-round, allowing for the presence of rainforests and cloud forests at high elevation (Motley *et al.* 2014). Rapa Iti is one of only two Pacific islands with coal deposits, suggesting a long history of high vegetative productivity (Mueller-Dombois and Fosberg 1998). Rapa Iti has a significant history of human habitation, stretching back about 750 years (DiNapoli *et al.* 2018), with 515 inhabitants in 2017, and domestic livestock, especially goats, cattle, horses and pigs, have impacted the natural environment of the island (Prebble and Anderson 2012; Meyer *et al.* 2014, 2019). Uncontrolled fires are having an increasing impact on native vegetation, particularly through the promotion of introduced grasses (Meyer *et al.* 2014). Introduced plants, especially strawberry guava *Psidium cattleianum* Sabine (Myrtaceae) and the thimbleberry *Rubus rosifolius* Sm. (Rosaceae), are also adding pressure to native remnant vegetation (Meyer *et al.* 2019). Rapa Iti and nearby Austral Islands are recognized by WWF to host several threatened endemic plant and animal species such as the Rapa fruit dove *Ptilinopus huttoni* and the Kuhl’s lorikeet *Vini kuhlii*, only present in Rimatara (Zicus 2020). Many of the more than 60 endemic plant species are of conservation concern (Meyer and Claridge 2014a; Meyer *et al.* 2014).

The relatively young geological age, but often great isolation of Pacific islands makes for a very mixed flora of widespread, recently arrived species, and older chance dispersals that have led to subsequent speciation and relatively high local endemism (van Balgooy *et al.* 1996; Mueller-Dombois and Fosberg 1998; Kreft *et al.* 2008). Unfortunately, remoteness is negatively correlated with the impacts of invasive alien species (Moser *et al.* 2018).

The primary biogeographic connections, and therefore the biogeographic regionalisation of Rapa Iti and nearby islands have been the subject of much debate (see van Balgooy 1971; van Balgooy *et al.* 1996). Edwin B. Copeland (1873–1964), a US pteridologist with expertise on ferns in the Pacific islands, noted that Rapa appeared to be an exception to the general pattern of fern relationships where New Zealand origins were proposed for most Pacific species on the basis of morphological similarity, and a similar origin was postulated for most Cyperaceae in the Pacific (Copeland 1948). Rouhan *et al.* (2004, 2008), using phylogenetic analyses of relationships, showed that this was not true for the fern genus *Elaphoglossum* Schott ex J.Sm., but Viljoen *et al.* (2013) confirmed that an Austral origin is true for at least taxa in Cyperaceae tribe Schoeneae, with primary diversification taking place in Australia. Garnock-Jones (1976) established that *Veronica rapensis* F.Br. is most closely allied to New Zealand species.

Phylogenetic studies are now revealing both the potential origins and timing of dispersal events to remote Pacific islands (e.g. Price and Wagner 2018). Baldwin and Wood (2016) determined that the Rapa endemic genus *Apostates* Lander originated as a dispersal from North America, rather than being a radiation from Australia as suggested by its original description in the Australasian genus *Olearia* Moench. (see Lander 1989). Iwanycki Ahlstrand *et al.* (2019) found that two Rapa Iti endemic species of *Plantago* L. have their origins in North America, defying the usual pattern of proximity to major land masses, rather following the Pacific flyway for large marine birds. The expanded genus *Sclerotheca* A.DC. (Campanulaceae, now including *Apetahia* Baill.), endemic to South East Polynesia, appears to be sister to a Hawaiian radiation of lobelioids (Pillon *et al.* 2018).

Some authors are suggesting that the southern Austral Islands should be excluded from neighbouring biogeographic zones as their composition is a greater mix of both western (New Zealand, Australian), northern (Hawaiian, North American) and eastern (South American) connections than surrounding archipelagos (see Funk and Wood 2014; Zicus 2020). Florence (1997) and Meyer *et al.* (2014) recognise the Rapa group as distinct from the Austral Archipelago. Rapa in particular is unique in this region for having high, year-round rainfall, and lower temperatures compared to the nearest islands of the Austral and the Society Archipelagos. We here suggest that this first characteristic, combined with low species diversity (or ‘taxonomic disharmony’) typical of remote islands, high topographic diversity and highly fertile soils, offers significant opportunities for new arrivals to establish year-round (rather than in only seasonally suitable conditions). These combinations may be enough to explain the relatively high plant diversity and endemism on Rapa Iti compared with other islands in the region, including the high diversity of Cyperaceae.

Rapa Iti is host to 59 endemic plant species, out of a total of 191 (135 native) recorded species, the endemism rate of 31% is the highest rate in French Polynesia and Eastern Polynesia (Meyer *et al.* 2014). Endemic species continue to be described, such as *Melicope balgooyi* Appelhans, W.L.Wagner & K.R.Wood (Appelhans *et al.* 2014), *Bidens meyeri* V.A.Funk & K.R. Wood (Funk and Wood 2014) and *Pacifigeron indivisus* Saldivia (Saldivia *et al.* 2020).

Ten genera of flowering plants found on Rapa are endemic to the Pacific, seven of which are endemic to Eastern Polynesia, and three of these are endemic to Rapa Iti (Florence 1997; Meyer *et al.* 2014; Table 1). *Exocarpos* Labill. (Santalaceae) is widespread in Australia and New Caledonia (Kuijt 2015) and is here excluded from this list. *Geniostoma* J.R.Forst. & G.Forst. (Loganiaceae) has been re-circumscribed and includes species extending to Australia and the Indian Ocean (Gibbons *et al.* 2012). *Hebe* Comm. ex Juss. (Plantaginaceae) is now generally subsumed under a broadly circumscribed and monophyletic *Veronica* L. (Garnock-Jones *et al.* 2007). *Nesoluma* Baill. (Sapotaceae), is now included under *Sideroxylon* L. (Smedmark and Anderberg 2007). *Kadua* Cham. & Schltld. (Rubiaceae) is endemic to the Pacific, its generic status having been supported by recent molecular phylogenetic data (Neupane *et al.* 2015; Gibbons 2020). *Morelotia* as traditionally circumscribed would also be added to the list of Pacific endemic genera found on Rapa (Table 1). However, the circumscription of *Morelotia* has recently been expanded to include three species from south-west Australia (Barrett *et al.* 2021). The flora of Rapa is quite dissimilar to that of nearby islands, sharing less than a quarter of its species with even the high volcanic islands of Raivavae, Rurutu and Tubuai, which have a more tropical climate than Rapa Iti (Meyer *et al.* 2014).

**Table 1. List of Pacific Basin endemic angiosperm genera found on Rapa Iti.**

Rapa Iti endemic genera	French Polynesian endemic genera	Eastern Polynesia endemic genera	Pacific endemic genera
<i>Apostates</i> (Asteraceae)	<i>Haroldiella</i> (Urticaceae)	<i>Fitchia</i> (Asteraceae)	<i>Corokia</i> (Argophyllaceae) [also one species in New South Wales, Australia]
<i>Metatrophis</i> (Urticaceae)	<i>Oparanthus</i> (Asteraceae)	<i>Sclerotheca</i> (formerly <i>Apetahia</i> , Campanulaceae)	<i>Kadua</i> (Rubiaceae)
<i>Pacifigeron</i> (Asteraceae)			<i>Meryta</i> (Araliaceae)

## Cyperaceae on Rapa Iti

Cyperaceae (sedges) are commonly neglected components of ecosystems due to the challenges associated with identification and their often inconspicuous presence in the landscape. Ecosystem surveys commonly focus on dominants and common or showy species, and small or infertile species are easily overlooked, particularly when time-frames for surveys are limited. In remote locations, documentation of little-studied groups such as Cyperaceae remains an ongoing priority for research.

In Cyperaceae, whether species are local endemics or widespread appears to be correlated with the likelihood and mechanism of seed dispersal, which is partly correlated with the habitat, as discussed by Jacobs and Wilson (1996) for aquatic species (including Cyperaceae) in the Australasian region. Nineteen species of Cyperaceae have been collected on Rapa Iti (Table 2). Five species are highly localised in south-eastern Polynesia (three endemic to Rapa Iti), while the others have very broad distributions. Most of these have very small fruit, or are aquatic species, that are commonly dispersed by birds (Sorensen 1986; Bryson and Carter 1998; Cain *et al.* 2000).

**Table 2. Cyperaceae recorded from Rapa Iti and their current status (based on Brown 1931; Meyer 2002; Meyer and Claridge 2014a; Sykes 2016; and specimens or images examined from B, BISH, BM, K, L, NY, P, PAP, PTBG, WAG and US). Alternative determinations are included to assist curation of herbarium specimens where only digital images were seen.**

Current name	Native or Introduced	Endemic to Rapa	Type from Rapa
<i>Carex rapaensis</i> (H.St John) K.L.Wilson [some collections labelled as <i>Uncinia rapaensis</i> ]	native	yes	<i>Uncinia rapaensis</i> H.St John
<i>Carex stokesii</i> F.Br.	native (Rapa, Rarotonga)	no	<i>Carex stokesii</i> ; <i>C. stokesii</i> var. <i>aristata</i> F.Br.
<i>Carex</i> sp. (R.Taputuarai 861) [allied to <i>C. uncinata</i> L.f.]	native	unknown	
<i>Cladium mariscus</i> subsp. <i>jamaicense</i> (H.J.Crantz) Kük.	probably native but possibly introduced	no	
<i>Cyperus brevifolius</i> (Rottb.) Endl. ex Hassk. [some collections labelled as <i>Kyllingia brevifolia</i> ]	uncertain	no	
<i>Cyperus cyperinus</i> (Retz.) Suringar [listed as <i>C. umbellatus</i> by Brown 1931]	introduced	no	
<i>Cyperus cyperoides</i> (L.) Kuntze	probably introduced but possibly native	no	
? <i>Cyperus ferax</i> Rich. [records by Brown 1931 at least partially based on sterile <i>Digitaria</i> ; records may also refer to <i>Cyperus odoratus</i> L.]	?native	no	
<i>Cyperus javanicus</i> Houtt. [some collections labelled as <i>Mariscus javanicus</i> ]	probably introduced but possibly native	no	
<i>Cyperus mindorensis</i> (Steud.) Huygh [collections labelled as <i>Kyllingia nemoralis</i> ]	probably native	no	
<i>Cyperus rapensis</i> F.Br.	native (Rapa, Raivavae)	no	<i>Cyperus rapensis</i>
<i>Eleocharis geniculata</i> (L.) Roem. & Schult. [some collections labelled as <i>Eleocharis caribbaea</i> var. <i>stokesii</i> ]	probably native but possibly introduced	no	<i>Eleocharis caribbaea</i> var. <i>stokesii</i> F.Br.
<i>Ficinia nodosa</i> (Rottb.) Goetgh., Muasya & D.A.Simpson [some collections labelled as <i>Scirpus nodosus</i> or <i>Isolepis nodosus</i> ]	native	no	
<i>Fimbristylis dichotoma</i> (L.) M.Vahl	native	no	
<i>Gahnia aspera</i> (R.Br.) Spreng. [some collections labelled as <i>Gahnia stokesii</i> ]	native	no	<i>Gahnia stokesii</i> F.Br.
? <i>Isolepis levynsiana</i> (as <i>Cyperus tenellus</i> L.) [possibly confused with <i>Isolepis subtilissima</i> ; E.H.Quayle 352, BISH; not examined]	probably introduced or an incorrect identification	no	
<i>Isolepis subtilissima</i> Boeckeler [some collections labelled as <i>Scirpus nodosus</i> ]	probably native but possibly introduced	no	
<i>Morelotia involuta</i> (H.St John) J.J.Bruhl & R.L.Barrett [collections variously labelled as Cyperaceae sp., <i>Carex</i> sp., <i>Carex stokesii</i> or <i>Machaerina involuta</i> ]	native	yes	<i>Machaerina involuta</i> H.St John
<i>Rhynchospora stokesii</i> F.Br. [some collections labelled as <i>Rhynchospora sclerioides</i> var. <i>stokesii</i> (F.Br.) Kük.]	native	yes	<i>Rhynchospora stokesii</i> ; <i>R. stokesii</i> forma <i>saxicola</i> F.Br.
<i>Schoenoplectus subulatus</i> (Vahl) Lye [or recognised as <i>Schoenoplectus littoralis</i> subsp. <i>subulatus</i> (M.Vahl) T.Koyama]	probably native but possibly introduced	no	

Generic circumscription in Cyperaceae tribe Schoeneae has remained challenging due to very high levels of morphological variability (Bruhl 1995; Goetghebeur 1998), with resolution only being achieved recently through detailed molecular phylogenies (Zhang *et al.* 2004, 2007; Bruhl *et al.* 2008a, 2008b; Viljoen *et al.* 2013; Muasya 2016; Musili *et al.* 2017; Barrett *et al.* 2017, 2019; Semmouri *et al.* 2019). Considerable re-circumscription has been required in some genera (Wilson *et al.* 2012; Larridon *et al.* 2018a, 2018b, 2019; Barrett *et al.* 2017, 2019, 2020).

Recognition and definition of both *Machaerina* Vahl and *Morelotia* Gaudich. has been debated for many years (Benl 1940a, 1940b; 1950; Kükenthal 1943; St John 1958; Kern 1962; Blake 1969; Bruhl 1995). Consensus has recently been reached, with *Machaerina* expanded to include *Baumea* Gaudich. and *Morelotia* accepted as a distinct genus from *Gahnia* J.R.Forst. & G.Forst. (Viljoen *et al.* 2013; Semmouri *et al.* 2019).

Larridon *et al.* (2018b) estimated that the *Tricostularia* Nees ex Lehm. clade originated around 28.4 (19.8–39.2) Ma. Viljoen *et al.* (2013) found that this clade likely originated in Australia, with the current distribution of genera and species outside Australia most likely due to long-distance dispersal events.

### Methods

The description of *Morelotia involuta* is based on a specimen examined at NSW and specimen images available through online databases (indicated by \*): Global Plants project on JSTOR, Consortium of Pacific Herbaria website, Naturalis, Australasian Virtual Herbarium, B, BISH, BM, K, NY, P, PAP and US.

### Taxonomy

*Morelotia* Gaudich., *Voy. Uranie* 4(10): 416 (1829).

Type species: *Morelotia gahniiformis* Gaudich.

Kern (1962) considered *Morelotia affinis* and *M. gahniiformis* to belong in *Machaerina* based on the trigonous stems, revolute leaves, distichous glumes, presence of an imperfect second flower and greatly thickened style-base. This may have influenced St John's decision to describe his new species as *Machaerina involuta* (St John 1984), but no notes to this effect have been found. Morphological examination of the original collections and comparison with *Morelotia affinis* and *M. gahniiformis* confirm that *Machaerina involuta* also belongs in *Morelotia*. It appears to be closer in morphology to *M. affinis* than *M. gahniiformis*, but molecular data are yet to be obtained for *M. involuta* to confirm evolutionary relationships and estimate the age of divergence events. The three Pacific species of *Morelotia* are allied to three species from southern Western Australia that have historically been included in *Tetraria* (Barrett *et al.* 2021). The four geographic regions where *Morelotia* species occur are separated by distances of between 3950 and 7030km (Figure 1).



**Fig. 1.** Location of Rapa Iti and distances between *Morelotia* species in the Pacific Ocean (Hawaii, Rapa Iti and New Zealand) and their nearest relatives in southern Western Australia (adapted by R.L. Barrett from the *CIA World Factbook: Political Oceania*).

***Morelotia involuta*** (H.St John) J.J.Bruhl & R.L.Barrett, *comb. nov.*

Basionym: *Machaerina involuta* H.St John, *Nordic J. Bot.* 4: 57, fig. 1 (1984).

Type: French Polynesia: Austral Islands, Bass Islands, Rapa Island [Rapa Iti], S of Morongota [Morongo Uta *pare* (fort)], 275 m alt., 8 July 1934, *H. St. John & J. Maireau 15434* (holo: BISH 1001238\*; iso: BISH 1001239\*, BISH 1001240\*, BRI AQ0193095\*, GH 00050565\*, K!, NSW 1099912!, NY 4106228\*, P 00641812\*, P 00641813\*, SING 0064504\*, US 00512838\*).

Perennial tufted *herb*, 0.25–0.6 m high; plants clonal, 0.2–0.5 m across; rhizome thick, woody, short, branched, 10–15 mm diam., not pseudobulbous; old leaf sheaths covering the rhizome, breaking apart into fibres and becoming recurved with age, pale brown to dark brown; roots not sand-binding. *Stems* stout, erect, with 1 leafy node above the middle of the culm, trigonous, 1.3–1.7 mm diam., smooth, glabrous, base not or slightly enlarged. *Leaves* mostly basal, numerous, and 1 cauline; phyllotaxy loosely spirotristichous, sheath glabrous, open, 26–38 mm long, 4–5 mm wide, broader than the leaf blade, pale brown, upper margin smooth, ligule absent; basal leaves 20–60 cm long, 2.5–4 mm wide, but involute and appearing 1–1.3 mm wide, lamina  $\pm$ linear, often twisted or curved, finely multi-striate, glabrous, dark green, paler below, margins very finely scabrous, usually recurved, apex gradually attenuate; cauline leaf blade 15–25 cm long. *Inflorescence* a dense panicle, narrow, linear, 10.5–21 cm long, 5–10 mm diam., with 5–8 fertile nodes; axis green; bracts leaf-like, with pale brown sheaths 15–25 mm long, becoming progressively smaller up the stem, exceeding the spikelet clusters, basal bract longer than inflorescence; branches 20–25 mm long, erect, with (1)2 or 3 clustered spikelets on peduncles 0.5–3 mm long, arising in each bract axil; cladophyll subtending each spikelet glume-like, sheath 3.5–4.2 mm long, brown, with 1 distinct vein, partially enclosing the spikelet, with a slender blade 1.8–2.1 mm long, brown. *Spikelets* brown, lanceolate 7–9 mm long, 1.3–1.5 mm diam., ascending, not compressed, with usually 7 glumes, only topmost fertile, bisexual, lower glumes empty, glumes distichous, lowest glume 4 mm long, upper glumes 8–9 mm long, 1.7–2.1 mm wide, glabrous, lanceolate, acuminate, weakly keeled, with a mucro to 3 mm long; rachilla compact and not sinuous in fruiting spikelets. *Perianth segments* present, bristles *c.* 6, inconspicuous, filiform, glabrous, 0.4–1.1 mm long, 1/5–1/3 as long as the nutlet. *Stamens* 3; anther connective 5.1–6.8 mm long, linear, persistent at base of nutlet, distal portion held within the convolute apex of subtending glume, so mature nutlets pendent on the inflorescence post-release; anthers pale yellow, 4–5 mm long, linear-oblong, base auriculate, with a glabrous apical appendage up to 2 mm long. *Style* 3-fid, white; undivided part 3–5 mm long, glabrous, thin throughout; branches 7–10 mm long, hispidulous. *Nutlet* sessile, angular ellipsoid, subterete, but perceptibly 3-sided, mostly stramineous but apex brown and only slightly or not constricted, smooth, 2.1–2.7 mm long including the style base, 0.8–1.0 mm diam., epidermal cells square–hexagonal, but inconspicuous; style base cylindrical, hard, persistent, glabrous, *c.* 0.5 mm long and wrinkled when immature, expanding to *c.* 0.7 mm long, smooth and somewhat angular due to continuation of ribs from nutlet. (Figure 2).

**Diagnostic characters:** Differs from *M. affinis* in: Stems with 1 leafy node (*vs* 0–2(–4) leafy nodes), 1.3–1.7 mm diam. (*vs* 1.9–3.5 mm). Leaf sheath 26–38 mm long (*vs* 35–60 mm). Basal leaves 2.5–4 mm wide (*vs* 4–8 mm), but involute and appearing 1–1.3 mm wide (*vs* 1.5–2.1 mm wide), margins very finely scabrous, (*vs* harshly scabrous), usually recurved (*vs* strongly revolute) when dry. Inflorescence branches 20–25 mm long (*vs* 20–70 mm), with (1)2 or 3 clustered spikelets (*vs* 3–15). Perianth segments present, filiform, 0.4–1.1 mm long (*vs* absent). Nutlet mostly stramineous but apex brown (*vs* lustrous red-brown to black, apex black).

**Distribution:** Until 2020, only known from seven collections made on one expedition in July 1934 and another in 2002 on Rapa Iti in the Austral Islands, French Polynesia, where it is apparently endemic. Targeted surveys for the species in March 2020 located at least seven populations on Rapa Iti (Figure 3).

**Habitat:** Grassy volcanic slopes, crests and ridges in open, often disturbed, sunny fernlands with scattered remnant or marginal trees between 80 and 400 m elevation (Figure 4) Recorded in association with *Aristida aspera*, *Asplenium polyodon*, *Athyrium membranaceum*, *Blechnum vulcanicum*, *Bolbitis lonchophora*, *Callistopteris calyculata*, *Coprosma rapensis*, *Cyathea medullaris*, *Cyperus brevifolius*, *Dianella adenantha*, *Dicranopteris linearis*, *Dryopteris stokesii*, *Elaphoglossum meyeri*, *Eragrostis brownei*, *Erythrina variegata*, *Eurya japonica* var. *nitida*, *Ficinia nodosa*, *Fitchia rapensis*, *Gahnia aspera*, *Glochidion longfieldiae*, *Haloragis stokesii*, *Histiopteris incisa*, *Hymenophyllum* sp., *Lycopodiella cernuua*, *Lycopodiella venustum*, *Metrosideros collina*, *Peperomia rapensis*, *Pittosporum rapense*, *Rhynchospora stokesii*, *Vaccinium rapense* and *Veronica rapensis* collected in the vicinity. Introduced taxa recorded in direct association include *Bidens pilosa*, *Miscanthus floridulus*, *Pinus caribaea* and *Psidium cattleianum*.



**Fig. 2.** *Morelotia involuta*, Rapa Iti, French Polynesia. A, B: Plant habit with mature inflorescences. C: Flowering inflorescence. D: Close-up of inflorescence with fresh styles and old anthers. Photos: R. Taputuarai.

**Phenology:** Flowers recorded for March and April. Fruit recorded for April and July.

**Specimens and images examined:** French Polynesia: Austral Islands, Bass Islands, Rapa Iti, E slope of Mt Ruatara, 260 m., 9 July 1934, *F.R. Fosberg 11453* (L\*, S\*, US\*), *loc. cit.*, 8 July 1934, *F.R. Fosberg 11454* (P\*, US\*); sentier vers le Mont Maungaoa, 400 m, 21 Mar. 2002, *J.-Y. Meyer 1007 & R. Fenstemacher* (PAP, PTBG 1000028324\*); just west of Area village, 80 m, 19 Mar. 2002, *T.J. Motley 2621 & R. Fenstemacher*, collected by *J.-F. Butaud* (PAP, PTBG 1000028319\*); Mt. Manguoa (Marugaoa) on ridge just east of Pa (fortress), 380 m, 8 Apr. 2002, *T.J. Motley 2721 & R. Fenstemacher* (PAP, PTBG 1000028323\*); Hiri Valley, back slopes below Pukumaru Peak, north facing slope, 400 ft, 13 Apr. 2002, *S. Perlman 18062* (PAP, PTBG 1000028318\*); Maunga'ai'ai, sur les flancs du fort, 20 May 2020, *R. Taputuarai 859, 860* (PAP).

**Conservation:** Remnant native habitats in Rapa Iti are commonly heavily invaded by *Psidium cattleyanum*, *Rubus rosifolius*, *Hedychium flavescens* and weedy grasses, particularly *Melinis minutiflora*, *Miscanthus floridulus* and several *Paspalum* species (Meyer 1996; Mueller-Dombois and Fosberg 1998; Meyer *et al.* 2019), and in some areas by the naturalized Caribbean pine *Pinus caribaea*. This species is likely to be threatened by habitat loss or fragmentation. Fire and goats are additional threats that appear to be increasing (Meyer *et al.* 2014).

It is noted that Brown (1931) did not examine any material of this taxon for his treatment of Cyperaceae in the *Flora of Southeastern Polynesia*, despite collections of other Cyperaceae from nearby locations on Rapa,



**Fig. 3.** Populations of *Morelotia involuta* on Rapa Iti, French Polynesia located in May 2020. Map by R. Taputuarai.

suggesting the species may have already been quite rare at the time of preceding expeditions, though it may have simply been overlooked given the diversity of ‘more interesting’ species on the island.

Surveys in 2002 aimed at documenting all vascular plants on the island located four populations, though they were not recognised as *Machaerina involuta* at the time.

Targeted surveys in March 2020 located populations on the Maunga’ai’ai ridge, on the many ridges above Tukou, above Akatamiro Bay, above Anarua Bay, below Vairu (on the Tupuaki side and Haurei Bay side, with most populations occurring between 100 m and 400 m altitude (Figure 4). It was found growing in highly exposed situations in low, open fernlands dominated by *Dicranopteris* and *Lycopodiella*, with some disturbance by feral cattle and goats. At the scale of Rapa Iti as a whole, the species is very sparsely distributed in small populations and as a local endemic, all populations are likely to be subject to the same threats.





**Fig. 4.** Habitat of *Morelotia involuta* on Rapa Iti, French Polynesia. A, B: Maunga'ai'ai site in fernland with introduced *Psidium cattleianum* and *Pinus caribaea*. C: Habitat on slopes at Tukou. D: Habitat on ridgelines looking east from Vairu. Photos by R. Taputuarai.

Following the IUCN (2012) threat classification system, we assess *Morelotia involuta* as Endangered (EN). The IUCN alphanumeric summary of our evaluation of criteria and subcriteria is: B1b(iii, iv); B2a; B2b(iii); C1; C2a(i); D2. These criteria are defined as: B1, extent of occurrence less than 20,000 km<sup>2</sup>; B1b(iii, iv) continuing decline inferred in area, extent and quality of habitat and number of mature individuals; B2, total area of occupancy less than 2000 km<sup>2</sup>; B2a, severely fragmented and known to exist as no more than 10 populations; B2b(iii, v), continuing decline inferred in area, extent and quality of habitat and number of mature individuals; C1, an estimated continued decline of at least 10% within three generations; C2a(i), a projected decline in the number of individuals and no subpopulation estimated to contain more than 1000 mature individuals; D2, populations very restricted area of occupancy, less than 10 km<sup>2</sup> such that it is prone to human activities or stochastic events within a short time period. Threats to *M. involuta* include fire frequency, habitat degradation by feral goats and cattle, competition with non-native plants, particularly *Psidium cattleianum*, and climate change (mainly increased air temperature).

**Etymology:** St John (1984) named the species from the Latin *involvere* (I roll in), presumably intending *involvere* (to roll in), in reference to the involute leaf blades.

**Notes:** St John (1984) allied his *Machaerina involuta* to *M. schoenoides* (R.Br.) Koyama [= *Machaerina acuta* (Labill.) J.Kern], a relationship that is only based on superficial morphological similarities.

Most of the fruit on the isotype at NSW are immature, with small style bases, but a few mature fruit are present on this specimen, with greatly enlarged style bases.

A specimen at US suggests the collection location was on Tubuai Island, but this is an error. St John did collect on Tubuai Island, but three months later than his collections from Rapa Iti, and the Morongo Uta *pare* (fort) is on Rapa Iti. The confusion may have arisen as Rapa Iti is part of the Austral Islands, sometimes referred to as the Tubuai Islands.

### Notes on other Cyperaceae from Rapa Iti

*Carex rapaensis* (H.St.John) K.L.Wilson, *Bot. J. Linn. Soc.* 179: 36 (2015). *Uncinia rapaensis* H.St.John, *Nordic J. Bot.* 4(1): 60 (1984).

Type: French Polynesia, Austral Islands, Rapa, Kamaru, Mt. Perahu, 475 m, 13 July 1934, *H. St. John & J. Maireau 15521* (holo: BISH 1001258\*; iso: BISH 1001257\*, GH 00050566\*, K 000960349\*, P 00641823\*, US 00512839\*).

Sparsely distributed on Rapa Iti, observed along the crest of the summit ridge in cloud forest, along the Munga'ai'ai ridge, below Karere summit in wet forest and on the Parau-Namuere ridge, where it is locally common at each site. (Figure 5).

This species may be the same as the widespread Pacific species *Carex uncinata* L.f. (*Uncinia uncinata* (L.f.) Kük.), with further studies in progress to determine its taxonomic status (K.L. Wilson in prep.).

*Carex stokesii* F.Br., *Bull. Bernice P. Bishop Mus.* 84: 116, fig. 13 (1931).



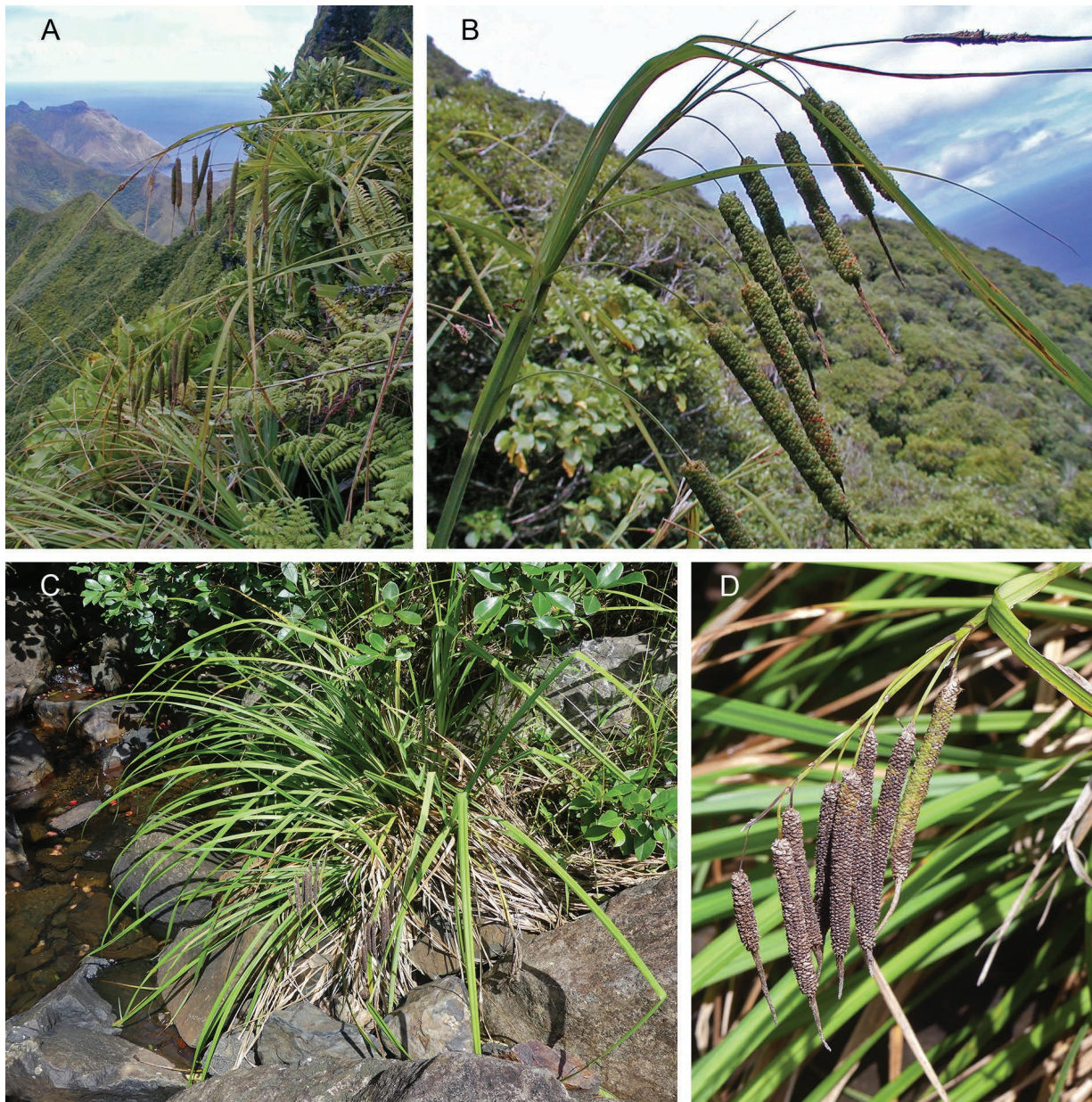
**Fig. 5.** *Carex rapaensis*, Rapa Iti, French Polynesia. A: Plant habit. B, C: Inflorescence. D: Mature infructescence. Photos: R. Taputuarai.

Type: French Polynesia, Austral Islands, Rapa, 100+ m, 21 September 1921, [?A.M.] J.F.G.Stokes 244A (holo (mounted on two sheets): BISH 1001205\*, BISH 1001206\*).

=*Carex stokesii* F.Br. var. *aristata* F.Br., F.Br., *Bull. Bernice P. Bishop Mus.* 84: 117 (1931), *syn. nov.*

Type: French Polynesia, Austral Islands, Rapa, 1922, E.H.Quayle *s.n.* (holo: BISH 1001207\*; iso: P 00586720\*).

Brown (1931) distinguished his variety *aristata* based on the single spikelets (*vs* 1–3) in bract axils and 10-veined perigynium (*vs* 3–5 veined). These characters are both considered to be variable in the species and we do not currently accept the variety as distinct. Common on Rapa Iti, from the seashore to plains and ridges, with some plants extending to the summit of the peaks (Figure 6).



**Fig. 6.** *Carex stokesii*, Rapa Iti, French Polynesia. A–C: Plant habit. B: Mature inflorescence. Photos: A, B: J.-Y. Meyer. C, D: R. Taputuarai.

*Carex* sp. (R. Taputuarai 861)

Just three tussocks of a currently unidentified species with affinity to *Carex uncinata* were found at a single locality along the Kaimuru ridge, below Pakumaru Rock, on the Anarua side. The leaves were paler and broader than those here assigned to *C. rapaensis* and the inflorescence appears to be more compact, but this may simply be variation due to growth conditions. They were growing in a *Metrosideros* – *Cyathea* – *Freycinetia* wet

forest that has been invaded by *Psidium cattleianum*. Detailed morphological studies are yet to be undertaken to determine its taxonomic and therefore conservation status (Figure 7).

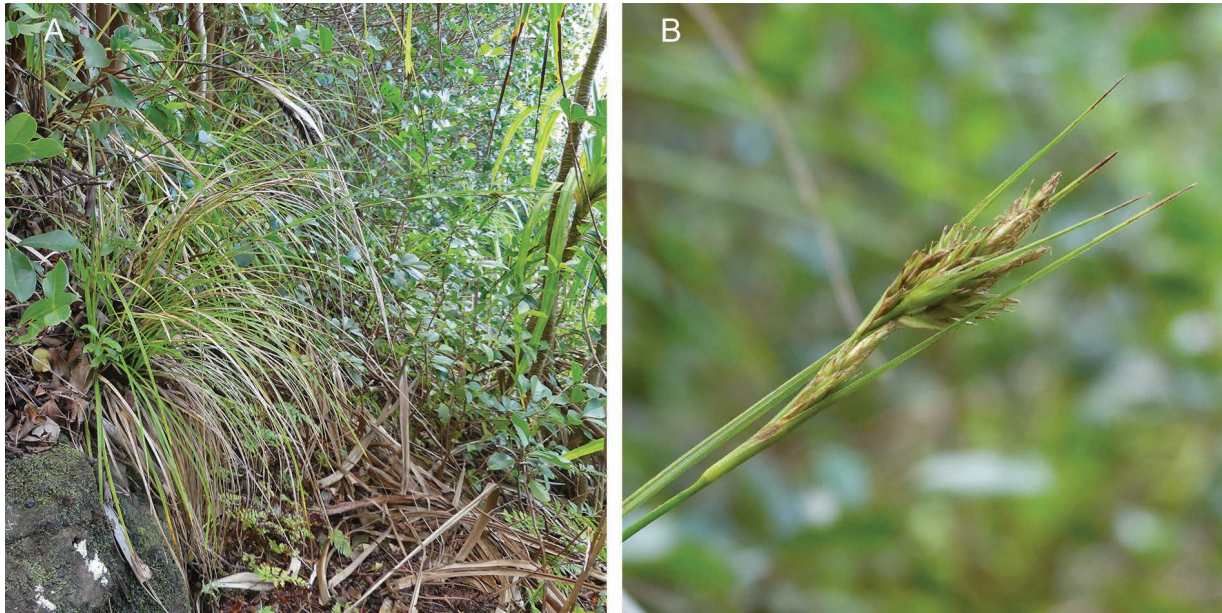


Fig. 7. *Carex* sp., Rapa Iti, French Polynesia. A: Plant habit and habitat. B: Mature inflorescence. Photos: R. Taputuarai.

*Cyperus rapensis* F.Br., *Bull. Bernice P. Bishop Mus.* 84: 98, pl. X c (1931).

Type: French Polynesia, Austral Islands, Rapa, 1922, *E.H.Quayle* 339 (holo: BISH 1001224\*; iso: BISH 1001223\*).

Poorly known on Rapa Iti, with three collections and one recent observation on open rocky slopes. Also known from Raivavae (Sykes 2016) (Figure 8).

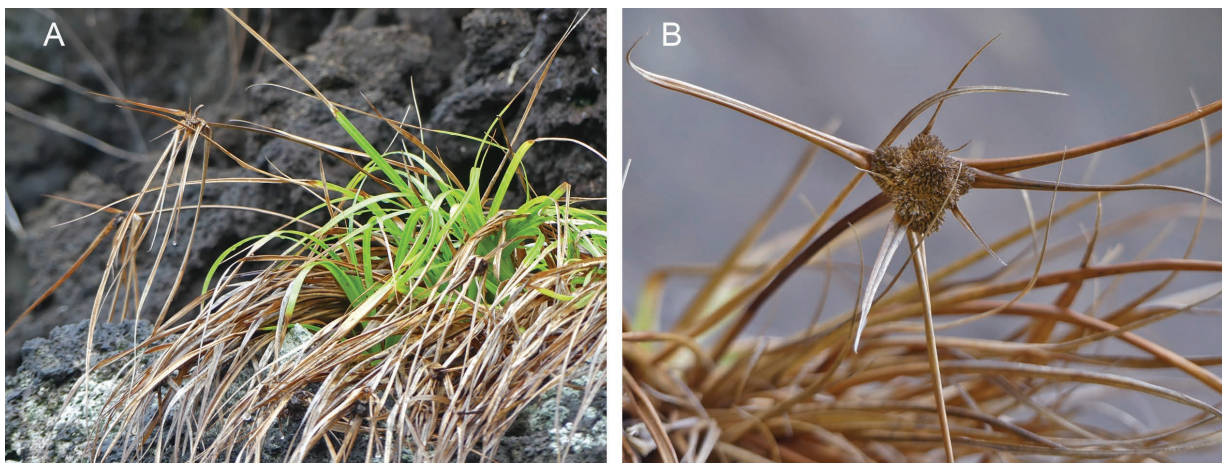


Fig. 8. *Cyperus rapensis*, Rapa Iti, French Polynesia. A: Plant habit. B: Mature infructescence. Photos: R. Taputuarai.

*Eleocharis geniculata* (L.) Roem. & Schult., *Syst. Veg.* 2: 150 (1817). *Scirpus geniculatus* L., *Sp. Pl.* 1: 48 (1753).

Type: Jamaica: Herb. Clifford 21, *Scirpus* 1 (lecto: BM 000557653), designated by Furtado, *Gard. Bull. Straits Settlement.* 9: 299 (1937).

=*Eleocharis caribaea* S.F.Blake var. *stokesii* F.Br., *Bull. Bernice P. Bishop Mus.* 84: 106, pl. XIV b (1931).

Type: French Polynesia, Austral Islands, Rapa, 14 September 1921, *J.F.G.Stokes* 180 (holo: BISH 1001227\*).

Plants described as *Eleocharis caribaea* var. *stokesii* are not considered distinct from the widespread tropical species *E. geniculata*, the type collection merely being a slightly depauperate form. Brown (1931) did not explicitly state why he considered the variety to differ from typical *E. caribaea* (Rottb.) S.F.Blake (= *E. geniculata*) and we can find no clear morphological distinction. In coastal marshes on Rapa Iti.

***Gahnia aspera*** (R.Br.) Spreng., *Syst. Veg.* 2: 114 (1825); *Lamprocarya aspera* R.Br., *Prodr.* 238 (1810); *Cladium asperum* F.Muell., *Fragm.* 9: 12 (1875); *Mariscus asper* (R.Br.) Kuntze, *Revis. Gen. Pl.* 2: 755 (1891), *nom. illeg.*

Type: New South Wales: Port Jackson, 1802, R.Brown [Bennett No. 6061] (lectotype (here designated): BM000991120; isolecto: BM000991121).



**Fig. 9.** *Gahnia aspera*, Rapa Iti, French Polynesia. A: Plant habit. B: Mature infructescence. C: Infructescence with mature fruit. Photos: A, B: R. Taputuarai. C: J.-Y. Meyer.

Residual syntypes: Australia: 1770, *J.Banks & D.C.Solander s.n.* (syn: BM000991123, BM000991124); from Port Curtis (Port 1) to Broad Sound, 1802, *R.Brown s.n.* (syn: BM00099119, BM0009922).

=*Gahnia stokesii* F.Br., *Bernice P. Bishop Mus. Bull.* 84: 113, pl. XIV a (1931).

Type: French Polynesia: Austral Islands, Raivavae, Mount Taraia, alt. 274 m, 10 March 1922, *J.F.G.Stokes 38* (holo: BISH 1001234\*).

*Gahnia stokesii* was described as a new species from Raivavae and Rapa Iti, but it clearly belongs to the widespread *G. aspera* complex. Further study is required across the range of *G. aspera* subsp. *aspera* s. lat. before any segregate taxa can be justified and we include *G. stokesii* within *G. aspera* subsp. *aspera*, a taxon which has dispersed widely across the western Pacific from Australia. We consider it common on Rapa Iti, from the seashore, to plains and ridges, with some plants extending to the summit of the peaks (Figure 9).

*Rhynchospora stokesii* F.Br., *Bull. Bernice P. Bishop Mus.* 84: 109 (1931). *Rhynchospora sclerioides* var. *stokesii* (F.Br.) Kük., *Bot. Jahrb. Syst.* 74: 505 (1949).

Type: French Polynesia, Austral Islands, Rapa, Pariati, between Kapitanga and Kalele, on side of ridge, 280 m alt., 19 October 1921, *J.F.G.Stokes 362* (holo: BISH 1001249\*; iso: BISH 1001250\*).

=*Rhynchospora stokesii* forma *saxicola* F.Br., *Bull. Bernice P. Bishop Mus.* 84: 110 (1931).

Type: French Polynesia, Austral Islands, Rapa, Nukumaala, on face of cliff, by waterfall, 70 m alt., 21 September 1921, *J.F.G.Stokes 264* (holo: BISH 1001251\*; BISH 1001252\*).

On slopes in remnant vegetation on Rapa Iti. (Figure 10). Brown (1931) described this as merely a ‘dwarf form’ and we consider this morphological reduction to be entirely due to the exposed habitat of the type specimen, with no taxonomic significance.

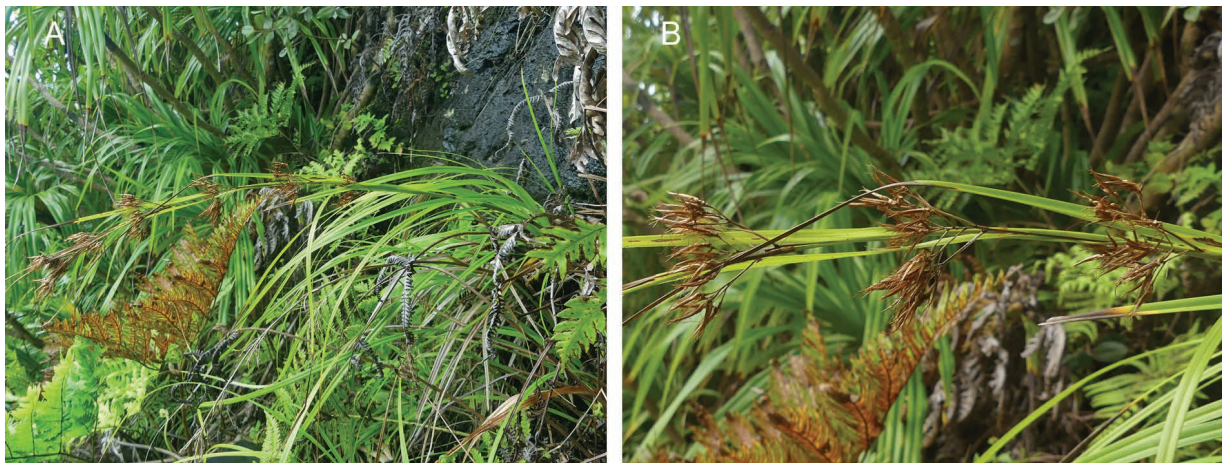


Fig. 10. *Rhynchospora stokesii*, Rapa Iti, French Polynesia. A: Plant habit. B: Mature infructescence. Photos: R. Taputuarai.

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