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Systematics and relationships of *Tryssophyton* (Melastomataceae), with a second species from the Pakaraima Mountains of Guyana

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Abstract

The systematics of *Tryssophyton*, herbs endemic to the Pakaraima Mountains of western Guyana, is reviewed and *Tryssophyton quadrifolius* K.Wurdack & Michelang., **sp. nov.** from the summit of Kamakusa Mountain is described as the second species in the genus. The new species is distinguished from its closest relative, *Tryssophyton merumense*, by striking vegetative differences, including number of leaves per stem and leaf architecture. A phylogenetic analysis of sequence data from three plastid loci and Melastomataceae-wide taxon sampling is presented. The two species of *Tryssophyton* are recovered as monophyletic and associated with mostly Old World tribe Sonerileae. Fruit, seed and leaf morphology are described for the first time, biogeography is discussed and both species are illustrated.

Keywords

Guyana, leaf anatomy, Melastomataceae, molecular phylogeny, seeds, Sonerileae

Introduction

The flora of Guyana contains about 290 taxa of Melastomataceae in 40 genera, including three small endemic genera, *Maguireanthus* Wurdack, *Ochthephilus* Wurdack and *Tryssophyton* Wurdack (Wurdack 1993, Funk et al. 2007). These endemics are poorly known herbs from wet slope-forests in the Pakaraima Mountains, a region that is rich

in Guiana Shield biota. *Boyania* Wurdack had been an additional Pakaraima Mountains endemic genus, based on *B. ayangannae* Wurdack, until a second species (*B. colombiana* Humberto Mend.) was unexpectedly discovered in Colombia (Mendoza-Cifuentes 2010). *Tryssophyton* was described in 1964 by John Wurdack as a very distinct monotypic genus that he assigned to tribe Bertolonieae. As a small, rhizomatous herb with a single stem crowned by a cluster of 10–16 narrow leaves, it vegetatively presents an atypical melastome, even amongst the highly variable, mostly herbaceous Bertolonieae. However, Bertolonieae, as traditionally circumscribed (i.e. sensu lato), has been shown to be polyphyletic with genera formerly assigned to it resolved within the Merianieae and two other distinct clades (Michelangeli et al. 2011, Goldenberg et al. 2015). The tribe has been recently narrowly circumscribed to contain only *Bertolonia* Raddi (Bacci et al. 2019).

Tryssophyton has been little studied since its description and collections have remained few. A 2012 expedition in the Pakaraima Mountains to reach the botanically unexplored ca. 1700 m summit of Kamakusa Mountain yielded new collections of the type species, *T. merumense* Wurdack, at lower elevations and a novel new species at the summit, which is described herein. We also provide further observations on the morphology and relationships of both species. Kamakusa Mountain and its vicinity at the wet, eastern edge of the Pakaraima Mountains have yielded many new plant taxa from the two expeditions (1960, 2012) that have traversed this remote region and it deserves further scientific exploration (Wurdack et al. 2013, Wurdack 2017).

Materials and methods

In order to ascertain the phylogenetic position of both species of *Tryssophyton*, we sequenced plastid *rbcL* and/or *ndhF* following protocols and primers used in previous broad studies of the Melastomataceae (i.e. Clausing and Renner 2001, Michelangeli et al. 2011, 2014, Goldenberg et al. 2012, 2015). These data were analysed in the context of a family-wide taxon sampling for three plastid loci, *ndhF*, *rbcL* and *rpl16* (last locus treated as missing data for *Tryssophyton*) that included six representatives of other families of Myrtales as outgroups (see Appendix 1). All other sequences were obtained from GenBank (https://www.ncbi.nlm.nih.gov/genbank/) and mostly published in previous studies (Clausing and Renner 2001, Michelangeli et al. 2011, 2014, Goldenberg et al. 2012, 2015, Zeng et al. 2016), although a few have not been previously cited. Contigs were assembled in Geneious ver. 11 (http://www.geneious.com, Kearse et al. 2012) and alignments were performed with MUSCLE (Edgar 2004) as implemented through the Geneious plugin with the following parameters: maximum trees to build 20, optimal and diagonal optimisations on, anchor spacing 32 and minimum length of 24. The loci were analysed separately for quality control and then as a concatenated 3-locus analysis with no character exclusion sets. A maximum likelihood (ML) analysis was performed with RAxML ver. 8 (Stamatakis 2014) as implemented on CIPRES XSEDE (https://www.phylo.org/) with each locus as a separate partition. Clade support was estimated by bootstrap percentages (BP) using the same search conditions on 1000 ML replicates.

Scanning electron microscopy (SEM) used a Zeiss EVO MA15 (Carl Zeiss SMT, Inc., Peabody, Massachusetts) at 6–12 kV after sputter-coating herbarium specimen seeds or critical point dried (CPD) field-fixed (in ethanol) leaves with 25 nm of C + Au/Pd using a Leica EM ACE600 (Leica Microsystems GmbH, Wetzlar, Germany). Leaves were examined for venation after clearing in ethanol or 2.5% sodium hydroxide. For internal structure, they were hand cut for SEM or, for light microscopy (LM), they were paraffin-embedded, sectioned at 10 μm, stained with toluidine blue O and examined with a Zeiss Universal Compound Microscope. The anatomy of the delicate leaves was more intact with CPD and SEM than after traditional thin sectioning from the same starting material, thus our observations are largely based on SEM.

Phylogenetic results

Melastomataceae are resolved as a strongly supported (BP 100) family with mixed backbone support, which of relevance here was notably weak (BP 60 or less) amongst the deepest nodes of Sonerileae (Fig. 1). Both species of *Tryssophyton* form a strongly supported clade (BP 93) that is weakly resolved (BP 65) with African *Calvoa* near the base of the Sonerileae-Dissochaeteae complex (sensu Renner et al. 2001). *Boyania* is weakly supported (BP 60) as the earliest diverging member of Sonerileae. Marcetieae are sister to Melastomateae and distant from *Tryssophyton*.

Taxonomic treatment

***Tryssophyton quadrifolius* K.Wurdack & Michelang., sp. nov.**
urn:lsid:ipni.org:names:77203430-1
Figure 2

Diagnosis. Differs from *Tryssophyton merumense* in 4-verticillate, ovate, petiolate leaves, versus 10–16 verticillate, oblanceolate-lanceolate, subsessile leaves.

Type. Guyana. Cuyuni-Mazaruni Region: Summit of Kamakusa Mtn. (i.e. on top of 4th escarpment of four); impenetrable elfin forest to 3 m, extremely dense and wet, rich in epiphytes, with *Bonnetia* (2 spp.), *Brocchinia* cf. *tatei*, Malpighiaceae, Melastomataceae, Cyperaceae spp., *Weinmannia*, *Ilex* cf. *retusa*, 5°52'50.9"N, 60°6'11.7"W, 1691 m elev., 8 June 2012 (fl.), *K. Wurdack 5865* with E. Tripp, A. Radosavljevic, and J. Ralph (holotype: BRG!, isotype: US-3731242!).

Description. ***Habit*** perennial, rhizomatous herbs; rhizomes persistent, fleshy, horizontal, to 10 cm long, 3–6 mm diam., rarely branched, bearing 1–2 leafy, erect, aerial stems per axis and older cup-shaped (collar to 0.3 mm high and centre sunken) aerial stem scars; adventitious roots fine, fibrous. ***Indument*** sparse on aerial stems, leaves, pedicels, hypanthium and sepal margins; trichomes simple, to 0.1 mm long, glandular, reddish. ***Aerial stems*** 8.5–11.5 cm tall, 0.9–2 mm diam., terete, purple, slightly flared

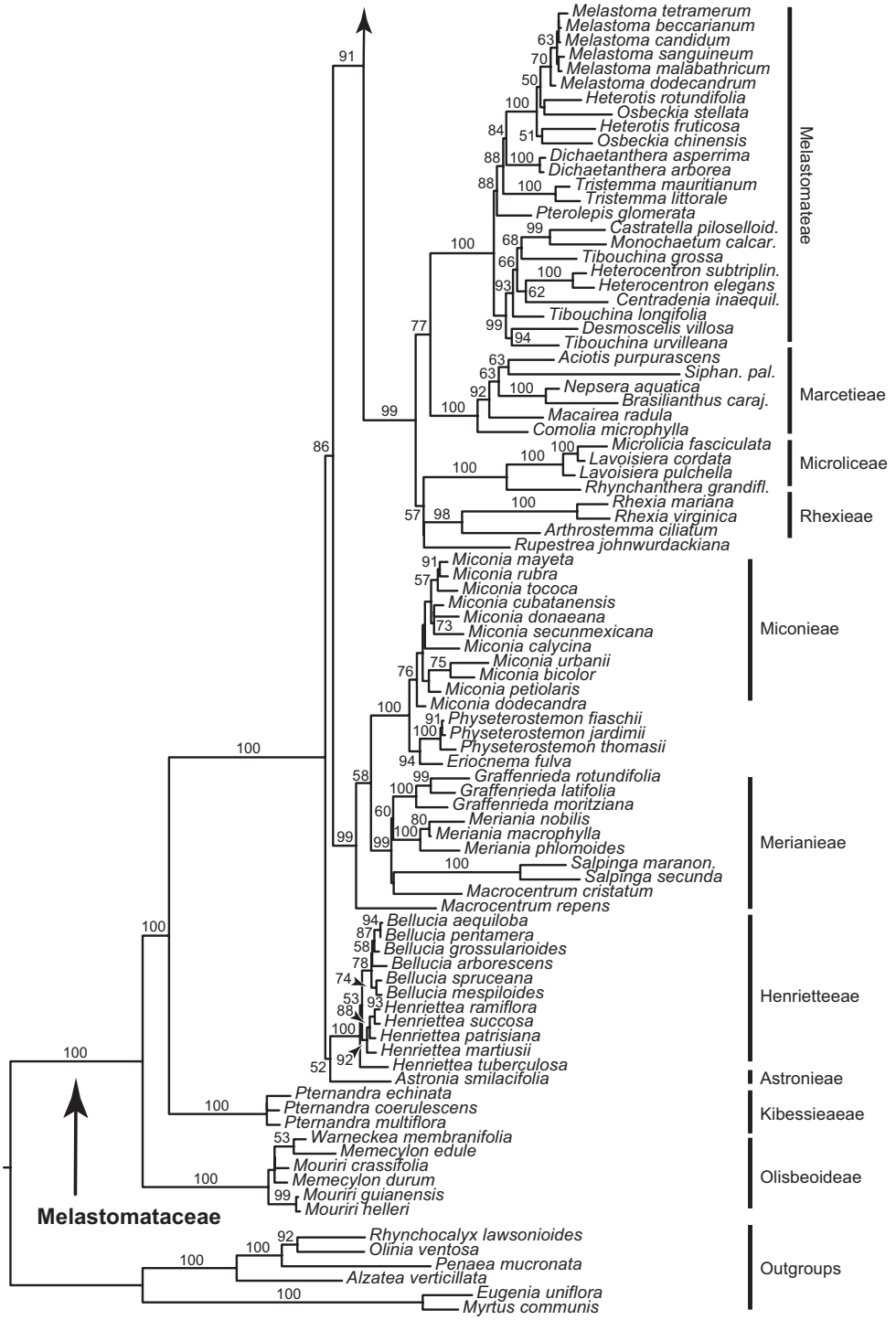

Figure 1. Relationships of *Tryssophyton* in a 3-locus phylogeny of Melastomataceae. Maximum likelihood tree with bootstrap support values based on analysis of plastid *ndhF*, *rbcL* and *rpl16* data.

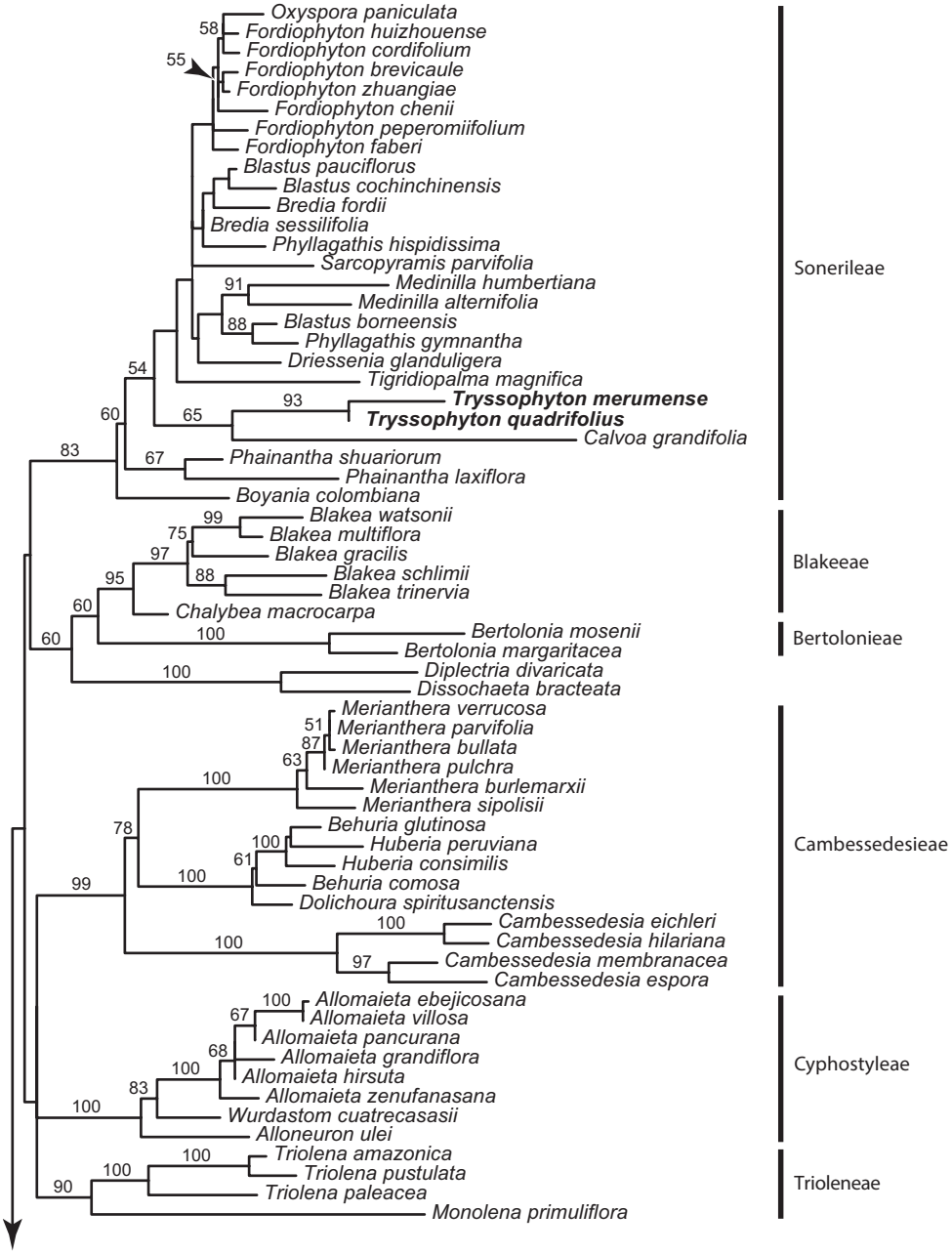

Figure 1. Continued.

at rhizome attachment, summit with cluster of leaves and often 1 secondary branch 1–2 cm long and crowned by another cluster of leaves. ***Leaves*** 4-verticillate, opposite pairs sub-equal in size, simple, petiolate, exstipulate; petioles 2–5 mm long (of slightly subequal length within whorl), ca. 1 mm diam.; lamina 2.1–5.2 × 1.0–1.9 cm, length:width ratio 2.2–3.7:1 (mean = 3.0, SD = 0.50, *n* = 11), symmetrical, ovate to lanceolate, membranous, apex acuminate, base cuneate, margin minutely serrate, with 6–12 teeth per side (2–5 teeth/cm); teeth 0.5–0.9 × 0.1 mm, first-order, spacing regular, projecting 0.2–0.3 mm from margin, sinus shape rounded, distal flank concave and proximal flank straight, apex long-attenuate; leaf tip with 1–3(13) adaxial scales, 0.6–1 × 0.1 mm, similar to attenuate teeth apices. ***Venation*** suprabasal acrodromous, with one pair of major (costal) secondaries 1/2 of the gauge of the midvein, joining the midvein 0.5–1 mm above the leaf base; and one pair of intramarginal secondaries < 1/3 of the gauge of the midvein (poorly defined from tertiary thickness), joining < 0.5 mm from base, traversing 0.2–0.8 mm from margin, distally fading into exterior tertiary loops; up to 12 interior tertiary veins per side, quaternaries random reticulate. ***Inflorescence*** terminal, pedunculate, bearing 1–4 flowers; peduncle 2.2–2.6 cm long, 0.5–0.7 mm diam. mid-length, terete, flaring at base, purple; bracts persistent, lanceolate, 1–1.3 × 0.3–0.4 mm, apex apiculate, margin entire. ***Flowers*** 4-merous, bisexual, pedicellate; pedicels 8.5–11.5 mm long, 0.4–0.6 mm diam. mid-length, terete, purple; hypanthium at anthesis ca. 2.5 mm × 2–2.5 mm (excluding calyx), campanulate, obscurely costate with thin ribs; calyx lobes 4, in bud narrowly triangular, ascending, protective of young corolla, at anthesis spreading, 0.8–1 mm tall, broadly triangular above short calyx tube ca. 0.4 mm high; petals ca. 9.5 × 5 mm, margins entire, in vivo red outside and pink inside. ***Stamens*** 8, incurved in bud with tips extending into hypanthium below point of filament attachment, slightly anisomorphic, with the antesepalous whorl larger than the antepetalous, glabrous; filaments 5–6 (antesepalous) or 4 (antepetalous) mm long, 0.2 mm diam., linear, pink in vivo; thecae 4.5 or 3.5 mm long, basifixed, connective basally prolonged, dilated below thecae, forming a thickened annulus that is more or less ventrally bilobate, thickening 0.8 or 0.5–0.6 mm diam., yellow in vivo; anther 0.1–0.2 mm wide at terminal pore. ***Ovary*** superior, ca. 1.8 × 1.3–1.5 mm, glabrous. ***Style*** ca. 10 mm long, 0.2 mm diam., curved, glabrous; stigma punctiform, minutely papillose. ***Capsule*** ovate, ca. 3 × 3.5 mm, crowned by persistent calyx. ***Seeds*** ovoid, ca. 0.7 × 0.4 mm (immature and partly collapsed), sparsely papillose, brown.

Etymology. The specific epithet is derived from *quadri-* (Latin, four) and *folium* (Latin, leaf) and refers to the 4-verticillate leaves.

Distribution and ecology. *Tryssophyton quadrifolius* is only known from the summit of Kamakusa Mountain where it was encountered as an infrequent epiphyte on moss and lichen covered branches and trunks of large shrubs. Scattered small plants with single stems were observed sporadically along the main trail transect cut along the north-south orientated narrow summit. The few reproductive plants were in a more sheltered spot on the western edge of the summit on a branch trail that was cut to a cliff edge for a view. Flowers and young fruit were collected in June. The summit of Kamakusa Mountain is covered by low montane evergreen cloud forest, 3–4 m tall, with

Figure 2. Illustration of *Tryssophyton quadrifolius* (**A–G**) and *T. merumense* (**H, I**). **A** Habit (right view in flower) **B** young flower with anthers inflexed **C** flower with anthers erect and petals fallen **D** shorter antepetalous anther, dorsal **E** longer antesepalous anther, dorsal **F** longer anther, lateral **G** young fruit **H** habit **I** capsular, 3-merous fruit. Sources: **A–G** *Wurdack 5865* **H** *Radosavljevic 165* **I** *Wurdack 5870* (all US).

dense thickets dominated by *Bonnetia tepuiensis* Kobuski & Steyerm. and *B. roraimae* Oliv. (Bonnetiaceae), *Byrsonima pachypoda* W.R. Anderson (Malpighiaceae), *Miconia acutifolia* Ule and *M. silicicola* Gleason (Melastomataceae), *Raveniopsis microphyllus* K. Wurdack (Rutaceae) and species of *Weinmannia* L. (Cunoniaceae) on a peat substrate overlying sandstone. Vascular epiphytes included species of *Utricularia* L. (Lentibulariaceae), Bromeliaceae and Orchidaceae.

Conservation status. While the upper part of Kamakusa Mountain is presently pristine and undisturbed, the new species is a delicate epiphytic herb with few reproductive plants (2 of 15 aerial stems collected had buds, flowers and/or fruit) in an area of extremely limited montane habitat. The species is vulnerable to climate and land use changes, such as regional gold mining (see Wurdack 2017). Following the criteria and categories of IUCN (2012, 2019) and similar to the recently described Kamakusa endemic *Raveniopsis microphyllus*, *Tryssophyton quadrifolius* is given a preliminary status of Critically Endangered (CR) under geographic range criteria B1 (extent of occurrence < 100 km^2 (B1) and area of occupancy < 10 km^2 (B2a, number of locations =1; B2b, continuing decline projected).

Tryssophyton merumense Wurdack, Mem. New York Bot. Gard. 10: 155. 1964.

Type. Guyana. Cuyuni-Mazaruni Region, Partang River, Merume Mtns., Merume Mt.; common on mossy logs in forest, 1140 m elev., 4 Jul 1960 (fl., fr.), *S.S. Tillett*, *C.L. Tillett*, *& R. Boyan 43988* (holotype: US-2343844!; isotypes: K-000329332!, NY-00245868!).

It should be noted that both the US and NY sheets are each marked as the holotype. However, the protologue clearly states that the US specimen is the holotype, even citing the sheet number and has that designation in J. Wurdack's handwriting. The NY sheet has "holotype" merely typed on the label. Thus, there is no need to lectotypify this name and the NY specimen should be considered as an isotype.

Etymology. The genus is combined from *tryssos* (Greek, dainty or delicate) and *phyton* (Greek, plant) and refers to the plant habit. The specific epithet refers to Merume Mountain where the type was collected.

Additional collections examined. Guyana. Cuyuni-Mazaruni Region: Pakaraima Mountains, upper Karowrieng River at Maipuri Falls; mixed bryophyte, pteridophyte, herb community; sandstone boulders, white sand, large cave behind falls, 5°41'N, 60°13'W, 575–600 m elev., 13 Oct 1992 (fl.), *B. Hoffmann 2939* (NY!, US!). 2nd and 3rd escarpments (of four) of Kamakusa Mt., upper west-facing slopes below summit, rich forest with *Licania*, Ebenaceae, tree ferns, Arecaceae, 5°52'55.2"N, 60°6'34.5"W, 1330 m elev., 8 June 2012 (fl., fr.), *K. Wurdack 5870* (US!). Potaro-Siparuni Region: Mt. Wokomung, easternmost pinnacle of massif, scrub forest on sandstone and peat, with *Guadua*, *Euterpe*, and *Sphagnum*, 5°5'34.4"N, 59°50'13.3"W, 1524 m elev., 13 Jul 2003 (fl.), *H.D. Clarke 10822* (NY!, US!). Mt. Ayanganna, east slope, plateau above second escarpment, growing on mossy tree trunks and roots, 5°22'28"N, 59°58'06"W, 1340 m elev., 16 Mar 2014 (fl.), *A. Radosavljevic 165* (US!).

Distribution and ecology. The five collections of *T. merumense* span a 90 km section of the central Pakaraima Mountains, but further exploration is likely to expand its range into similar habitats. The species was only recently discovered (*Radosavljevic 165*) on the slopes of relatively well-explored Mount Ayanganna, the highest mountain (2041 m) wholly within Guyana. At mid-elevations on the western slopes of Kamakusa Mountain, it occurred (*Wurdack 5870*) as scattered, rarely-reproductive individuals on rotting logs and peaty-humus zones around the bases of trees.

The mountainous area north of the village of Imbaimadai and including Kamakusa Mountain has been variously mapped as the Merume Mountains. However, exactly what corresponds to the peak "Merume Mountain" within the region and indicated as the type locality of *T. merumense*, is unclear. Field notes (Bassett Maguire Field Collections, vol. 19, Archives of The New York Botanical Garden) reveal that during 11 Jun–16 Jul 1960, after leaving Imbaimadai, the collecting team, led by Stephen Tillett entered the Kamakusa Mountain area from along the Partang River. After reaching Partang Falls, they ascended into the uplands following existing trails, which were probably made by gold-miners or "pork-knockers." It is likely that "Merume Mountain" of Tillett et al. is equivalent to Kamakusa Mountain, but details referring to lower elevations, southeast ridge, southeast side and cliffs do not indicate they reached summit where *T. quadrifolius* was collected.

Discussion

The broader relationships which we recovered within Melastomataceae largely agree with those from prior studies using the underlying sequence data (i.e. Clausing and Renner 2001, Michelangeli et al. 2011, 2014, Goldenberg et al. 2012, 2015, Zeng et al. 2016, Bacci et al. 2019). *Tryssophyton* is clearly monophyletic and a member of the Sonerileae-Dissochateae complex, although a sister-relationship with *Calvoa* Hook. f. has low support and resolution within the tribe is also poor. A weaker (BP < 50) placement with *Calvoa* was recently reported for *T. merumense*, based on ITS data (Bacci et al. 2019). *Calvoa* is a tropical African genus containing about 19 species of herbs to small, woody shrubs (Jacques-Félix 1981, Figueiredo 2001). *Calvoa* has funnelform and costate hypanthia that develop into apically dehiscent capsules and are features common to most genera that have been assigned to the Bertolonieae + Sonerileae (Renner 1993, Bacci et al. 2019). However, the staminal morphology of *Calvoa* with short pedoconnectives and dorsal appendages (Jacques-Félix 1981) does not resemble that of *Tryssophyton*. *Sarcopyramis* Wall. (not sampled here; see Bacci et al. 2019), a southeast Asian genus of one morphologically variable (*S. napalensis* Wall., sensu lato; Hansen 1978) or multiple species of herbs was found by Bacci et al. (2019) to also belong to this clade and is similar to *Calvoa* in details of stamen morphology and long-papillose stigmas.

The more robust placement of *Tryssophyton* within Sonerileae has clearer implications for taxonomy and historical biogeography. When originally describing *Tryssophyton*, J. Wurdack (1964) placed it in Bertolonieae, presumably based on its herbaceous habit and

fruit morphology, but he also compared it to Asian and African members of the Sonerileae as possible relatives. Bertolonieae has been shown as widely polyphyletic (Bacci et al. 2019). Wurdack (1964) also compared the stamens of *Tryssophyton* to those of *Marcetia* DC., due to their elongated shape and lack of pedoconnectives or appendages. *Marcetia* (not sampled here but clearly affiliated with other genera included in the Marcetieae; see Rocha et al. 2016, 2018) is not related to *Tryssophyton* and its seed morphology is markedly different in being cochleate and large-tuberculate (Rocha et al. 2018: fig. 7T).

The great majority of the species in the Sonerileae-Dissochaeteae complex are found in the Old World. The exceptions are *Tryssophyton* and the Neotropical genera *Boyania* and *Phainantha*, resolved as successive branches, with poor support, at the base of the clade. *Boyania* contains two trailing (stoloniferous) or climbing herbaceous species with disjunct distributions. One of them, *Boyania ayangannae*, also grows in the same region as *Tryssophyton*, while the second species, *Boyania colombiana*, is restricted to the easternmost slopes of the Colombian Andes (Mendoza-Cifuentes 2010). *Boyania* was also initially placed in the Bertolonieae, based on habit and fruit and anther morphology, but J. Wurdack remarked that, given its 5-locular ovaries, it was intermediate between New World Bertolonieae and Old World Sonerileae. Recent phylogenetic evidence has suggested that *Boyania* may not be monophyletic (Bacci et al. 2019), although both species are morphologically similar. *Phainantha* contains five mostly climbing woody species (trailing herb in *P. steyermarkii* Wurdack), four of which are found in the Guiana Shield and one in southern Ecuador from the Cordillera del Condor which has phytogeographic ties with the Guiana Shield (Wurdack 1993, Berry et al. 2001, Ulloa Ulloa and Neill 2006). *Phainantha* was initially unplaced when described by Gleason (1948) due to lack of seeds and subsequently Renner (1993) placed it with Merianieae in her family-wide morphological analysis of the Melastomataceae. The character evolution and biogeography implications with the resolution of these three neotropical genera at or near the base of the Sonerileae-Dissochaeteae complex are important for understanding the evolution of the entire clade. For example, there are notable differences in merosity; *Phainantha*, *Sarcopyramis* and *Tryssophyton* are 4-merous and *Boyania* and *Calvoa* are 5-merous. The support for the early-diverging nodes of this clade is presently poor and the taxonomic and geographical sampling is too small for firm conclusions. However, if this topology holds with increased sampling of taxa and genetic loci, it would suggest that the mostly Asian Sonerileae-Dissochaeteae complex originated in South America and then dispersed to Africa and later to Asia where it diversified. A similar pattern has been found to the Melastomateae (Michelangeli et al. 2013, Veranso-Libalah et al. 2017). Recent phylogenetic studies of the Sonerileae-Dissochaeteae complex have already shown that most genera are not monophyletic and the group needs considerable further study (Zeng et al. 2016, Zhou et al. 2019a, 2019b).

Morphology of *Tryssophyton*

Although reproductive features (flowers and fruit) and overall habit (rhizomatous herbs) are nearly identical between the two species, *Tryssophyton quadrifolius* is vegetatively

easily distinguished by fewer leaves per stem and differences in leaf architecture (see Diagnosis; Figs 2, 3). Both species have short stems (6.5–11.5 cm tall), which are each crowned with a cluster of leaves; they sometimes possess additional leaf sets topping 1–5 shorter (1.5–3.5 cm tall) secondary branches arising from the first crown. This pattern of reiteration with secondary branches crowned by leaves has not been previously reported for *T. merumense*; it is not seen on the holotype but occurs on some plants in all other collections. In *T. quadrifolius*, each leaf cluster is comprised of two decussate pairs of opposite leaves that are nearly superposed so as to appear 4-verticillate. In *T. merumense*, the 10–16 leaves of varying sizes form a tight verticillate-like cluster and is likely a spiral decussate arrangement of multiple, nearly superposed leaf pairs. The rows (parastichies) of leaf attachment scars apparently form genetic spirals (Fig. 3K) and self-shading is largely absent (Fig. 3A, B). *Tryssophyton quadrifolius* resembles a typical melastome with regard to leaf form while *T. merumense* deviates with its narrow leaves, which have juvenile aspects of young leaves before full expansion. The leaves of *T. merumense* have been described as sessile (Wurdack 1964, 1993). The laminar base is finely tapering (attenuate) and decurrent, obscuring any defined petiole which is in marked contrast with *T. quadrifolius* where the petiole is well defined from the cuneate base. The venation of *T. quadrifolius* is suprabasal acrodromous with two sets of lateral major veins including a pair of costal secondaries diverging clearly above the leaf base and a pair of thinner intramarginal secondaries diverging closer to the base (Fig. 3E). It has well-developed higher order veins including tertiaries connecting the major veins and a ramified quaternary vein network and has simple teeth partly penetrated by a thickened principal vein (Fig. 3F). The venation of *T. merumense* is acrodromous with only a single pair of lateral major veins that traverse the attenuate leaf base (i.e. not suprabasal) through the length of the leaf and sparse higher order veins (Fig. 3H). The teeth (Fig. 3I, J) are similar, but shorter and the thickening of their principal vein is more pronounced than in *T. quadrifolius*. *Boyania*, *Calvoa* and *Sarcopyramis* usually have two pairs of lateral major veins (prominent costal and thinner intramarginal secondaries) that begin at the leaf base. *Phainantha* is more diverse with variation in costal secondary vein position relative to the margin and often well-developed intramarginal veins. In *Phainantha shuariorum* C. Ulloa & D.A. Neill (*Palacios et al. 8565*, US), the costal veins are so close to the margins so as to appear nearly marginal; however a narrow pair of intramarginal veins remains along the lower edges before distally merging with the adjacent costal veins.

While both *Tryssophyton* species grow on Kamakusa Mountain, they do not appear to be sympatric (K. Wurdack, personal observation) and their local habitats differ in elevation, exposure and vegetation type. *Tryssophyton quadrifolius* would appear poorly adapted from an ecophysiology perspective as a summit endemic, with relatively large thin leaves, compared with much of the associated montane vegetation which has reduced sclerophyllous and/or coriaceous physiognomies as adaptations to cold and exposure (see Wurdack 2017). It is fundamentally terrestrial in nature with very similar rhizome and root morphologies to *T. merumense* and the observed epiphytism is likely opportunistic (i.e. a facultative epiphyte) in a very wet, dense-shrub habitat with sparse herbaceous understorey. The delicate leaf of *T. merumense* in transverse view shows dorsiventral differentiation and consists of a lamina up to six layers thick, organised as a

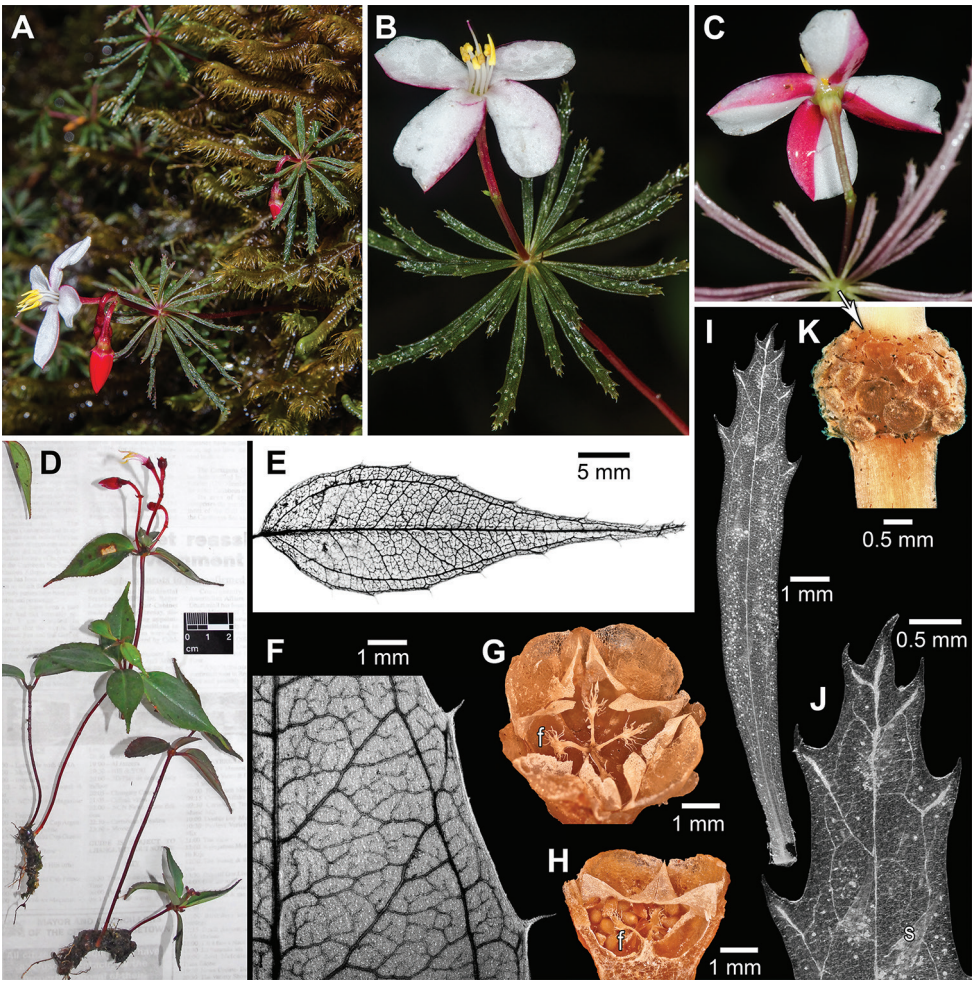

Figure 3. Macromorphology of *Tryssophyton merumense* (**A–C, G–K**) and *T. quadrifolius* (**D–F**). **A** habit, growing with bryophytes and downward pointing red buds **B** flowering plant, adaxial **C** Flowering plant showing bicoloured petals, abaxial **D** part of type collection in vivo just before pressing **E** whole leaf venation, abaxial **F** venation close-up showing major veins and reticulate quaternaries, abaxial **G** Dehisced 4-merous fruit, with interior persistent fimbriate placenta remnants (f), axial (tips of 8 triangular valves partly broken) **H** fruit, with seeds, fimbriae (f) and carpel septa, transverse view **I** whole leaf venation and crystal druses (white spots), adaxial **J** close-up of leaf tip with marginal teeth and non-vascularised scales (s), adaxial **K** phyllotactic arrangement with leaf attachment scars surrounded by darkened glandular trichomes, lateral view with main stem at bottom, peduncle at top. Sources: **A–C, I–K** *Radosavljevic 165* **D–F** *Wurdack 5865* **G, H** *Wurdack 5870* (all US).

single epidermal layer of thin-walled cells lacking thickened cuticles (adaxial epidermal layer of larger cells than the abaxial layer), a single layer of elongate tapered palisade parenchyma cells, rich in plastids and having considerable intercellular space towards their abaxial ends and a spongy parenchyma layer 2–3 cells thick (Fig. 4C, F). Sto-

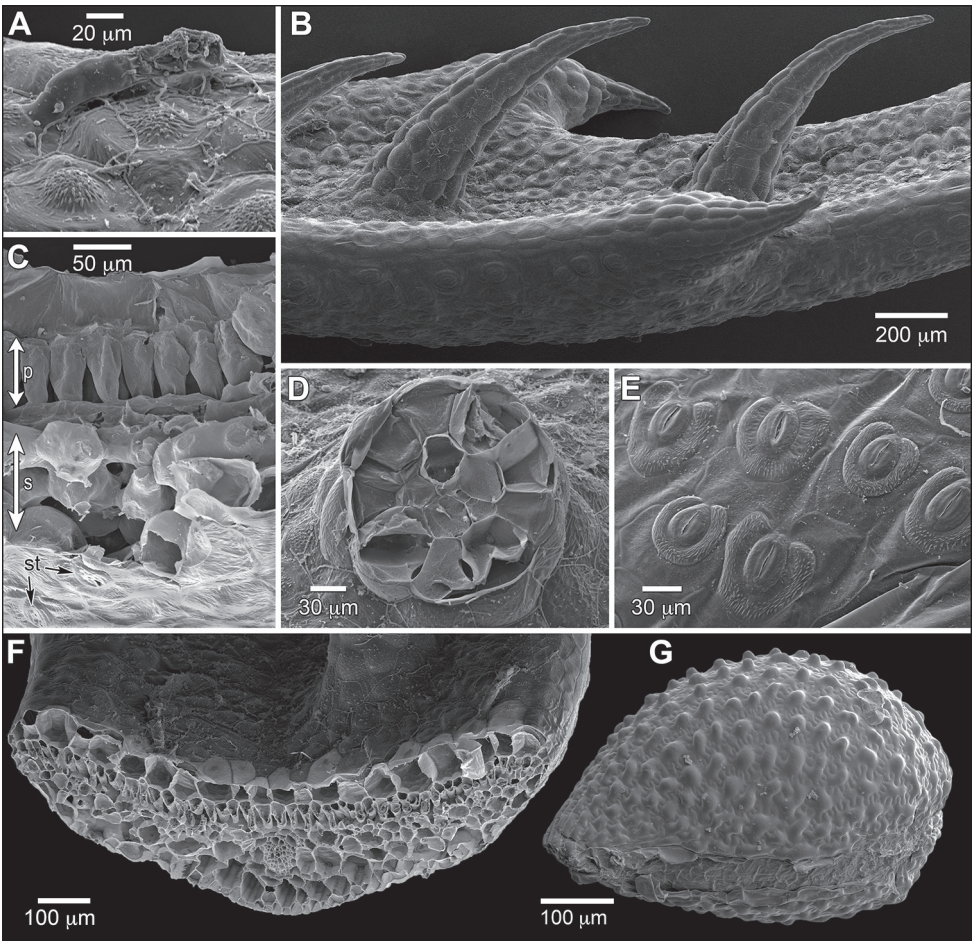

Figure 4. Micromorphology of *Tryssophyton merumense*. **A** Leaf glandular trichome, adaxial **B** leaf with marginal teeth, erect adaxial scales and glandular trichomes, lateral view of distal part **C** leaf, with single file palisade parenchyma (p), loose spongy parenchyma (s) and stomata (st) beneath intercellular spaces, close-up of transverse view **D** leaf scale, transverse view near adaxial scale base **E** stomata, abaxial **F** leaf, transverse view **G** seed, lateral view with raphal zone near bottom. Sources: **A–F** *Radosavljevic 165* **G** *Wurdack 5870* (all US).

mata of the paracytic type are confined to the relatively smooth abaxial side (Fig. 4E) and large crystal druses occur occasionally in the mesophyll. The leaf ornamentation consists of short-stalked glandular trichomes (sensu classification of Wurdack [1986], but not surveyed there; Fig. 4A) and sparse adaxial scales ("sparsely strigulose," according to Wurdack 1964, 1993), resembling erect horns that are typically collapsed in herbarium specimens (Fig. 4B, not collapsed due to CPD). These scales are 0.3–1 by 0.2 mm in size, loosely arranged in two files parallel to the midvein, multicellular, non-vascularised and have a rosette-like base of two undifferentiated cell layers (Figs 3J, 4B, D). While the scales and marginal teeth are superficially similar in form,

the slightly shorter, fatter teeth terminate principal veins that traverse halfway into the tooth (i.e. submarginal principal vein termination; Figs 3J, 4B). The thin leaves of *T. quadrifolius* were not examined in transverse view, but clearly possess many of the same features including paracytic stomata and crystal druses; surface ornamentation is similar but the scales are slightly larger and only occur sparsely at the leaf tip. The teeth apices are also more prolonged in *T. quadrifolius* (0.5–0.9 mm long) than *T. merumense* (0.2–0.3 [0.4] mm). Species of *Boyania*, *Calvoa* and *Phainantha* variously have similar glandular trichomes along with long simple trichomes, but not the scales. In addition, other taxa formerly placed in the Bertolonieae (e.g. *Salpinga peruviana* [Cogn.] Wurdack and *Sarcopyramis napalensis* Wall.) have glandular trichomes and/or scales.

Amongst reproductive features, the buds of both *Tryssophyton* species are red due to a pigmented layer of the outer (abaxial) exposed parts of the petals, which then open to reveal lighter inner surfaces. *Tryssophyton merumense* has white inner (adaxial) petal surfaces and filaments, leaving the exterior strikingly bicoloured where the petals overlapped in bud (giving them a distinctive "candy-cane" pattern) and were still evident on the holotype (Fig. 3A–C). *Tryssophyton quadrifolius* differs slightly in floral colour with petals that are pink on the adaxial surfaces and pink filaments (Fig. 3D). The fruits and seeds of *Tryssophyton* have not been described due to mature fruit previously lacking (Wurdack 1964, 1993). When originally described, *T. merumense* (Wurdack 1964) was reported as 4-locular and mature fruits were not known. With additional collections made afterwards, here we can report that the fruits of *Tryssophyton merumense* (*Wurdack 5870*, US) are of the angular capsule type and 3–4 locular. The mature capsule is ca. 3 mm tall by 3–5 mm wide on a thickened, tapering pedicel (totalling 15–18 mm long with capsule plus poorly differentiated pedicel), obscurely angular with twice as many ridges as locules (e.g. 6-sided if 3-locular), lacks a central column and crowned by stiff valves and short calyx lobes (Figs 2I, 3G, H). The valves are two per carpel (6 or 8 total per capsule), cartilaginous, 1.5 mm tall, triangular and attached at the capsule periphery such that the interior edges (septicidal and loculicidal splits) are free to flex for dispersal of the < 20 seeds loosely filling each locule. The fruit placenta remnants persist as basal-axillary clavate structures distally bearing fine fimbriae (Fig. 3G, H). Each fimbria is 0.2–0.4 mm long, terminated by a delicately attached seed and appears to consist of vasculature extending from the fruit placenta through a funiculus of uncertain length to the seed. At dehiscence, the erect fruit apex remains covered by the flexible valves.

Fruit and placenta morphology are remarkably diverse in Melastomataceae and phylogenetic evidence indicates complexity and homoplasy in fruit type evolution (Baumgratz 1983–1985, Clausing et al. 2000, Bacci et al. 2019). The broadly defined angular capsule fruit type, common in the Sonerileae-Dissochaeteae complex and many of its relatives, encompasses several distinct morphologies whose underlying developmental and structural differences are poorly understood. *Tryssophyton* presents its own fruit variant with the unusual features of basal-axile placentae, central column lacking and odd valves. Close relatives (i.e. *Calvoa orientalis* Taub., *J. Wurdack 2853*, US; *Phainantha laxiflora* (Triana) Gleason, *Henkel 1689*, US; *Sarcopyramis napalensis*, *Henry 13562c*, US) are mostly quite different, with axile placentae along a central column with

seeds subsessile or on distinct short funiculi and fimbriae lacking. *Boyania ayangannae* (*Henkel 147*, US) has more similarity with basal-axile fruit placentae, central column lacking and fimbriae present (funiculi to 0.1 mm, but fimbriae appearing longer due to frayed placental vasculature), although the overall fruit morphology differs in an apical glandular collar that lacks the stiff valves. In *Bertolonia*, the seeds are attached on long lateral placental branches of a usually distally-elaborated central column and have variable fimbriae that can be long (e.g. *B. acuminata* Gardner) or short to absent (e.g. *B. maculata* DC.) at dehiscence (see Baumgratz 1983–1985, 1989–1990). The long fimbriae – tips of a complex vascular skeleton – are also a combination of distally funicular and proximally placental origin and resemble those in *Tryssophyton*.

The seeds of *Tryssophyton merumense* are 0.6–0.7 by 0.4–0.5 mm, ovoid, lack appendages and are minutely papillose with sinuous interdigitating testa cell patterning (Fig. 4G). The seeds of *T. quadrifolius* appear similar (see Description), but were immature in one partly dissected young fruit. They fall within the variable "bertolonoid" type and most closely resemble the seeds of *Triolena* Naudin (Whiffin and Tomb 1972, Bacci et al. 2019: fig. 7).

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Appendix 1

Sources for plastid data used in the phylogenetic analysis of *Tryssophyton*. Ordered as: Taxon, Voucher (new data only), GenBank numbers for *ndhF*, *rbcL* and *rpl16*, respectively. Dash (-) indicates missing data, asterisk (*) indicates taxa that presently appear under a synonym in GenBank and **bold** indicates new data.

Outgroups: *Alzatea verticillata* Ruiz & Pav., AF215591, -, AY151598. *Eugenia uniflora* L., AF215592, AF294255, AF215627. *Myrtus communis* L., AF215593, AF294254, AF215628. *Olinia ventosa* (L.) Cufod., AF215594, AF215546, -. *Penaea mucronata* L., AF270756, AJ605090, AF222782. *Rhynchocalyx lawsonioides* Oliv., AF270757, AF215547, AF215631. Melastomataceae: *Aciotis purpurascens* (Aubl.) Triana, AF215561, -, AF322231. *Allomaieta ebejicosana* Lozano, JF831961, JF831986, JF832012. *Allomaieta grandiflora* Gleason, JF831962, JF831987, JF832013. *Allomaieta hirsuta* (Gleason) Lozano, JF831963, JF831988, JF832014. *Allomaieta pancurana* Lozano, JF831967, JF831993, JF832017. *Allomaieta villosa* (Gleason) Lozano, JF831969, JF831994, JF832019. *Allomaieta zenufanasana* Lozano, JF831970, JF831995, JF832020. *Alloneuron ulei* Pilg., JF831971, JF831996, JF832021. *Arthrostemma ciliatum* Pav. ex D.Don, AF215562, AF215522, AF215605. *Astronia smilacifolia* Triana ex C.B.Clarke, AF215549, -, AF215596. "*Behuria comosa* R.Tavares, Baumgratz & R.Goldenb.", JQ899111, JQ899084, JQ899060. *Behuria glutinosa* Cogn., JQ899112, JQ899085, JQ899061. *Bellucia aequiloba* Pilg., JF831972, JF831997, JF831997. *Bellucia arborescens* (Aubl.) Baill.*, EU711377, JQ626318, JF832035. *Bellucia grossularioides* (L.) Triana, EU711372, EU711385, JF832023.

Bellucia mespiloides (Miq.) J.F.Macbr.*, GU968822, KF781623, -. *Bellucia pentamera* Naudin, AF215578, KF781624, AF215615. *Bellucia spruceana* (Benth. ex Triana) J.F.Macbr.*, GU968823, KF781625, -. *Bertolonia margaritacea* Naudin*, JQ899130, AF215512, JQ899080. *Bertolonia mosenii* Cogn., JF831973, JF831998, JF832024. *Blakea gracilis* Hemsl., JF831974, JF831999, JF832025. *Blakea multiflora* D.Don*, JQ899132, JQ899107, JQ899082. *Blakea schlimii* (Naudin) Triana, EU711373, EU711386, JF832026. *Blakea trinervia* L., AF215555, AF215516, AF215600. *Blakea watsonii* (Cogn.) Penneys & Almeda, JQ899133, JQ899108, JQ899083. *Blastus borneensis* Cogn. ex Boerl., AF215585, -, AF215621. *Blastus cochinchinensis* Lour., KX066244, KP094575, KM521849. *Blastus pauciflorus* (Benth.) Guillaumin, KX066245, KP095022, KM521850. *Boyania colombiana* Humberto Mend., -, JQ899086, JQ899062. *Brasilianthus carajensis* Almeda & Michelang., KX765168, KX765169, KX765170. *Bredia fordii* (Hance) Diels, KT354883, KT354892, KM521851. *Bredia sessilifolia* H.L.Li, -, KP094838, -. *Calvoa grandifolia* Cogn., -, AY667151, AY660632. *Cambessedesia eichleri* Cogn., JQ899113, JQ899087, JQ899063. *Cambessedesia espora* (A.St.Hil. ex Bonpl.) DC., JQ899114, JQ899088, JQ899064. *Cambessedesia hilariana* (A.St.Hil. ex Bonpl.) DC., JQ899115, JQ899089, JQ899065. *Cambessedesia membranacea* Gardner, AY553782, -, AY553775. *Castratella piloselloides* (Bonpl.) Naudin, AY553783, AY553779, AY553774. *Centradenia inaequilateralis* (Schltdl. & Cham.) G.Don, AF215563, EU711387, AF215606. *Chalybea macrocarpa* (Uribe) Penneys & Morales-P, JQ899121, JQ899095, JQ899071. *Comolia microphylla* Benth., JF831975, JF832000, JF832028. *Desmoscelis villosa* (Aubl.) Naudin, EU711374, EU711389, JF832029. *Dichaetanthera arborea* Baker, AF272800, -, AF294470. *Dichaetanthera asperrima* Cogn., AF215564, AF215523, AF215607. *Diplectria divaricata* (Willd.) O.Ktze, AF215556, AF270746, AF215601. *Dissochaeta bracteata* (Jack) Blume, AF289369, -, AF294471. *Dolichoura spiritusanctensis* Brade, JQ899116, JQ899090, JQ899066. *Driessenia glanduligera* Stapf, AF215586, AF270749, AF215622. *Eriocnema fulva* Naudin, AY553781, AY553777, AY553772. *Fordiophyton brevicaule* C.Chen, KT354884, KT354893, KM521852. *Fordiophyton chenii* S.Jin Zeng & X.Y.Zhuang, KT354886, KT354895, KM521854. *Fordiophyton cordifolium* C.Y.Wu ex C.Chen, KT354885, KT354894, KM521853. *Fordiophyton faberi* Stapf, KU208089, KU208090, KM521855. *Fordiophyton huizhouense* S.Jin Zeng & X.Y.Zhuang, KT354887, KT354896, KM521856. *Fordiophyton peperomiifolium* (Oliv.) C.Hansen, KT354888, KT354897, KM521857. *Fordiophyton zhuangiae* S.Jin Zeng & G.D.Tang, KX066246, -, KX037425. *Graffenrieda latifolia* (Naudin) Triana, AM235411, AM235644, AM235447. *Graffenrieda moritziana* Triana, EU055944, EU711390, JF832031. *Graffenrieda rotundifolia* (Bonpl.) DC., AF215576, AF215532, AF215613. *Henriettea martiusii* (DC.) Naudin, EU711375, EU711391, JF832032. *Henriettea patrisiana* DC., JF831977, JF832002, JF832033. *Henriettea ramiflora* (Sw.) DC., GU968811, KF781627, -. *Henriettea succosa* (Aubl.) DC., GU968815, KF781628, -. *Henriettea tuberculosa* (Donn. Sm.) L.O.Williams*, GU968816, KF781629, -. *Heterocentron elegans* (Schltdl.) Kuntze, AF272804, AY456135, AF325926 *Heterocentron subtriplinervium* (Link & Otto) A.Braun &

C.D.Bouché, AF215566, AF270747, AF210374. *Heterotis fruticosa* (Brenan) Veranso-Libalah & G.Kadereit, AF272802, -, AF210377. *Heterotis rotundifolia* (Sm.) Jacq.-Fél., AF215565, U26323, AF270745. *Huberia consimilis* Baumgratz, JQ899117, JQ899091, JQ899067. *Huberia peruviana* Cogn., JQ899118, JQ899092, JQ899068. *Lavoisiera cordata* Cogn., AF215582, AF215540, AF210371. *Lavoisiera pulchella* Cham., EU711376, EU711392, JF832034. *Macairea radula* (Bonpl.) DC., EU711378, EU711394, JF832036. *Macrocentrum cristatum* (DC.) Triana, AM235412, AM235645, AM235448. *Macrocentrum repens* (Gleason) Wurdack, AF215551, AF215513, AF215598. *Medinilla alternifolia* Blume, AF289374, -, AF322229. *Medinilla humbertiana* H. Perrier, AF215557, AF215517, AF215602. *Melastoma beccarianum* Cogn., AF272805, AM235646, AM235449. *Melastoma candidum* D.Don, AB436365, GQ436728, AF215608. *Melastoma dodecandrum* Lour., AF272808, GQ436727, -. *Melastoma malabathricum* L., AF272810, AF270748, AB436376. *Melastoma sanguineum* Sims, AF270754, HQ415218, AB436378. *Melastoma tetramerum* Hayata, AB436364, -, AB436373. *Memecylon durum* Cogn., AM235408, AM235641, AM235444. *Memecylon edule* Roxb., AF215574, AF215528, AF215609. *Meriania macrophylla* (Benth.) Triana, AM235414, AM235647, AM235450. *Meriania nobilis* Triana, AF215577, AF215533, AF215614. *Meriania phlomoides* (Triana) Almeda, EU055971, EU711395, JF832037. "*Merianthera bullata* R.Goldenb., Fraga & A.P.Fontana", JQ899129, JQ899104, JQ899078. *Merianthera burlemarxii* Wurdack, JQ899122, JQ899096, JQ899072. "*Merianthera parvifolia* R.Goldenb., Fraga & A.P.Fontana", JQ899127, JQ899102, JQ899077. *Merianthera pulchra* Kuhlm., JQ899124, JQ899098, JQ899073. *Merianthera sipolisii* (Glaz. & Cogn.) Wurdack, JQ899126, JQ899100, JQ899075. "*Merianthera verrucosa* R.Goldenb., Fraga & A.P.Fontana", JQ899125, JQ899099, JQ899074. *Miconia bicolor* (Mill.) Triana*, EU056130, KX397981, -. *Miconia calycina* Cogn., EU056001, JF832003, JF832038. *Miconia cubatanensis* Hoehne, EU056020, -, -. *Miconia dodecandra* (Desr.) Cogn., EU056026, EU711396, JF832039. *Miconia donaeana* Naudin, AM235415, AM235648, AM235451. *Miconia fasciculata* Gardner, EU056033, -, -. *Miconia mayeta* (D. Don.) Michelang.*, AF215581, AF215537, AF215618. *Miconia petiolaris* (Schltdl. & Cham.) Michelang., AM235410, AM235643, AM235446. *Miconia rubra* (Aubl.) Mabb.*, AF215579, AF215535, AF215616. *Miconia secunmexicana* G.Ocampo & Almeda*, AF215580, AF215536, AF215617. *Miconia tococa* (Desr.) Michelang.*, AM235417, AM235650, -. *Miconia urbani* (Cogn.) Cogn.*, AF270753, AF215538, AF215619. *Monochaetum calcaratum* (DC.) Triana, AF215568, AF215524, AF210372. *Monolena primuliflora* Hook. f., AF215552, AF215514, AF270743. *Mouriri crassifolia* Sagot, -, FJ038111, -. *Mouriri guianensis* Aubl., AF215575, AF215529, AF215610. *Mouriri helleri* Britton, AF322230, AF270752, AF215611. *Nepsera aquatica* (Aubl.) Naudin, AF215569, JQ592692, AF210373. *Osbeckia chinensis* L., AF215570, AF215525, AF210378. *Osbeckia stellata* Buch.-Ham. ex Ker Gawl., AF272818, U26330, -. *Oxyspora paniculata* (D.Don) DC.*,, KX527089, MH722293. *Phainantha laxiflora* (Triana) Gleason, JF831980, JF832006, JF832043. *Phainantha shuariorum* C.Ulloa & D.A.Neill,

JF831981, JF832007, JF832044. *Phyllagathis gymnantha* Korth., AF215590, -, AF215626. *Phyllagathis hispidissima* (C.Chen) C.Chen, KT354889, KT354899, KM521858. *Physeterostemon fiaschii* R.Goldenb. & Amorim, EU711379, EU711397, JF832045. *Physeterostemon jardimii* R.Goldenb. & Amorim, EU711381, EU711399, JF832046. "*Physeterostemon thomasii* Amorim, Michelangeli & R.Goldenb.", EU711383, EU711401, JF832047. *Pternandra coerulescens* Jack, AF215558, AF215518, AF322232. *Pternandra echinata* Jack, AF215559, AF215520, AF270744. *Pternandra multiflora* Cogn., AF215560, -, AF215603. *Pterolepis glomerata* (Rottb.) Miq., AF215571, AF215526, AF210376. *Rhexia mariana* L., AF272819, KJ773817, AF323723. *Rhexia virginica* L., AF215587, MG248427, AF215623. *Rhynchanthera grandiflora* (Aubl.) DC., AF215584, AF215542, AF210369. "*Rupestrea johnwurdackiana* (Baumgratz & D'El Rei Souza) Michelang., Almeda, & R.Goldenb.", KM373899, KM373900, KM373901. *Salpinga maranonensis* Wurdack, JF831982, JF832008, JF832048. *Salpinga secunda* Schrank & Mart. ex DC., EU711384, EU711402, JF832049. *Sarcopyramis parvifolia* Merr. ex H.L.Li, -, KX527237, -. *Siphanthera paludosa* (DC.) Cogn., -, AY553780, AY553776. *Tibouchina grossa* (L.f.) Cogn., JF831983, JF832009, JF832050. *Tibouchina longifolia* (Vahl) Baill., AF215572, JQ592704, AF210375. *Tibouchina urvilleana* (DC.) Cogn., AF272820, U26339, AF322234. *Tigridiopalma magnifica* C.Chen, KT354891, KT354900, KM521859. *Triolena amazonica* (Pilg.) Wurdack, JF831984, JF832010, JF832051. *Triolena paleacea* (Triana) Almeda & Alvear, JF831976, JF832001, JF832030. *Triolena pustulata* Triana*, JQ899135, JQ899110, AF215599. *Tristemma littorale* Benth., -, AY667150, AY660631. *Tristemma mauritianum* J.F.Gmel., AF272821, -, AF322233. *Tryssophyton merumense* Wurdack, *A. Radosavljevic 165* (US), **MK284234**, **MK284232**, -. *Tryssophyton quadrifolius* K.Wurdack & Michelang., *K. Wurdack 5865* (US), -, **MK284233**, -. *Warneckea membranifolia (*Hook. f.) Jacq.-Fél., AF331711, KC628335, -. *Wurdastom cuatrecasasii* (Wurdack) B.Walln., JF831985, JF832011, -.

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RESEARCH ARTICLE

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Linum aksehirense (sect. *Dasylinum*, Linaceae), a new species from Central Anatolia (Turkey)

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Abstract

Linum aksehirense (Linaceae) is described as a new species known from the slopes of the Sultan Mountains in the Akşehir district of Konya in Central Anatolia (Turkey). It is most similar to *L. pubescens* Banks & Sol. and *L. anisocalyx* P.H.Davis, from which it is easily distinguished by its stem leaf shape, sepal shape and petal colour. Seed and pollen surface ornamentations were photographed under SEM microscopy to explore micromorphological characters distinguishing the new species from close relatives. In addition, photographs of living material, a distribution map, ecological details, and an identification key are provided.

Keywords

Endemic, Konya, Linaceae, *Linum*, taxonomy

Introduction

The genus *Linum* Linnaeus (Linaceae) is comprised of about 200 species in the Linaceae family. *Linum* is distributed mainly in North America, the Balkan Peninsula, Anatolia, as well as in Eurasia and Africa (Robertson 1971), but it is also represented in South America and Australasia.

Linum was first described by Linnaeus (1753). The first comprehensive study on the genus was made by Planchon (1847, 1848). The most recent worldwide treatment of *Linum* was done by Winkler (1931). According to Winkler (1931) and Planchon (1847, 1848), *Linum* is divided into five sections. The genus has been the subject of several taxonomic studies and regional revisions, such as those focusing on American

and South African *Linum* species (Rogers 1963, 1981; Mildner and Rogers 1978), as well as Flora Europaea (Ockendon and Walters 1968), Flora of the U.S.S.R. (Yuzepchuk 1974), and Flora of Turkey and the Aegean Islands (Davis 1967). The genus plays an important role in the economic and social development of humans. For example, the seeds of *L. usitatissimum* are used nutritionally and medicinally. Linseed oil is also a significant source of inks, varnishes, and lubricants (McDill et al. 2009).

Linum is represented by four sections in Turkey: sect. *Syllinum* Grisebach (1843: 115), sect. *Linastrum* Planchon (1847: 597), sect. *Dasylinum* Planchon (1847: 598), and sect. *Linum* Planchon (1847: 598). With 54 taxa (Yılmaz 2018), Turkey is one of the most important centres of genetic diversity for the genus *Linum*. The new species described in this paper brings the number to 55 taxa in Turkey, 26 (47%) of which are endemic.

Linum sect. *Dasylinum* is characterised by having perennial or annual life cycles and distinct morphological characteristics. Leaves are alternate, often hairy. Petals usually have coherent claws and are blue, pink or white. Capsules are hairy or glabrous (Davis 1967). There have been numerous studies on the morphology of *Linum* in Turkey by several authors (Davis 1967; Yılmaz and Kaynak 2008, 2010; Yılmaz 2010). There have also been investigations on a worldwide scale concerning the palynology (Erdtman 1969; Rogers and Xavier 1971; Saad 1961, 1962; Xavier et al. 1980; Rogers 1985; Talebi et al. 2012), karyology (Ray 1944; Harris 1968; Rogers et al. 1972) and anatomy (Winkler 1931; Metcalfe and Chalk 1950) of the genus. There has been just one study on *Linum* seeds, which covers several species of the genus (Özcan and Zorlu 2009).

From a biogeographical and evolutionary point of view, McDill et al. (2009) reported that section *Linum* and *Dasylinum* were not monophyletic and that *Linum* appears to have arisen in Eurasia, from which it spread to Africa, North America, South America and Australasia.

We collected samples of what we suspected could be a new species of *Linum* while conducting field work around the Sultan Mountains between 2011 and 2017. The specimens were checked against the Flora of Turkey and the East Aegean Islands, as well as neighbouring floras (Flora Iranica, Flora Iraq, Flora of the U.S.S.R. and Flora Europaea). We subsequently decided that it was a species new to science.

The aim of this study was to describe the new species, named *Linum aksehirense*, occurring in the Sultan Mountains (Akşehir, Konya), in terms of its morphology, palynology and seed micromorphology.

Material and methods

Field collections were carried out in the Sultan Mountains from 2011 to 2017. Collected specimens were dried using traditional procedures and were deposited in the KNYA Herbarium. They were identified using the Flora of Turkey and the East Aegean Islands using stereo microscopy and checking them against other *Linum* accounts found in relevant literature. The taxonomical description of the species was made according to Davis (1967).

For palynological investigations, pollen slides were prepared according to Wodehouse's (1935) technique. The pollen micromorphology of *L. aksehirense* was scrutinized by scanning electron microscopy (SEM) techniques. For SEM, pollen grains were directly placed on double-sided carbon tape affixed to aluminium stubs, covered with gold with a Hummle VII sputter coater and photographed at magnifications of 2000× to 7000× with a JEOL-5600. SEM micrographs were used to determine exine sculpturing of the pollen. Pollen terminology was based on Punt et al. (2007). For seed investigations, SEM micrographs were used to determine seed coat sculpturing. The terminology of Stearn (1983) and Özcan and Zorlu (2009) was adopted to describe the SEM aspects of the seed coat.

Taxonomy

***Linum aksehirense* Tugay & Ulukuş, sp. nov.**
urn:lsid:ipni.org:names:77203431-1
Figures 1–6

Diagnosis. *Linum aksehirense* belongs to *Linum* sect. *Dasylinum*. The new species is similar to *L. pubescens* but is distinguished by its spathulate lower stem leaves that are not evanescent (*vs.* oblong-spathulate evanescent), subequal lanceolate sepal shape (*vs.* subequal linear), petals 27–33 mm (*vs.* 18–27 mm) and petals that are blue-violet with a yellowish limb base (*vs.* pink with a bluish limb base).

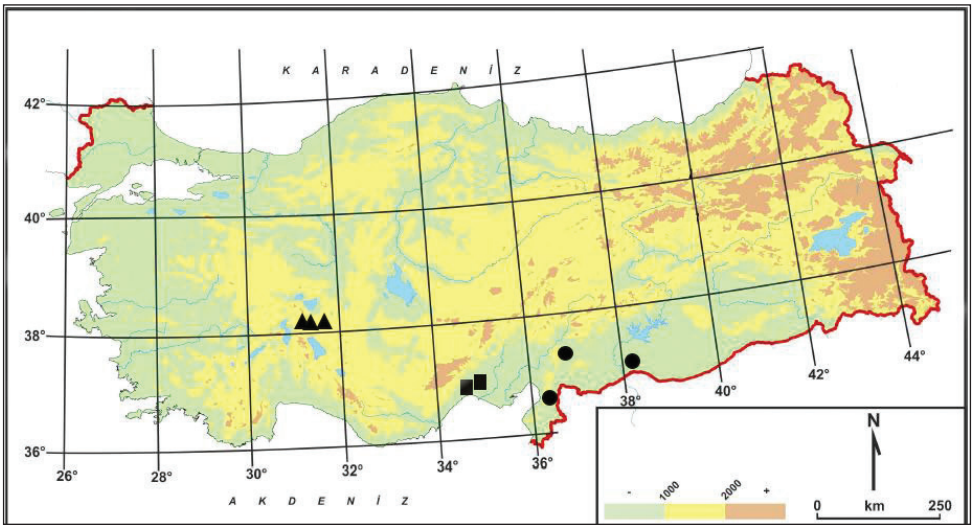

Figure 1. Distribution map of *Linum aksehirense* (triangle), and closely related *Linum pubescens* (circle) and *Linum anisocalyx* (square) in Turkey.

Figure 2. Holotype specimen of *Linum aksehirense* Tugay & Ulukuş.

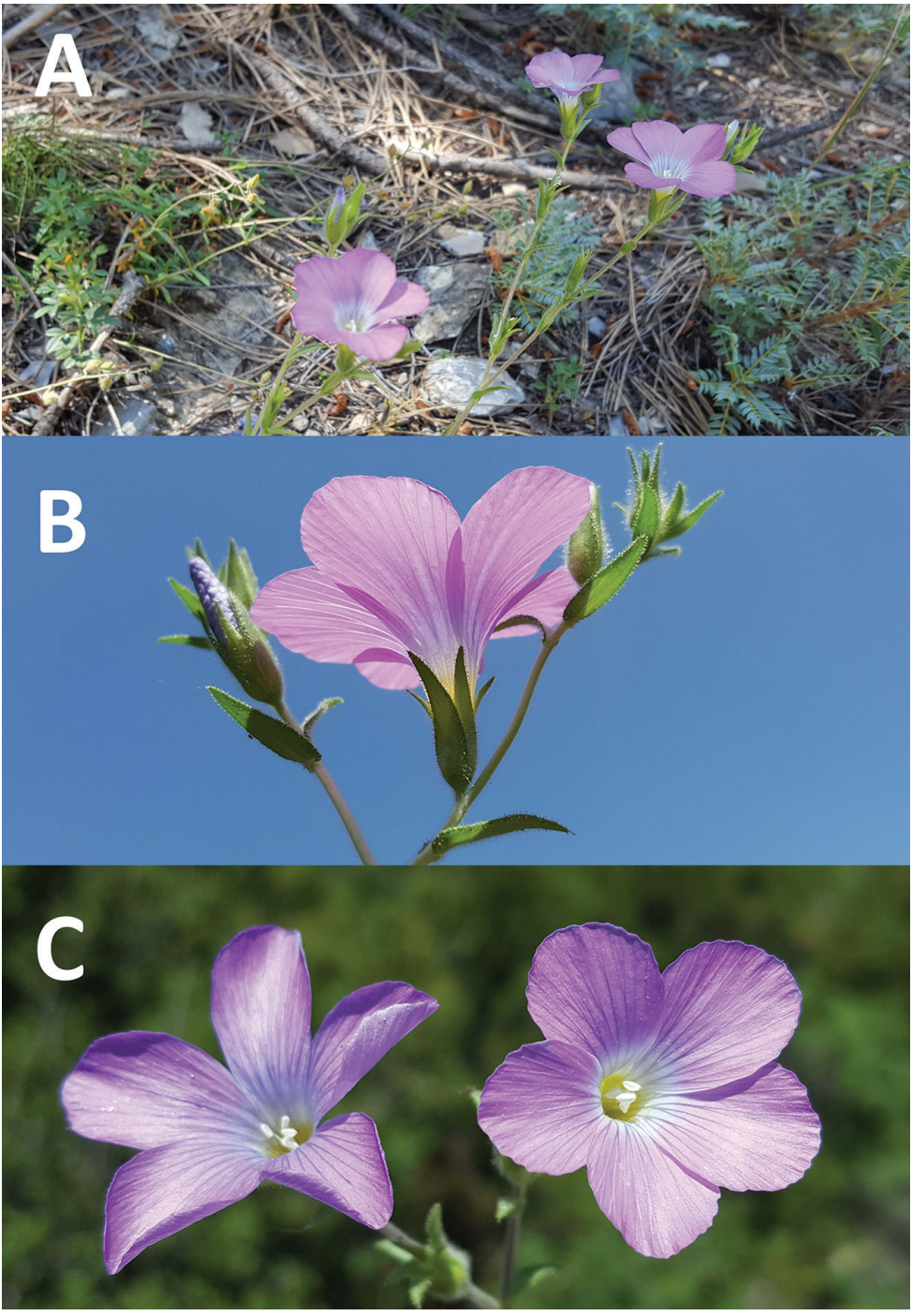

Figure 3. General view of habit and flower **A–C** *Linum aksehirense*.

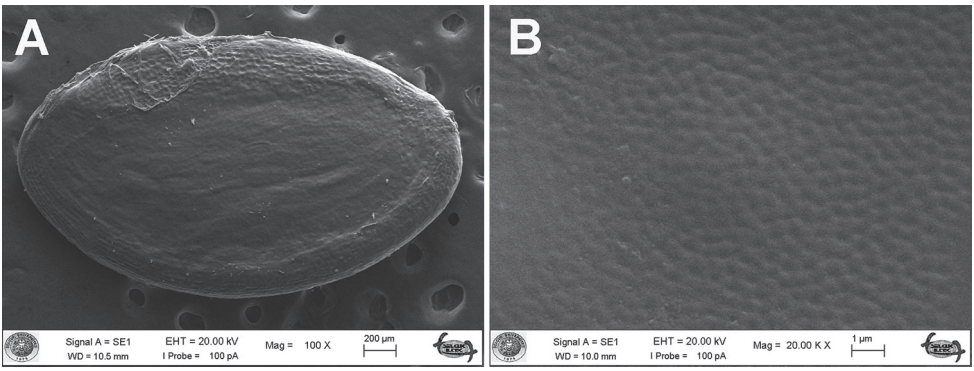

Figure 4. Scanning electron micrographs of seeds *Linum aksehirense* species **A** general view and **B** surface sculpturing pattern.

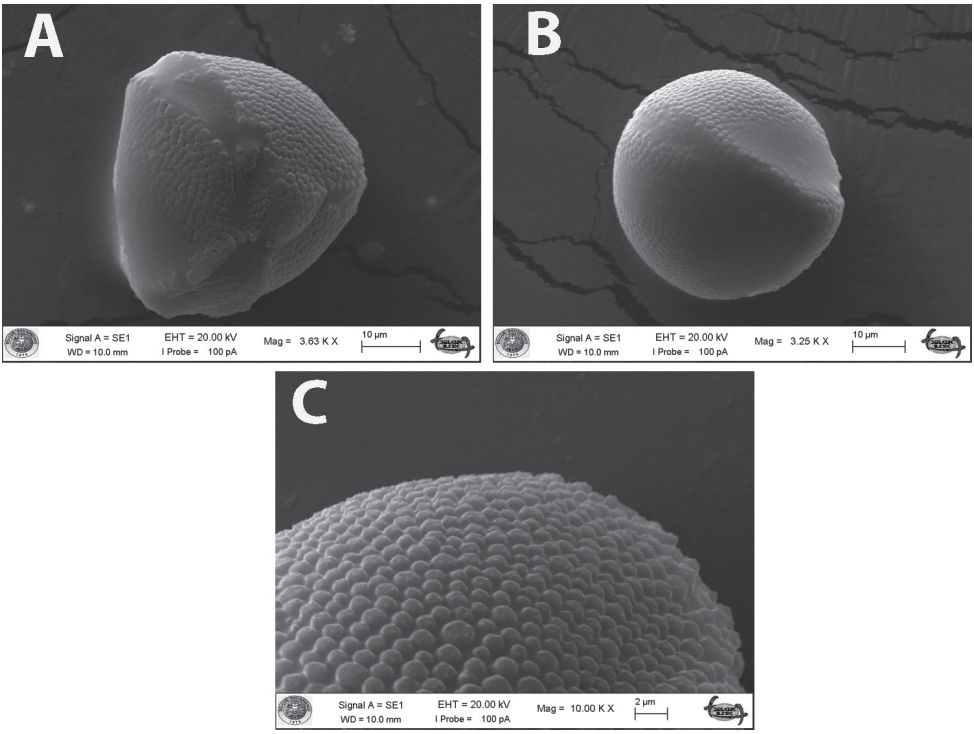

Figure 5. SEM micrographs of the pollen grains of *L. aksehirense* **A–C** polar, equatorial view and ornamentation (*O. Tugay* 14.542 & *D. Ulukuş*).

Type. Turkey. B3 Konya; Akşehir, Sultan Mountains, slopes in *Pinus nigra* forest, 1150 m alt., 38°19.230'N, 31°23.181'E, 01 August 2017, *O. Tugay* 14.542 & *D. Ulukuş* (holotype KNYA, isotypes KNYA 28.229).

Description. The plant is a green annual. Flowering stems villous, erect, 22–33 cm; sterile shoots few. Lower stem leaves spathulate, not evanescent, 10–13 × 2–4 mm; median stem leaves lanceolate-elliptic, acute, 16–19 × 2–3.5 mm, 1–3 nerved.

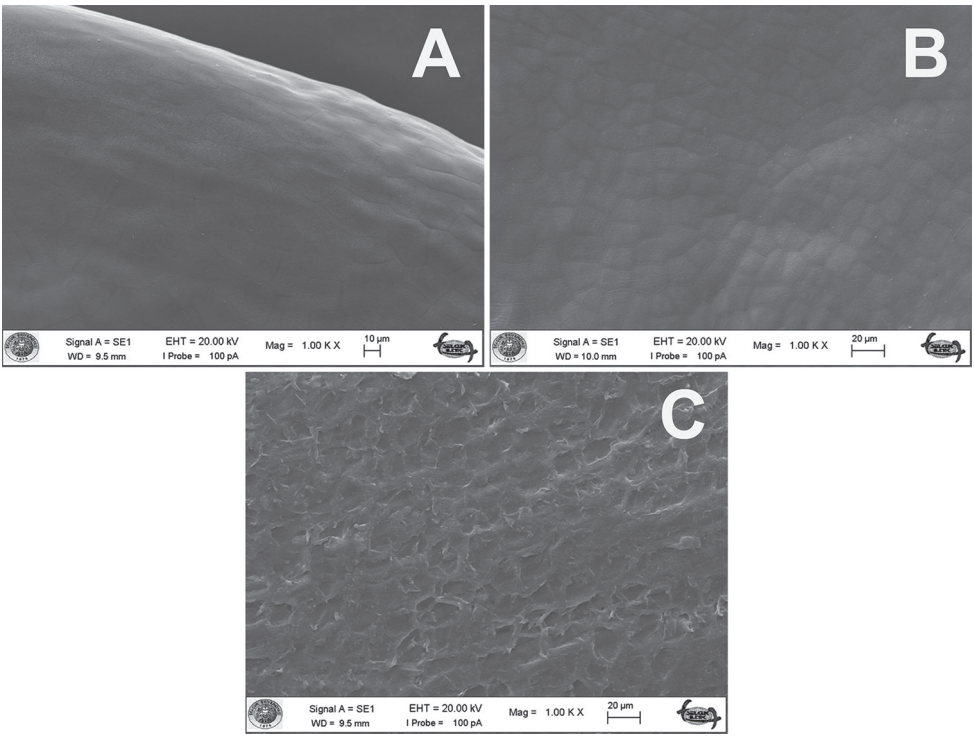

Figure 6. Scanning electron micrographs of seeds sculpturing patterns *Linum* species **A** *L. aksehirense* **B** *L. anisocalyx* **C** *L. pubescens*.

Bract (similar to median stem leaves) stipitate glandular margined, lanceolate, 14–15 × 3–3.5 mm. Cymes divaricate, lax, few-flowered; flowers 3–7 per stem; pedicels 1–2 mm, not elongated in fruit. Sepals subequal, lanceolate, 12–14 × 2–3 mm, bearing long hairs and stiputate glandular margined. Petals blue-violet (blue when dry) with a yellowish base to the limb, 27–33 mm. Capsule 5 × 5 mm diam. with 1–1.5 mm beak. Seeds elliptic-oblong, 2–2.5 × 1–1.5 mm, brown, glossy. Sculpturing of seed coat is reticulate-rugolose-ruminate (Fig. 4A–B).

Paratypes. Turkey. B3 Konya; Akşehir, slopes, 1170 m alt., 38°20'N, 31°24'E, 31 August 2011, *O. Tugay* 7.182 (KNYA); Akşehir, Hıdırlık, slopes, 1100 m alt., 38°19'N, 31°23'E, 01 August 2017, *O. Tugay* 14.520 & *D. Ulukuş* (KNYA).

Ecology. *Linum aksehirense*, which is endemic to Turkey, grows between 1100 and 1170 m elevation on slopes with *Pinus nigra* forest. The vegetation of this habitat is composed mainly of herbaceous and suffruticose plants including: *Agrimonia eupatoria* L. subsp. *asiatica*, *Campanula lyrata* Lam. subsp. *lyrata*, *Centaurea virgata* Lam., *Cistus laurifolius* L., *Cota tinctoria* (L.) J.Gay ex Guss. var. *tinctoria*, *Digitalis ferruginea* L. subsp. *ferruginea*, *Dianthus crinitus* Sm. var. *crinitus*, *Hedysarum varium* Willd. subsp. *varium*, *Phlomis armeniaca* Willd., *Pinus nigra* J.F.Arnold subsp. *nigra*, *Prunus divaricata* Ledeb. var. *divaricata*, *Scabiosa rotata* M.Bieb., *Securigera varia* (L.) Lassen, *Teucrium chamaedrys* L. subsp. *chamaedrys* and *Teucrium polium* L.

Phenology. The new species was observed flowering in July and collected fruiting from July to August.

Etymology. The species epithet comes from 'Akşehir', where the new species is found.

Proposed Turkish name for the new species. Akşehir keteni.

Distribution and conservation status. *Linum aksehirense* is known from three localities in Konya province, in the Irano-Turanian phytogeographic region (Fig. 1). Its area of occupancy is estimated to be less than 500 km^2. The number of mature individual plants is estimated to be less than 250. Being an annual gives this new species a crucial advantage for survival against potential threats, which include the destruction of brush by locals, road construction and deterioration of habitat. Thus, according to criterion B and D, it can be included in the EN (Endangered) category (IUCN 2001; 2016).

Key to the species of *Linum* sect. *Dasylinum* in Turkey

1 Annuals....**2**
– Perennials....**5**
2 Petals c. 8 mm, free; sepals not or slightly longer than capsule....***L. seljukorum***
– Petals 18 mm or more; coherent; sepals much longer than capsule....**3**
3 Petals 27–33 mm, blue-violet with a yellowish base to the limb....***L. aksehirense***
– Petals 18–27 mm, pink with a bluish base to the limb....**4**
4 Sepals subequal....***L. pubescens***
– Sepals very unequal, the outer two hiding the much shorter inner sepals....***L. anisocalyx***
5 Median cauline leaves margined by stalked glands....**6**
– Median cauline leaves not margined by glands....**8**
6 Inflorescence compact; petal claw 1/4 as long as limb....***L. densiflorum***
– Inflorescence widely spreading, or rarely 1–3 flowered....**7**
7 Petal claw c. ½ as long as limb; median stem leaves not attenuate below....***L. hirsutum***
– Petal claw c. 1–1½ as long as limb; median stem leaves attenuate at both ends....***L. unquiculatum***
8 Plants very twiggy at base, with many sterile shoots; 1–7 flowers....***L. olympicum***
– Plant herbaceous, with few or no sterile shoots; usually > 7 flowers....**9**
9 Cymes usually spreading, lax; leaves 1–3 nerved, oblong, linear or subspathulate; petal claw c. ½ as long as limb....***L. hirsutum***
– Cymes compact; leaves 3–7 nerved, broadly lanceolate; petal claw ¼–1/3 as long as limb....***L. hypericifolium***

Pollen morphology

The pollen shape of the new species was subprolate (P/E: 1.13) with a polar axis of 53.85 ± 1.75 μm (mean ± standard deviation) μm and an equatorial axis of

47.70 ± 4.70 µm. The aperture was tricolpate. The colpus was long-acute ended with a colpus length of 34.82 ± 3.26 µm and width of 12.91 ± 2.23 µm. Exine thickness was 0.5 µm and intine thickness was 0.4 µm. Exine ornamentation was densely gemmate (Fig. 5 A–C).

Discussion

Linum aksehirense is similar to *L. pubescens*, *L. anisocalyx* and *L. viscosum* in morphology. However, it differs from these similar species in several vegetative and reproductive characters (Table 1).

According to Davis (1967), *L. anisocalyx* is closely related to *L. pubescens*, differing from *L. pubescens* primarily by its strongly dimorphic sepals (not dimorphic), which are rhomboid-lanceolate and glandular-margined.

Linum aksehirense differs from *L. pubescens* by its spatulate, not evanescent lower stem leaves (*vs.* oblong-spathulate evanescent), lanceolate-elliptic, acute median stem leaves, 16–19 × 3–4 mm (*vs.* oblong, subacute 12–23 × 2–5 mm), subequal lanceolate sepals (*vs.* subequal linear), sepal size of 12–14 × 2–3 mm (*vs.* 9–12 × 1–2 mm) and its petal colour, which is blue-violet with a yellowish limb base (*vs.* pink with a bluish limb base) (Table 1).

Linum aksehirense is similar to *L. anisocalyx*, differing in its lanceolate-elliptic, acute median stem leaves, 16–19 × 3–4 mm (*vs.* oblong, oblong, subacute 12–23 × 2–5 mm), subequal lanceolate sepals (*vs.* very unequal elliptic-lanceolate), sepal size of 12–14 × 2–3 mm (*vs.* outer sepals 11–12 × 3–3.5 mm, inner sepals 6–8 × 2.5–3 mm), petal colour, which blue-violet with a yellowish limb base (*vs.* pink with a bluish limb base) and in its petal size, which is 27–33 mm (*vs.* 18–26 mm) (Table 1).

Linum aksehirense can be distinguished from *L. viscosum*, by its spathulate not evanescent (*vs.* lanceolate, ovate-lanceolate, evanescent), sepal size of 12–14 × 2–3 mm (*vs.* 6–9 × 1–1.5 mm), petal colour, which is blue-violet with a yellowish limb base (*vs.* pink), and in its petal size, which is 27–33 mm (*vs.* 18–21 mm).

Xavier et al. (1980) described the basic pollen grain in *Linum* as subspheroidal, about 50 µm in diameter, isopolar, radially symmetric, tricolpate, colpi with pointed ends. However, in our study *L. aksehirense* had subprolate pollen shape. According to Talebi et al. (2012)'s palynologic study on four section of the Linaceae, including 15 taxa of *Linum*, in all examined taxa the pollen shape in polar view was circular (except in *L. densifolorum* where it was concave-triangular) and also the exine sculpturing pattern showed a clavate, pilate and gemmate to baculate form. Talebi et al. (2012) reported that pollen features of *L. densifolorum* consisted of an oblate-spheroidal pollen shape and small and large gemmate exine ornamentation. Our findings showed that *L. aksehirense* had subprolate pollen shape and the exine ornamentation was densely gemmate (Fig. 5 A–C). In terms of pollen micromorphology, palynological results demonstrated that there are no clear differences among species of the same section. However, pollen shape can be used to distinguish species.

Özcan and Zorlu (2009) studied seed surface patterns *Linum* genus and found reticulate-ruminate patterns in sect. *Dasylinum*. Özcan and Zorlu (2009) showed that seed patterns provide characters to distinguish taxa at specific and infraspecific levels.

Table 1. Morphological comparison of *Linum aksehirense*, *L. pubescens*, *L. anisocalyx* and *L. viscosum*.

Characters	*L. aksehirense*	*L. pubescens*	*L. anisocalyx*	*L. viscosum*
Stem	unbranched or branched at the upper stem	branched at the median stem	branched at the base	unbranched or branched at the upper stem
Lower stem leaf shape	spathulate not evanescent	oblong-spathulate evanescent	oblong-spathulate evanescent	lanceolate, ovate-lanceolate evanescent
Median stem leaf shape	lanceolate-elliptic, acute, 16–19 × 3–4 mm	oblong, subacute 12–23 × 2–5 mm	oblong, subacute 12–23 × 2–5 mm	lanceolate, subacute 14–21 × 3–5 mm
Sepal shape	subequal lanceolate	subequal linear	very unequal elliptic-lanceolate	subequal lanceolate
Sepal size (mm)	12–14 × 2–3	9–12 × 1–2	outer sepals 11–12 × 3–3.5; inner sepals 6–8 × 2.5–3	6–9 × 1–1.5
Petal colour	blue-violet with a yellowish base to the limb	pink with a bluish base to the limb	pink with a bluish base to the limb	pink
Petal size (mm)	27–33	18–27	18–26	16–21

In this study, the micromorphological study of the seeds showed that there were clear differences among the studied species. According to our findings, *Linum aksehirense* had reticulate-rugulose-ruminate sculpturing while *L. pubescens* exhibited reticulate-rugulose-granulate and *L. anisocalyx* showed reticulate-rugulose (Fig. 6 A–C).

Conclusion

With the discovery of this new species, the number of species of *Linum* in Turkey has risen to 55. This study provides material and data to aid further research on this significant genus of the Linaceae.

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Appendix I

Additional examined specimens

***Linum pubescens*;** C5/6 Turkey, Hatay: near sea level, rocky limestone slopes, 07 May 1965, *Coode* 620 & *Jones* (E!); C5/6 Syria/Turkey, Hatay: nr. Aleppo, or between there and Iskenderun, *Russell* (BM photo!); C6 Gaziantep: 30 km. S of Aintab, *Dinsmore* 8.935!; Urfa: Rum Kala'a, *Sint.* 1888: 268!; C8 Mardin: 11 km. W of Idil, 800 m, 05 May 1966, *Davis* 42.427 (E!).

***Linum anisocalyx*;** C5 Içel: plaine de Mersina, May 1855, *Balansa* (holo. K!); Içel: Mersin, 1896, *Siehe* 199 (E!); Içel: Mersin to Kuzucubelen, 18 June 1950, 500 m, *Hub.-Mor.* 10.567!

***Linum viscosum*;** Spain, Gerona: Roadside near Ripoll, 13 July 1979, *Rogers* 13.567 (B photo!), Huesca, near Jaca, 8 July 1979, *Rogers* 13.558 (B photo!); Austria: Ebersberg en Autriche. In campis aridis Sabulosis, 1812 (GDC photo!); Italy: Gênes, 08 July 1808, Candolle, (GDC photo!).

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RESEARCH ARTICLE

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Two new species of *Phyllanthus* (Phyllanthaceae) from Thailand

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Abstract

Two *Phyllanthus* species are newly described from a limestone mountain in the north of Thailand. The first species, *P. huamotensis* Pornp., Chantar. & J.Parn., **sp. nov.**, is one of the most distinct *Phyllanthus* species easily distinguished by its reddish branchlets and stem, conspicuous reddish venation, especially on the lower leaf surface, red sepals with long fimbriate margin and red capsule with papillose-puberulous surface. The second species, *P. chantaranothaii* Pornp., J.Parn. & Hodk., **sp. nov.**, is similar to *P. pulcher* Wall. ex Müll. Arg., but it is distinguished by its puberulous upper leaf surface and pistillate flowers which have red, narrowly lanceolate sepals with a white, long fimbriate margin, puberulous outer side as well as puberulous pedicel.

Keywords

diversity, Euphorbiaceae, new taxa, revision, taxonomy

Introduction

Phyllanthus L. (Phyllanthaceae) is mainly distributed in tropical and subtropical regions (Radcliffe-Smith 2001; Webster 2014). The classification of *Phyllanthus* is still contentious (Kawakita and Kato 2017) because molecular phylogenetic studies have indicated that *Phyllanthus*, as previously circumscribed, was not monophyletic (Kathriarachchi et al. 2006). Therefore, some authors suggested merging other closely related

genera in *Phyllanthus*, such as *Breynia* J.R.Forst. & G.Forst., *Glochidion* J.R.Forst. & G.Forst. and *Sauropus* Blume (Hoffmann et al. 2006), while others suggested division of *Phyllanthus* into several monophyletic and morphologically recognisable genera (Pruesapan et al. 2012; van Welzen et al. 2014). The most recent publication by Bouman et al. (2018) recorded 880 species of *Phyllanthus* and, amongst these, they were able to place 837 species in 18 subgenera, 70 sections and 14 subsections; 43 species remained unassigned. *Phyllanthus* is, therefore, one of the most diverse genera of flowering plants and its species often have a high degree of endemism. For example, in China, there are about 32 species reported, 13 of which are endemic (Li and Gilbert 2008). Thirty-six species of *Phyllanthus* s.str. (excluding *Breynia*, *Glochidion* and *Sauropus*) were reported for the Flora of Thailand by Chantaranothai (2007). Lately, two more new species have been included by Kantachot and Chantaranothai (2013) and Pornpongrungrueng et al. (2017). Thus, the total Thai species number has increased to 38, five of which are endemic to Thailand. Recently, two *Phyllanthus* taxa were discovered in Umpang district, Tak province, in the northern part of Thailand; they were investigated and are described herein as new species.

Methods

Field collections and herbarium specimens from various herbaria, as well as taxonomic literature, were examined. The herbarium abbreviations follow Index Herbariorum (Thiers 2019, continuously updated). The morphological descriptions and measurements were taken from dried specimens.

Results

Taxonomic treatment

Phyllanthus huamotensis **Pornp., Chantar. & J.Parn., sp. nov.**
urn:lsid:ipni.org:names:77203519-1
Figs 1, 2

Diagnosis. *Phyllanthus huamotensis* is one of the most distinct species of *Phyllanthus* in Thailand, easily distinguished by its reddish branchlets and stem, conspicuous reddish venation, especially on the lower leaf surface, red sepals with long fimbriate margins and red capsule with a papillose-puberulous surface. It is most similar to *P. pulcher* Wall. ex Müll.Arg., but differs in its undershrub habit that is up to 30 cm high (*P. pulcher* is a shrub up to 1.5 m high), small sized leaves (2–9 × (2–)3–8 mm) (leaves in *P. pulcher* are 7–28 × 6–17 mm) with conspicuous reddish venation (inconspicuous on both leaf surfaces in *P. pulcher*) and a red capsule with a papillose-puberulous surface (glabrous in *P. pulcher*).

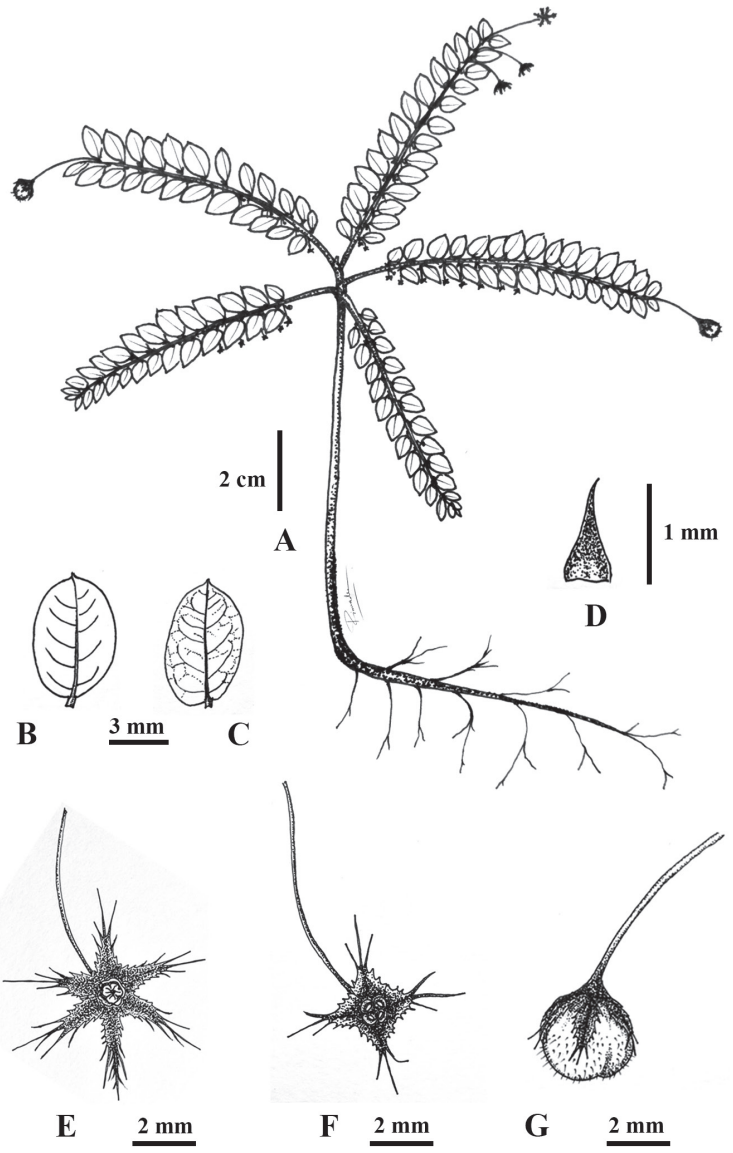

Figure 1. *Phyllanthus huamotensis* Pornp., Chantar. & J.Parn., sp. nov. **A** habit **B, C** leaf shapes (**B** adaxial surface **C** abaxial surface) **D** stipule **E** pistillate flower **F** staminate flower **G** mature capsule. Drawn by Pimwadee Pornpongrungrueng.

Type. Thailand. Tak, Umpang district, Doi Hua Mot; 16°2.63'N, 98°51.26'E; alt. 901 m; 22 Aug. 2019; *P. Pornpongrungrueng*, *N. Triyutthachai*, *S. Ninkaew & S. Sukcharoen 1287* (***holotype*** KKU; ***isotypes*** BKF, K, QBG, TCD).

Description. Undershrubs up to 30 cm high, branchlets and stem reddish, terete, young branchlets minutely puberulous. *Stipules* triangular-lanceolate, 0.5–1 × 0.3–0.5

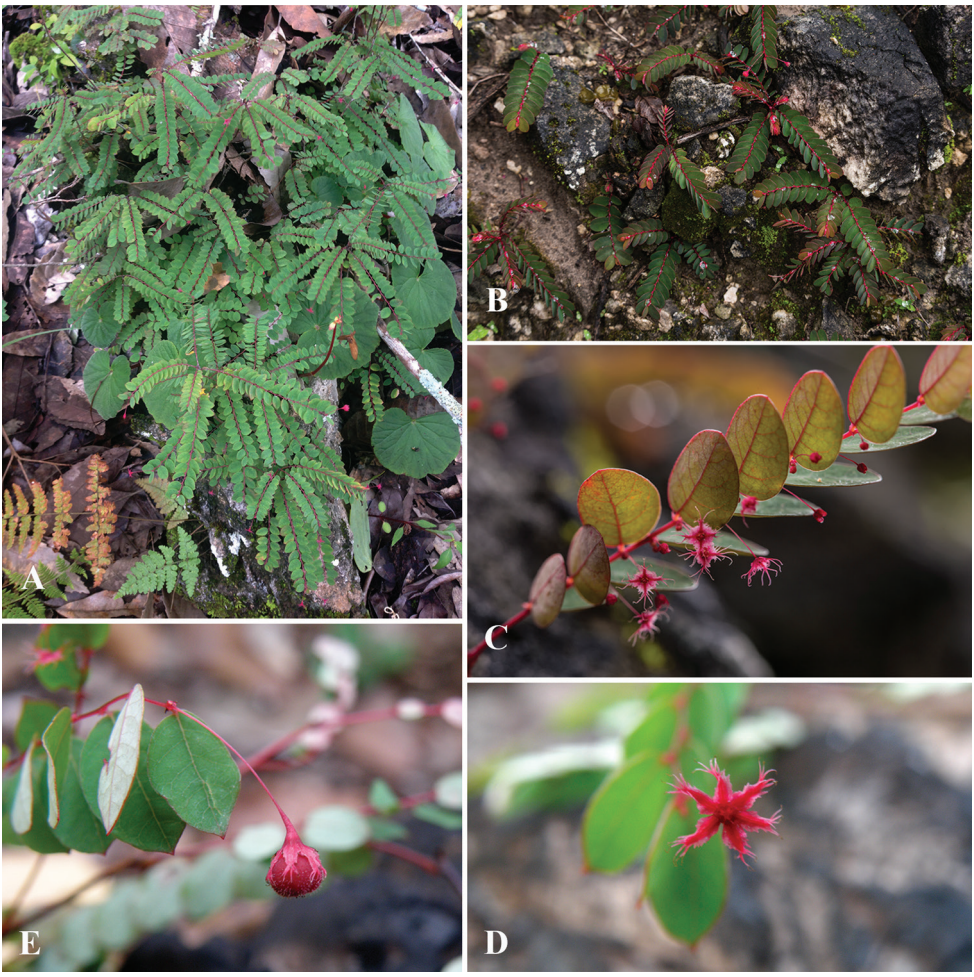

Figure 2. *Phyllanthus huamotensis* Pornp., Chantar. & J.Parn., sp. nov. **A, B** habit **C** branchlet showing axillary fascicle of staminate flowers **D** branchlet showing pistillate flower **E** branchlet showing young red capsule. **A** Photo by Natthawut Triyuttachai **B, C** photos by Suchart Chanhomhual **D, E** photos by Kanokorn Ruengsawang.

mm, glabrous. *Leaves* alternate; petioles 0.4–0.9 mm long, glabrous; lamina broadly ovate, obovate, rounded, broadly elliptic, ovate-oblong, 2–9 × (2–)3–8 mm, subcoriaceous, glabrous on both surfaces, base oblique, cordate, broadly cuneate, truncate, rounded, margin entire, revolute, apex acute, acuminate, rounded; nerves in 4–6 pairs; reticulation reddish, conspicuous, especially on the lower surface. *Flowers* red, unisexual; staminate flowers 2–3(–4) in axillary fascicles in proximal axils; pistillate flower solitary in distal axils. *Bracts* subulate, 0.2–0.3 × 0.1–0.2 mm, glabrous. *Staminate flowers*: pedicel 4–10 mm long, glabrous; sepals 4, red, triangular, rhombic-ovate, lanceolate, 1.5–2 × 1–1.2 mm, glabrous, margin long fimbriate; disc glands 4, reniform; stamens

4, staminal column ca. 0.2 mm long, anthers ca. 0.2 mm long, transversely dehiscent. *Pistillate flowers*: pedicel 7–17 mm long, glabrous; sepals 5–6, red, rhombic-ovate, 1.5–3 × 0.6–1 mm, membranous, glabrous, margin fimbriate; disc glands 5 or 6, free, obovate with truncate apex; ovary superior, ca. 0.7 mm diam., 3-locular, ovules 2 per locule, papillose-puberulous; styles 3, free, ca. 0.1 mm long; stigmas nearly completely bifid, ca. 0.2 mm long, glabrous. *Fruits* capsule, red, 2.5–3 mm diam., papillose-puberulous; pedicel 7–17 mm long. *Seeds* trigonous, brown, 1.5–1.8 × 1.1–1.2 mm, surface transversely striate.

Phenology. Flowering and fruiting period is June to December.

Habitat and distribution. This species grows on open limestone hills, at 880–937 m above sea level. Currently, it is known only from the type location Doi Huamot, Tak province in northern Thailand.

Conservation status. The species is only known from the type locality. It should be categorised as Critically endangered [CR, B1ab (iii)] according to the IUCN Red List Criteria and Categories version 3.1 (IUCN 2012). The extent of occurrence is estimated to be less than 20 km^2 and this species is found in a restricted area on open limestone hills which is a threatened ecosystem.

Etymology. The name of this species is given, based on the location where the plant was first discovered.

Vernacular. Ma Kham Pom Din Huamot.

Additional specimens examined. Thailand: Tak, Umpang district, Doi Hua Mot; 15°56.46'N, 98°51.93'E; alt. 937 m; 2 Dec. 2018; *P. Pornpongrungrueng, N. Triyutthachai & P. Chantaranothai 1270* (BKF, KKU), ibid.; 15°51.40'N, 98°50.88'E; alt. 882 m; 22 Aug. 2019; *P. Pornpongrungrueng, S. Ninkaew, S. Sukcharoen & N. Triyutthachai 1285* (BKF, KKU, TCD).

Phyllanthus chantaranothaii **Pornp., J.Parn. & Hodk., sp. nov.**
urn:lsid:ipni.org:names:77203520-1
Figs 3, 4

Diagnosis. *Phyllanthus chantaranothaii* is most similar to *P. pulcher*, but differs in its puberulous upper leaf surface with white, simple and dendritic hairs and pistillate flowers that have red, narrowly lanceolate sepals with a white long fimbriate margin, puberulous on the outer side and puberulous pedicel, whereas in *P. pulcher*, the leaf is glabrous on both surfaces and the sepals of the pistillate flower are rhombic-ovate with the upper part greenish and lower part red, glabrous on the outside and glabrous pedicel.

Type. Thailand. Tak, Umpang district, Pa La Ta waterfall, 15°49.14'N, 98°51.37'E, alt. ca. 500 m, 23 Aug. 2019, *P. Pornpongrungrueng, S. Ninkaew, S. Sukcharoen & N. Triyutthachai 1291* (***holotype*** KKU; ***isotypes*** BKF, K, QBG, TCD).

Description. Small shrubs up to 80 cm high, branchlets terete, young branchlets puberulous with white, simple and dendritic hairs. *Stipules* lanceolate-subulate, 1.4–2 ×

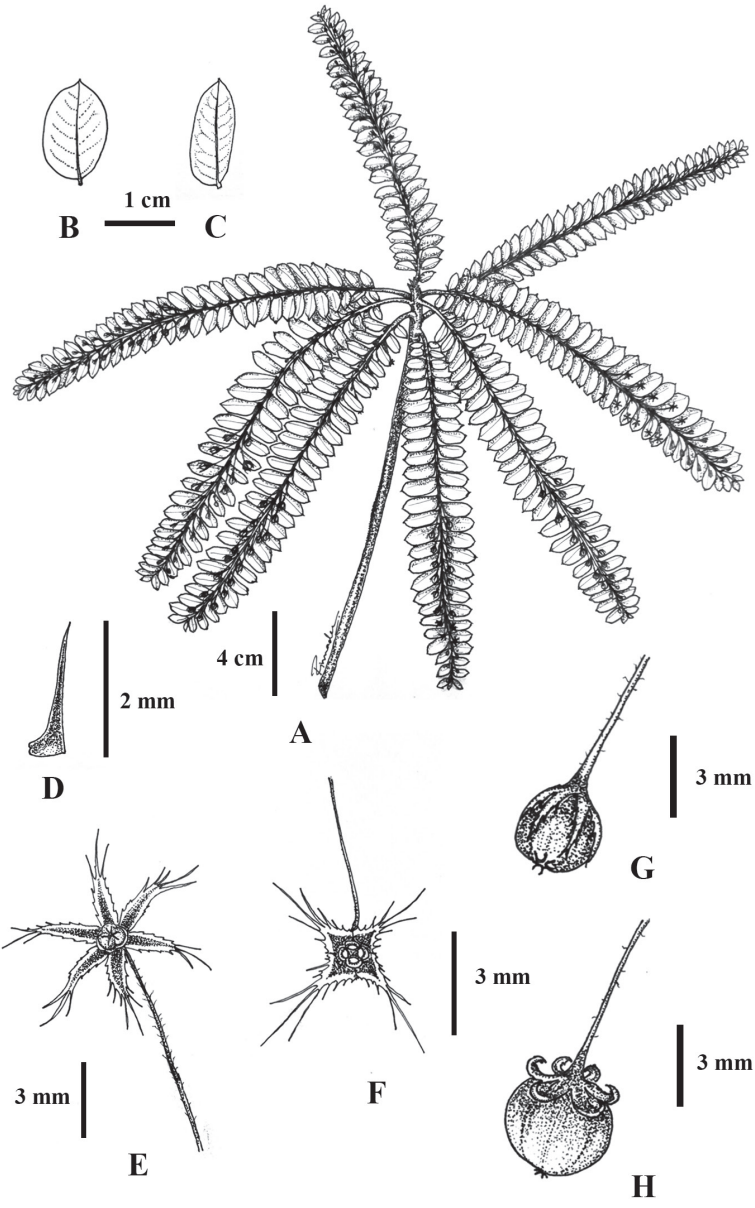

Figure 3. *Phyllanthus chantaranothaii* Pornp., J.Parn. & Hodk., sp. nov. **A** habit **B, C** leaf shapes (**B** adaxial surface **C** abaxial surface) **D** stipule **E** pistillate flower **F** staminate flower **G** young capsule **H** mature capsule. Drawn by Pimwadee Pornpongrungrueng.

0.1–0.4 mm, glabrous. *Leaves* alternate; petioles ca. 0.5 mm long, glabrous; lamina oblong, obovate, 1–2.1 × 0.5–0.8 cm, membranous, upper surface puberulous with white, simple and dendritic hairs, lower surface glabrous, base oblique, margin entire, revolute, apex mucronate; nerves in 4–7 pairs; reticulation inconspicuous on both sur-

Figure 4. *Phyllanthus chantaranothaii* Pornp., J.Parn. & Hodk., sp. nov. **A** habit **B** branchlet showing axillary fascicle of staminate flowers **C** branchlet showing pistillate flower **D** branchlet showing young capsule **E** branchlet showing mature capsule. **A–C** photos by Natthawut Triyuttachai **D, E** photos by Siriyakorn Sukcharoen.

faces. *Flowers* unisexual; staminate flowers 2–3 in axillary fascicles along lower half of the branchlets; pistillate flower solitary in leaf-axils along upper half of the branchlets. *Bracts* subulate, 0.6–1.4 × ca. 0.2 mm, puberulous-glabrous. *Staminate flowers*: pedicel 5–11 mm long, glabrous; sepals 4, red, triangular, rhombic-ovate, 2–3 × ca. 1 mm,

glabrous, margin white long fimbriate; disc glands 4, reniform; stamens 4, staminal column ca. 0.2 mm long, anthers ca. 0.2 mm long, transversely dehiscent. *Pistillate flowers*: pedicel 8–11 mm long, puberulous; sepals 6, reddish, narrowly lanceolate, 3–3.5 × 0.5–0.8 mm, outer surface puberulous, margin white long fimbriate; disc glands 6, free, obovate with truncate apex; ovary superior, ca. 1 mm diam., 3-locular, ovules 2 per locule, glabrous or papillose; styles 3, free, ca. 0.1 mm long; stigmas nearly completely bifid, 0.4–0.6 mm long, glabrous. *Fruits* capsule, young capsule white to pale greenish, 2.5–4 mm diam., glabrous or papillose; pedicel 5–13 mm long. *Seeds* trigonous, brown, 1.5–2 × 1–1.3 mm, surface transversely striate.

Phenology. Flowering and fruiting from August to November.

Habitat and distribution. This species grows in mixed deciduous forest, at ca. 500 m elevation. It is currently known from the type location near Pa La Ta waterfall and Doi Huamot, Tak province, Thailand.

Conservation status. As only the type collection, which was collected from mixed deciduous forest, has been investigated in detail, more field exploration in similar habitats in the surrounding areas should be conducted in order to provide a more accurate distribution range of this species. However, based on information that is available to us, this species is preliminarily categorised here as Endangered [EN, B1ab(i, iv)], according to the IUCN Red List Criteria and Categories version 3.1 (IUCN 2012). The extent of occurrence is estimated to be less than 50 km^2 and, previously, it was found in two locations (Doi Huamot and Pa La Ta waterfall in Umpang district, Tak province), but recently, the extent of occurrence seems to be in decline, because the species has not been found in Doi Huamot since it was first photographed in November 2008.

Etymology. The name of this species honours Prof. Dr. Pranom Chantaranothai for his major contributions to plant taxonomy, in general, but especially for his extensive work on *Phyllanthus* in the Flora of Thailand.

Vernacular. Mayom Noi.

Discussion

The two species described herein should be classified in subgenus *Eriococcus* (Hassk.) Croizat & Metcalf and Section *Eriococcus* (Hassk.) Croizat & Metcalf, because they have staminate flowers composed of four sepals with a long fimbriate margin, four stamens with transversely dehiscent anthers and the stigmas in pistillate flowers are free and bifid. These are diagnostic characters of the section *Eriococcus* which occurs predominantly in mainland Asia, especially in Indochina (Kawakita and Kato 2017; Bouman et al. 2018). Prior to this paper, there were seven species recorded in Thailand that belonged to this section, including *P. elegans* Wall. ex Müll.Arg., *P. gracilipes* (Miq.) Müll.Arg., *P. pulcher*, *P. pulchroides* Beille, *P. sikkimensis* Müll.Arg., *P. sootepensis* and *P. taxodiifolius* Beille (Chantaranothai 2007; Bouman et al. 2018). The two newly described species are most similar to *P. pulcher*, but there are a number of different characters as presented in Table 1. Actually, *P. huamotensis* is one of the most distinct

Table 1. Comparison of morphological characteristics of *P. huamotensis*, *P. chantaranothaii* and *P. pulcher*.

Characters	*P. huamotensis*	*P. chantaranothaii*	*P. pulcher*
habit	undershrubs up to 30 cm high	small shrubs up to 80 cm high	shrubs up to 1.5 m high
branchlet	young branchlets minutely puberulous with simple hairs	young branchlets puberulous with white, simple and dendritic hairs	young branchlets puberulous with white dendritic hairs
leaf shape	broadly ovate, obovate, rounded, broadly elliptic, ovate-oblong	oblong, obovate	oblong to elliptic
leaf size	2–9 × (2)3–8 mm	10–21 × 5–8 mm	7–28 × 6–17 mm
leaf texture	subcoriaceous	membranous	subcoriaceous
leaf base	oblique, cordate, broadly cuneate, truncate, rounded	oblique	oblique
leaf apex	acute, acuminate, rounded	mucronate	abruptly mucronate
upper leaf surface	glabrous	puberulous with white, simple and dendritic hairs	glabrous
leaf reticulation	conspicuous, especially on lower surface	inconspicuous on both surfaces	inconspicuous on both surfaces
staminate flower arrangement	2–3(4) flowers in axillary fascicle along lower half of the branchlets	2–3 flowers, in axillary fascicle along lower half of the branchlets	2–6 flowers in axillary fascicle in proximal axils
staminate flower pedicel	4–10 mm long, glabrous	5–11 mm long, glabrous	6–15 mm long, glabrous
staminate flower sepal	4, red, triangular, rhombic-ovate, 1.5–2 × 1–1.2 mm, long fimbriate margin	4, red, triangular, rhombic-ovate, 2–3 × 1 mm, long fimbriate margin	(3)4, red, triangular or ovate, 2–3 × 1–1.6 mm, long fimbriate margin
pistillate flower arrangement	solitary in distal axils	solitary in leaf-axils along upper half of the branchlets	solitary in distal axils
pistillate flower pedicel	7–17 mm long, glabrous	8–11 mm long, puberulous	14–25 mm long, glabrous
pistillate flower sepal	5–6, red, rhombic-ovate, 1.5–3 × 0.6–1 mm, glabrous	6, reddish, narrowly lanceolate, 3–3.5 × 0.5–0.8 mm, outer surface puberulous	(5)6, lower part red, upper part greenish, rhombic-ovate, 2–4.5 × 1.1–2.5 mm, glabrous
ovary	papillose-puberulous	glabrous or papillose	glabrous
styles	ca. 0.1 mm long	ca. 0.1 mm long	ca. 0.1 mm long
stigma	ca. 0.2 mm long	0.4–0.6 mm long	0.3–0.4 mm long
capsule	young capsule red, 2.5–3 mm diam., papillose-puberulous	young capsule white to pale greenish, 2.5–4 mm diam., glabrous or papillose	young capsule light greenish-red, ca. 2.5 mm diam., glabrous
seed	1.5–1.8 × 1.1–1.2 mm	1.5–2 × 1–1.3 mm	2–3 × 0.3–0.5 mm

species of *Phyllanthus* in Thailand. It can be easily distinguished by its reddish branchlets and stem, conspicuous reddish venation, especially on the lower leaf surface, red sepals with long fimbriate margin and red capsule with papillose-puberulous surface.

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RESEARCH ARTICLE

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The endemic plants of Mozambique: diversity and conservation status

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Abstract

An annotated checklist of the 271 strict-endemic taxa (235 species) and 387 near-endemic taxa (337 species) of vascular plants in Mozambique is provided. Together, these taxa constitute c. 9.3% of the total currently known flora of Mozambique and include five strict-endemic genera (*Baptorhachis*, *Emicocarpus*, *Gyrodoma*, *Icuria* and *Micklethwaitia*) and two near-endemic genera (*Triceratella* and *Oligophyton*). The mean year of first publication of these taxa is 1959, with a marked increase in description noted following the onset of the two major regional floristic programmes, the "Flora of Tropical East Africa" and "Flora Zambesiaca", and an associated increase in botanical collecting effort. New taxa from Mozambique continue to be described at a significant rate, with 20 novelties described in 2018. Important plant families for endemic and near-endemic taxa include Fabaceae, Rubiaceae and Euphorbiaceae s.s. There is a high congruence between species-rich plant families and endemism with the notable exceptions of the Poaceae, which is the second-most species rich plant family, but outside of the top ten families in terms of endemism, and the Euphorbiaceae, which is the seventh-most species rich plant family, but third in terms of endemism. A wide range of life-forms are represented in the endemic and near-endemic flora, with 49% being herbaceous or having herbaceous forms and 55% being woody or having woody forms. Manica

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Province is by far the richest locality for near-endemic taxa, highlighting the importance of the cross-border Chimanimani-Nyanga (Manica) Highlands shared with Zimbabwe. A total of 69% of taxa can be assigned to one of four cross-border Centres of Endemism: the Rovuma Centre, the Maputaland Centre sensu lato, and the two mountain blocks, Chimanimani-Nyanga and Mulanje-Namuli-Ribaue. Approximately 50% of taxa have been assessed for their extinction risk and, of these, just over half are globally threatened (57% for strict-endemics), with a further 10% (17% for strict-endemics) currently considered to be Data Deficient, highlighting the urgent need for targeted conservation of Mozambique's unique flora. This dataset will be a key resource for ongoing efforts to identify "Important Plant Areas – IPAs" in Mozambique, and to promote the conservation and sustainable management of these critical sites and species, thus enabling Mozambique to meet its commitments under the Convention on Biological Diversity (CBD).

Resumo

Apresenta-se a lista das plantas vasculares de Moçambique, que compreende 271 taxa endémicos (235 espécies) e 387 taxa quase-endémicos (337 espécies). Estes taxa constituem cerca de 9,3% da flora total actualmente conhecida em Moçambique e incluem cinco géneros estritamente endémicos (*Baptorhachis*, *Emicocarpus*, *Gyrodoma*, *Icuria* e *Micklethwaitia*) e dois géneros quase-endémicos (*Triceratella* e *Oligophyton*). O ano médio das primeiras publicações destes taxa é 1959. Um aumento significativo na descrição de espécies novas foi verificado, relacionado com o início de dois projectos regionais, a "Flora of Tropical East Africa" e a "Flora Zambesiaca", permitindo um esforço maior de colheitas botânicas. Novos taxa têm vindo a ser descritos a um ritmo significativo, com 20 novas espécies descritas em 2018 para a flora de Moçambique. As famílias Fabaceae, Rubiaceae e Euphorbiaceae, incluem importantes taxa endémicos e quase-endémicos. Existe uma estreita relação entre as famílias de plantas com elevado número de espécies e o grau de endemismo, excepção feita às Poaceae, que embora seja a segunda família mais rica em espécies não se posiciona no grupo das dez principais famílias em termos de endemismo. Por outro lado a família Euphorbiaceae, que é a sétima mais rica em espécies, posiciona-se em terceiro lugar quanto ao número de endemismo. A flora endémica apresenta diferentes formas de vida, sendo 49% das espécies herbáceas e 55% lenhosas. A Província de Manica é o local mais rico em taxa quase-endémicos, realçando assim a importância da área transfronteiriça Chimanimani-Nyanga (Manica) entre Moçambique e Zimbabwe. Refira-se ainda que 69% dos taxa encontra-se num dos quatro centros de endemismo transfronteiriços: o Centro do Rovuma, o Centro de Maputaland sensu lato e nas regiões montanhosas de Chimanimani-Nyanga e Mulanje-Namuli-Ribáuè. Cerca de 50% dos taxa foram avaliados quanto ao risco de extinção, estando mais da metade ameaçados globalmente (57% de endemismos) e 10% (17% de endemismos) foram incluídos na categoria Informação Insuficiente (DD), revelando que a maioria das plantas endémicas de Moçambique necessitam de conservação urgente. Este estudo fornece novos dados indispensáveis à identificação das "Áreas Importantes de Plantas – IPAs" em Moçambique, contribuindo ainda para implementar as estratégias de conservação anteriormente estabelecidas pela Convenção sobre a Diversidade Biológica (CBD).

Keywords

centre of endemism, checklist, conservation, flora, herbarium, IUCN Red List, range-restricted

Introduction

Endemic species are an important component of a country's biodiversity stewardship and natural capital (Mapaura 2002). Narrowly restricted endemics are often amongst the species most sensitive to environmental change and disturbance, and so at highest risk of extinction (Crisp et al. 2001; Işik 2011; Borokini 2014; Abdelaal et al.

2018; Orsenigo et al. 2018). These species therefore form important components for a range of methods for identifying and conserving biodiversity priorities, such as Important Plant Areas (Darbyshire et al. 2017), Key Biodiversity Areas (IUCN 2016), and the site criteria of the Alliance for Zero Extinction (Ricketts et al. 2005; http://zeroextinction.org/the-alliance/about-the-alliance/). Furthermore, endemic species can be an important consideration when applying the mitigation hierarchy in environmental impact assessments associated with industrial or commercial development projects, particularly at the avoidance and offsetting stages. Therefore, it is important for countries to have an accurate record of their endemic flora, including how many and which species are endemic, and where they are found. At this time of unparalleled rates of biodiversity loss, it is essential to mobilise such information so that countries can effectively prioritise the conservation and sustainable management of their natural resources (Onana 2013). This paper presents the first detailed account of the endemic flora of Mozambique, a biodiversity-rich country in southern tropical Africa (Fig. 1).

Mozambique: species richness, phytogeography and centres of endemism

Despite its obvious diversity and interest, the flora of Mozambique has received only limited and patchy coverage, particularly when compared to the floras of neighbouring countries. Frodin (2001) estimated the total Mozambican flora as approximately 5,500 species, but noted this was likely to be an under-estimate as "many parts of the country remain imperfectly known" (p. 529). Da Silva et al. (2004) listed only 3,932 indigenous species in their SABONET checklist of Mozambique, of which 177 were noted as endemic. However, it was acknowledged that this list, compiled primarily using specimens held at the LMA and LMU herbaria in Maputo (herbarium acronyms follow Thiers [continuously updated]) with additional records from literature sources, was only provisional, and it has proven to be under-representative. As a good example, da Silva et al. (2004) record nine species of *Barleria* L. (Acanthaceae), but in the "Flora Zambesiaca" (F.Z.) account of Acanthaceae, 33 species of *Barleria* are listed for Mozambique (Darbyshire et al. 2015). In an independent, and more comprehensive analysis, Timberlake et al. (2006) documented 5,692 taxa and 251 endemics in Mozambique including cross-border range-restricted endemics, with an endemism rate of 4.4%. With F.Z. (1960–present) nearing completion, a more accurate measure of species richness in Mozambique is now possible. As of August 2019, the "Flora of Mozambique" website (Hyde et al. 2019a) and associated database of species records, which combine data from F.Z. with updates from relevant literature and field surveys, lists 6,157 native and naturalised species. This figure continues to grow at a rapid rate as targeted botanical surveys of new and botanically interesting areas are conducted, adding new records and new species to science. For example, during surveys of the coastal dry forests in the most north-eastern part of Mozambique in Cabo Delgado Province between 2003 and 2009, during which over 3,000 botanical collections were made, a total of 738 plant taxa were recorded. Of these, 68 were new records for Mozambique, and a further 36 taxa were either entirely new to science or previously known only from fragmentary material and so undescribed (Timberlake et al. 2011).

Mozambique (Fig. 1) derives its rich and varied plant life in part from its diverse geography, geology and climate, including the influence of its extensive Indian Ocean coastline. These factors have resulted in a wide range of habitats and complex biogeography. Thirteen terrestrial ecoregions are recorded in Mozambique (https://ecoregions2017.appspot.com/; Olson et al. 2001; Burgess et al. 2004; Dinerstein et al. 2017). Moreover, Mozambique features several recognised Centres of Plant Endemism. The majority of the country is included within the Zambezian Regional Centre of Endemism (White 1983), which is widely distributed across southern tropical Africa. Of greater significance in terms of concentrations of range-restricted species, are four cross-border Centres of Endemism (Fig. 2). The first is the recently proposed Rovuma Centre (Burrows and Timberlake 2011) of northeast Mozambique and southeast Tanzania, an extension of the previously recognised Lindi Local Centre in Tanzania (Clarke 2001) or a part of the wider Swahelian Centre of Endemism in coastal East Africa (Clarke 1998). The Rovuma Centre extends along the Mozambique coast through Cabo Delgado, Nampula and Zambézia Provinces approximately as far south as the city of Quelimane (J. Burrows, pers. comm.). The second is the Maputaland Centre (van Wyk 1996; van Wyk and Smith 2001), shared with South Africa and eSwatini (formerly Swaziland), which extends along the coastal lowlands of southern Mozambique to the Limpopo River. This region has several recognised Sub-Centres including the Lebombo Mountains, which straddle the border of the three countries (van Wyk and Smith 2001; Loffler and Loffler 2005). In a wider sense, the Maputaland Centre potentially also extends further northwards from the mouth of the Limpopo River all the way to the mouth of the Save River in Inhambane Province, although this has also been proposed as a putative Centre of Endemism in its own right, the Inhambane Centre (J. Burrows, pers. comm.; A. Massingue, unpubl. data). The third cross-border Centre of Endemism is the Chimanimani-Nyanga (or Manica) Highlands that run along the border with Zimbabwe and form the north-eastern-most extent of the Great Escarpment of southern Africa (Clark et al. 2011). These mountains are well known for their rich floras and high plant endemism (Wild 1964; Mapaura 2002; Clark et al. 2017; Wursten et al. 2017; Cheek et al. 2018). The fourth comprises the larger massifs of the belt of inselbergs running from southern Malawi to Zambézia and Nampula Provinces of northern Mozambique (Bayliss et al. 2014). The most significant peaks are Mount Mulanje (including Mount Mchese) and the Zomba Plateau in Malawi, and Mounts Namuli, Mabu, Inago and the Ribaue Mountains in Mozambique – here shortened to the Mulanje-Namuli-Ribaue Mountains. Mount Mulanje is well established as a site of botanical importance with high endemism (Strugnell 2002, 2006), but the botanical importance of the Mozambique massifs and their links to Mulanje are also becoming increasingly evident (Timberlake et al. 2009, 2012; Harris et al. 2011; Bayliss et al. 2014; Downes and Darbyshire 2017). The latter two Centres form a part of the Africa-wide Afromontane Archipelago-like Centre of Endemism of White (1983).

As these four important Centres of Plant Endemism all cross national borders, it is clearly evident that the political boundary of Mozambique does not reflect species distributions and biogeographic patterns. When considering endemic taxa, therefore, it is pertinent to include within this review those cross-border range-restricted taxa that

Figure 1. Map of Mozambique showing the ten provinces and neighbouring countries. Provincial borders are shown in pale grey, country borders are in black.

have a globally significant portion of their range in Mozambique, rather than restricting coverage to taxa that only occur within the political border. Hence the definition of the endemic plants is here extended to include all such relevant near-endemic taxa.

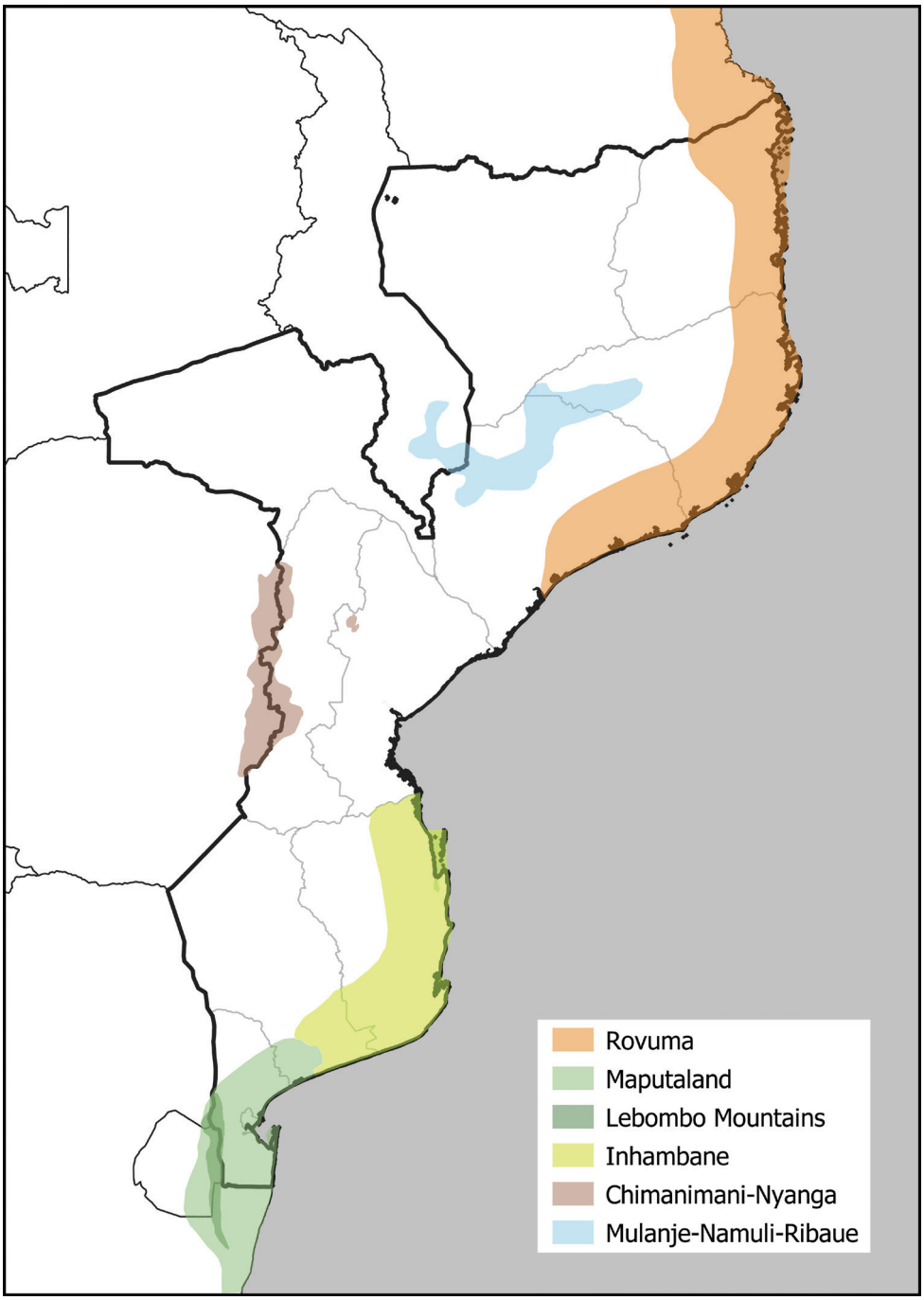

Figure 2. Cross-border Centres of Plant Endemism in Mozambique. Note that the boundaries of these Centres of Endemism are only intended to be indicative; further research is required to more accurately delimit these centres. The two montane Centres (Chimanimani-Nyanga and Mulanje-Namuli-Ribaue) are drawn as continuous blocks for clarity, but in reality they are a discontinuous series of peaks.

Motivation for the current study: conservation of the Mozambique flora

In order to address Mozambique's commitments under the Convention on Biological Diversity (CBD), the "National Strategy and Action Plan of Biological Diversity of Mozambique 2015–2035" (MITADER 2015) sets out a series of detailed national targets for documenting and conserving the biodiversity of Mozambique. Target 6 of this strategy aims to "by 2025, have at least 30% of habitats of endemic and/or threatened flora and fauna species with strategies and action plans for their conservation in place" with a series of related priority actions, including:

- Action 6.1: establish and implement coordinated programs for the systematic assessment of the conservation status of endemic and endangered species;
- Action 6.2: identify and describe the Areas of Plant Importance;
- Action 6.3: disseminate the Red data Book on national flora and fauna.

To address these targets, and to enable effective conservation of Mozambique's plant diversity in light of increasingly severe pressure on natural resources, a number of botanical initiatives have been launched. A plant Red Listing programme and working group was established in 2011 through the IUCN-SSC Southern African Plant Specialist Group, with the current aim to complete at least 400 new or updated plant species assessments in the period 2017–2020, focussing on strict-endemic and near-endemic species of Mozambique (IUCN SSC Southern African Plant Specialist Group 2017; Matimele 2019). In 2015, the Instituto de Investigação Agrária de Moçambique (the Agrarian Research Institute of Mozambique – IIAM) and the Royal Botanic Gardens, Kew (Kew), together with in-country and international collaborators, launched the "Tropical Important Plant Areas: Mozambique" project (https://www.kew.org/science/projects/tropical-important-plant-areas-tipas-mozambique). This project aims to combine existing data and expertise with targeted field survey data to identify and document Important Plant Areas (IPAs) in Mozambique, and to promote the conservation and sustainable management of these critical sites. This builds on the provisional identification of IPAs through the Southern African Botanical Diversity Network (SABONET) programme (Smith 2005). Further, it draws on the series of extensive botanical surveys in sites of high biodiversity interest across Mozambique that have been conducted by IIAM, Kew and collaborators over the past 15 years. Documentation of the endemic taxa and where they occur is an important step in the IPA and Red Listing programmes, and so provides the motivation for the detailed checklist presented here.

Materials and methods

Key resources for compiling the checklist

Compilation of the checklist was based primarily upon extensive reviews of literature on the taxonomy and floristics of Mozambique and neighbouring countries, combined

with reference to relevant herbarium collections (notably at BM, BNRH, EA, K, LISC, LMA, LMU, NH, P, PRE and SRGH; herbarium codes follow Thiers [continuously updated]), and the authors' collective knowledge of the Mozambican flora. A key source for information on the plants of Mozambique, and the starting point for this current work, is the "Flora Zambesiaca" series (F.Z.; 1960–present; http://apps.kew.org/efloras/search.do). This Flora is currently c. 90% complete, with 13 volumes and 47 parts published to date (Exell and Wild 1960, Timberlake and Martins 2015). We have also had access to completed and partially completed accounts for the outstanding volumes: Apocynaceae (Part 2), Commelinaceae, Asteraceae (Compositae) in part, Cyperaceae, and Hyacinthaceae. However, it should be noted that Asteraceae may be under-represented in this checklist in view of the fact that this family has not yet been completed for F.Z.

The "Flora de Moçambique" project ran alongside F.Z. from 1969, but was discontinued in 1981. The accounts in this Flora were derived from F.Z., but with some additional specimen citations and Mozambique-relevant habitat information, thus providing useful additional information for the current work. However, Beentje (2016) estimates that this Flora is less than 40% complete. Other key published works used repeatedly are the recently published landmark volume "Trees and Shrubs [of] Mozambique" (T.S.M.; Burrows et al. 2018); the first national Plant Red List for Mozambique produced through the SABONET programme (S.R.D.L.; Izidine and Bandeira 2002); the field guide to wild flowers of southern Mozambique (Bandeira et al. 1997); and reports on recent botanical surveys and checklists of key localities in Mozambique (Timberlake et al. 2007, 2009, 2010, 2011, 2012, 2016a, 2016b; Bayliss et al. 2010; Harris et al. 2011; Müller et al. 2012; Clark et al. 2017; Wursten et al. 2017). The "Flora of Tropical East Africa" (1952–2012; Beentje 2012, 2016) was also an important source of information for many northern near-endemic species. Key online sources that were widely consulted are the "Flora of Mozambique and Flora of Zimbabwe" sites (Hyde et al. 2019a, 2019b), the African Plant Database (2019), the IUCN Red List of Threatened Species (IUCN 2019), the Botanical Database of Southern Africa / Plants of Southern Africa (South African National Biodiversity Institute 2019), the Red List of South African Plants (South African National Biodiversity Institute 2017) and Plants of the World Online (POWO 2019).

Definitions of endemism and near-endemism

The taxa treated in the checklist are either strictly endemic to Mozambique (i.e. they only occur within its political borders – labelled E), or are "near-endemic" (NE), as defined by one or more of the following criteria:

(a) the majority of the taxon's range lies within Mozambique, and they are scarce and/or highly range-restricted beyond (NE1); and/or
(b) the global range of the taxon is less than 10,000 km^2 (NE2); and/or
(c) the taxon is known globally from five or fewer localities (NE3).

The aim is to include all taxa for which Mozambique has a particularly high responsibility for their global survival and protection, thus those taxa that have the majority of their range in Mozambique, but are also widespread and/or frequent in other parts of southeast tropical Africa are excluded. For example, *Barleria repens* Nees (Acanthaceae) is widely distributed along the East African coast, but with the majority of its distribution in Mozambique because of the vast length of the country's coastline. However, we do include under (b) and (c) those taxa that do not necessarily have the majority of their range in Mozambique but, because of their highly restricted range and/or scarcity, the Mozambique portion of the population is of global significance to their future survival. We acknowledge that no definition of "near-endemic" is perfect, but we have tried to be as objective as possible when applying the criteria set out above. We have tried to be exhaustive, but our intention is to maintain this list and publish additions and amendments as they are uncovered.

Estimates of range size used in (b) above are based on mapping of known locality data. An offline BRAHMS database (https://herbaria.plants.ox.ac.uk/bol/) of all known collections and sight records of endemic, range-restricted and threatened species is in advanced progress at RBG Kew and IIAM, with approximately 6,000 records compiled to date. Hence, for most of the species on the list we have an accurate measure of range size. For others, where the data are yet to be finalised, ranges have been estimated, aided where available by use of data available via the GeoCAT tool (http://geocat.kew.org/; Bachman et al. 2011); this includes access to relevant GBIF data (GBIF.org 2019). In most cases, the range size is based on the Minimum Convex Polygon (MCP) method commonly applied in the calculation of extent of occurrence (EOO) in the IUCN Red List criteria (Joppa et al. 2016; Bachman et al. 2011; IUCN 2012). However, in a few circumstances where species have highly disjunct distributions with unsuitable habitat in most of the intervening areas, we have estimated range based on the known localities. Of particular note are montane species that are found in the Chimanimani-Nyanga (Manica) Highlands along the Mozambique-Zimbabwe border, but which also extend to Mount Gorongosa, an isolated peak over 100 km to the east in Sofala Province. This usually results in a MCP range of over 10,000 km^2 (depending on the distribution within the Manica Highlands), but as there is no suitable montane habitat in the intervening region, we treat this range as being less than 10,000 km^2, and include these species as near-endemics.

Taxonomy and literature sources

Plant family circumscription follows the Angiosperm Phylogeny Group (APG IV) classification for flowering plants (Stevens 2001 onwards; Angiosperm Phylogeny Group 2016), the Pteridophyte Phylogeny Group (PPG 1; 2016) classification for pteridophytes, and Christenhusz et al. (2011) for gymnosperms. Accepted names of species and infraspecific taxa generally follows the African Plant Database (2019; henceforth APD) except in rare cases where the APD has not been updated to the most recent name, or in the few cases where we disagree with the species circumscription adopted by APD,

e.g. *Elaeodendron fruticosum* N.Robson, which is treated as a synonym of *E. matabelicum* Loes. in APD, but we follow Burrows et al. (2018) in recognising it as distinct. Where the taxonomic concept adopted is not universally accepted, or where a taxon has been very recently re-combined, the alternative name is given in brackets. Included on the checklist are all published endemic and near-endemic taxa, together with eight new taxa that are currently either in press or in the late stages of preparation (e.g. *Cyanotis namuliensis* Faden, *Sericanthe chimanimaniensis* Wursten & de Block) such that we are confident of their status. Only species, subspecies and varieties are included in this list; we do not include endemic or near-endemic forms. We have additionally compiled a list of undescribed taxa that are provisionally considered to be endemic or near-endemic to Mozambique, but that have not yet been studied in sufficient detail or are represented by incomplete specimens, for example *Dicliptera* spp. B, C and E of F.Z. (Darbyshire et al. 2015). These are not presented in the checklist, but are available on request from the corresponding author, and included in some of the analyses in the Results and Discussion. Highly doubtful and imperfectly known taxa are excluded. For example, both *Acacia purpurea* Bolle and *Oxyanthus querimbensis* Klotzsch were described from collections made in Mozambique by Wilhelm Peters in the mid-nineteenth century (Peters 1861), and are believed to have been destroyed during the bombing of the Berlin Herbarium in World War II. These species were treated in F.Z. as insufficiently known, and potentially conspecific with other, more widespread species (Brenan 1970; Bridson and Verdcourt 2003).

The date of the original publication (the protologue) is recorded for each taxon. As the aim is to chart the discovery of Mozambique's endemic flora, it is the date of first publication of the taxon that is of importance, rather than the publication date of the currently accepted name. In many cases these are one and the same, for example *Euphorbia angularis* Klotzsch (in Peters 1861: 92) has been the accepted name ever since its first publication. However, many taxa have changed genus or taxonomic rank since they were first published; for example, the combination for the endemic *Barleria setosa* (Klotzsch) I.Darbysh. was first published in 2015 (Darbyshire et al. 2015), but is based on *B. prionitis* L. var. *setosa* Klotzsch, published in Peters (1861: 209), hence 1861 is the date of first publication of this taxon.

For each taxon, we include key references for further information on the plant and its distribution and ecology. Wherever relevant, we include the F.Z. volume and page number, and the page number in T.S.M. and S.R.D.L. For taxa that have been described since the relevant F.Z. volume, we cite the protologue. For those taxa that have changed name or taxonomic rank since F.Z. (for example, have been transferred to a different genus), we cite the relevant F.Z. volume and page number for the taxon account, but also cite the protologue for the currently accepted name.

Plant life-forms

The growth habit and life cycle of each species are recorded using a simple classification, with six main categories: tree, shrub, liana, herb, pteridophyte and cycad. The herb category is further subdivided into annual (a), perennial (p), succulent-perennial (s),

epiphytic-perennial (e), climbing-perennial (c), geophyte (geo), graminoid (gram-a for annual and gram-p for perennial) and seagrass. Trees and shrubs also have a succulent subdivision. Species with variation in growth habit and/or life cycle are recorded in two or more categories.

Distribution and phytogeography

Taxa known only from the type specimen or type locality are noted. The distribution of each taxon within Mozambique is then recorded, first by scoring which of the provinces it is recorded in (Maputo City Province is included within Maputo Province, hence 10 provinces, Fig. 1), and second by recording key localities in Mozambique arranged by province. The latter are taken from the BRAHMS database noted above, and from additional site observations from the authors. We have attempted to standardise the Mozambican place names, but have used anglicised forms where they are in common use in the literature and/or in gazetteers (such as Mt Mabu and Ribaue Mts, rather than Serra de Mabu and Serra do Ribáuè), and we have avoided use of Portuguese accents on place names, as these are often inconsistently applied. This locality information is provided to help with future study of these species, and to assist with the identification and demarcation of Important Plant Areas. It is not intended to be exhaustive and should not be read as such.

For near-endemic species, the other country (or countries) in which the species occurs is recorded, together with a brief note of key localities; these are not intended to be exhaustive or specific, rather to show how far the species extends beyond Mozambique.

Finally, in order to provide phytogeographic context, the taxa are provisionally assigned where possible to botanical Centres of Endemism (see Introduction). We exclude the widespread Zambezian Regional Centre (White 1983), instead focussing on the more restricted cross-border Centres: (1) Rovuma; (2) Maputaland sensu lato, which we subdivide into (2a) Maputaland sensu stricto (coastal lowlands north to Limpopo River), (2b) Lebombo Mountains (Sub-) Centre, and (2c) Inhambane (Sub-) Centre; (3) Eastern Afromontane, which we subdivide into (3a) Chimanimani-Nyanga (Manica) Highlands, and (3b) Mulanje-Namuli-Ribaue Mountains.

Extinction risk using the IUCN Red List

Using the categories and criteria of the IUCN Red List (IUCN 2012, 2019), the extinction risk is recorded if the taxon has been assessed; the Red List provides additional information on these species, and so can be considered a further key reference. Red List assessments in need of updating are marked with an asterisk; in most cases these were assessed using an earlier version of the Red List criteria. Red List assessments that have been finalised, but not yet published are listed in italics. Only global Red List assessments are included; we do not list the national assessments of Izidine and Bandeira (2002), as these were highly provisional and are in the process of being re-evaluated on a global scale.

Results

An annotated checklist of the strict-endemic and near-endemic taxa of Mozambique is presented in Suppl. material 1, with a summary of the checklist provided in Appendix 1. It includes all taxa (species, subspecies and varieties) that have been described to date or are in the process of being described. In total, 658 taxa (572 species) are documented, comprising 271 strict-endemic taxa (235 species) and 387 near-endemic taxa (337 species) (Table 1, Fig. 3). In addition, 105 currently undescribed but potentially new taxa (98 species) that are believed to be strict-endemic or near-endemic are noted, but not included in Suppl. material 1 or Appendix 1. If the total number of native and naturalised vascular plant species in Mozambique is taken as ± 6,157 (as per Hyde et al. 2019a), then approximately 3.8% of the species are strict-endemics, whereas the strict-endemics and near-endemics combined account for 9.3% of the plants in Mozambique at the species rank, discounting undescribed taxa. If undescribed taxa are included then approximately 10% of the flora of Mozambique is endemic or near-endemic.

Mozambique currently has five strict-endemic genera, all of which are monospecific: *Baptorhachis* Clayton & Renvoize (Poaceae) from the granite inselbergs of Nampula Province; *Emicocarpus* K.Schum. & Schltr. (Apocynaceae) from sandy soils around Maputo Bay; *Gyrodoma* Wild (Asteraceae) widespread on alluvial plains, estuaries and margins of lagoons in coastal Mozambique from Zambézia Province southwards; and *Icuria* Wieringa (Fabaceae) and *Micklethwaitia* G.P.Lewis & Schrire (Fabaceae), both occurring as locally dominant trees in the coastal dry forests of northern Mozambique. A further two potential new strict-endemic genera in Asparagaceae (former Hyacinthaceae) are currently under research (T. Rulkens, pers. comm.). In addition, two monospecific genera are near-endemic to Mozambique: *Triceratella* Brenan (Commelinaceae), occurring in moist sands in coastal Zambézia Province, but also known from one locality in Zimbabwe; and *Oligophyton* H.P.Linder & G.Will. (Orchidaceae), restricted to the Chimanimani Mountains on the Zimbabwe-Mozambique border. Two other genera have their sole African representative in Mozambique: *Dolichandrone* Fenzl (Bignoniaceae) and *Eriolaena* DC. (Malvaceae), both of which are predominantly Asian genera (Diniz 1988; Dorr and Wurdack 2018).

Of the near-endemic taxa, 179 are shared with Zimbabwe, 93 with Tanzania, 79 with South Africa, 59 with Malawi, 20 with eSwatini, two with Madagascar and one each with Kenya and Zambia.

Tables 2–6 provide further summaries of the findings presented in Suppl. material 1, namely the most important plant families for strict-endemic and near-endemic taxa (Table 2); the range of life forms of these taxa (Table 3); their geographic distribution by province in Mozambique (Table 4); their distribution within recognised and proposed Centres of Endemism (Table 5); and the extinction risk status of these taxa (Table 6). These tables exclude unpublished taxa. Figure 4 charts the history of publication of the currently accepted strict-endemic and near-endemic taxa in scientific literature.

In Suppl. material 2, we provide a list of taxa that were considered for inclusion in the checklist during its preparation but were ultimately excluded as they did not meet the criteria set out in the Methodology.

Table 1. Summary of endemic taxa in Mozambique. Note that genera are not included in the "Total taxa" row.

Taxon rank	Mozambique strict-endemics	Mozambique near-endemics	Mozambique strict-endemics and near-endemics
Genus	5	2	7
Species	235	337	572
Subspecies	18	28	46
Variety	18	22	40
Total taxa	**271**	**387**	**658**

Table 2. Important plant families for published endemic taxa in Mozambique. The 10 plant families with the highest number of endemic taxa, with comparison to the ten most species-rich plant families for the total Mozambican flora (derived from Hyde et al. 2019a). Numbers refer to number of taxa; where two or more plant families share the same number of taxa, the "=" symbol is used to denote that these families have an equal standing in the table.

Mozambique strict-endemics		Mozambique strict-endemics and near-endemics		Total vascular plants of Mozambique	
1. Fabaceae	40	1. Fabaceae	84	1. Fabaceae	759
2. Euphorbiaceae	26	2. Rubiaceae	71	2. Poaceae	445
3. Rubiaceae	23	3. Euphorbiaceae	42	3. Rubiaceae	377
4. Malvaceae	12	4. Lamiaceae	30	4. Asteraceae	352
5. Apocynaceae	11	5.= Apocynaceae	27	5. Orchidaceae	232
6.= Acanthaceae	10	5.= Asteraceae	27	6. Acanthaceae	219
6.= Lamiaceae	10	7. Acanthaceae	26	7.= Euphorbiaceae	194
8. Lythraceae	9	8.= Malvaceae	21	7.= Malvaceae	194
9.= Asphodelaceae	8	8.= Orchidaceae	21	9. Lamiaceae	185
9.= Melastomataceae	8	10. Asphodelaceae	20	10. Apocynaceae	156

Table 3. Life forms (growth habits) of published endemic taxa of Mozambique. Note that species can fall under more than one habit category or sub-category. Numbers refer to number of taxa.

Life form (growth habit)		Mozambique strict-endemics	Mozambique strict-endemics and near-endemics
Tree	Non-succulent	54	134
	Succulent	2	9
	Tree Total	**56**	**143**
Shrub	Non-succulent	103	283
	Succulent	19	27
	Shrub Total	**122**	**310**
Liana		7	28
Woody life forms Total		144	363
Herb	Annual	27	51
	Perennial – non-succulent	67	175
	Perennial -succulent	12	28
	Perennial -epiphyte	1	4
	Perennial – climber/twiner	4	12
	Perennial – geophyte	14	43
	Graminoid – annual	2	4
	Graminoid – perennial	5	11
	Seagrass	1	2
	Herb Total	**136**	**324**
Pteridophyte		0	1
Cycad		4	11
Unknown		1	1

Table 4. Summary of the geographic distribution of published endemic taxa in the ten provinces of Mozambique. The table is ordered alphabetically by Province; numbers refer to number of taxa.

Province	Mozambique strict-endemics	Mozambique strict-endemics and near-endemics	Provincial endemics	Strict-endemics and near-endemics restricted to one Province
Cabo Delgado (CD)	56	125	27	54
Gaza (G)	26	62	5	7
Inhambane (I)	48	93	15	17
Manica (Mn)	22	192	20	150
Maputo (Mp)	36	119	13	50
Nampula (Na)	86	154	29	38
Niassa (Ni)	19	40	10	21
Sofala (S)	47	105	16	21
Tete (T)	7	18	2	3
Zambézia (Z)	81	159	34	56

Table 5. Number of published endemic taxa restricted to Centres and Sub-Centres of Endemism. For the Sub-Centres under (2) Maputaland and (3) [Eastern] Afromontane, taxa are only recorded if they are exclusive to that Sub-Centres.

Centre of Endemism code	(Sub-) Centre of Endemism	Mozambique strict-endemics	Mozambique strict-endemics and near-endemics
1	Rovuma	55	110
2	Maputaland sensu lato (including Inhambane)	50	114
2a	Maputaland sensu stricto	13	32
2b	Lebombo Mountains (Sub-) Centre	3	17
2c	Inhambane (Sub-) Centre	20	20
3	[Eastern] Afromontane sensu lato	46	229
3a	Chimanimani-Nyanga (Sub-) Centre	16	158
3b	Mulanje-Namuli-Ribaue (Sub-) Centre	30	59

Table 6. Summary of the extinction risk status of published endemic taxa in Mozambique. The "% of taxa" figure for "Total taxa assessed" is given as a percentage of all the endemic (left) and endemic plus near-endemic (right) taxa listed in Appendix 1; for each of the Red List categories (LC = Least Concern; NT = Near Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered; DD = Data Deficient), the "% of taxa" is given as a percentage of those taxa that have been assessed.

	Mozambique strict-endemics		Mozambique strict-endemics and near-endemics	
IUCN Red List Category	Number of taxa	% of taxa	Number of taxa	% of taxa
Total taxa assessed	145	53.5	332	50.5
LC	33	22.8	107	32.2
NT	4	2.8	19	5.7
VU	32	22.1	86	25.9
EN	32	22.1	69	20.8
CR	19	13.1	19	5.7
DD	25	17.2	32	9.6

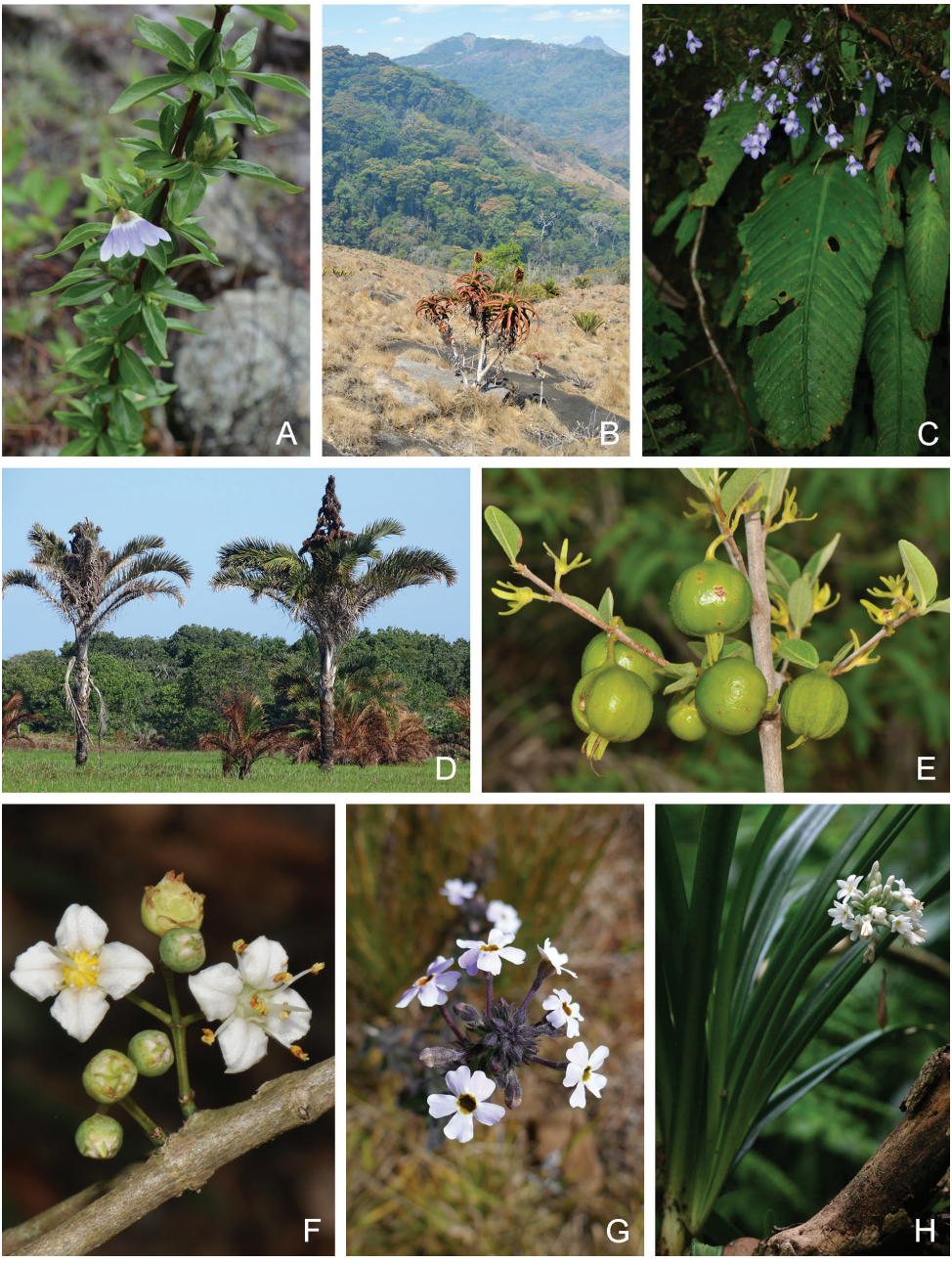

Figure 3. Examples of the strict-endemic and near-endemic plants of Mozambique. **A** *Sclerochiton coeruleus*, Maronga, Manica (I. Darbyshire) **B** *Aloe ribauensis*, Ribaue, Nampula (I. Darbyshire) **C** *Streptocarpus brachynema*, Mount Gorongosa, Sofala (B. Wursten) **D** *Raphia australis*, Bilene, Gaza (H. Matimele) **E** *Vangueria monteiroi*, Bilene, Gaza (H. Matimele) **F** *Memecylon incisilobum*, Bilene, Gaza (H. Matimele) **G** *Jamesbrittenia carvalhoi*, Tsetserra, Manica (J. Osborne) **H** *Cryptostephanus vansonii*, Mount Gorongosa, Sofala (B. Wursten)

Figure 3. Continued. **I** *Orbea halipedicola*, Gorongosa National Park, Sofala (B. Wursten) **J** *Helichrysum moorei*, Chimanimani Mountains, Manica (B. Wursten) **K** *Eriolaena rulkensii*, Palma Bay, Cabo Delgado (T. Rulkens) **L** *Barleria torrei*, Njesi Plateau, Niassa (J. Osborne) **M** *Xylopia torrei*, Licuati Forest, Maputo (H. Matimele) **N** *Aeschynomene grandistipulata*, Chimanimani Mountains, Manica (B. Wursten) **O** *Lobelia cobaltica*, Chimanimani Mountains, Manica (B. Wursten) **P** *Euphorbia crebrifolia*, Chimanimani Mountains, Manica (B. Wursten) **Q** *Dissotis pulchra*, Chimanimani Mountains, Manica (B. Wursten) **R** *Pavetta pumila*, Cheringoma, Sofala (B. Wursten).

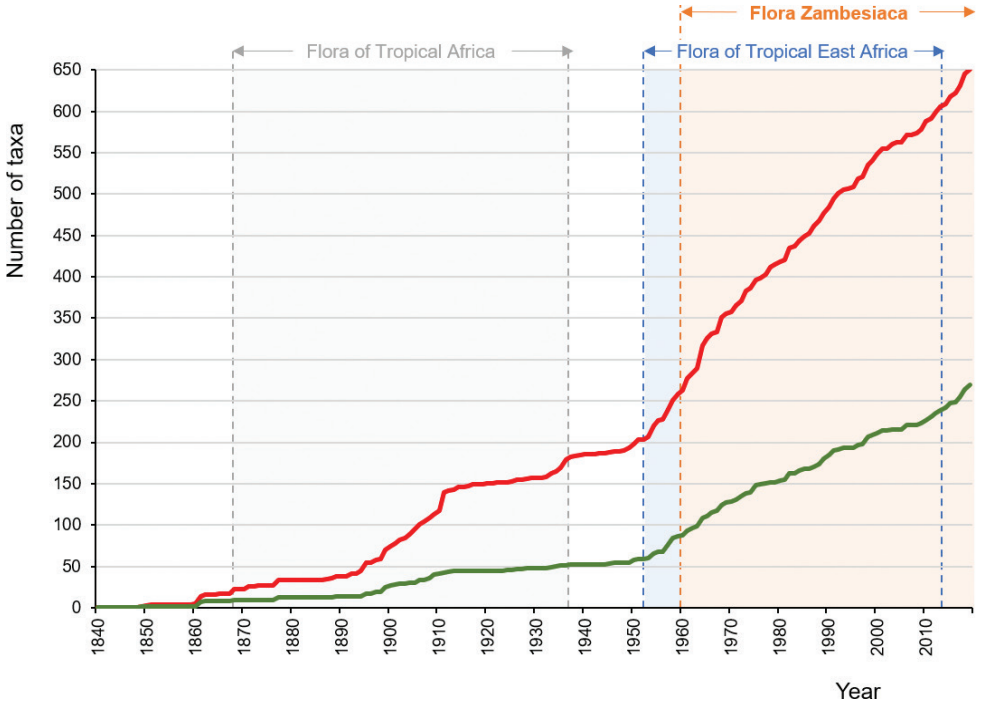

Figure 4. History of publication of the endemic taxa of Mozambique. Cumulative publication dates (basionyms) for currently accepted strict-endemic taxa (green line), and combined strict-endemic and near-endemic taxa (red line), 1840 to present. Also highlighted are the date ranges for the three relevant Tropical African Flora programmes: "Flora of Tropical Africa" (1868–1937), "Flora of Tropical East Africa" (1952–2012) and "Flora Zambesiaca" (1960–present).

For the sake of brevity in the following Discussion, we refer to the combined strict-endemic and near-endemic taxa as “endemics”, whilst we refer to “strict-endemics” if referring only to those taxa unique to Mozambique; the two groups are separated out in the accompanying tables.

Discussion

Species richness and endemism in the flora of Mozambique

Based on extrapolation from the RAINBIO mega-database – one of the most comprehensive datasets for plant diversity in tropical Africa, with distribution data for 25,356 native species (Dauby et al. 2016) – Sosef et al. (2017) estimated species richness in Mozambique as between 5,220–5,309 and recorded a relatively high rate of endemism (8.4%, equating to c. 440 spp.) compared to neighbouring countries of southern tropical Africa (Malawi 6.5%, Zambia 7.2%, Zimbabwe 7.6%), although notably lower than Tanzania to the north (19.4%). Current evidence demonstrates that the RAINBIO figure for total species richness is a significant under-estimate, with the total vascu-

lar flora currently at 6,157 species (Hyde et al. 2019a), over 15% higher than the upper estimate of Sosef et al. (2017). The known strict-endemism rate of 3.8% is considerably lower than the predicted endemism of Sosef et al. (2017), but if we use the broader definition of endemism applied here to include cross-border near-endemics, then 9.3–10% of taxa are endemics (depending on omission or inclusion of unpublished taxa), which is comparable with the RAINBIO estimate. This figure is considerably higher than the 4.4% endemism rate earlier recorded by Timberlake et al. (2006).

Whilst new discoveries are likely to continue to be made in Mozambique (see below), the percentage endemism of the flora is unlikely to increase, and may even decline as the rate of new country records of non-endemic taxa outstrips the rate of new taxon discovery. For example, in the surveys of the coastal dry forests of northeast Cabo Delgado in 2003–2009, the 68 records of taxa new to Mozambique (Timberlake et al. 2011) included only six near-endemic taxa following the definition applied here. Hence, whilst the discovery of 36 putative new, endemic taxa during these surveys was quite exceptional for eastern tropical Africa in the twenty-first century, it was surpassed at the rate of 1.7:1 by the discovery of new country records of more widespread, non-endemic taxa.

Discovery of the endemic flora of Mozambique

There have been concerted efforts to document the tropical African flora for over a century and a half, with the first major sub-continental work – the "Flora of Tropical Africa" – dating back to 1868–1937 (Beentje 2016), and the first strict-endemic plant species described in Mozambique as early as 1849 [*Fornasinia ebenifera* Bertolini (1849) = *Millettia ebenifera* (Bertol.) J.E.Burrows & Lötter; see Burrows et al. 2018]. Given these facts, the relatively recent discovery and/or description of many of Mozambique's endemic plants – the mean year of first publication being 1959, or 1967 for strict-endemics (Fig. 4) – is somewhat surprising. A marked increase in taxon description is observed post-1950, which coincides with the onset of the major eastern African Flora projects – the first fascicle of "Flora of Tropical East Africa" was published in 1952 and the first part of "Flora Zambesiaca" in 1960 (Beentje 2016). Coupled with these Flora projects was major regional-scale botanical exploration to collect herbarium material on which the Flora volumes could be based, and to fill the many gaps in our knowledge of these floristic regions. It was these combined efforts that resulted in the major discoveries of the Mozambique flora, a clear demonstration of how important an active Flora project can be in unlocking information on national and/or regional plant diversity. The completed Floras have, in turn, highlighted localities of high botanical interest, encouraging targeted collecting efforts in Mozambique particularly over the past two decades. Mozambique remains one of the African countries with the highest rates of new species publication. For example, in 2018, 20 new species and one new variety of vascular plants were described from the country, including eight new woody species in the "Trees and Shrubs [of] Mozambique" (Burrows et al. 2018), and four new species of *Memecylon* L. in the Melastomataceae family (Stone et al. 2018).

Of the published endemics, 60 (47 species, 3 subspecies, and 10 varieties) are known only from the type specimen and/or the type locality. This comprises nearly one quarter (22%) of the strict-endemics of Mozambique. A small number of these taxa are of somewhat doubtful status, for example *Teclea crenulata* (Engl.) Engl. (Rutaceae) from Zambézia Province, and some may be subsumed within other, more widespread taxa following further research. However, most are accepted in all relevant taxonomic and floristic works (African Plant Database 2019), and in many cases have been upheld in multiple treatments. The fact that these taxa are so poorly known demonstrates how limited our knowledge of the Mozambique flora remains, and reinforces the likelihood that further discoveries of narrowly range restricted endemics in Mozambique will be made through future botanical exploration.

Important plant families for endemic and near-endemic taxa in Mozambique

There is generally a high congruence between total species richness per plant family in Mozambique and those families that contain the highest number of endemics, with all but two of the families featuring in both lists of top ten families (Table 2). Fabaceae (Leguminosae) is the most species-rich plant family in Mozambique, and also has the highest number of published endemics. As in most of the African continent, the Fabaceae have diversified significantly in nearly all habitats and ecoregions of Mozambique, and display a large variety of life-forms (Lewis et al. 2005). This, coupled with the high rate of endemism, indicates that the Fabaceae may be considered a suitable proxy group for the study of vascular plant distribution and diversity in Mozambique. Other families that combine high species diversity and high rates of endemism include Acanthaceae, Asteraceae, Malvaceae, Orchidaceae and Rubiaceae. In total, the ten most endemics-rich families contain over half (56%) of the total endemic taxa.

Some species-rich families do not, however, feature prominently in the endemics list, most notably the Poaceae, which is the second largest family in Mozambique, but falls outside the top ten families (twelfth) for endemics. This phenomenon is not isolated to Mozambique, and high proportions of grass taxa globally are known to have large ranges. Linder et al. (2017) noted a range of ecological adaptations that enable grasses to successfully colonise and dominate many ecosystems, including effective long-distance dispersal through wind pollination and seed dispersal, ecological flexibility, resilience to disturbance, and an ability to modify environments by changing fire regimes and mammalian herbivory. Many of these factors could also facilitate wide ranges and abundance of individual grass species.

Conversely, some plant families feature more highly on the endemics list than in terms of total species richness. Euphorbiaceae is the third highest family for endemism, but only equal-seventh for total species richness; this is primarily a result of the high number of range-restricted *Euphorbia* species that occur in Mozambique, most of which are succulents (see Plant life forms below). Furthermore, three plant families feature on the list of families with the highest number of strict-endemics, but not amongst the most spe-

cies-rich families. The first is Asphodelaceae, which is a result of the high number of *Aloe* L. species. *Aloe* is the single largest genus for endemics in Mozambique with many species being narrowly range-restricted in montane areas and inselbergs (Carter et al. 2011). This is a general trend amongst aloes: while a few species are widespread, the majority have restricted distribution ranges (Reynolds 1950; Grace et al. 2011). The second is Lythraceae, a result of the high number of *Ammannia* L. (including *Nesaea* Comm. ex Kunth.) species that typically occur as small herbs in seasonal wetlands and ephemeral pools. This genus is one of the few groups of aquatic plants to support large numbers of narrowly restricted endemics, with many species known from only one or few collections (see Fernandes 1978; Verdcourt 1994). *Ammannia* should be considered a priority for future study here and elsewhere in tropical Africa with targeted field surveys required in order to better understand the diversity and distribution of this group. The third is Melastomataceae, which is driven largely by the closely related genera *Memecylon* and *Warneckea* Gilg, both of which are primarily forest taxa with high numbers of narrowly range-restricted species throughout their global range (see Stone 2014). As an example, Burrows et al. (2018) note that Namacubi Forest (at Quiterajo in Cabo Delgado Province) is home to seven species in these two genera, three of which are known nowhere else, and a further three of which are strict-endemics or near-endemics to northern Mozambique.

Plant life forms

A wide range of plant life forms are represented in the checklist (Table 3). Overall, just under half (49%) of taxa listed are herbaceous or have herbaceous forms, whilst just over half (55%) are woody or have woody forms – the small overlap is due to taxa that can be either perennial herbs or shrubs/lianas. Such a range of life forms is unsurprising in view of the wide range of habitats containing endemic and near-endemic species. As with the endemic flora of Zimbabwe (Mapaura 2002), succulent taxa are well represented, with 58 taxa (c. 9%). This reflects the importance of rock outcrops and mountain ranges as key habitats for endemics, as these often support a specialised, drought-tolerant flora.

Geographic distribution of the endemic and near-endemic taxa of Mozambique

A detailed analysis of the geographic distribution of the endemic flora of Mozambique is premature until the collation of all the specimen and observation data is completed. However, some initial observations can be noted.

By far the most frequently recorded locality for endemics (see Suppl. material 1) is the Chimanimani Mountains (Manica Province, 128 taxa), which has more than double the number of these taxa when compared to the second-most frequently recorded site, Mount Namuli (Zambézia, 60 taxa). The Chimanimani Mountains were also noted as the principal locality in Zimbabwe for strict-endemic and near-endemic species (Mapaura 2002). Other localities rich in endemics, with over 20 taxa each, include Quiterajo, the lower Rovuma River, Quirimbas National Park, and Palma and

environs (Cabo Delgado); Pomene and Vilanculos (Inhambane); Tsetserra (Manica); Maputo municipality and Inhaca Island (Maputo); Nampula and environs, and the Ribaue Mountains (Nampula); Gorongosa National Park including Mount Gorongosa (Sofala); and Mocuba and environs (Zambezia). All of these localities are of high national and global importance for their assemblages of endemic and range-restricted taxa, and are clear candidates for inclusion in the Important Plant Areas network, although some have been heavily degraded by man and so are in danger of losing their botanical value. The most notable example is the Maputo municipality, where intact habitats are now reduced to small and isolated pockets, or have been largely destroyed by the rapid expansion of the capital city. Such loss of habitat may have resulted in local extinction of important taxa or, as with *Emicocarpus fissifolius* K.Schum. & Schltr. (Matimele et al. 2016), potentially even global extinction.

There is considerable variation in the number of endemics at the provincial level (Table 4). When only strict-endemics are considered, Nampula and Zambézia provinces register the highest numbers. These two provinces are adjacent to one another and both combine significant stretches of coastal vegetation within the Rovuma Centre of Endemism and inselbergs and massifs associated with the Mulanje-Namuli-Ribaue belt of mountains. The wide range of associated habitats (including coastal dry forest and thickets, granite outcrops, submontane forest, montane grassland) are known to support significant numbers of endemic species. However, when near-endemics are included in the analysis, Manica is found to surpass Nampula and Zambézia in terms of both total numbers of taxa and taxa unique to a single province in Mozambique. This highlights the great importance of the Chimanimani-Nyanga Highlands for cross-border endemism. This also explains the high number of near-endemic taxa shared with Zimbabwe. The least rich province for endemics is Tete, despite being the third largest province in the country. Much of Tete is characterised by a prolonged dry season with extreme high temperatures, and with extensive stands of low-diversity mopane [*Colophospermum mopane* (Benth.) Léonard] woodland. However, it is of note that parts of Tete are amongst the least well-explored regions botanically in Mozambique, and so numbers of endemics may be under-represented in this province.

Approximately 69% of taxa (453) can be assigned with confidence to one of the Centres or Sub-Centres of Endemism (Table 5), highlighting the importance of these mainly cross-border regions in terms of their unique and rich floras. Further, the two sub-centres of the [Eastern] Afromontane phytochorion – the Chimanimani-Nyanga Highlands and the Mulanje-Namuli-Ribaue Mountains – are well-defined, with most species readily assigned to one or the other, strengthening the case for treating them as separate Centres of Endemism. The Lebombo Mountains Sub-Centre of Maputaland is also well-represented by endemics, with 17 of the endemics confined to that Sub-Centre. Similarly, there is support for recognition of the Inhambane Sub-Centre with 20 strict-endemics confined to that region, although there is also considerable overlap between Inhambane and Maputaland sensu stricto, with 42 of the endemics shared between the two regions. Further research may nevertheless conclude that both the Lebombo Mountains and the Inhambane region should be considered as separate Centres of Endemism in their own right. The most important Centre of Endemism for numbers of endemics is

again that of the Chimanimani-Nyanga Highlands. However, the Rovuma Centre is also notable for its high number of strict-endemics, a reflection of the high rates of species turnover between dry coastal forest patches within this phytogeographic region (Timberlake et al. 2010, 2011), with many species restricted to few or even single forest blocks.

Extinction risk in the endemic flora of Mozambique

To date, the global extinction risk status has been assessed for 332 (approximately 50%) of the endemics of Mozambique using the IUCN Red List categories and criteria (IUCN 2012; Table 6). Of those assessed, 52% (57% of the strict-endemics) are considered to be globally threatened. The main causal factors behind this high rate of extinction risk are habitat loss and degradation driven by high population growth and resultant increasing demands for land, agricultural products and supplies of a range of natural resources, all of which place increasing pressure on natural habitats. This high rate of threat emphasises the urgent need for effective site-based conservation action and sustainable management to safeguard the future of Mozambique's unique flora. Added to this is the fact that nearly 10% of the endemics (and over 17% of the strict-endemics) assessed are listed as Data Deficient, i.e. there is insufficient information on these taxa to provide a full assessment. This highlights how little is known about many of these apparently rare and poorly documented taxa, and the urgent need for targeted field surveys to gather information on range size, population size, and threats. It is quite possible that the percentage of threatened taxa will increase once these Data Deficient taxa are reassessed with more information to hand.

On a more positive note, approximately one third of endemics assessed are currently considered to be of Least Concern (LC) – i.e. they are not currently threatened on a global scale. Some of the endemics are widespread within Mozambique and can be locally abundant. For example, the strict-endemic *Grewia transzambesica* Wild (Malvaceae) has an extent of occurrence of c. 220,000 km^2 and is frequent in the central lowlands of the country (Darbyshire et al. 2019). However, many of the LC species are much more range-restricted, but are not under threat owing to their habitat preferences. Many occur in rocky terrain and/or montane grasslands that are some of the least threatened habitats in Mozambique, due to a combination of remoteness, inaccessibility and limited agricultural value. A good example is the Chimanimani montane quartzite endemics, the majority of which are not significantly threatened (Timberlake et al. 2016b).

For the Mozambique flora as a whole, as of July 2019, 1,050 plant taxa (c. 17% of the total vascular flora) are listed on the IUCN Red List (https://www.iucnredlist.org). A total of 812 (77%) of these taxa are listed as LC, a much higher percentage than the equivalent for the endemics. Therefore, whilst there is still a long way to go before an exhaustive Red List can be achieved for Mozambique, the focus of the IUCN-SSC Southern African Plant Specialist Group on the endemic flora appears to be an effective strategy in identifying the taxa in most urgent need of conservation action.

Conclusion: future priorities for the study of the endemic flora of Mozambique and its conservation

The checklist of endemic plants presented here provides a useful basis from which to build the evidence-base for effective conservation of the unique flora of Mozambique, for which the following next steps are underway:

- Complete the collation of existing data on endemic and near-endemic taxa, so that a detailed spatial analysis can be conducted to more accurately define Centres of Endemism and specific localities with concentrations of endemics. These results will allow for identification of critical knowledge gaps, and help effectively target sites for future field surveys.
- Complete a Red List of globally threatened species in Mozambique, with the eventual aims to assess the extinction risk for all endemic and near-endemic taxa, gather more information on species currently assessed as Data Deficient, and take active steps towards the conservation of all threatened species.
- Apply the accumulated plant distribution and Red List data, together with information on critical habitats, to identify and document Important Plant Areas. These data will also provide the botanical component for the identification of Key Biodiversity Areas.

Critical to the success of this work is the continued development of in-country capacity in field botany, taxonomy and conservation science in Mozambique, so that Mozambican practitioners are well placed to take forward the implementation of Mozambique's commitments to protecting plant diversity under the CBD.

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Appendix 1

Summary checklist of the endemic and near-endemic vascular plant taxa of Mozambique. Strict-endemic taxa are listed in bold. "Endemism" categories are abbreviated as follows: E = strict-endemic; NE1 = majority of range in Mozambique; NE2 = global range < 10,000 km^2, NE3 = taxon known from five sites or fewer. Under "Life form", (a) = annual; (c) = herbaceous climbing perennial; (e) = epiphytic perennial; (geo) = geophyte; (gram-a) = annual graminoid; (gram-p) = perennial graminoid; (p) = perennial (terrestrial, non-succulent); (par) = parasitic perennial; (s) = succulent. Under "Type only", Y = known only from the type specimen or type locality. "Provinces" of Mozambique are abbreviated as follows CD = Cabo Delgado; G = Gaza; In = Inhambane; Mc = Manica; Mp = Maputo; Na = Nampula; Ni = Niassa; S = Sofala; T = Tete; Z = Zambezia. Under "Other Countries", provinces of South Africa are abbreviated as follows: KN = KwaZulu Natal; LP = Limpopo; MP = Mpumalanga. Centres of Endemism ("CoE") are coded as follows: 1 = Rovuma; 2 = Maputaland sensu lato; 2a = Maputaland sensu stricto; 2b = Lebombo Mountains (Sub-) Centre; 2c = Inhambane (Sub-) Centre; 3 = [Eastern] Afromontane sensu lato; 3a = Chimanimani-Nyanga (Sub-) Centre; 3b = Mulanje-Namuli-Ribaue (Sub-) Centre. See Materials and methods section for further explanation.

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
PTERIDOPHYTA							
Pteridaceae	*Adiantum mendoncae* Alston	NE1	fern		Mc, Na, S	Zimbabwe	
GYMNOSPERMAE							
Zamiaceae	*Encephalartos aplanatus* Vorster	NE2+3	cycad		Mp	eSwatini	2b
Zamiaceae	*Encephalartos chimanimaniensis* R.A.Dyer & I.Verd.	NE2+3	cycad		Mc	Zimbabwe	3a
Zamiaceae	***Encephalartos ferox* G.Bertol subsp. *emersus* P.Rousseau, Vorster & A.E.van Wyk**	E	cycad		In		2c
Zamiaceae	*Encephalartos ferox* G.Bertol subsp. *ferox*	NE1	cycad		G, In, Mp	South Africa KN	2a, 2c
Zamiaceae	*Encephalartos gratus* Prain	NE1	cycad		Z	Malawi	3b
Zamiaceae	***Encephalartos munchii* R.A.Dyer & I.Verd.**	E	cycad		Mc		3a
Zamiaceae	*Encephalartos ngoyanus* I.Verd.	NE2	cycad		Mp	eSwatini, South Africa KN	2b
Zamiaceae	***Encephalartos pterogonus* R.A.Dyer & I.Verd.**	E	cycad		Mc		3a
Zamiaceae	*Encephalartos senticosus* Vorster		cycad		Mp	eSwatini, South Africa KN, MP	2b
Zamiaceae	***Encephalartos turneri* Lavranos & D.L.Goode**	E	cycad		Na, Ni		
Zamiaceae	*Encephalartos umbeluziensis* R.A.Dyer	NE2	cycad		Mp	eSwatini	2b
ANGIOSPERMAE: MAGNOLIIDS							
Annonaceae	***Hexalobus mossambicensis* N.Robson**	E	shrub, tree		CD, Na		1
Annonaceae	***Huberantha mossambicensis* (Vollesen) Chaowasku**	E	shrub		Z		1
Annonaceae	*Monanthotaxis maputensis* P.H.Hoekstra	NE1	shrub, liana		G, In, Mp	South Africa KN	2a, 2c
Annonaceae	*Monanthotaxis suffruticosa* P.H.Hoekstra INED.	NE1+3	shrub		CD, Na	Tanzania	1
Annonaceae	*Monanthotaxis trichantha* (Diels) Verdc.	NE1	shrub		CD, Na	Tanzania	1
Annonaceae	*Monodora carolinae* Couvreur	NE2+3	shrub, tree		CD	Tanzania	1
Annonaceae	*Monodora stenopetala* Oliv.	NE1	shrub, tree		S, T	Malawi	

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Annonaceae	***Uvaria rovumae* Deroin & Lötter**	E	liana		CD		1
Annonaceae	*Xylopia lukei* D.M.Johnson & Goyder	NE2	shrub, tree		CD	Tanzania	1
Annonaceae	***Xylopia tenuipetala* D.M.Johnson & Goyder**	E	shrub, tree		CD		1
Annonaceae	***Xylopia torrei* N.Robson**	E	shrub		G, In, Mp, Na		2a, 2c
ANGIOSPERMAE: MONOCOTS							
Amaryllidaceae	*Cryptostephanus vansonii* I.Verd.	NE1	herb (geo)		Mc, S, Z	Zimbabwe	3a, 3b
Amaryllidaceae	*Tulbaghia friesii* Suess.	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Araceae	*Stylochaeton euryphyllum* Mildbr.	NE1	herb (geo)		CD, Na	Tanzania	1
Araceae	*Stylochaeton natalense* Schott subsp. *maximum* (Engl.) Bogner & Haigh	NE3	herb (geo)		Mp	Tanzania	
Araceae	***Stylochaeton tortispathum* Bogner & Haigh**	E	herb (geo)	Y	CD		1
Arecaceae	*Raphia australis* Oberm. & Strey	NE1	tree		Mp	South Africa KN	2a
Asparagaceae	*Asparagus chimanimanensis* Sebsebe		shrub		Mc	Zimbabwe	3a
Asparagaceae	*Asparagus petersianus* Kunth	NE1	shrub		CD, S, Z	Tanzania	
Asparagaceae	*Asparagus radiatus* Sebsebe	NE2+3	shrub		Mp	eSwatini	2b
Asparagaceae	*Chlorophytum pygmaeum* (Weim.) Kativu subsp. *rhodesianum* (Rendle) Kativu	NE2	herb (geo)		Mc	Zimbabwe	3a
Asparagaceae	*Dracaena pedicellata* (la Croix) Byng & Christenh. (=*Sansevieria pedicellata* la Croix)	NE1	herb (s)		Mc	Zimbabwe	3a
Asparagaceae	***Dracaena subspicata* (Baker) Byng & Christenh. (=*Sansevieria subspicata* Baker)**	E	herb (s)		Mp, Na, S, Z		
Asparagaceae	*Eriospermum mackenii* (Hook.f.) Baker subsp. *phippsii* (Wild) P.L.Perry	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Asphodelaceae	***Aloe argentifolia* T.A.McCoy, Rulkens & O.J.Baptista**	E	shrub (s)		CD		
Asphodeleaceae	*Aloe ballii* Reynolds var. *makurupiniensis* Ellert	NE2	herb (s)		Mc	Zimbabwe	3a
Asphodelaceae	***Aloe cannellii* L.C.Leach**	E	herb (s)		Mc		3a
Asphodelaceae	***Aloe decurva* Reynolds**	E	herb (s)		Mc		3a
Asphodeleaceae	*Aloe excelsa* A.Berger var. *breviflora* L.C.Leach	NE2	tree (s)		Na, Z	Malawi	
Asphodeleaceae	*Aloe hazeliana* Reynolds var. *hazeliana*	NE2	herb (s)		Mc	Zimbabwe	3a
Asphodeleaceae	*Aloe hazeliana* Reynolds var. *howmanii* (Reynolds) S.Carter	NE2	herb (s)		Mc	Zimbabwe	3a
Asphodeleaceae	*Aloe inyangensis* Christian var. *kimberleyana* S.Carter	NE2	herb (s)		Mc	Zimbabwe	3a
Asphodeleaceae	*Aloe marlothii* A.Berger subsp. *orientalis* Glen & D.S.Hardy	NE1	tree (s)		G, Mp, S	eSwatini, South Africa KN	2a, 2c
Asphodeleaceae	*Aloe mawii* Christian	NE1	tree (s)		CD, Na, Ni, Z	Malawi, Tanzania	
Asphodelaceae	***Aloe menyharthii* Baker subsp. *ensifolia* S.Carter**	E	herb (s)		Na, Z		
Asphodelaceae	***Aloe mossurilensis* Ellert**	E	herb (s)		Na		1
Asphodeleaceae	*Aloe munchii* Christian	NE2	shrub (s), tree (s)		Mc	Zimbabwe	3a
Asphodeleaceae	*Aloe plowesii* Reynolds	NE2	herb (s)		Mc	Zimbabwe	3a

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Asphodelaceae	***Aloe ribauensis* T.A.McCoy, Rulkens & O.J.Baptista**	E	herb (s)		CD, Na		
Asphodelaceae	***Aloe rulkensii* T.A.McCoy & O.J.Baptista**	E	herb (s)		Na		3b
Asphodeleaceae	*Aloe suffulta* Reynolds	NE1	herb (s)		Mp	Malawi, Zimbabwe, South Africa KN	
Asphodelaceae	***Aloe torrei* I.Verd. & Christian**	E	herb (s)		Z		3b
Asphodeleaceae	*Aloe wildii* (Reynolds) Reynolds	NE2	herb (s)		Mc	Zimbabwe	3a
Asphodeleaceae	*Aloidendron tongaense* (Van Jaarsv.) Klopper & Gideon F.Sm. (=*Aloe tongaensis* Van Jaarsv.)	NE1	tree (s)		In, Mp, S	South Africa KN	
Commelinaceae	*Aneilema arenicola* Faden	NE2	herb (a)		Mp	South Africa KN	2a
Commelinaceae	***Aneilema mossambicense* (Faden) Faden INED. (=*A. dregeanum* Kunth subsp. *mossambicense* Faden)**	E	herb (p)		Na, Z		1
Commelinaceae	*Cyanotis chimanimaniensis* Faden INED.	NE2+3	herb (p)		Mc	Zimbabwe	3a
Commelinaceae	***Cyanotis namuliensis* Faden INED.**	E	herb (p)		Z		3b
Commelinaceae	*Triceratella drummondii* Brenan	NE3	herb (a)		Z	Zimbabwe	
Cymodoceaceae	*Thalassodendron leptocaule* Maria C.Duarte Bandeira & Romeiras	NE2	herb (seagrass)		Mp	South Africa KN	
Cyperaceae	*Cyperus longispicula* Muasya & D.A.Simpson	NE3	herb (gram-p)		Mc	Zimbabwe	
Eriocaulaceae	***Eriocaulon infaustum* N.E.Br.**	E	herb (a)	Y	Z		
Eriocaulaceae	*Eriocaulon mulanjeanum* S.M.Phillips	NE1+3	herb (a)		Z	Malawi	3b
Eriocaulaceae	*Mesanthemum africanum* Moldenke	NE2	herb (p)		Mc	Zimbabwe	3a
Hydrocharitaceae	***Halophila ovalis* (R.Br.) Hook.f. subsp. *linearis* (Hartog) Hartog**	E	herb (seagrass)		In, Mp		
Iridaceae	*Dierama inyangense* Hilliard	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Iridaceae	*Dierama plowesii* Hilliard	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Iridaceae	***Freesia grandiflora* (Baker) Klatt subsp. *occulta* J.C.Manning & Goldblatt**	E	herb (geo)	Y	Z		
Iridaceae	*Gladiolus brachyphyllus* F.Bolus	NE2	herb (geo)		Mp	eSwatini, South Africa MP	2b
Iridaceae	*Gladiolus zimbabweensis* Goldblatt	NE1	herb (geo)		Mc, Z	Zimbabwe	3a
Iridaceae	*Hesperantha ballii* Wild	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Iridaceae	***Moraea niassensis* Goldblatt & J.C.Manning**	E	herb (geo)	Y	Ni		
Iridaceae	***Tritonia moggii* Oberm.**	E	herb (geo)		G, In, Mp, Z		2a, 2c
Orchidaceae	*Bonatea pulchella* Summerh.	NE1+3	herb (geo)		Mp	South Africa KN, LP, MP	2a
Orchidaceae	*Bulbophyllum ballii* P.J.Cribb	NE1	herb (e)		Mc, Na, Z	Zimbabwe	3a, 3b
Orchidaceae	*Cynorkis anisoloba* Summerh.	NE2	herb (geo)		Mc, S	Zimbabwe	3a
Orchidaceae	***Cyrtorchis glaucifolia* Summerh.**	E	herb (e)		Na		
Orchidaceae	*Disa chimanimaniensis* (H.P.Linder) H.P.Linder	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Orchidaceae	*Disa zimbabweensis* H.P.Linder	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Orchidaceae	***Disperis mozambicensis* Schltr.**	E	herb (geo)	Y	S		
Orchidaceae	***Eulophia biloba* Schltr.**	E	herb (?geo)	Y	S		
Orchidaceae	***Eulophia bisaccata* Kraenzl.**	E	herb (geo)	Y			

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Orchidaceae	***Habenaria hirsutissima* Summerh.**	E	herb (geo)		Na, Ni		
Orchidaceae	***Habenaria mosambicensis* Schltr.**	E	herb (?geo)	Y	S		
Orchidaceae	*Habenaria stylites* Rchb.f. & S.Moore subsp. *johnsonii* (Rolfe) Summerh.	NE2+3	herb (geo)		Ni	Tanzania	
Orchidaceae	***Liparis hemipilioides* Schltr.**	E	herb (geo)	Y	S		
Orchidaceae	*Neobolusia ciliata* Summerh.	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Orchidaceae	*Oeceoclades perrieri* (Schltr.) Garay & P.Taylor	NE3	herb (p)		Mp, S	Madagascar	
Orchidaceae	*Oligophyton drummondii* H.P.Linder & G.Will.	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Orchidaceae	*Polystachya songaniensis* G.Will.	NE2	herb (e)		Z	Malawi	3b
Orchidaceae	*Polystachya subumbellata* P.J.Cribb & Podz.	NE2	herb (e)		Mc, S	Zimbabwe	3a
Orchidaceae	*Polystachya valentina* la Croix & P.J.Cribb	NE1	herb (p)		Mc, Z	Zimbabwe	3a, 3b
Orchidaceae	*Satyrium flavum* la Croix	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Orchidaceae	*Schizochilus lepidus* Summerh.	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Poaceae	***Alloeochaete namuliensis* Chippind.**	E	herb (gram-p)		Z		3b
Poaceae	***Baptorhachis foliacea* (Clayton) Clayton**	E	herb (gram-a)	Y	Na		3b
Poaceae	*Brachychloa fragilis* S.M.Phillips	NE2	herb (gram-a)		Mp	South Africa KN, LP	2a
Poaceae	*Brachychloa schiemanniana* (Schweick.) S.M.Phillips	NE1	herb (gram-p)		G, In, Mp	South Africa KN	2a, 2c
Poaceae	*Danthoniopsis chimanimaniensis* (J.B.Phipps) Clayton	NE2+3	herb (gram-p)		Mc	Zimbabwe	3a
Poaceae	***Digitaria appropinquata* Goetgh.**	E	herb (gram-a)	Y	Z		3b
Poaceae	***Digitaria fuscopilosa* Goetgh.**	E	herb (gram-p)	Y	Mc		3a
Poaceae	***Digitaria megasthenes* Goetgh.**	E	herb (gram-p)		Ni, Z		
Poaceae	*Eragrostis desolata* Launert	NE2+3	herb (gram-p)		Mc	Zimbabwe	3a
Poaceae	*Eragrostis moggii* De Winter	NE1	herb (gram-p)		In, Mp	South Africa KN	2a, 2c
Poaceae	***Eragrostis sericata* Cope**	E	herb (gram-p)		In		2c
Poaceae	*Eriochloa rovumensis* (Pilg.) Clayton	NE1	herb (gram-a)		Na, Ni, Z	Tanzania	
Poaceae	***Trichoneura schlechteri* Ekman**	E	herb (gram-p)		In, Mp		2a, 2c
Restionaceae	*Platycaulos quartziticola* (H.P.Linder) H.P.Linder & C.R.Hardy	NE2+3	herb (gram-p)		Mc	Zimbabwe	3a
Velloziaceae	*Xerophyta argentea* (Wild) L.B.Sm. & Ayensu	NE2+3	shrub, herb (p)		Mc	Zimbabwe	3a
Velloziaceae	*Xerophyta kirkii* (Hemsl.) L.B.Sm. & Ayensu	NE1	shrub, tree		Ni, Z	Malawi	3b
Velloziaceae	*Xerophyta pseudopinifolia* Behnke	NE1	shrub		Na, Ni, Z	Malawi	
Velloziaceae	*Xerophyta splendens* (Rendle) N.L.Menezes	NE2+3	shrub, tree		Z	Malawi	3b
Xyridaceae	*Xyris asterotricha* Lock	NE2+3	herb (p)		Mc	Zimbabwe	3a
Xyridaceae	*Xyris makuensis* N.E.Br.	NE2	herb (p)		Z	Malawi	3b

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Zingiberaceae	***Siphonochilus kilimanensis* (Gagnep.) B.L.Burtt**	E	herb (geo)		Na, S, Z		
ANGIOSPERMAE: EU-DICOTS							
Acanthaceae	*Barleria delagoensis* Oberm.	NE1	herb (p), shrub		G, In, Mp, S	South Africa KN	
Acanthaceae	*Barleria fissimuroides* I.Darbysh.	NE2+3	shrub		Mc	Zimbabwe	3a
Acanthaceae	*Barleria fulvostellata* C.B.Clarke subsp. *mangochiensis* I.Darbysh.	NE2+3	herb (p), shrub		Ni	Malawi	
Acanthaceae	*Barleria laceratiflora* Lindau	NE2+3	herb (p)		Na	Tanzania	1
Acanthaceae	*Barleria oxyphylla* Lindau	NE2	herb (p)		Mp	eSwatini, South Africa MP	
Acanthaceae	***Barleria setosa* (Klotzsch) I.Darbysh.**	E	herb (p), shrub		Na		1
Acanthaceae	***Barleria torrei* I.Darbysh.**	E	shrub		Ni		
Acanthaceae	*Barleria vollesenii* I.Darbysh.	NE2+3	herb (p)		Ni	Tanzania	
Acanthaceae	***Blepharis dunensis* Vollesen**	E	herb (p)		Na, Z		1
Acanthaceae	***Blepharis gazensis* Vollesen**	E	herb (p)		G, S		
Acanthaceae	*Blepharis swaziensis* Vollesen	NE2	herb (p)		Mp	eSwatini, South Africa KN	2b
Acanthaceae	*Blepharis torrei* Vollesen	NE2+3	herb (p)		Ni	Tanzania	
Acanthaceae	*Cephalophis lukei* Vollesen	NE3	herb (p)		S	Kenya	
Acanthaceae	*Dicliptera quintasii* Lindau	NE2	herb (p)		Mp	South Africa KN	2a
Acanthaceae	***Duosperma dichotomum* Vollesen**	E	herb (p), shrub		CD		1
Acanthaceae	*Ecbolium glabratum* Vollesen	NE1	herb (p)		G, Mp	eSwatini, South Africa KN, MP	2a, 2b
Acanthaceae	***Ecbolium hastatum* Vollesen**	E	herb (p), shrub		G, In, Mp		2a, 2c
Acanthaceae	***Isoglossa namuliensis* I.Darbysh. & T.Harris**	E	herb (p)	Y	Z		3b
Acanthaceae	*Justicia attenuifolia* Vollesen	NE1	herb (p)		Ni	Tanzania	
Acanthaceae	***Justicia gorongozana* Vollesen**	E	herb (p)		CD, S		
Acanthaceae	***Justicia niassensis* Vollesen**	E	shrub		CD, Na		1
Acanthaceae	*Justicia subcordatifolia* Vollesen & I.Darbysh. (=*J. hedrenii* Vollesen)	NE2	herb (p)		Mc	Zimbabwe	3a
Acanthaceae	*Lepidagathis plantaginea* Mildbr.	NE1	herb (p)		CD, Na	Tanzania	1
Acanthaceae	*Sclerochiton apiculatus* Vollesen	NE1+2	shrub		Mp	South Africa KN	2a
Acanthaceae	*Sclerochiton coeruleus* (Lindau) S.Moore	NE1	shrub		G, In, Mc, Na, Z	Zimbabwe	
Acanthaceae	***Sclerochiton hirsutus* Vollesen**	E	shrub		Z		3b
Aizoaceae	***Trianthema mozambiquense* H.E.K.Hartmann & Liede**	E	herb	Y	Mp		2a
Amaranthaceae	*Caroxylon littoralis* (Moq.) Akhani & Roalson	NE2	herb (p), shrub		In	Madagascar, Europa Is.	
Amaranthaceae	***Celosia nervosa* C.C.Towns.**	E	herb		In, Mp, Na		
Amaranthaceae	***Celosia pandurata* Baker**	E	herb		S, Z		
Amaranthaceae	***Salicornia mossambicensis* (Brenan) Piirainen & G.Kadereit**	E	herb (p)		In		2c
Anacardiaceae	***Ozoroa gomesiana* R.Fern. & A.Fern.**	E	shrub, tree		In		2c
Anacardiaceae	*Ozoroa obovata* (Oliv.) R.Fern. & A.Fern. var. *elliptica* R.Fern. & A.Fern.	NE1	shrub, tree		G, In, Mc, Mp, S, T, Z	Zimbabwe	
Anacardiaceae	*Rhus acuminatissima* R.Fern. & A.Fern. (=*Searsia acuminatissima* (R.Fern. & A.Fern.) Moffett)	NE1	shrub, tree		Na, Z	Malawi	
Apiaceae	*Afrosciadium rhodesicum* (Cannon) P.J.D.Winter	NE2	herb (p)		Mc	Zimbabwe	3a

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Apiaceae	***Centella obtriangularis* Cannon**	E	herb (p)		Mc		3a
Apiaceae	*Pimpinella mulanjensis* C.C.Towns.	NE2+3	herb (p)		Z	Malawi	3b
Apocynaceae	*Asclepias cucullata* (Schltr.) Schltr. subsp. *scabrifolia* (S.Moore) Goyder	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Apocynaceae	*Asclepias graminifolia* (Wild) Goyder	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Apocynaceae	*Aspidoglossum glabellum* Kupicha	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Apocynaceae	*Aspidoglossum hirundo* Kupicha	NE1	herb (geo)		Na, Z	Zimbabwe	
Apocynaceae	***Ceropegia aloicola* M.G.Gilbert INED.**	E	herb (s)		Mp		2b
Apocynaceae	*Ceropegia chimanimaniensis* M.G.Gilbert INED.	NE2+3	herb (geo)		Mc	Zimbabwe	3a
Apocynaceae	***Ceropegia cyperifolia* Bruyns**	E	herb (geo)		Ni		
Apocynaceae	***Ceropegia gracilidens* Bruyns**	E	herb (geo)		CD, Na, Z		
Apocynaceae	*Ceropegia monteiroae* Hook.f.	NE1	herb (s)		In, Mp	South Africa KN	2a, 2c
Apocynaceae	***Ceropegia muchevensis* M.G.Gilbert INED.**	E	herb (s)		S		
Apocynaceae	***Ceropegia nutans* (Bruyns) Bruyns**	E	herb (geo)		Z		3b
Apocynaceae	*Ceropegia vahrmeijeri* (R.A.Dyer) Bruyns	NE1+2	herb (geo)		Mp	South Africa KN	2a
Apocynaceae	***Cynanchum oresbium* (Bruyns) Goyder**	E	herb (s)		Na		
Apocynaceae	***Emicocarpus fissifolius* K.Schum.& Schltr.**	E	herb (p)		Mp		2a
Apocynaceae	***Huernia erectiloba* L.C.Leach & Lavranos**	E	shrub (s)		CD, Na, Z		
Apocynaceae	*Huernia leachii* Lavranos	NE1+2	herb (s)		Mc	Malawi	
Apocynaceae	***Huernia verekeri* Stent subsp. *pauciflora* (L.C.Leach) Bruyns**	E	shrub (s)		In, S		
Apocynaceae	*Huernia volkartii* Werderm. & Peitsch. var. *repens* (Lavranos) Lavranos	NE2+3	herb (s)		Mc	Zimbabwe	
Apocynaceae	*Marsdenia cynanchoides* Schltr.	NE1	liana		CD, S, Z	Tanzania, Zimbabwe	
Apocynaceae	*Marsdenia gazensis* S.Moore	NE2	liana		Mc	Zimbabwe	3a
Apocynaceae	***Orbea halipedicola* L.C.Leach**	E	shrub (s)		S		
Apocynaceae	*Orbea longidens* (N.E.Br.) L.C.Leach	NE1+2	herb (s)		Mp	South Africa KN	2a
Apocynaceae	*Pachycarpus concolor* E.Mey. subsp. *arenicola* Goyder	NE2	herb (geo)		Mp	South Africa KN	2a
Apocynaceae	*Raphionacme pulchella* Venter & R.L.Verh.	NE3	herb (geo)		Mc	Zimbabwe	3a
Apocynaceae	*Secamone delagoensis* Schltr.	NE1	liana		G, In, Mp	South Africa KN	2a, 2c
Apocynaceae	*Stapelia unicornis* C.A.Luckh.	NE2	herb (s)		Mp	eSwatini, South Africa KN	2b
Apocynaceae	***Stomatostemma pendulina* Venter & D.V.Field (=*Cryptolepis pendulina* (Venter & D.V.Field) P.I.Forst.)**	E	shrub		Na, Z		
Araliaceae	*Cussonia arenicola* Strey	NE1	shrub		In, Mp	South Africa KN	2a, 2c
Asteraceae	***Adelostigma athrixioides* Steetz [uncertain species]**	E	herb		In		2c
Asteraceae	*Anisopappus paucidentatus* Wild	NE2	herb (p)		Mc	Zimbabwe	3a

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Asteraceae	*Aster chimanimaniensis* W.Lippert (=*Afroaster chimanimaniensis* (W.Lippert) J.C.Manning & Goldblatt)	NE2	herb (p)		Mc	Zimbabwe	3a
Asteraceae	***Bothriocline moramballae* (Oliv. & Hiern) O.Hoffm.**	E	herb (s), shrub (s)		Na, Z		3b
Asteraceae	***Bothriocline steetziana* Wild & G.V.Pope**	E	herb (a)		In, Na, Z		
Asteraceae	*Chrysocoma mozambicensis* Ehr. Bayer	NE1	shrub		In, Mp	South Africa KN, MP	2a, 2c
Asteraceae	*Cineraria pulchra* Cron	NE2	herb (p), shrub		Mc, S	Zimbabwe	3a
Asteraceae	*Distephanus inhacensis* (G.V.Pope) R.G.C.Boon & Glen	NE1	shrub, liana		G, In, Mp	South Africa KN	2a, 2c
Asteraceae	*Gutenbergia westii* (Wild) Wild & G.V.Pope	NE1+2	herb (p)		Mc	Zimbabwe	3a
Asteraceae	***Gyrodoma hispida* (Vatke) Wild**	E	herb (a)		G, In, Mp, S, Z		
Asteraceae	*Helichrysum acervatum* S.Moore	NE2	herb (p)		Mc	Zimbabwe	3a
Asteraceae	*Helichrysum africanum* (S.Moore) Wild (=*Calomeria africana* (S.Moore) Heine)	NE2+3	herb (p), shrub		Mc	Zimbabwe	3a
Asteraceae	*Helichrysum chasei* Wild	NE2	herb (p)		Mc	Zimbabwe	3a
Asteraceae	*Helichrysum lastii* Engl.	NE2	herb (p), shrub		Z	Malawi	3b
Asteraceae	***Helichrysum moggii* Wild**	E	herb (p)		Mp		2a
Asteraceae	*Helichrysum moorei* Staner	NE2+3	herb (p)		Mc	Zimbabwe	3a
Asteraceae	*Helichrysum rhodellum* Wild	NE2+3	herb (p)		Mc	Zimbabwe	3a
Asteraceae	*Helichrysum silvaticum* Hilliard		herb (p)		G, In, Mp	South Africa KN	2a, 2c
Asteraceae	*Kleinia chimanimaniensis* van Jaarsv.	NE2+3	herb (s), shrub (s)		Mc	Zimbabwe	3a
Asteraceae	*Lopholaena brickellioides* S.Moore	NE2+3	shrub, tree		Mc	Zimbabwe	3a
Asteraceae	*Schistostephium oxylobum* S.Moore	NE2	herb (p), shrub		Mc	Zimbabwe	3a
Asteraceae	*Senecio aetfatensis* B.Nord.	NE2+3	herb (p)		Mc	Zimbabwe	3a
Asteraceae	***Senecio forbesii* Oliv. & Hiern [uncertain species]**	E	herb	Y	Unknown		
Asteraceae	*Senecio peltophorus* Brenan	NE2+3	herb (p)		Z	Malawi	3b
Asteraceae	*Vernonia calvoana* (Hook.f.) Hook.f. subsp. *meridionalis* (Wild) C.Jeffrey (=*Baccharoides calvoana* (Hook.f.) Isawumi, El-Ghazaly & B.Nord. subsp. *meridionalis* (Wild) Isuwami, El-Ghazaly & B.Nord.)	NE2	herb (p), shrub		Mc, S	Zimbabwe	3a
Asteraceae	*Vernonia muelleri* Wild subsp. *muelleri*	NE2	shrub		Mc	Zimbabwe	3a
Asteraceae	*Vernonia nepetifolia* Wild	NE2+3	shrub		Mc	Zimbabwe	3a
Balsaminaceae	*Impatiens psychadelphoides* Launert	NE1	herb (p)		Mc, Z	Zimbabwe	3a, 3b
Balsaminaceae	*Impatiens salpinx* G.M.Schulze & Launert	NE2	herb (p)		Mc	Zimbabwe	3a
Balsaminaceae	***Impatiens wuerstenii* S.B.Janssens & Dessein**	E	herb (p)		S		3a
Bignoniaceae	***Dolichandrone alba* (Sim) Sprague**	E	shrub, tree		G, In, Mp		2a, 2c
Boraginaceae	***Cordia mandimbana* E.S.Martins**	E	tree	Y	Ni		
Boraginaceae	***Cordia megiae* J.E.Burrows**	E	tree		S		

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Boraginaceae	***Cordia stuhlmannii* Gürke**	E	shrub, tree		S, Z		
Burseraceae	*Commiphora mombassensis* Engl.	NE3	shrub, tree		CD	Tanzania	1
Burseraceae	*Commiphora schlechteri* Engl.	NE1	shrub, tree		G, In, Mp	South Africa KN, ?Zimbabwe	2a, 2c
Campanulaceae	*Lobelia blantyrensis* E.Wimm.	NE2	herb (a), herb (p)		Z	Malawi	3b
Campanulaceae	*Lobelia cobaltica* S.Moore	NE2+3	herb (a), herb (p)		Mc	Zimbabwe	3a
Campanulaceae	*Wahlenbergia subaphylla* (Baker) Thulin subsp. *scoparia* (Wild) Thulin	NE2+3	herb (p)		Mc	Zimbabwe	3a
Capparaceae	*Capparis viminea* Hook.f. & Thomson ex Oliv. var. *orthacantha* (Gilg & Gilg-Ben.) DeWolf	NE2+3	shrub		CD	Tanzania	1
Capparaceae	*Maerua acuminata* Oliv.	NE1	shrub, tree		CD	Tanzania	1
Capparaceae	***Maerua andradae* Wild**	E	herb (p), shrub		CD		1
Capparaceae	***Maerua brunnescens* Wild**	E	shrub		In, Mc, Mp, S, T, Z		
Capparaceae	***Maerua scandens* (Klotzsch) Müll.Berol. ex B.D.Jacks.**	E	shrub, liana		G, Na, T, Z		
Capparaceae	*Maerua schliebenii* Gilg-Ben.	NE1	shrub		Na	Tanzania	1
Caprifoliaceae	***Pterocephalus centennii* M.J.Cannon**	E	shrub	Y	Mc		3a
Caryophyllaceae	***Dianthus chimanimaniensis* S.S.Hooper**	E	herb	Y	Mc		3a
Celastraceae	***Crossopetalum mossambicense* I.Darbysh.**	E	shrub		CD		1
Celastraceae	***Elaeodendron fruticosum* N.Robson**	E	shrub, tree		G, In		2a, 2c
Celastraceae	*Gymnosporia arenicola* Jordaan	NE1	shrub, tree		G, In, Mp, S, Z	South Africa KN	
Celastraceae	***Gymnosporia gurueensis* (N.Robson) Jordaan**	E	shrub, tree		Z		
Celastraceae	*Gymnosporia markwardii* Jordaan	NE1	shrub		In, Mp, Z	South Africa KN	
Celastraceae	*Gymnosporia oxycarpa* (N.Robson) Jordaan	NE2	shrub		G	South Africa LP	
Celastraceae	*Maytenus chasei* N.Robson	NE1	shrub, tree		Mc, Z	Zimbabwe	3a, 3b
Celastraceae	*Prionostemma delagoensis* (Loes.) N.Hallé var. *delagoensis* (=*Hippocratea delagoensis* Loes.)	NE1	shrub, liana		G, Mp	South Africa KN	2a, 2c
Celastraceae	*Salacia orientalis* N.Robson	NE1	shrub, liana		CD	Tanzania	1
Chrysobalanaceae	*Maranthes goetzeniana* (Engl.) Prance	NE1	tree		Mc, Na, S, Z	Zimbabwe, Tanzania	3a, 3b
Cleomaceae	*Cleome bororensis* (Klotzsch) Oliv. (=*Sieruela bororensis* (Klotzsch) Roalson & J.C.Hall)	NE1	herb (a)		G, Mp, S, Z	Tanzania, South Africa KN	
Clusiaceae	*Garcinia acutifolia* N.Robson	NE1	shrub, tree		CD	Tanzania	1
Combretaceae	*Combretum andradae* Exell & J.G.García	NE1	shrub, liana		CD, Na, Ni	Tanzania	
Combretaceae	***Combretum caudatisepalum* Exell & J.G.García**	E	shrub		CD, Na		1
Combretaceae	***Combretum lasiocarpum* Engl. & Diels**	E	shrub, tree		Na, T, Z		
Combretaceae	*Combretum lindense* Exell & Mildbr.	NE2+3	shrub, liana		CD	Tanzania	1

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Combretaceae	***Combretum stocksii* Sprague**	E	shrub		CD		1
Combretaceae	***Terminalia barbosae* (Exell) Gere & Boatwr. (=*Pteleopsis barbosae* Exell)**	E	tree		CD, Na		1
Convolvulaceae	***Ipomoea ephemera* Verdc.**	E	herb (a)		Na, Z		
Convolvulaceae	***Ipomoea venosa* (Desr.) Roem. & Schult. subsp. *stellaris* (Baker) Verdc. var. *obtusifolia* Verdc.**	E	herb (p)	Y	Mp		2a
Convolvulaceae	***Turbina longiflora* Verdc.**	E	herb (c)		CD, In, Mp		
Crassulaceae	***Crassula leachii* R.Fern.**	E	herb (p)		Mc		
Crassulaceae	*Crassula maputensis* R.Fern.	NE1	herb (a), herb (p)		Mp	South Africa KN	2a
Crassulaceae	***Crassula morrumbalensis* R.Fern.**	E	herb (p)	Y	Z		
Crassulaceae	*Crassula zombensis* Baker f.	NE2+3	herb (p)		Z	Malawi	3b
Crassulaceae	*Kalanchoe elizae* A.Berger	NE1	herb (s)		Na, Ni, Z	Malawi	
Crassulaceae	***Kalanchoe fernandesii* Raym.-Hamet**	E	herb (p)	Y	Na		1
Crassulaceae	***Kalanchoe hametiorum* Raym.-Hamet**	E	herb (p)		CD, Na, Z		
Crassulaceae	*Kalanchoe velutina* Welw. ex Britten subsp. *chimanimaniensis* (R.Fern.) R.Fern.	NE2+3	herb (s)		Mc	Zimbabwe	3a
Cucurbitaceae	*Eureiandra eburnea* C.Jeffrey	NE1	herb (c)		T	Zambia, Zimbabwe	
Cucurbitaceae	*Momordica henriquesii* Cogn.	NE1	herb (c)		CD, Na	Tanzania	1
Cucurbitaceae	***Momordica mossambica* H.Schaef.**	E	liana	Y	Na		1
Dichapetalaceae	*Dichapetalum barbosae* Torre	NE1	shrub, liana		CD, S, Z	Tanzania	
Dichapetalaceae	*Dichapetalum deflexum* (Klotzsch) Engl.	NE1	shrub		CD, In, Na	Tanzania	
Dichapetalaceae	*Dichapetalum macrocarpum* Engl.	NE1	shrub		CD	Tanzania	1
Dilleniaceae	*Tetracera bussei* Gilg	NE3	shrub		Ni	Tanzania	
Ebenaceae	*Diospyros rotundifolia* Hiern	NE1	tree		G, In, Mp	South Africa KN	2a, 2c
Ebenaceae	*Euclea racemosa* L. subsp. *sinuata* F.White	NE1	shrub, tree		In, Mp	South Africa KN	2a, 2c
Ericaceae	*Erica lanceolifera* S.Moore	NE2	shrub		Mc	Zimbabwe	3a
Ericaceae	*Erica pleiotricha* S.Moore var. *blaerioides* (Wild) R.Ross	NE2	shrub		Mc	Zimbabwe	3a
Ericaceae	*Erica pleiotricha* S.Moore var. *pleiotricha*	NE2+3	shrub		Mc	Zimbabwe	3a
Ericaceae	*Erica wildii* Brenan	NE2+3	herb (p), shrub		Mc	Zimbabwe	3a
Erythroxylaceae	*Nectaropetalum carvalhoi* Engl.	NE1+2	shrub, tree		CD, Na	Tanzania? - see note in F.T.E.A. Erythroxylaceae: 8 (1984)	1
Euphorbiaceae	***Croton aceroides* Radcl.-Sm.**	E	tree		In		2c
Euphorbiaceae	***Croton inhambanensis* Radcl.-Sm.**	E	shrub, tree		In		2c
Euphorbiaceae	*Croton kilwae* Radcl.-Sm.	NE1	shrub		CD, Na	Tanzania	1
Euphorbiaceae	***Croton leuconeurus* Pax subsp. *mossambicensis* Radcl.-Sm.**	E	shrub, tree		S, Z		
Euphorbiaceae	*Crotonogynopsis australis* Kenfack & Gereau	NE2	tree		Z	Tanzania	
Euphorbiaceae	*Erythrococca zambesiaca* Prain	NE2	shrub		S	Malawi	

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Euphorbiaceae	***Euphorbia ambroseae* L.C.Leach var. *ambrosae***	E	shrub (s)		In, S, Z		
Euphorbiaceae	*Euphorbia ambroseae* L.C.Leach var. *spinosa* L.C.Leach	NE1	shrub (s)		In, S, T	Malawi	
Euphorbiaceae	***Euphorbia angularis* Klotzsch**	E	shrub (s)		CD, Na		1
Euphorbiaceae	***Euphorbia baylissii* L.C.Leach**	E	shrub (s)		G, In, Mp		2a, 2c
Euphorbiaceae	***Euphorbia bougheyi* L.C.Leach**	E	tree (s)		CD, In, S, Z		
Euphorbiaceae	*Euphorbia citrina* S.Carter	NE2	shrub		Mc, S	Zimbabwe	3b
Euphorbiaceae	***Euphorbia contorta* L.C.Leach**	E	shrub (s)		Na, Ni, Z		
Euphorbiaceae	***Euphorbia corniculata* R.A.Dyer**	E	shrub (s)		CD, Na, Ni		
Euphorbiaceae	*Euphorbia crebrifolia* S.Carter	NE2	herb (p)		Mc	Zimbabwe	3a
Euphorbiaceae	***Euphorbia crenata* (N.E.Br.) Bruyns (=*Monadenium crenatum* N.E.Br.)**	E	herb (p)	Y	Mc		
Euphorbiaceae	*Euphorbia decliviticola* L.C.Leach	NE1+2+3	shrub (s), tree (s)		Na, Z	Malawi	3b
Euphorbiaceae	*Euphorbia depauperata* A.Rich. var. *tsetserrensis* S.Carter	NE2+3	herb (p)		Mc	Zimbabwe	3a
Euphorbiaceae	*Euphorbia grandicornis* Blanc subsp. *grandicornis*	NE1	shrub (s)		G, Mc, Mp	eSwatini, South Africa KN	
Euphorbiaceae	***Euphorbia grandicornis* Blanc subsp. *sejuncta* L.C.Leach**	E	shrub (s)		Na		
Euphorbiaceae	***Euphorbia graniticola* L.C.Leach**	E	shrub (s), tree (s)		Mc		3a
Euphorbiaceae	*Euphorbia keithii* R.A.Dyer	NE2+3	shrub (s), tree (s)		Mp	eSwatini	2b
Euphorbiaceae	***Euphorbia knuthii* Pax subsp. *johnsonii* (N.E.Br.) L.C.Leach**	E	shrub (s)		Mp, S		
Euphorbiaceae	*Euphorbia knuthii* Pax subsp. *knuthii*	NE1	shrub (s)		Mp	eSwatini, South Africa KN, MP	2a, 2b
Euphorbiaceae	***Euphorbia marrupana* Bruyns**	E	shrub (s)		Ni		
Euphorbiaceae	*Euphorbia mlanjeana* L.C.Leach	NE1+3	shrub (s)		Na, Ni, Z	Malawi	
Euphorbiaceae	***Euphorbia namuliensis* Bruyns**	E	shrub (s)		Z		3b
Euphorbiaceae	***Euphorbia neohalipedicola* Bruyns (=*Synadenium halipedicola* L.C.Leach)**	E	shrub	Y	S		
Euphorbiaceae	*Euphorbia neorugosa* Bruyns nom. inval. (=*Monadenium rugosum* S.Carter)	NE2+3	herb (p)		CD	Tanzania	1
Euphorbiaceae	***Euphorbia plenispina* S.Carter**	E	shrub (s)		Mc		
Euphorbiaceae	***Euphorbia ramulosa* L.C.Leach**	E	shrub (s)		Na, Ni, Z		
Euphorbiaceae	***Euphorbia schlechteri* Pax**	E	herb (p)		G, Mp		2a
Euphorbiaceae	***Euphorbia stenocaulis* Bruyns**	E	shrub (s)	Y	Z		
Euphorbiaceae	*Euphorbia torrei* (L.C.Leach) Bruyns	NE1	shrub		CD	Tanzania	1
Euphorbiaceae	***Euphorbia unicornis* R.A.Dyer**	E	shrub (s)		CD		
Euphorbiaceae	***Jatropha latifolia* Pax var. *subeglandulosa* Radcl.-Sm.**	E	herb (p)	Y	Mp		2b
Euphorbiaceae	***Jatropha scaposa* Radcl.-Sm.**	E	herb (p)		Mp, Na, S		
Euphorbiaceae	***Jatropha subaequiloba* Radcl.-Sm.**	E	shrub		In		2c
Euphorbiaceae	*Mallotus oppositifolius* (Geiseler) Müll.Arg. var. *lindicus* (Radcl.-Sm.) Radcl.-Sm.	NE1	tree		CD, Na	Tanzania	1
Euphorbiaceae	***Tragia glabrata* (Müll.Arg.) Pax & K.Hoffm. var. *hispida* Radcl.-Sm.**	E	herb (c)	Y	Mp		2a

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Euphorbiaceae	***Tragia shirensis* Prain var. *glabriuscula* Radcl.-Sm.**	E	herb (p)	Y	Na		
Euphorbiaceae	*Tragia shirensis* Prain var. *shirensis*	NE1	herb (p)		Z	Malawi	
Fabaceae	***Acacia latispina* J.E.Burrows & S.M.Burrows (=*Vachellia latispina* (J.E.Burrows & S.M.Burrows) Kyal. & Boatwr.)**	E	tree		CD		1
Fabaceae	*Acacia latistipulata* Harms (=*Senegalia latistipulata* (Harms) Kyal. & Boatwr.)	NE1	shrub		CD, Na, T	Tanzania	
Fabaceae	***Acacia quiterajoensis* Timberlake & Lötter**	E	shrub, tree		CD		1
Fabaceae	***Acacia torrei* Brenan (=*Vachellia torrei* (Brenan) Kyal. & Boatwr.)**	E	shrub		S		
Fabaceae	***Adenopodia schlechteri* (Harms) Brenan**	E	liana, shrub		G, Mp		2a
Fabaceae	*Aeschynomene aphylla* Wild	NE2+3	shrub		Mc	Zimbabwe	3a
Fabaceae	*Aeschynomene chimanimaniensis* Verdc.	NE2+3	shrub		Mc	Zimbabwe	3a
Fabaceae	*Aeschynomene grandistipulata* Harms	NE2+3	shrub		Mc	Zimbabwe	3a
Fabaceae	*Aeschynomene inyangensis* Wild	NE2+3	shrub		Mc	Zimbabwe	3a
Fabaceae	***Aeschynomene minutiflora* Taub. subsp. *grandiflora* Verdc.**	E	herb (a)		Na, Z		
Fabaceae	***Aeschynomene mossambicensis* Verdc. subsp. *mossambicensis***	E	herb (a), herb (p)		Na, Z		
Fabaceae	*Aeschynomene pawekiae* Verdc.	NE2+3	herb (p)		Ni	Malawi	
Fabaceae	*Baphia macrocalyx* Harms	NE1	tree		CD	Tanzania	1
Fabaceae	***Baphia massaiensis* Taub. subsp. *gomesii* (Baker f.) Brummitt**	E	shrub, tree		CD, In, Na, Ni	Tanzania?	
Fabaceae	***Baphia ovata* Sim (=*Baphia kirkii* Baker subsp. *ovata* (Sim) Soladoye)**	E	shrub, tree		G, In		2c
Fabaceae	***Baphia punctulata* Harms subsp. *palmensis* Soladoye**	E	shrub, tree	Y	CD		1
Fabaceae	***Bauhinia burrowsii* E.J.D.Schmidt**	E	shrub		In		2c
Fabaceae	*Berlinia orientalis* Brenan	NE1	tree		CD	Tanzania	1
Fabaceae	***Brachystegia oblonga* Sim**	E	tree		Na, Z		1
Fabaceae	***Bussea xylocarpa* (Sprague) Sprague & Craib**	E	tree		Mc		
Fabaceae	***Chamaecrista paralias* (Brenan) Lock**	E	herb (p), shrub, tree		In, Na		
Fabaceae	*Crotalaria assurgens* Polhill	NE3	herb (p)		Ni	Tanzania	
Fabaceae	*Crotalaria dura* J.M.Wood & M.S.Evans subsp. *mozambica* Polhill	NE1	herb (p), shrub		G, In, Mp	South Africa KN	2a, 2c
Fabaceae	*Crotalaria insignis* Polhill	NE2	shrub		Mc	Zimbabwe	3a
Fabaceae	*Crotalaria lanceolata* E.Mey. subsp. *exigua* Polhill	NE1	herb (a), herb (p)		Na, Z	Malawi	
Fabaceae	***Crotalaria misella* Polhill**	E	herb (a)		CD	Tanzania?	1
Fabaceae	***Crotalaria mocubensis* Polhill**	E	herb (a)		S, T, Z		
Fabaceae	***Crotalaria namuliensis* Polhill & T.Harris**	E	herb (a), herb (p)		Z		3b
Fabaceae	***Crotalaria paraspartea* Polhill**	E	herb (a)		Na		
Fabaceae	*Crotalaria phylicoides* Wild	NE2+3	herb (p), shrub		Mc	Zimbabwe	3a
Fabaceae	*Crotalaria schlechteri* Baker f.	NE1+2	herb (p)		G, Mp	South Africa MP	2a

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Fabaceae	*Crotalaria schliebenii* Polhill	NE1+2+3	herb (a), herb (p)		Na	Tanzania	1
Fabaceae	***Crotalaria torrei* Polhill**	E	shrub		Z		3b
Fabaceae	*Dialium schlechteri* Harms	NE1	tree		G, In, Mp	South Africa KN	2a, 2c
Fabaceae	*Dichrostachys cinerea* (L.) Wight & Arn. subsp. *africana* Brenan & Brummitt var. *pubescens* Brenan & Brummitt	NE1	shrub, tree		G, Mc, S	Zimbabwe	
Fabaceae	***Entada mossambicensis* Torre**	E	shrub		Na		
Fabaceae	*Entada stuhlmannii* (Taub.) Harms	NE1	liana		CD, Na, Z	Tanzania	1
Fabaceae	*Gelrebia rostrata* (N.E.Br.) Gagnon & G.P.Lewis (=*Caesalpinia rostrata* N.E.Br.)	NE2+3	shrub, liana		Mp	South Africa MP	2a, 2b
Fabaceae	***Guibourtia sousae* J.Leonard**	E	tree	Y	In		2c
Fabaceae	***Icuria dunensis* Wieringa**	E	tree		Na, Z		1
Fabaceae	*Indigofera cecilii* N.E.Br.	NE1	herb (p), shrub		Mc, S	Zimbabwe	3a
Fabaceae	*Indigofera concinna* Baker	NE1	herb (a)		CD, Na	Tanzania	1
Fabaceae	***Indigofera emarginella* A.Rich. var. *marrupaënsis* Schrire**	E	shrub	Y	Ni		
Fabaceae	*Indigofera erythrogramma* Baker subsp. *nampulensis* Schrire	NE1+3	herb (a)		Na	Malawi	
Fabaceae	***Indigofera gobensis* Schrire**	E	herb (p)		Mp		2b
Fabaceae	*Indigofera graniticola* J.B.Gillett	NE2+3	herb (a)		Na	Tanzania	1
Fabaceae	***Indigofera mendoncae* J.B.Gillett**	E	herb (p)		G, In		2c
Fabaceae	***Indigofera namuliensis* Schrire**	E	herb (a)		Z		3b
Fabaceae	*Indigofera nyassica* Gilli var. *brevior* (J.B.Gillett) J.B.Gillett	NE3	herb (a), herb (p)		Ni	Tanzania	
Fabaceae	*Indigofera podophylla* Harv.	NE1	herb (p)		G, In, Mp	South Africa KN	2a, 2c
Fabaceae	***Indigofera pseudomoniliformis* Schrire**	E	shrub		Na, Ni, Z		
Fabaceae	***Indigofera torrei* J.B.Gillett**	E	herb (p), shrub		G		
Fabaceae	*Indigofera vicioides* Jaub. & Spach subsp. *excelsa* Schrire	NE2+3	herb (p), shrub		Mc	Zimbabwe	3a
Fabaceae	*Lotus wildii* J.B.Gillett	NE2	herb (p), shrub		S	Zimbabwe	3a
Fabaceae	***Macrotyloma decipiens* Verdc.**	E	herb	Y	Na		1
Fabaceae	***Micklethwaitia carvalhoi* (Harms) G.P.Lewis & Schrire**	E	tree		CD, Na		1
Fabaceae	***Millettia ebenifera* (Bertol.) J.E.Burrows & Lötter**	E	shrub, tree		G, In		2c
Fabaceae	*Millettia makondensis* Harms	NE1	shrub		CD	Tanzania	1
Fabaceae	***Millettia mossambicensis* J.B.Gillett**	E	tree		Na, S		
Fabaceae	*Mimosa mossambicensis* Brenan	NE1	shrub, liana		S, T	Malawi	
Fabaceae	*Ormocarpum schliebenii* Harms	NE1	shrub		CD, Na	Tanzania	1
Fabaceae	*Otholobium foliosum* (Oliv.) C.H.Stirt. subsp. *gazense* (Baker f.) Verdc.	NE2+3	shrub		Mc	Zimbabwe	3a
Fabaceae	*Pearsonia mesopontica* Polhill	NE2+3	herb (p)		Mc	Zimbabwe	3a
Fabaceae	*Rhynchosia chimanimaniensis* Verdc.	NE2+3	herb (p), shrub		Mc	Zimbabwe	3a
Fabaceae	***Rhynchosia clivorum* S.Moore subsp. *gurueensis* Verdc.**	E	herb (p), shrub	Y	Z		3b
Fabaceae	*Rhynchosia genistoides* Burtt Davy	NE2+3	shrub		Mp	South Africa MP	2b

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Fabaceae	*Rhynchosia stipata* Meikle	NE2+3	herb (c), herb (p)		Mc	Zimbabwe	3a
Fabaceae	*Rhynchosia swynnertonii* Baker f.	NE2	herb (c), liana		Mc	Zimbabwe	3a
Fabaceae	***Rhynchosia torrei* Verdc.**	E	shrub		Z		3b
Fabaceae	***Scorodophloeus torrei* Lock**	E	shrub, tree		Na, Z		1
Fabaceae	*Sphenostylis zimbabweensis* Mithen	NE3	herb (c), herb (p)		Mc	Zimbabwe	3a
Fabaceae	*Tephrosia chimanimaniana* Brummitt	NE1+2+3	shrub		Mc	Zimbabwe	3a
Fabaceae	***Tephrosia faulknerae* Brummitt**	E	shrub		Na, Z		
Fabaceae	*Tephrosia forbesii* Baker subsp. *forbesii*	NE1	herb (p)		G, Mp	South Africa KN	2a
Fabaceae	***Tephrosia forbesii* Baker subsp. *inhacensis* Brummitt**	E	herb (p)		Mp		2a
Fabaceae	*Tephrosia gobensis* Brummitt	NE2+3	shrub		Mp	eSwatini	2b
Fabaceae	*Tephrosia longipes* Meisn. var. *drummondii* (Brummitt) Brummitt	NE2+3	herb (p)		Mc	Zimbabwe	3a
Fabaceae	*Tephrosia longipes* Meisn. var. *swynnertonii* (Baker f.) Brummitt	NE2	herb (p), shrub		Mc	Zimbabwe	3a
Fabaceae	***Tephrosia miranda* Brummitt**	E	shrub		Na		
Fabaceae	*Tephrosia montana* Brummitt	NE2	shrub		Mc, S	Zimbabwe	3a
Fabaceae	*Tephrosia praecana* Brummitt	NE2	shrub, tree		Mc	Zimbabwe	3a
Fabaceae	***Tephrosia reptans* Baker var. *microfoliata* (Pires da Lima) Brummitt**	E	herb (a)		CD, Na, Z		1
Fabaceae	***Tephrosia whyteana* Baker f. subsp. *gemina* Brummitt**	E	shrub		Z		3b
Fabaceae	***Xylia mendoncae* Torre**	E	shrub, tree		In		2c
Gentianaceae	*Exacum zombense* N.E.Br.	NE1	herb (a)		Mc, Na, Ni, Z	Malawi	3a, 3b
Gentianaceae	***Faroa involucrata* (Klotzsch) Knobl.**	E	herb (a)		Na, Z		
Geraniaceae	*Geranium exellii* J.R.Laundon	NE2+3	herb (p)		Mc	Zimbabwe	3a
Geraniaceae	*Pelargonium mossambicense* Engl.	NE2	herb (p)		S	Zimbabwe	3a
Gesneriaceae	***Streptocarpus acicularis* I.Darbysh. & Massingue**	E	herb (p)	Y	Mc		3a
Gesneriaceae	***Streptocarpus brachynema* Hilliard & B.L.Burtt**	E	herb		S		3a
Gesneriaceae	*Streptocarpus erubescens* Hilliard & B.L.Burtt	NE2	herb		Ni	Malawi	3b
Gesneriaceae	*Streptocarpus grandis* N.E.Br. subsp. *septentrionalis* Hilliard & B.L.Burtt	NE2	herb		Mc	Zimbabwe	3a
Gesneriaceae	*Streptocarpus hirticapsa* B.L.Burtt	NE2	herb (p)		Mc	Zimbabwe	3a
Gesneriaceae	*Streptocarpus leptopus* Hilliard & B.L.Burtt	NE2	herb (p)		Z	Malawi	3b
Gesneriaceae	*Streptocarpus michelmorei* B.L.Burtt	NE2	herb (p)		Mc, S?	Zimbabwe	3a
Gesneriaceae	*Streptocarpus milanjianus* Hilliard & B.L.Burtt	NE2+3	herb (p)		Z	Malawi	3b
Gesneriaceae	***Streptocarpus montis-bingae* Hilliard & B.L.Burtt**	E	herb (p)	Y	Mc		3a
Gesneriaceae	***Streptocarpus myoporoides* Hilliard & B.L.Burtt**	E	herb (p)		Na		3b
Gesneriaceae	*Streptocarpus umtaliensis* B.L.Burtt	NE2	herb		Mc	Zimbabwe	3a
Lamiaceae	***Acrotome mozambiquensis* G.Taylor**	E	herb (p)		Mp		2a
Lamiaceae	*Aeollanthus viscosus* Ryding	NE2+3	shrub		Mc	Zimbabwe	3a

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Lamiaceae	***Clerodendrum abilioi* R.Fern.**	E	herb (p)	Y	Na		1
Lamiaceae	***Clerodendrum cephalanthum* Oliv. subsp. *cephalanthum* var. *torrei* R.Fern.**	E	liana, shrub	Y?	CD		1
Lamiaceae	*Clerodendrum lutambense* Verdc.	NE1+3	shrub		CD	Tanzania	1
Lamiaceae	***Clerodendrum robustum* Klotzsch var. *macrocalyx* R.Fern.**	E	herb (p)	Y	Mc		
Lamiaceae	*Coleus caudatus* (S.Moore) E.Downes & I.Darbysh. (=*Plectranthus caudatus* S.Moore)	NE2+3	herb (p)		Mc	Zimbabwe	3a
Lamiaceae	***Coleus cucullatus* (A.J.Paton) A.J.Paton (=*Plectranthus cucullatus* A.J.Paton)**	E	herb (p), shrub		Na		3b
Lamiaceae	***Coleus namuliensis* E.Downes & I.Darbysh.**	E	herb (p)		Z		3b
Lamiaceae	*Coleus psammophilus* (Codd) A.J.Paton (=*Plectranthus psammophilus* Codd)	NE1	herb (p)		In, Mp	South Africa KN	2a, 2c
Lamiaceae	*Coleus sessilifolius* (A.J.Paton) A.J.Paton (=*Plectranthus sessilifolius* A.J.Paton)	NE2	herb (p)		Mc	Zimbabwe	3a
Lamiaceae	***Leucas nyassae* Gürke var. *velutina* (C.H.Wright ex Baker) Sebald**	E	herb (p)		Ni		
Lamiaceae	*Ocimum natalense* Ayob. ex A.J. Paton	NE2	herb (p), shrub		G, Mp	South Africa KN	2a
Lamiaceae	*Ocimum reclinatum* (S.D.Will. & K.Balkwill) A.J.Paton	NE2	herb (p)		Mp	South Africa KN	2a
Lamiaceae	*Orthosiphon scedastophyllus* A.J.Paton	NE2+3	herb (p)		CD	Tanzania	1
Lamiaceae	*Plectranthus chimanimanensis* S.Moore	NE1	herb (p), shrub		Mc, S	Zimbabwe	3a
Lamiaceae	***Plectranthus guruensis* A.J.Paton**	E	herb (p)		Z		3b
Lamiaceae	*Plectranthus mandalensis* Baker	NE2	herb (a), herb (p)		Z	Malawi	3b
Lamiaceae	*Premna hans-joachimii* Verdc.	NE2	shrub		CD	Tanzania	1
Lamiaceae	*Premna tanganyikensis* Moldenke	NE1	shrub, tree		CD, Na	Tanzania	1
Lamiaceae	***Rotheca luembensis* (De Wild.) R.Fern. subsp. *niassensis* (R.Fern.) R.Fern.**	E	herb (p)		Ni		
Lamiaceae	***Rotheca sansibarensis* (Gürke) Steane & Mabb. subsp. *sansibarensis* var. *eratensis* (R.Fern.) R.Fern.**	E	shrub	Y	Na		
Lamiaceae	*Rotheca teaguei* (Hutch.) R.Fern.	NE2+3	herb (p)		Mc	Zimbabwe	
Lamiaceae	*Rotheca verdcourtii* (R.Fern.) R.Fern.	NE2	shrub, tree		Mc	Zimbabwe	3a
Lamiaceae	*Stachys didymantha* Brenan	NE2	herb (p)		Z	Malawi	3b
Lamiaceae	*Syncolostemon flabellifolius* (S.Moore) A.J.Paton	NE2+3	shrub, tree		Mc	Zimbabwe	3a
Lamiaceae	*Syncolostemon namapaensis* D.F.Otieno	NE2+3	herb (p)		Na	Tanzania	
Lamiaceae	*Syncolostemon oritrephes* (Wild) D.F.Otieno	NE2+3	herb (p), shrub		Mc	Zimbabwe	3a
Lamiaceae	*Vitex carvalhi* Gürke	NE1	shrub, tree		CD, Na	Tanzania	1
Lamiaceae	*Vitex mossambicensis* Gürke	NE1	tree		CD, Na	Tanzania	1
Lentibulariaceae	*Utricularia podadena* P.Taylor	NE2+3	herb (p)		Ni	Malawi	
Linaceae	***Hugonia elliptica* N.Robson**	E	shrub, liana		Z		1

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Linaceae	*Hugonia grandiflora* N.Robson	NE3	shrub, tree, liana		CD	Tanzania	1
Linderniaceae	*Crepidorhopalon flavus* (S.Moore) I.Darbysh. & Eb.Fisch. (=*Lindernia flava* S.Moore)	NE2	herb (p)		Mc	Zimbabwe	3a
Linderniaceae	***Crepidorhopalon namuliensis* I.Darbysh. & Eb.Fisch.**	E	herb (p)		Z		3b
Loranthaceae	***Agelanthus deltae* (Baker & Sprague) Polhill & Wiens**	E	shrub (par)		S, T, Z		
Loranthaceae	*Agelanthus igneus* (Danser) Polhill & Wiens	NE1+3	shrub (par)		CD, S, T, Z	Tanzania	
Loranthaceae	*Agelanthus patelii* Polhill & Timberlake INED.	NE2+3	shrub (par)		Z	Malawi	3b
Loranthaceae	*Englerina oedostemon* (Danser) Polhill & Wiens	NE2	shrub (par)		Mc	Zimbabwe	3a
Loranthaceae	***Englerina schlechteri* (Engl.) Polhill & Wiens**	E	shrub (par)		G, In, Mp		2a, 2c
Loranthaceae	*Englerina swynnertonii* (Sprague) Polhill & Wiens	NE2+3	shrub (par)		Mc	Zimbabwe	3a
Loranthaceae	*Englerina triplinervia* (Baker & Sprague) Polhill & Wiens	NE3	shrub (par)		CD, Na	Tanzania	1
Loranthaceae	***Helixanthera schizocalyx* T.Harris, I.Darbysh. & Polhill**	E	shrub (par)		Z		3b
Lythraceae	***Ammannia elata* R.Fern.**	E	herb (a)	Y	Z		
Lythraceae	***Ammannia fernandesiana* S.A.Graham & Gandhi**	E	herb (p)		In, S		
Lythraceae	***Ammannia gazensis* (A.Fern.) S.A.Graham & Gandhi**	E	herb (a)	Y	G		
Lythraceae	*Ammannia linearis* (Hiern) S.A.Graham & Gandhi	NE1	herb (a)		Na, S, Z	Tanzania	
Lythraceae	***Ammannia moggii* (A.Fern.) S.A.Graham & Gandhi**	E	herb (p)	Y	Na		1
Lythraceae	*Ammannia mossambicensis* (A.Fern. & Diniz) S.A.Graham & Gandhi	NE3	herb (a), herb (p)		Na	Tanzania, Zimbabwe	
Lythraceae	***Ammannia parvula* S.A.Graham & Gandhi**	E	herb (a)		Na		
Lythraceae	***Ammannia pedroi* (A.Fern. & Diniz) S.A.Graham & Gandhi**	E	herb (a)		CD, Na		1
Lythraceae	***Ammannia polycephala* (Peter) S.A.Graham & Gandhi**	E	herb (p)		S		
Lythraceae	***Ammannia ramosissima* (A.Fern. & Diniz) S.A.Graham & Gandhi**	E	herb (a)	Y	Ni	?Malawi	
Lythraceae	***Ammannia spathulata* (A.Fern.) S.A.Graham & Gandhi**	E	herb (p)	Y	S		
Malpighiaceae	*Acridocarpus natalitius* A.Juss. var. *linearifolius* Launert	NE1	shrub, tree, liana		In, Mp	eSwatini, South Africa KN	2a
Malpighiaceae	*Triaspis hypericoides* (DC.) Burch. subsp. *canescens* (Engl.) Immelman	NE2	shrub		Mp	South Africa MP	2b
Malpighiaceae	***Triaspis suffulta* Launert**	E	liana		In		2c
Malvaceae	***Cola cheringoma* Cheek**	E	tree		S		
Malvaceae	***Cola clavata* Mast.**	E	tree		S, Z		
Malvaceae	*Cola mossambicensis* Wild	NE1	tree		Mc, Na, S, Z	Malawi, Tanzania	
Malvaceae	*Corchorus velutinus* Wild	NE1	shrub		G, In	Zimbabwe, South Africa LP	
Malvaceae	***Dombeya lastii* K.Schum.**	E	shrub		Z		3b
Malvaceae	***Dombeya leachii* Wild**	E	shrub		Na		3b
Malvaceae	***Eriolaena rulkensii* Dorr**	E	shrub, tree		CD		1
Malvaceae	*Glyphaea tomentosa* Mast.	NE1	shrub, tree		Na, S, Z	Malawi	
Malvaceae	*Grewia filipes* Burret	NE2+3	shrub, tree		CD	Tanzania	1

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Malvaceae	*Grewia hornbyi* Wild	NE1	shrub		G, In, Mc, Mp, S, T	Zimbabwe, South Africa KN	
Malvaceae	***Grewia limae* Wild**	E	shrub, tree		CD		1
Malvaceae	***Grewia occidentalis* L. var. *littoralis* Wild**	E	shrub		G, In, Mp		2a, 2c
Malvaceae	***Grewia transzambesica* Wild**	E	shrub, tree		CD, Na, S, Z		
Malvaceae	*Hermannia micropetala* Harv.	NE1	herb (p), shrub		G, In, Mp, S	South Africa KN	2a, 2c
Malvaceae	***Hermannia torrei* Wild**	E	herb (p), shrub	Y	G		2c
Malvaceae	*Hibiscus burtt-davyi* Dunkley	NE3	shrub, tree		Mc	Malawi, Zimbabwe	3a, 3b
Malvaceae	***Hibiscus rupicola* Exell**	E	herb (p), shrub	Y	T	?Malawi	
Malvaceae	***Hibiscus torrei* Baker f.**	E	herb (p), shrub	Y	Ni		
Malvaceae	*Microcos microthyrsa* (K.Schum. ex Burret) Burret (=*Grewia microthyrsa* K.Schum. ex Burret)	NE1	shrub		G, In, Mp	South Africa KN, LP	2a, 2b, 2c
Malvaceae	***Thespesia mossambicensis* (Exell & Hillc.) Fryxell**	E	shrub, tree		CD		1
Malvaceae	*Triumfetta kirkii* Mast.	NE1	herb (a)		CD, Na, S	Tanzania	
Melastomataceae	***Antherotoma angustifolia* (A.Fern. & R.Fern.) Jacq.-Fél.**	E	herb (p), shrub		CD, Na		1
Melastomataceae	*Dissotis johnstoniana* Baker f. var. *johnstoniana* (=*Dissotidendron johnstonianum* (Baker f.) Ver,-Lib. & G.Kadereit var. *johnstonianum*)	NE2+3	shrub		Z	Malawi	3b
Melastomataceae	*Dissotis pulchra* A.Fern. & R.Fern.	NE2+3	herb (p), shrub		Mc	Zimbabwe	3a
Melastomataceae	*Dissotis suynnertonii* (Baker f.) A.Fern. & R.Fern. (=*Pseudosbeckia suynnertonii* (Baker f.) A. Fern. & R.Fern.)	NE2+3	shrub		Mc	Zimbabwe	3a
Melastomataceae	***Memecylon aenigmaticum* R.D.Stone**	E	shrub	Y	CD		1
Melastomataceae	***Memecylon incisilobum* R.D.Stone & I.G.Mona**	E	tree		G		2a
Melastomataceae	***Memecylon insulare* A.Fern. & R.Fern.**	E	shrub		In		2c
Melastomataceae	*Memecylon nubigenum* R.D.Stone & I.G.Mona	NE1+2+3	tree		Na, Z	Malawi	3b
Melastomataceae	*Memecylon rovumense* R.D.Stone & I.G.Mona	NE2+3	shrub, tree		CD	Tanzania	1
Melastomataceae	***Memecylon torrei* A.Fern. & R.Fern.**	E	shrub, tree		CD, Na		1
Melastomataceae	***Warneckea albiflora* R.D.Stone & N.P.Tenza**	E	tree		CD		1
Melastomataceae	***Warneckea cordiformis* R.D.Stone**	E	shrub, tree		CD		1
Melastomataceae	*Warneckea parvifolia* R.D.Stone & Ntetha	NE2+3	shrub, tree		Mp	South Africa KN	2a
Melastomataceae	***Warneckea sessilicarpa* (A.Fern. & R.Fern.) Jacq.-Fel.**	E	shrub, tree		Na		1
Melastomataceae	*Warneckea sousae* (A.Fern. & R.Fern.) A.E.van Wyk	NE1	shrub, tree		CD, Na, S, Z	Tanzania	
Melianthaceae	*Bersama suynnertonii* Baker f.	NE2	shrub, tree		Mc	Zimbabwe	3a
Menispermaceae	*Albertisia delagoensis* (N.E.Br.) Forman	NE1	shrub, liana		In, Mp, Na, S, Z	South Africa KN	

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Menispermaceae	*Cissampelos hirta* Klotzsch	NE1	liana		G, In, Mp	South Africa KN	2a, 2c
Menispermaceae	*Tinospora mossambicensis* Engl.	NE3	liana		Unknown	Tanzania	
Moraceae	*Bosqueiopsis carvalhoana* Engl.		shrub		CD, Na	Tanzania	1
Moraceae	***Dorstenia zambesiaca* Hijman**	E	herb (p)		Na, S		
Moraceae	***Ficus muelleriana* C.C.Berg**	E	shrub		Mc		3a
Myricaceae	*Myrica chimanimaniana* (Verdc. & Polhill) Christenh. & Byng (=*Morella chimanimaniana* Verdc.& Polhill)	NE2+3	shrub		Mc	Zimbabwe	3a
Myrtaceae	*Syzygium komatiense* Byng & Pahlad.	NE2+3	tree		Mp	South Africa MP	2b
Myrtaceae	*Syzygium niassense* Byng & J.E.Burrows	NE1	tree		CD, Na, Ni, S, Z	Tanzania?	
Ochnaceae	***Ochna angustata* N.Robson**	E	shrub, tree		CD, Na, S, Z		
Ochnaceae	***Ochna beirensis* N.Robson**	E	shrub, tree		S		
Ochnaceae	***Ochna dolicharthros* F.M.Crawford & I.Darbysh.**	E	shrub		CD		1
Oleaceae	*Olea chimanimani* Kupicha	NE2+3	shrub, tree		Mc	Zimbabwe	3a
Orobanchaceae	*Buchnera chimanimaniensis* Philcox	NE2	herb (a), herb (p)		Mc	Zimbabwe	3a
Orobanchaceae	***Buchnera namuliensis* Skan**	E	herb (a)		S, Z		
Orobanchaceae	*Buchnera subglabra* Philcox	NE2+3	herb (a)		Mc	Zimbabwe	3a
Orobanchaceae	*Buchnera wildii* Philcox	NE2	herb (a), herb (p)		Mc	Zimbabwe, ?Malawi	3a
Orobanchaceae	***Striga diversifolia* Pires de Lima**	E	herb (a)	Y	CD		1
Orobanchaceae	*Striga junodii* Schinz	NE1	herb (p)		In, Mp	South Africa KN, MP	2a, 2c
Passifloraceae	*Adenia dolichosiphon* Harms	NE1	herb (c)		CD, Mc, S, Z	Tanzania	
Passifloraceae	***Adenia mossambicensis* W.J.de Wilde**	E	herb (c)	Y	Na		
Passifloraceae	***Adenia zambesiensis* R.Fern. & A.Fern.**	E	herb (c)	Y	Z		
Passifloraceae	***Tricliceras auriculatum* (A.Fern. & R.Fern.) R.Fern.**	E	herb (a)		Na		
Passifloraceae	***Tricliceras elatum* (A.Fern. & R.Fern.) R.Fern.**	E	herb (a)		Na		
Passifloraceae	***Tricliceras lanceolatum* (A.Fern. & R.Fern.) R.Fern.**	E	herb (a)		Na, S		
Passifloraceae	***Tricliceras longepedunculatum* (Mast.) R.Fern. var. *eratense* R.Fern.**	E	herb (p)		Na		
Penaeaceae	*Olinia chimanimani* T.Shah & I.Darbysh.	NE2+3	shrub, tree		Mc	Zimbabwe	3a
Peraceae	*Clutia sessilifolia* Radcl.-Sm.	NE2+3	shrub		Mc	Zimbabwe	3a
Phyllanthaceae	*Phyllanthus bernierianus* Müll.Arg. var. *glaber* Radcl.-Sm.	NE2+3	shrub		Mc	Zimbabwe	3a
Phyllanthaceae	***Phyllanthus manicaensis* Jean F.Brunel ex Radcl.-Sm.**	E	herb (p)		Mc	?Zimbabwe	3a
Phyllanthaceae	***Phyllanthus reticulatus* Poir. var. *orae-solis* Radcl.-Sm.**	E	shrub, tree		Mp		2a
Phyllanthaceae	***Phyllanthus tsetserrae* Jean F.Brunel ex Radcl.-Sm.**	E	herb (p)	Y	Mc		3a
Podostemaceae	***Inversodicraea torrei* (C.Cusset) Cheek**	E	herb (p)		Z		3b
Polygalaceae	***Carpolobia suaveolens* Meikle**	E	shrub, tree		CD, In, Na, S, Z		
Polygalaceae	*Polygala adamsonii* Exell	NE2+3	herb (a)		Na, Z	Malawi	3b

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Polygalaceae	***Polygala francisci* Exell**	E	herb (p), shrub		In, Mp	?Zimbabwe	2a, 2c
Polygalaceae	***Polygala limae* Exell**	E	herb (a)	Y	CD		1
Polygalaceae	***Polygala torrei* Exell**	E	herb (p)	Y	Mp		2a
Polygalaceae	*Polygala zambesiaca* Paiva	NE2	shrub		Mc	Zimbabwe	3a
Primulaceae	*Lysimachia gracilipes* (P.Taylor) U.Manns & Anderb.	NE2+3	herb (p)		S	Zimbabwe	3a
Proteaceae	*Faurea racemosa* Farmar	NE1+3	tree		Z	Malawi	3b
Proteaceae	*Faurea rubriflora* Marner	NE2	tree		Mc	Zimbabwe	3a
Proteaceae	*Leucospermum saxosum* S.Moore	NE3	shrub		Mc	Zimbabwe, South Africa LP MP	3
Proteaceae	*Protea caffra* Meisn. subsp. *gazensis* (Beard) Chisumpa & Brummitt	NE2	shrub, tree		Mc, S	Zimbabwe	3a
Proteaceae	*Protea enervis* Wild	NE2+3	herb (p)		Mc	Zimbabwe	3a
Putranjivaceae	***Drypetes gerrardii* Hutch. var. *angustifolia* Radcl.-Sm.**	E	shrub, tree	Y	Mc		
Rhizophoraceae	*Cassipourea mossambicensis* (Brehmer) Alston	NE1	shrub, tree		CD, In, Mp	Tanzania, eSwatini, South Africa KN	
Rubiaceae	*Afrocanthium ngonii* (Bridson) Lantz	NE2	shrub, tree		Mc	Zimbabwe	3a
Rubiaceae	*Afrocanthium racemulosum* (S.Moore) Lantz var. *nanguanum* (Tennant) Bridson	NE1	shrub, tree		CD, Z	Tanzania	1
Rubiaceae	*Afrocanthium vollesenii* (Bridson) Lantz	NE3	shrub, tree		CD, Na	Tanzania	1
Rubiaceae	*Anthospermum ammanioides* S.Moore	NE1	shrub		Mc, S	Zimbabwe	3a
Rubiaceae	*Anthospermum vallicola* S.Moore	NE1	shrub		Mc, S	Zimbabwe	3a
Rubiaceae	*Anthospermum zimbabwense* Puff	NE2	shrub		Mc	Zimbabwe	3a
Rubiaceae	*Canthium oligocarpum* Hiern subsp. *angustifolium* Bridson	NE1	tree		Mc, S	Zimbabwe	3a
Rubiaceae	*Catunaregam stenocarpa* Bridson	NE1	shrub, tree		CD, Na, Ni, Z	Tanzania	
Rubiaceae	*Catunaregam swynnertonii* (S.Moore) Bridson	NE1	shrub, tree		CD, G, Mc, Na, S, T, Z	Zimbabwe	
Rubiaceae	***Chassalia colorata* J.E.Burrows**	E	shrub		CD		1
Rubiaceae	*Coffea salvatrix* Swynn. & Phillipson	NE1	shrub, tree		Mc, Z	Tanzania, Malawi, Zimbabwe	
Rubiaceae	*Coffea schliebenii* Bridson	NE2	shrub, tree		CD	Tanzania	1
Rubiaceae	***Conostomium gazense* Verdc.**	E	herb (p)	Y	G		2c
Rubiaceae	*Cuviera schliebenii* Verdc.	NE1	shrub, tree		CD, Na, Z	Tanzania	1
Rubiaceae	*Didymosalpinx callianthus* J.E.Burrows & S.M.Burrows	NE1+2+3	shrub		CD	Tanzania	1
Rubiaceae	*Empogona jenniferae* Cheek	NE2+3	tree		Mc	Zimbabwe	3a
Rubiaceae	*Empogona maputensis* (Bridson & A.E.van Wyk) Tosh & Robbr.	NE2+3	shrub		Mp	South Africa KN	2a
Rubiaceae	***Heinsia mozambicensis* (Verdc.) J.E.Burrows & S.M.Burrows**	E	shrub		Na		1
Rubiaceae	*Hymenodictyon austro-africanum* J.E.Burrows & S.M.Burrows	NE2	shrub, tree		G	South Africa LP	
Rubiaceae	*Hyperacanthus microphyllus* (K.Schum.) Bridson	NE1	shrub, tree		G, Mp, Na, S	South Africa KN, ?Zimbabwe	
Rubiaceae	*Leptactina papyrophloea* Verdc.	NE1+3	tree		CD	Tanzania	1
Rubiaceae	*Oldenlandia cana* Bremek.	NE2	herb (a)		Mc	Zimbabwe	3a
Rubiaceae	***Oldenlandia verrucitesta* Verdc.**	E	herb (a), herb (p)	Y	Z		

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Rubiaceae	*Otiophora inyangana* N.E.Br. subsp. *inyangana*	NE1+2	herb (p), shrub		Mc	Zimbabwe	3a
Rubiaceae	*Otiophora inyangana* N.E.Br. subsp. *parvifolia* (Verdc.) Puff	NE1+2	herb (p), shrub		Mc	Zimbabwe	3a
Rubiaceae	*Otiophora lanceolata* Verdc.	NE1+2	herb (p), shrub		Mc	Zimbabwe	3a
Rubiaceae	*Oxyanthus biflorus* J.E.Burrows & S.M.Burrows	NE1+2+3	shrub		CD	Tanzania	1
Rubiaceae	*Oxyanthus latifolius* Sond.	NE1	tree		G, In, Mp, S, Z	South Africa KN	
Rubiaceae	*Oxyanthus strigosus* Bridson & J.E.Burrows	NE1+2	shrub		CD	Tanzania	1
Rubiaceae	*Pavetta chapmanii* Bridson	NE2	shrub, tree		Z	Malawi	3b
Rubiaceae	*Pavetta comostyla* S.Moore subsp. *comostyla* var. *inyangensis* (Bremek.) Bridson	NE1+2	shrub, tree		Mc, S	Zimbabwe	3a
Rubiaceae	***Pavetta curalicola* J.E.Burrows**	E	shrub		CD, Na		1
Rubiaceae	*Pavetta decumbens* K.Schum. & K.Krause	NE1	shrub		CD, Na, S, Z	Tanzania	1
Rubiaceae	***Pavetta dianeae* J.E.Burrows & S.M.Burrows**	E	shrub		CD, Na, Z		1
Rubiaceae	***Pavetta gardeniifolia* A.Rich. var. *appendiculata* (De Wild.) Bridson**	E	shrub, tree		Ni, Z		
Rubiaceae	*Pavetta gracillima* S.Moore	NE1	shrub		In, Mc, S	Zimbabwe	
Rubiaceae	***Pavetta gurueensis* Bridson**	E	shrub		Z		3b
Rubiaceae	***Pavetta incana* Klotzsch**	E	shrub		T		
Rubiaceae	*Pavetta klotzschiana* K.Schum.	NE1	shrub		CD, In, Mc, Na, S, T, Z	Malawi, Zimbabwe	
Rubiaceae	*Pavetta lindina* Bremek.	NE1+2	shrub		CD	Tanzania	1
Rubiaceae	*Pavetta micropunctata* Bridson	NE1+2	shrub		Na	Tanzania	1
Rubiaceae	***Pavetta mocambicensis* Bremek.**	E	shrub		CD, Na		1
Rubiaceae	***Pavetta pumila* N.E.Br.**	E	shrub		S		
Rubiaceae	*Pavetta tendagurensis* Bremek.	NE1	shrub		CD, Na	Tanzania	1
Rubiaceae	*Pavetta umtalensis* Bremek.	NE1+2	shrub, tree		Mc	Zimbabwe	3a
Rubiaceae	*Pavetta vanwykiana* Bridson	NE2	shrub		Mp	South Africa KN	2a, 2b
Rubiaceae	*Pentas zanzibarica* (Klotzsch) Vatke subsp. *milangiana* (Verdc.) Verdc.	NE1	herb (p), shrub		Na, Z	Malawi	3b
Rubiaceae	***Polysphaeria harrisii* I.Darbysh. & C.Langa**	E	shrub		Z		3b
Rubiaceae	***Polysphaeria ribauensis* I. Darbysh. & C.Langa**	E	shrub		Na		3b
Rubiaceae	***Psychotria amboniana* K.Schum. subsp. *mosambicensis* (E.M.A.Petit) Verdc.**	E	shrub		G, In, Mp		2a, 2c
Rubiaceae	*Psychotria angustibracteata* (Verdc.) J.E.Burrows	NE1	shrub, tree		Mc, Na, S, Z	Zimbabwe	3a, 3b
Rubiaceae	*Psydrax fragrantissimus* (K.Schum.) Bridson	NE1	shrub, tree		Mp	South Africa KN	2a
Rubiaceae	*Psydrax micans* (Bullock) Bridson	NE1	tree, liana		CD, Na, S	Tanzania	
Rubiaceae	***Psydrax moggii* Bridson**	E	shrub, tree		CD, G, In, Mp, Na, S		
Rubiaceae	*Pyrostria chapmanii* Bridson	NE1+2+3	shrub, tree		Na, Z	Malawi	3b
Rubiaceae	*Rothmannia fischeri* (K.Schum.) Bullock subsp. *moramballae* (Hiern) Bridson	NE1	tree		CD, In, Mc, Mp, S, Z	South Africa KN; Zimbabwe	

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Rubiaceae	*Rytigynia celastroides* (Baill.) Verdc. var *australis* Verdc.	NE1	shrub		In, Mp	South Africa KN	2a, 2c
Rubiaceae	***Rytigynia torrei* Verdc.**	E	shrub		CD, Na		
Rubiaceae	*Sericanthe chimanimaniensis* Wursten & De Block INED.	NE1+2	shrub, tree		Mc	Zimbabwe	3a
Rubiaceae	***Spermacoce kirkii* (Hiern.) Verdc.**	E	herb (a), herb (p)		G, In, S, Z		
Rubiaceae	***Spermacoce schlechteri* K.Schum. ex Verdc.**	E	herb (p)		In, Na, S, Z	?Tanzania	
Rubiaceae	***Tarenna longipedicellata* (J.G.García) Bridson**	E	shrub		S, Z		
Rubiaceae	***Tarenna pembensis* J.E.Burrows**	E	tree		CD, Na		1
Rubiaceae	***Triainolepis sancta* Verdc.**	E	shrub		In		2c
Rubiaceae	*Tricalysia coriacea* (Benth.) Hiern subsp. *angustifolia* (J.G.Garcia) Robbr.	NE1	shrub, tree		Mc, S	Zimbabwe	3a
Rubiaceae	*Tricalysia ignota* Bridson	NE2+3	shrub, tree		Mc	Malawi; Zimbabwe	3a, 3b
Rubiaceae	***Tricalysia jasminiflora* (Klotzsch) Benth. & Hook.f. ex Hiern var. *hypotephros* Brenan**	E	shrub, tree		Z		
Rubiaceae	*Tricalysia schliebenii* Robbr.	NE1	shrub		CD, Na, Z	Tanzania	1
Rubiaceae	*Tricalysia semidecidua* Bridson	NE1	shrub		CD	Tanzania	1
Rubiaceae	***Vangueria domatiosa* J.E.Burrows**	E	tree		CD		1
Rubiaceae	*Vangueria monteiroi* (Oliv.) Lantz (=*Lagynias monteiroi* (Oliv.) Bridson)	NE1	shrub, tree		G, Mp	eSwatini, South Africa KN	2a, 2c
Rutaceae	***Teclea crenulata* (Engl.) Engl. (=*Todallia crenulata* Engl.)**	E	unknown	Y	Z		
Rutaceae	***Vepris allenii* I.Verd.**	E	shrub, tree		CD	Possibly Tanzania	1
Rutaceae	*Vepris carringtoniana* Mendonça	NE1	shrub		In, Mp	eSwatini, South Africa KN, LP, MP	2a, 2b, 2c
Rutaceae	*Vepris drummondii* Mendonça	NE2+3	shrub		Mc	Zimbabwe	3a
Rutaceae	***Vepris macedoi* (Exell & Mendonça) Mziray**	E	tree		Na		3b
Rutaceae	*Vepris myrei* (Exell & Mendonça) Mziray	NE1	shrub, tree		In, S, T	Malawi, Zimbabwe	
Rutaceae	***Zanthoxylum delagoense* P.G.Waterman**	E	shrub, tree		G, In, Mp, S		2a, 2c
Rutaceae	*Zanthoxylum tenuipedicellatum* (Kokwaro) Vollesen	NE2+3	shrub, tree		Na	Tanzania	1
Santalaceae	*Thesium chimanimaniense* Brenan	NE2+3	herb (p)		Mc	Zimbabwe	3a
Santalaceae	*Thesium dolichomeres* Brenan	NE2+3	herb (p)		Mc	Zimbabwe	3a
Santalaceae	***Thesium inhambanense* Hilliard**	E	herb (p)	Y	In	Possibly Malawi	2c
Santalaceae	*Thesium pygmaeum* Hilliard	NE2+3	herb (p)		Mc	Zimbabwe	3a
Santalaceae	*Thesium vahrmeijeri* Brenan	NE1	herb (a)		In, Mp	South Africa KN	2a, 2c
Santalaceae	***Viscum littorum* Polhill & Wiens**	E	shrub		CD		1
Sapindaceae	***Allophylus mossambicensis* Exell**	E	shrub		G, In		2a, 2c
Sapindaceae	***Allophylus torrei* Exell & Mendonça**	E	shrub, tree		CD, Na		
Sapotaceae	*Synsepalum chimanimani* S.Rokni & I.Darbysh.	NE2+3	shrub, tree		Mc	Zimbabwe	3a
Sapotaceae	*Synsepalum muelleri* (Kupicha) T.D.Penn.	NE1	shrub, tree		Na, Z	Malawi	3b

Family	Taxon	Endemism	Life form	Type only	Provinces	Other countries	CoE
Scrophulariaceae	*Jamesbrittenia carvalhoi* (Engl.) Hilliard	NE2	herb (p), shrub		Mc, S	Zimbabwe	3a
Scrophulariaceae	*Selago anatrichota* Hilliard	NE2+3	herb (p)		Mc	Zimbabwe	3a
Scrophulariaceae	*Selago swynnertonii* (S.Moore) Eyles var. *leiophylla* (Brenan) Hilliard	NE2	herb (p)		Mc	Zimbabwe	3a
Solanaceae	***Solanum litoraneum* A.E.Gonç.**	E	shrub		In, Mp		2a, 2c
Solanaceae	*Solanum torreanum* A.E.Gonç.	NE1	herb (c)		Mp	eSwatini, South Africa KN MP	2a
Thymelaeaceae	*Gnidia chapmanii* B.Peterson	NE2+3	shrub		Z	Malawi	3b
Thymelaeaceae	*Struthiola montana* B.Peterson	NE2+3	shrub		Mc	Zimbabwe	3a
Thymelaeaceae	*Synaptolepis oliveriana* Gilg	NE1	shrub, liana		CD, G, In, Mp, Na, Z	South Africa KN	
Vahliaceae	***Vahlia capensis* (L.f.) Thunb. subsp. *macrantha* (Klotzsch) Bridson**	E	herb (a), herb (p)		Mc, S, Z	Possibly Madagascar	
Verbenaceae	*Chascanum angolense* Moldenke subsp. *zambesiacum* (R.Fern.) R.Fern.	NE2+3	shrub, herb (p)		In	Malawi	
Verbenaceae	***Chascanum schlechteri* (Gürke) Moldenke var. *torrei* Moldenke**	E	herb (p)	Y	Mp		2a
Verbenaceae	*Lantana swynnertonii* Moldenke	NE1	shrub		Mc, Z	Zimbabwe	3a, 3b
Vitaceae	*Cissus aristolochiifolia* Planch.	NE1	herb (c)		Na, Z	Malawi	3b
Vitaceae	*Cissus bathyrhakodes* Werderm.	NE1	herb (p)		CD, Mc, Z	Tanzania	
Vitaceae	*Cyphostemma barbosae* Wild & R.B.Drumm.	NE1	herb (geo)		Mp	eSwatini, South Africa KN, MP	2b

Supplementary material 1

Annotated checklist of the endemic and near-endemic vascular plant taxa of Mozambique

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Data type: species data

Explanation note: Explanatory notes in addition to those for Appendix 1: For "Sources", F.Z. = Flora Zambesiaca; S.R.D.L. = Southern African Plant Red Data Lists (Izidine and Bandeira 2002); T.S.M. = Trees and Shrubs of Mozambique (Burrows et al. 2018). For "IUCN Status", assessments in italics are awaiting publication; those marked with an asterisk (*) require updating.

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Supplementary material 2

Taxa that were considered for their potential status as near-endemics for Mozambique in preparation of the checklist but that do not meet the criteria set out in the Materials and methods

Authors: Iain Darbyshire, Jonathan Timberlake, Jo Osborne, Saba Rokni, Hermenegildo Matimele, Clayton Langa, Castigo Datizua, Camila de Sousa, Tereza Alves, Alice Massingue, Jeneen Hadj-Hammou, Sonia Dhanda, Toral Shah, Bart Wursten

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The taxonomic identities of *Pholidota wenshanica* and *P. subcalceata* (Orchidaceae, Coelogyninae)

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Abstract

P. wenshanica S.C.Chen & Z.H.Tsi and *P. subcalceata* Gagnep. have long been recognized as synonyms of *P. leveilleana* Schltr. In the present study, detailed morphological comparisons suggest that specimens referred to as *P. wenshanica* and *P. subcalceata* differ significantly in both vegetative and floral characters from those of *P. leveilleana*. Here we resurrect *P. wenshanica* and *P. subcalceata* as independent species. Key diagnostic characters essential for delineating identities of these species are presented.

Keywords

China, emended description, orchid taxonomy, Vietnam

Introduction

The orchid genus *Pholidota* Lindl. ex Hook. was established by Hooker (1825: pl. 138). The generic epithet is from the Greek *pholidotos*, referring to the imbricate bracts of the inflorescence of some species (Pridgeon et al. 2005). As currently circumscribed,

the genus is classified within the subtribe Coelogyninae, subfamily Epidendroideae, comprising about 30 species, distributed from Pakistan, India, Sri Lanka, Nepal, Bhutan, Myanmar, S China, Taiwan, Indo-China and the Malesian region into the SW Pacific (Seidenfaden 1986; de Vogel 1988; Seidenfaden and Wood 1992; Pearce and Cribb 2002; Pridgeon et al. 2005).

The taxonomic status of the Chinese species *P. wenshanica* S.C.Chen & Z.H.Tsi (1988: 7) has long been in doubt. Soon after its publication in the same year, this species has been placed in synonym with *P. leveilleana* Schltr. (1913: 107) by de Vogel (1988) while revising the genus *Pholidota*. There have been no further references to that species, except in the protologue (Chen and Tsi 1988) and subsequent reports (Chen and Tsi 1998; Chen 1999). In Flora Reipulicae Popularis Sinicae, Chen (1999) regarded this species as an independent species and consistently named *P. wenshanica*. However, in the revised edition Flora of China, Chen and Wood (2009) followed the treatment of de Vogel (1988) and reduced it as the synonym of *P. leveilleana* with some doubts. According to the addendum made by de Vogel (1988): " I have not seen the holotype, Tsi 223 (PE), but the description and the line drawings do agree so very well with *P. leveilleana* Schltr. that I am convinced that it is conspecific with that species". These more or less ambiguous treatments of *P. wenshanica* caught our attention.

Comparison of *Pholidota* specimens collected from different localities in China showed those representing *P. wenshanica* could be distinguished from *P. leveilleana* on the basis of several morphological characters recognized in this study. Further investigation revealed that a Vietnamese species *P. subcalceata*, which has been treated as a synonym of *P. leveilleana*, also differs in its unique characters. The present paper includes confirmation of the validities of *P. wenshanica* and *P. subcalceata*, assessments of diagnostic characters of these species and descriptions of newly recognized diagnostic characters.

Material and methods

To clarify the taxonomic status of *Pholidota wenshanica* in China, morphological studies were performed using specimens deposited at herbaria E, GXMG, IBK, IBSC, KUN, P and PE, and online databases such as JSTOR Global Plants (http://plants.jstor.org) and Chinese Virtual Herbarium (http://www.cvh.ac.cn/), with special focus on the type specimens. The only type of *P. wenshanica* was thoroughly examined and compared with various specimens of *P. leveilleana* from China including some type materials of its synonym *P. subcalceata* from Vietnam. Relevant literature, including the protologue, was consulted. We also conducted field investigations in the type localities of *P. wenshanica* and *P. leveilleana*. Living plants were collected and transplanted to the nursery of South China Botanical Garden (**SCBG**) for further observation. Measurements and photographs of the fresh material were made under a stereomicroscope Olympus MD-90. Herbarium abbreviations follow Index Herbariorum (Thiers 2015, http://sweetgum.nybg.org/science/ih/).

Results and discussion

Pholidota wenshanica S.C.Chen & Z.H.Tsi was described based on a specimen collected from Wenshan County, Yunnan (Chen and Tsi 1988). According to the protologue, this species is characterized by having fusiform-cylindrical pseudobulbs with two apical leaves, well-spaced on creeping rhizomes, lanceolate-oblong leaves.

Pholidota leveilleana Schltr. was described by Schlechter (1913) on the basis of a specimen collected by J. Esquirol from Guizhou (= Kweichow or Kouy-tchou), China. In the protologue, the author stated that the species is easily distinguished from the related species *P. yunnanensis* Rolfe (1903: 24) by unifoliate pseudobulbs (vs. two-leaved), loose (vs. tight) inflorescences with larger, white and crimson-red (vs. white) flowers. Unfortunately, the type sheet of *P. leveilleana* is nearly complete (Fig. 1D). In his monograph, de Vogel (1988) pointed out that the type specimen of *P. leveilleana* has only one leaf because it is a weakly developed plant, and thus this character cannot be used to distinguish these species. At the same time, he placed *P. subcalceata* Gagnep. (1950: 508) as the synonym of *P. leveilleana. P. subcalceata* was described based on two collections from Vietnam (Fig. 1G, H). Gagnepain (1950) stated in the protologue that *P. subcalceata* has two linear to lanceolate leaves ca. 30 cm long. De Vogel's treatment has long been accepted until Chen (1999) noticed the clear difference in the leaf number of *P. leveilleana.* He placed *P. leveilleana* in section *Pholidota*, which is characterized by pseudobulbs with only one leaf.

Based on our close examination of the type specimens of *P. wenshanica* (Fig. 1A), *P. leveilleana* (Fig. 1D) and *P. subcalceata* (Fig. 1G, H), and of other specimens so named in E, P and PE (Fig. 1), as well as the field observation, we are convinced that the leaf number is unlikely to change with growth in either *P. leveilleana* or *P. wenshanica*. Although the type specimen of *P. leveilleana* is not seemingly perfect, the morphology of specimen J. Esquirol no. 2088 (Fig. 1D) actually conforms most closely to the diagnosis given in Schlechter (1913).

Morphological examinations indicate significant differences among these species. *P. wenshanica* is easily distinguished from the other two species by fusiform-cylindrical pseudobulbs, much more slender (7–8 cm long) and well apart (2 cm intervals or distance), with two oblong-lanceolate leaves, up to 30 cm long and ca. 3.5 cm wide. In floral morphology, *P. wenshanica* can be readily distinguished from *P. leveilleana* by the flower number and size, as well as the details of flowers. The former has distinctly more (30–40) flowers arranged alternately on the almost straight rachis, whereas *P. leveilleana* has fewer (12–18) flowers on the weakly zigzag rachis (Fig. 2). On the other hand, the pseudobulbs of *P. subcalceata* are ovoid and close together, which are superficially similar to those of *P. leveilleana*, but carry two apical linear leaves. The size of its leaves varies from 15–30 cm in length and ca. 2.5 cm in width, whereas the leaves of *P. leveilleana* ca. 3.5 cm in width. In addition, *P. subcalceata* has synanthous inflorescence, with partially developed leaves at anthesis. A comprehensive morphological comparison among these species is presented in Table 1.

Table 1. Morphological comparison of *Pholidota wenshanica*, *P. leveilleana* and *P. subcalceata*.

Characters	*P. wenshanica*	*P. leveilleana*	*P. subcalceata*
Pseudobulbs	fusiform-cylindrical, 7–8 cm × 6–8 mm, 1.5–2 cm apart, two-leaved	ovoid to conical-ovoid, 2.5–4.5 × ca. 3.5 cm, almost densely placed, unifoliate	narrowly ovoid to broadly fusiform, 1.5–3.5 × ca. 2 cm, densely placed, two-leaved
Leaves	lanceolate-oblong 25–30 × 3–3.5 cm	narrowly elliptic to elliptic-lanceolate 15–25 × 2–3.5 cm	linear to linear-lanceolate 15–30 × 1–2.5 cm
Petiole	3.5–4 cm long	4.5–7 cm long	4–8 cm long
Inflorescence	peduncle 3.5–4 cm, raceme with 30–40 flowers; rachis almost straight	peduncle ca. 7 cm, raceme with 12–18 flowers; rachis weakly zig-zag	peduncle 3–4 cm, raceme with 18–25 flowers; rachis almost straight
Lip	subovate when flattened, lateral lobes inconspicuous	broadly oblong when flattened, lateral lobes inconspicuous	subpandurate when flattened, trilobed, lateral lobes prominent
Hypochile	deeply saccated, with 4 prominent fleshy keels or carinae	shallowly cupular, with 3 thickened veins	deeply saccated, with 3 thickened veins
Epichile	transversely elliptic, apex deeply notched into 2 broadly rounded lobes	transversely oblong, apex shallowly emarginate	reniform-orbicular, apex emarginate and truncate-subbilobed
Column	2.5–3 mm, apex narrowly winged	3.5–4 mm, apex broadly winged	3 mm, apex broadly winged
Stelidia	rounded, with obtuse teeth along the upper margin	sharp, with conspicuous acute teeth along the upper margin	short and rounded, with obtuse teeth along the upper margin

An additional specimen's survey indicates that several collections previously identified as *P. wenshanica*, such as *China-UK Expedition Team ASBK365* (IBK) (Fig. 1E) actually belong to *P. leveilleana*, with their unifoliate pseudobulbs closely placed.

In distribution, both *P. wenshanica* and *P. leveilleana* are endemic to southwestern China. *P. leveilleana* occur in W to N Guangxi and S Guizhou. *P. wenshanica* is currently only found in SE Yunnan and SW Guangxi. *P. subcalceata* is endemic to southern Vietnam. The more or less disjunct distributions clearly indicate that *P. wenshanica* and *P. subcalceata* should be considered as distinct species.

Taxonomic treatment

Pholidota wenshanica S.C.Chen & Z.H.Tsi

Figs 1, 2

Pholidota wenshanica S.C. Chen & Z.H. Tsi, Bull. Bot. Res. 8(1): 7, fig. 1. 1988. Type: – CHINA. Yunnan, Wenshan County, cult. in Hort. Bot. Beijing, 4 Dec. 1984, *Z.H. Tsi 223* (holotype PE!).

Emended description. Plants lithophytic, up to 35 cm high; rhizome creeping, terete, 8–10 mm in diam., enclosed by coriaceous scales. Pseudobulbs fusiform-cylindrical, 7–8 × 6–8 mm, 2 cm apart, tapering to based and top, smooth or longitudinally wrinkled when dried, base usually enclosed by coriaceous sheaths. Leaves 2 per pseudobulb, arising from pseudobulb apex, oblong-lanceolate, 25–30 × 3–3.5 cm, apex acuminate, base cuneate, lamina glossy green, more or less coriaceous; petioles 3–4.5 cm long. Inflorescence a racemose, proteranthous, glabrous, pendulous, 17–19 cm long; peduncle 3.5–4 cm long, very thin, covered by sterile bracts at base of rachis; rachis slender, 13.5–20 cm long, almost straight or weakly zig-zag, laxly 30–40-flowered; floral bracts

Figure 1. The types and selected specimens of *P. wenshanica* (**A–C**), *Pholidota leveilleana* (**D–F**) and *P. subcalceata* (**G–I**) **A** holotype sheet of *P. wenshanica* **B** China, Guangxi, Longzhou, *HK Kadoorie PT 714* (PE) **C** China, Yunnan, *HK Kadoorie Team 2361* (PE) **D** holotype sheet of *P. leveilleana* **E** China, Guangxi, *China-UK Expedition Team ASBK365* (IBK) **F** China, Guangxi, *Y.S. Huang Y1229* (IBK) **G** Holotype sheet of *P. subcalceata* **H** isotype sheet of *P. subcalceata* **I** Vietnam, Kontum, *L.V. Averyanov & al.*, *VH 292* (P).

broadly rhombic-ovate, papyraceous, 4 × 6 mm, folded along the midrib, caduceus at anthesis. Flowers pinkish white, ca. 5 mm in diam., lip salmon-pink, tinged with yellowish-brown or orangish-brown blotches. Pedicel and ovary 3–4 mm long. Sepals subequal; dorsal sepal elliptic, 5 × 3 mm, apex acute, obscurely 7-nerved; lateral sepals ovate, slightly oblique, 5–6 mm long, strongly keeled on the back, apex shortly acuminate, obscurely 7-nerved. Petals ovate, 4 × 3mm, apex obtuse, obscurely 3–5-nerved; Labellum subovate in outline, 4–5 long; hypochile deeply saccated, with 4 prominent fleshy keels or carinae; epichile transversely elliptic, 4–5 mm wide, margin inconspicuously undulate, apex deeply notched into 2 broadly rounded lobes. Column stout, 2.5–3 mm long; apex narrowly winged, foot absent; stelidia obtuse, up margin with an inconspicuous rounded wing near the apex; anther incumbent, top retuse to rounded; pollinia 4 in 2 pairs, connected by caudicles to a sticky substance, pyriform, ca 0.5 by 0.4 mm; stigma broadly ovate; rostellum large, broadly triangular. Flowering in late November and early December. Capsule not seen.

Distribution and habitat. *Pholidota wenshanica* is currently known only from SE Yunnan (Wenshan) and SW Guangxi (Longzhou), China, where it grows as epiphyte on tree trunks or as lithophyte on somewhat shady slopes or on the edge of forests, often in exposed places, with elevations ranging from 1200 m to 1500 m a.s.l.

Additional specimens examined. China. Yunnan, Malipo County, Tiechang Town, at 1500 m alt., 13 Dec. 1992, *Tsi s.n.* (PE). China. Yunnan, *precise* locality unknown, Nov. 2001, *HK Kadoorie Team 2361* (PE). China. Guangxi Zhuang Autonomous Region, Longzhou County, May 2001, *HK Kadoorie PT 714* (PE).

Pholidota leveilleana Schlechter

Figs 1, 2

Pholidota leveilleana Schlechter, Repert. Spec. Nov. Regni Veg. 12: 107. 1913. Type: – CHINA. Guizhou (Kouy-tcheou), Huishui County, Tian sheng qiao (Tien-sey-kao), at alt. 900m, 8 May 1910, *J. Esquirol 2088* (holotype E!).

Emended description. Lithophytic or occasionally epiphytic plants with short and stout rhizomes, up to 30 cm high. Pseudobulbs borne close together, ovoid or conical-ovoid, often longitudinally sulcate, 2.5–4.5 cm × 8–12 mm, ca. 3.5 cm in diam., basally usually enveloped by scarious sheaths. Leaf solitary, arising from pseudobulb apex, narrowly elliptic or narrowly elliptic-lanceolate, 15–25 × 2–3.5 cm, papery, plicate, leaf vernation prominent, base contracted into a distinct petiole, apex short acuminate, lamina dark green to bluish green; petiole 4.5–8 cm. Inflorescence arising from base of mature pseudobulbs, often pendulous, 13–18 cm or longer; peduncle 4.5–7 cm long; rachis weakly zig-zag, laxly 12–18-flowered; floral bracts deciduous, elliptic or broadly ovate, papyraceous, 7 × 9 mm. Flowers pinkish white or salmon-pink, ca. 5 mm in diam., lip white or greenish white, tinged with orangish yellow or carmine red blotches, anther and stigma red; pedicel and ovary 3–4 mm. Sepals broadly ovate-elliptic, 5–7 × 4–6 mm, 7-veined, acute; lateral sepals dorsally carinate. Petals ovate-elliptic,

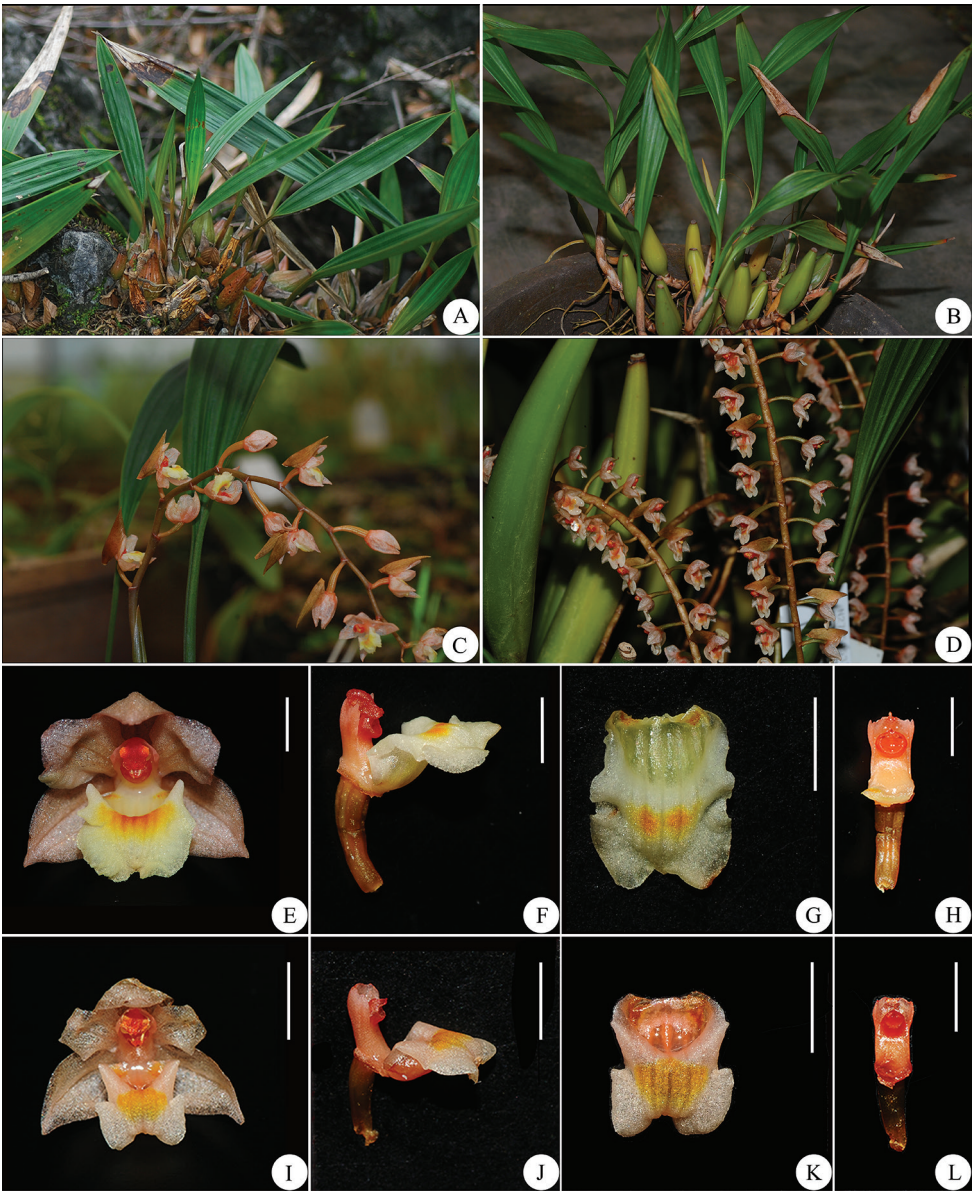

Figure 2. The morphology of *Pholidota leveilleana* (**A, C, E–H**) and *P. wenshanica* (**B, D, I–L**) **A–B** habit **C–D** inflorescences **E, I** flower, frontal view **F, J** column and lip, lateral view **G, K** lip, ventral view **H,L** column, front view. Scale bars: 5 mm (**E, I**), 3 mm (**F–H, J–L**).

4–5 × 2.5–3 mm, 3–5-veined, obtuse; lip broadly oblong in outline, 5–6 × 3 mm, contracted into epichile and hypochile at apical 2/3; hypochile shallowly cupular in center, margin spreading horizontally, with 3 thickened veins extending from base to above middle; epichile transversely oblong or elliptic, 4–5 mm wide, apex emarginate, slightly undulate margined. Column 3.5–4 mm, apex broadly winged; stelidia sharp, with conspicuous acute teeth along upper margin; anther broadly elliptic in

outline, top truncate to retuse; pollinia 4 in 2 pairs, connected by caudicles to a sticky substance, pyriform, ca 0.5 by 0.4 mm; stigma suborbicular; rostellum semi-orbicular. Flowering in April and May. Capsule narrowly obovoid, ca. 2 cm × 5–6 mm; fruiting pedicel 2–3 mm. 1.2–1.5 cm in diam.

Distribution and habitat. *Pholidota leveilleana* is endemic to N and W Guangxi (Luocheng, Du'an, Jingxi, Nandan, Huanjiang, Tian'e, Fengshan, Napo), S Guizhou (Huishui), China, where it grows as lithophyte in sparse forests and shaded rocks, with elevations ranging from 500 m to 900 m a.s.l.

Additional specimens examined. China, Guangxi Zhuang Autonomous Region, Hechi City, Luocheng Molao Autonomous County, Xunle Miao Ethnic Township, 11 Mar. 2013, *Luocheng County Exped. 45122513031 1036LY* (GXMG, *IBK*); Luocheng Mulao Autonomous County, 23 Jun. 1939, *W. Chen 84075* (PE). Guangxi Zhuang Autonomous Region, Hechi City, Huanjiang Maonan Autonomous County, Xunle Miao Ethnic Township, 26 Apr. 2013, *Huanjiang County Exped. 451226130426003LY* (GXMG, IBK); Huanjiang Maonan Autonomous County, Mulun Natural Reserve, 25 Apr. 2008, *W.B. Xu & Y. Liu 08025* (IBK); Mulun Natural Reserve, 25°06'43"N, 108°00'13"E, 27 Dec. 2008, *W.B. Xu*, *Y.Y. Liang*, *Y.S. Huang & X.X. Ye*, *Liuyan 0156* (KUN); Huanjiang Maonan Autonomous County, Mulun Town, NE Zhonglun, 10 Aug. 1994, *Mulun Exped. M0117* (PE). Guangxi Zhuang Autonomous Region, Tian'e County, 5 May 1997, *China-UK Expedition Team ASBK365* (IBK); Tian'e County, limestone Mt. at the junction of Lingdang and Liupai Town, 10 Aug. 1958, *Z.T. Li 601198* (PE). Guangxi Zhuang Autonomous Region, Du'an Yao autonomous County, Shangfu Township, *Y.K. Li P01539* (IBSC, PE). Guangxi Zhuang Autonomous Region, Fengshan County, Jinya Town, 24°38'4326.50"N, 106°45'00.96"E, 29 Mar. 2013, *H.Z. Lv*, *L.H. Liu & H.F. Chen 451223130329080LY* (GXMG). Guangxi Zhuang Autonomous Region, Nandan County, Lihu Town, 26 Jun 1937, C. Wang 40914 (IBSC, PE). Guangxi Zhuang Autonomous Region, Jingxi County, Sanhe Town, 15 Apr. 2012, *Y.S. Huang Y1229* (IBK); Jingxi County, Renzhuang Town, 14 Sep. 2006, *Y. Liu & W.B. Xu 0153* (IBK); Jingxi County, Longbang Town, Damo Village, 23 Apr. 2011, *F.Y. Huang & Z.H. LV LHZJX0248* (GXMG). Guangxi Zhuang Autonomous Region, Napo County, Chengxiang Town, 12 Apr. 1998, *H.N. Qin & al. 506* (IBSC, PE). Guangxi Zhuang Autonomous Region, Luchen (Luocheng?), 27 May 1928, *anonymous 5405* (IBSC; PE); Guangxi Zhuang Autonomous Region, precise locality unknown, 25 Aug. 1935, *S.P. Ko 55619* (PE). CHINA. Guizhou (Kouy-tchou), Dushan County, 13 Jul. 1959, *Lipo Expe.1072* (PE).

Pholidota subcalceata Gagnepain

Pholidota subcalceata Gagnepain, Bull. Mus. Natl. Hist. Nat., sér. 2, 22: 508, 1950.

Type. Vietnam. Annam, North Kon Tum, near Moi village, at 1000–1500 m alt., 25 Nov. 1941, M. Poilane *32058* (holotype P! Isotype P!). Fig. 1. Emended description Epiphytic or occasionally terrestrial plants with short and stout rhizomes, up to

1 m high. Pseudobulbs borne close together, narrowly ovoid to broadly fusiform, often longitudinally sulcate, 1.5–3.5 cm × 8–15 mm, ca. 2 cm in diam., basally usually enveloped by scarious sheaths. Leaves 2 per pseudobulb, arising from pseudobulb apex, linear to linear-lanceolate, 15–30 × 1–2.5 cm, somewhat coriaceous, base contracted into a distinct petiole, apex short acuminate, lamina dark green to bluish green; petiole 4–8 cm. Inflorescence arising from rather young pseudobulbs with just developing very young leaves, synanthous, often pendulous, ca. 23 cm long; peduncle 4–8 cm long; rachis almost straight or weakly zig-zag, laxly 18–25-flowered; floral bracts deciduous, broadly ovate-rhombic, 9 ×10 mm, paperaceous. Flowers white or slightly tinged with pink, ca. 5 mm in diam., lip white, tinged with pinkish yellow or yellow blotches, anther pink; stigma red; pedicel and ovary 3–4 mm. Sepals broadly ovate-elliptic, 5–7 × 4–6 mm, 7-veined, acute; lateral sepals dorsally carinate. Petals ovate-elliptic, 4–5 × 2.5–3 mm, 3–5-veined, obtuse; lip subpandurate when flattened, 5 × 3–4 mm, trilobed, with prominent lateral lobes; hypochile deeply saccated, with 3 thickened veins; epichile reniform-obicular, 4–5 mm wide, apex emarginate and truncate-subbilobed, slightly undulate margined. Column 3 mm, apex broadly winged; stelidia short and rounded, with obtuse teeth along the upper margin; anther broadly elliptic in outline, top convex and rounded; pollinia 4 in 2 pairs; stigma transversally reniform. Flowering in March and April. Capsule not seen.

Distribution and habitat. *Pholidota subcalceata* is endemic to the Central Highlands of southern Vietnam, north to Kon Tum, south to Lam Dong, where it grows as epiphyte on old trees in montane broadleaved forest in open areas and along streams, and occasionally grows as terrestrial herb, with elevations ranging from 1000–1800 m a.s.l.

Additional specimens examined. Vietnam. Prov. Lam Dong, distr. Lac Duong, municipalite Da Chay, 35 km to NE from Dalat city, 12°08'N, 108°39'E, at 1450 m alt., 19 Mar. 1997, *L.V. Averyanov*, *N.Q. Binh & P.K. Loc*, *VH 2897* (P). Vietnam. Prov. Lam Dong, distr. Lac Duong, municipalite Da Chay, 35 km to NE from Dalat city, 12°09'N, 108°41'E, at 1700–1800 m alt., 7 Apri. 1997, *L.V. Averyanov*, *N.Q. Binh & P.K. Loc*, *VH 3753* (P). Vietnam. Prov. Lam Dong, distr. Lac Duong, municipalite Da Chay, 26–28 km to NE from Dalat city, 12°07'N, 108°36'E, at 1500–1700 m alt., 4 Oct. 1997, *L.V. Averyanov*, *N.Q. Binh & P.K. Loc*, *VH 3842* (P). Vietnam. Prov. Kon Tum, NW slopes of Ngoc Linh mountain system, at 1600 m alt., 23 Feb. 1995, *L.V. Averyanov & al.*, *VH 290* (P); *L.V. Averyanov & al.*, *VH 291* (P); *L.V. Averyanov & al.*, *VH 292* (P); *L.V. Averyanov & al.*, *VH 294* (P);

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Freshwater diatoms in the Democratic Republic of the Congo: a historical overview of the research and publications

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Abstract

An overview of the diatom research in the DR Congo is given based on literature data starting in 1938 with the work of Zanon and excluding the East African Lakes as these were already discussed in previous papers. For each literature record the diatom genera mentioned are presented as well as all diatom taxa described from the Congo as new. In total, 106 new taxa were documented, of which *Nitzschia* with 40 taxa is far the most important genus followed by *Navicula* s.l. and *Pinnularia* and with 15 and 13 taxa respectively. Particular attention was paid to the local research of students found in unpublished theses at bachelor, licentiate, master and PhD level. Diatom records in these works are almost all restricted to genus level, although in the last decade an attempt to delimit species can be observed. This accompanies the renewed taxonomic interest in the Congo basin during the last decade. Renewed taxonomic interest can also be seen in the genera: the first period being situated during the lumping period, while more recent works follow the current taxonomic classification, for example *Navicula* s.l. versus *Navicula*, *Cavinula*, *Craticula*, *Diadesmis*, *Geissleria*, *Humidophila*, *Luticola*, *etc*.

Keywords

Algae, Bacillariophyta, Congo basin, tropical Africa, Zaire

Introduction

In the Democratic Republic of the Congo (DR Congo), research in the field of plant biology mostly concerned the study of terrestrial forest ecosystems (Anonymous 2012; Wasseige et al. 2014), while the interest given to the aquatic environments was mainly limited to ichthyology and fisheries (e.g. Chapman 2001; Paugy et al. 2011; Snoeks et al. 2011), fish being an important source of protein for local populations. Only a few publications are available in the field of microscopic algae, and diatoms in particular, from inland aquatic environments in DR Congo.

Early publications on freshwater algae in tropical Africa focused on the great lakes of the Albertine rift: Malawi (Nyassa/Nyasa), Tanganyika (Tanganika) and Victoria (Victoria Nyanzae) (e.g. Müller 1904a, b, 1905, 1910; West 1907). A review of the studies that have been carried out on these large lakes and the lentic and lotic ecosystems of East Africa is given by Cocquyt (2006) and Taylor and Cocquyt (2015).

The present paper aims to give an overview of the research that has been conducted in the DR Congo or that has investigated Congolese material, not only found in international publications, but also by means of local publications as well as unpublished theses at different levels (bachelor, licentiate, master and PhD).

Material and methods

Initially international publications on algae, and more specifically on the diatoms, of DR Congo (formerly Belgian Congo between 1908 and 1960, and the Republic of Zaire between 1971 and 1997) were searched for on the Web of Science and in the available international literature. Subsequently, inquiries were made regarding papers that were published locally in journals of the different universities in DR Congo and in final reports of national and international projects. The last step was to retrieve all theses, PhD level and other dissertations (licentiate, bachelor and master level) from universities and scientific institutions in DR Congo. Licentiate is an academic degree below that of a PhD, used in Belgium (and the DR Congo), and obtained after a university study of 4 to 5 years. In the Bachelor-Master structure, it is the degree that corresponds to (almost) a Master.

Results and discussion

A brief overview follows on the diatom research conducted on materials collected in DR Congo, including the former Congo and the Republic of Zaire, as found in mainstream literature, thus taking into consideration only published work accessible to the international scientific community.

The diatoms of Lake Kivu and its surroundings were first documented by Zanon (1938). From this region he reported 263 taxa belonging to 33 genera. Of these taxa, 16 were new to science of which 9 were *Pinnularia* Ehrenberg, the others belonging

to the genera *Cocconeis* Ehrenberg, *Cymbella* C. Agardh, *Eunotia* Ehrenberg, *Neidium* Pfitzer and *Synedra* Ehrenberg (for details see Table 1). However, we must point out that most of the genera names mentioned in this paper are in the broad sense (sensu lato) as they very probably combine several genera after the changes initiated in recent diatom classification (Round et al. 1990, and subsequent later taxonomic publications). These systematic changes were initially based on knowledge acquired through what were relatively new technologies at the time such as the scanning electron microscope and more recently molecular analyses.

Zanon (1938) described *Pinnularia borealis* var. *congolensis* Zanon (on page 641) with a drawing (fig. 27) from a puddle on the Karisimbi volcano in the region Lake Kivu and mentioned this taxon name also (on page 545) in his species list of the diatoms from the region of Lake Kivu. However, in the same publication Zanon (1938) wrote *Pinnularia borealis* var. *africana* v. n. (on page 556) and *Pinnularia congolensis* n. sp. (on page 571) and in the species list he mentioned sample nr 5 from a puddle on the Karisimbi volcano and sample nr 21 from a puddle from Nanindhja respectively. However, no description is given for these two taxa, consequently both names have to be considered nomina nuda and therefore invalidly published. Two decades later Cholnoky (1957) elevated the validly described *Pinnularia borealis* var. *congolensis* to species level: *Pinnularia congolensis* (Zanon) Cholnoky.

Zanon's research was followed in the middle of the 20th century by that of Hustedt (1949) who published a treatise on the diatoms of the "Parc national Albert", nowadays the Virunga National Park, which was created in 1925 and among the first protected areas in Africa. Among the 55 new taxa that Hustedt (1949) described, 25 belong to the genus *Nitzschia* Hassall, 11 to *Navicula* Bory and 6 to *Eunotia*. The other taxa are from more than 10 other genera including *Achnanthes* Bory, *Amphora* Ehrenberg, *Caloneis* Cleve, *Cymbella*, *Fragilaria* Lyngbye, *Gomphonema* Ehrenberg, *Pinnularia*, *Stauroneis* Ehrenberg, *Stephanodiscus* Ehrenberg and *Surirella* Turpin (for details see Table 1).

Further studies which included diatoms, were carried out in the Kivu region in the 1950's by Kufferath (1957). This author reported on diatoms from cataracts on the Rusizi River, which forms the overflow of Lake Kivu to Lake Tanganyika, near Bugarama. Although this village is located in Rwanda, formerly Ruanda-Urundi, we have included the new diatoms reported from the cataracts as the Rusizi River forms the border between DR Congo and Rwanda. Of the 59 taxa mentioned by Kufferath (1957), twelve were described as new to science (Table 1): five *Nitzschia*, two *Hantzschia* Grunow, two *Navicula*, one *Cymbellonitzschia* Hustedt, one *Gomphonema* and one *Pseudo-eunotia* Grunow. The other genera reported by Kufferath (1957) are *Amphora*, *Anomoeoneis* Pfitzer, *Cocconeis*, *Cymatopleura* W. Smith, *Cymbella*, *Gomphocymbella* O. Müller, *Mastogloia* (Thwaites) W. Smith, *Rhopalodia* O. Müller, *Rhoicosphenia* Grunow and *Synedra*.

At the beginning of the 21st century research on algae of Lake Kivu continued with the work of Sarmento (2006) and Sarmento et al. (2012). Although not concerning the DR Congo, it is noteworthy to mention the papers of Mpawenayo (1985, 1996) as these concerned diatoms from rivers in the Burundian part of the Rusizi plain. The

Table 1. New diatom taxa described from DR Congo, their references, geography, habitat and possible synonyms.

Taxon	Publication	Page	Plate	fig.	Province	Region	Waterbody	Synonym
Achnanthes atomus var. *congolensis* Hustedt***	Hustedt 1949	74–75	2	35, 36	North-Kivu	Bugazia	Lake Edward	*Achnanthes congolensis* Hustedt
Achnanthes pseudogrimmei Cholnoky*	Cholnoky 1970	11–2	1	1–3	Zambia	10 km from Kansenga	Lake Chali	
Amphora thermalis Hustedt*	Hustedt 1949	111–112	11	1–3	North-Kivu	May-ya-Moto	hot springs	*Halamphora thermalis* (Hustedt) Levkov
Amphora submontana Hustedt*	Hustedt 1949	112–113	11	4	North-Kivu	Butembo	Mosenda river mouth in Lake Edward	*Halamphora submontana* (Hustedt) Levkov
Cavinula lilandae Cocquyt, M. de Haan & J. C. Taylor	Cocquyt et al. 2013	158		2–11, 16–21	Tshopo	Lilanda	Baombe stream	
Cocconeis citrina Zanon*	Zanon 1938	598		6	South-Kivu	Kivu	stream	*Cocconeis vitellina* Schoeman
Cocconeis scaettae Zanon*	Zanon 1938	598–599		7	South-Kivu	Kivu	stream	
Coscinodiscus antiquus [var. *minor*] f. *bananaensis* Kufferath*	Kufferath 1956	43	3	1	Bas-Congo	Banana	creek near the ocean	
Craspedodiscus minutus Kufferath*	Kufferath 1956	45	3	2	Bas-Congo	Banana	creek near the ocean	
Cymbella naviculoides Hustedt*	Hustedt 1949	113–114	10	9–13	North-Kivu	Karisimbi	pond at 3800 m	*Encyonopsis naviculoides* (Hustedt) Krammer
Cymbella norvegica var. *parva* Zanon*	Zanon 1938	605–606		38	North-Kivu	Karisimbi	puddle at 3900 m	
Cymbellonitzschia cataractorum Kufferath*	Kufferath 1957	20–21		41	Rwanda	Bugarama	rapids on the Rusizi river	
Eunotia damasii Hustedt*	Hustedt 1949	67–68	3	1–12	North-Kivu	Karisimbi	crater lake at 3800 m	
Eunotia fuseyi J.C. Taylor & Cocquyt	Taylor et al. 2016a	305		11–14	Tshopo	Yangubu	Lobaye river	*Eunotia pierrefuseyi* (J.C. Taylor & Cocquyt) J.C. Taylor & Cocquyt
Eunotia leonardii J.C. Taylor & Cocquyt	Taylor et al. 2016a	295		6–10	Tshopo	Yangubu	Lobaye river	
Eunotia montana Hustedt*	Hustedt 1949	66–67	3	13–23	North-Kivu	Gando	lake	
Eunotia rudis Cocquyt & M. de Haan	Cocquyt et al. 2016	75–76		2–24	Tshopo	Yangambi	Libongo river	
Eunotia scaettae Zanon*	Zanon 1938	595–596		3	North-Kivu	Karisimbi	puddle at 2000 m	
Eunotia pseudoflexuosa Hustedt	Hustedt 1949	71–72	2	16–18	North-Kivu	Karisimbi	crater lake	
Fragilaria africana Hustedt*	Hustedt 1949	62	2	29–34	North-Kivu	Bugazia, Kamande	Lake Edward	*Staurosirella africana* (Hustedt) D.M. Williams & Round
Geissleria lubiluensis Cocquyt & Lokele	Cocquyt and Lokele 2019	243–244		1–4, 6–17	Tshopo	Yangambi	Lubilu river	
Gomphonema aequatoriale Hustedt*	Hustedt 1949	119–120	10	6–8	North-Kivu	Kamande	Lake Edward	
Gomphonema constrictum [var. *capitata*] f. *bipunctata* Kufferath*	Kufferath 1957	30–31		38	Rwanda	Bugarama	rapids on the Rusizi river	
Gomphonema grande B. Karthick, Kociolek, J.C. Taylor & Cocquyt	Karthick et al. 2016	188		1–24	Tshopo	Yangubu	Lomami river	
Gomphonema zairense Compère*	Compère 1995	32		1–14	Tshopo	Kisangani	Tshopo waterfalls	

Taxon	Publication	Page	Plate	fig.	Province	Region	Waterbody	Synonym
Hantzschia ruziziensis Kufferath*	Kufferath 1957	34		53	Rwanda	Bugarama	rapids on the Rusizi river	
Hantzschia uncinata Kufferath*	Kufferath 1957	34–35		45	Rwanda	Bugarama	rapids on the Rusizi river	
Melosira mareei Kufferath*	Kufferath 1956	42	2	5	Bas-Congo	Banana	ocean – brackish-water	
Navicula barbarica Hustedt*	Hustedt 1949	97	4	14–17	North-Kivu	Kamande	Lake Edward, Mosenda river mouth	
Navicula congolensis Hustedt*	Hustedt 1949	86	4	23, 24	North-Kivu	Gando	pond	
Navicula dartevellei Kufferath*	Kufferath 1957	23		25	Rwanda	Bugarama	rapids on the Rusizi river	
Navicula faceta Hustedt*	Hustedt 1949	88	4	25, 26	North-Kivu	Gando	lake	
Navicula finitima Hustedt*	Hustedt 1949	90	4	29, 30	North-Kivu	Kamande	creek	
Navicula marlieri Kufferath*	Kufferath 1957	23–24		26	Rwanda	Bugarama	rapids on the Rusizi river	
Navicula molestiformis Hustedt*	Hustedt 1949	86–87	5	9	North-Kivu	Kamande	Lakes Edward	*Craticula molestiformis* (Hustedt) Mayama
Navicula muraliformis Hustedt*	Hustedt 1949	85–86	4	31, 32	North-Kivu	Karisimbi	crater lake	*Mayamaea muraliformis* (Hustedt) Lange-Bertalot
Navicula muticoides Hustedt*	Hustedt 1949	82	4	33–36	North-Kivu		Lakes Kivu (Bera), Ndalaga	*Luticola muticoides* (Hustedt) D.G. Mann
Navicula nielsfogedii J.C. Taylor & Cocquyt	Taylor et al. 2016b	202		1–22, 34–51	Tshopo	Yangubu	Lomami river	
Navicula subcontenta var. *africana* Hustedt*	Hustedt 1949	85	4	27, 28	North-Kivu	Kasinga-Channel (Uganda)		
Navicula submolesta Hustedt*	Hustedt 1949	86	5	16–18	North-Kivu	Gando	puddle	*Craticula submolesta* (Hustedt) Lange-Bertalot
Navicula zanonii Hustedt*	Hustedt 1949	92–93	5	1–5	North-Kivu	Bougeria, Bugazia, Kamande	Lakes Edward, Kivu	
Neidium iridis var. *parallela* Zanon*	Zanon 1938	619		1	North-Kivu	Karisimbi	puddle at 3900 m	
Nitzschia accommodata Hustedt*	Hustedt 1949	139	12	27–31, 34, 35	North-Kivu	Ngoma	Lake Kivu	
Nitzschia adapta Hustedt*	Hustedt 1949	135	12	3–6	North-Kivu	Kamande	Lakes Edward, Kibuga, Ndalaga	
Nitzschia aequalis Hustedt*	Hustedt 1949	135–136	12	7, 8	North-Kivu	Bugazia	Lake Edward	
Nitzschia amphioxoides Hustedt*	Hustedt 1949	140	13	65–72	North-Kivu	Kamande, Bugazia	Lake Edward	
Nitzschia bacata f. *linearis* Hustedt*	Hustedt 1949	149	13	17–20	North-Kivu	Kamande	Lake Edward	

Taxon	Publication	Page	Plate	fig.	Province	Region	Waterbody	Synonym
Nitzschia baculumata Kufferath*	Kufferath 1956	55	7	3	Bas-Congo	Banana	ocean – brackish-water	
Nitzschia biconicacuta Kufferath*	Kufferath 1957	36–37		57	Rwanda	Bugarama	rapids on the Rusizi river	
*Nitzschia caparti**	Kufferath 1948	8		17	Equateur	Makanza (Nouvelle-Anvers)	Congo River	
Nitzschia confinis Hustedt*	Hustedt 1949	145	11, 13	49–54, 84–90	North-Kivu, South-Kivu	Ngoma, Keshero, Kishushu, Nyamirundi	Lakes Kivu, Ndalaga	
Nitzschia congolensis Hustedt*	Hustedt 1949	134	12	15, 16	North-Kivu	Kamande, Vitshumbi	Lake Edward	
Nitzschia consummata Hustedt*	Hustedt 1949	134–135	12	1, 2	North-Kivu	Semliki	Lake Edward	
Nitzschia curvirectangularis Kufferath*	Kufferath 1956	55	5	8	Bas-Congo	Banana	ocean – brackish-water	
Nitzschia diserta Hustedt*	Hustedt 1949	139	12	32, 33	South-Kivu	Nyamirundi	Lake Kivu	
Nitzschia elliptica Hustedt	Hustedt 1949	148–149	13	32–34	North-Kivu	May-ya-Moto	hot springs	
Nitzschia epiphyticoides Hustedt*	Hustedt 1949	144–145	13	48–55	North-Kivu	Semliki	Lakes Edward, Kivu	
Nitzschia fusulata Kufferath*	Kufferath 1956	56	5	9	Bas-Congo	Banana	creek near the ocean	
Nitzschia hexagonata Kufferath*	Kufferath 1956	56	2	10A, B	Bas-Congo	Banana	creek near the ocean	
Nitzschia hexagonata f. *minutissima* Kufferath*	Kufferath 1956	56	1, 2	12C, 9, 12A–E	Bas-Congo	Banana	ocean – brackish-water	
Nitzschia inflata Kufferath*	Kufferath 1957	38		64	Rwanda	Bugarama	rapids on the Rusizi river	
Nitzschia intermissa Hustedt*	Hustedt 1949	136	12	11–14	North-Kivu, South-Kivu	Kamande, Katana	Lake Edward, Machusa-waterfall near Lake Kivu	
Nitzschia latens Hustedt*	Hustedt 1949	148	13	30–31	North-Kivu	May-ya-Moto	hot springs	
Nitzschia mammalifera Kufferath*	Kufferath 1956	57	6	4, 5	Bas-Congo	Banana	ocean – brackish-water	
Nitzschia mareei Kufferath*	Kufferath 1956	58	5	11	Bas-Congo	Banana	creek near the ocean	
Nitzschia mediocris Hustedt*	Hustedt 1949	149	13	21–24	South-Kivu	Nyamirundi	Lake Kivu	
Nitzschia microsicula Kufferath*	Kufferath 1956	58	5	4	Bas-Congo	Banana	creek near the ocean	
Nitzschia obsidialis Hustedt*	Hustedt 1949	148	13	25	North-Kivu	Kamande	Lake Edward	
Nitzschia obsoleta Hustedt*	Hustedt 1949	146	13	94–99	North-Kivu	Kamande, Bugazia	Lake Edward	
Nitzschia ogivalis Kufferath*	Kufferath 1957	40–41		56	Rwanda	Bugarama	rapids on the Rusizi river	
Nitzschia palea var. *tropica* Hustedt*	Hustedt 1949	147	13	26–29	North-Kivu	Kamande, Bugazia, Gando	Lakes Edward, Kivu, Kibuga, Ndalaga ponds	

Taxon	Publication	Page	Plate	fig.	Province	Region	Waterbody	Synonym
Nitzschia pseudopectinalis Kufferath*	Kufferath 1957	42–43		73	Rwanda	Bugarama	rapids on the Rusizi river	
Nitzschia rectangulata Kufferath*	Kufferath 1957	43		70a, b	Rwanda	Bugarama	rapids on the Rusizi river	
Nitzschia robusta Hustedt*	Hustedt 1949	141	13	35–38	South-Kivu	Katana	Machusa-waterfall near Lake Kivu	
Nitzschia spiculoides Hustedt*	Hustedt 1949	151	13	5–6	North-Kivu	Semliki	Lake Edward	
Nitzschia spiculum Hustedt*	Hustedt 1949	136	13	1–4	North-Kivu, South-Kivu	Kasinga-Channel (Uganda), Bugazia, Kamande, Katana	Lake Edward, Machusa-waterfall near Lake Kivu	
Nitzschia spirilliformis Kufferath*	Kufferath 1956	58	6, 7	3, 1	Bas-Congo	Banana	ocean – brackish-water	
Nitzschia stricta Hustedt*	Hustedt 1949	136	12	9, 10	North-Kivu	Kamande	Lake Edward	
Nitzschia subcommunis Hustedt*	Hustedt 1949	146	11, 13	55–58, 101–106	South-Kivu, North-Kivu	Katana	Machusa-waterfall near Lake Kivu, Lakes Kibuga, Ndalaga	
Nitzschia tarda Hustedt*	Hustedt 1949	138–139	12	24, 25	North-Kivu	Kamande	Lake Edward	
Nitzschia tropica Hustedt*	Hustedt 1949	147	11	34–48	North-Kivu, South-Kivu	Kasinga-Channel (Uganda), Nyamirundi, Katana	Lakes Kibuga, Ndalaga, Lake Kivu, Machusa-waterfall	
Nitzschia umbilicata Hustedt*	Hustedt 1949	129–130	11	65	North-Kivu		Lake Kibuga	*Tryblionella umbilicata* (Hustedt) D.G. Mann
Pinnularia alpina var. *parallela* Zanon*	Zanon 1938	642–643		29	North-Kivu	Karisimbi	puddle at 3900 m	
Pinnularia borealis var. *congolensis* Zanon*	Zanon 1938	641		27	North-Kivu	Karisimbi	puddle at 3900 m	*Pinnularia congolensis* (Zanon) Cholnoky
Pinnularia congolensis Zanon**	Zanon 1938	545, 571			North-Kivu	Karisimbi, Nanindhja	puddle at 3900 m, puddle at 2000 m	
Pinnularia fusiformis Zanon*	Zanon 1938	645–646		24	North-Kivu	Nanindhja	puddle at 2000 m	
Pinnularia lata var. *biconstricta* Zanon*	Zanon 1938	642		28	North-Kivu	Karisimbi	crater pond at 3900 m	
Pinnularia lata var. *constricta* Zanon*	Zanon 1938	642		30	Uganda	Mufumbiru	peat bog at 2160 m	*Pinnularia borealis* var *constricta* (Zanon) Cholnoky
Pinnularia lata var. *media* Zanon*	Zanon 1938	643		25	North-Kivu	Karisimbi	puddle/crater pond at 3900 m	
Pinnularia lineolata Zanon*	Zanon 1938	647–648		23	North-Kivu	Nanindhja	puddle at 2000 m	
Pinnularia scaettae Zanon*	Zanon 1938	648		21	North-Kivu, South-Kivu	Karisimbi, Kahuzi	crater pond at 3950 m/ Bambu mud	

Taxon	Publication	Page	Plate	fig.	Province	Region	Waterbody	Synonym
Pinnularia scaettae var. *krasskei* Zanon*	Zanon 1938	648		22	North-Kivu, South-Kivu	Karisimbi, Kahuzi	puddle at 3900 m/ Bambu mud	
Pinnularia symoensii Cholnoky*	Cholnoky 1970	51	2	4	Zambia	Lake Bangweolo	Tushingo Channel	
Pinnularia tropica Hustedt	Hustedt 1949	108–109	7	1–12	North-Kivu	Karisimbi	crater pond, pond at 3000 m	
Pinnularia valida Hustedt*	Hustedt 1949	106	6	22	North-Kivu	Karisimbi	pond at 3000 m	
Pseudo-eunotia ruziziensis Kufferath*	Kufferath 1957	19–20		40	Rwanda	Bugarama	rapids on the Rusizi river	
Stauroneis subobtusa Hustedt*	Hustedt 1949	80	5	25	Kivu		Lake Kivu (Bera)	
Stauroneis zairensis Compère*	Compère et al. 1989	224		2–6, 8–13		Kinshasa	Fish pond	
Stephanodiscus damasii Hustedt*	Hustedt 1949	57–58	1	2–5	North-Kivu	Simliki, Bugazia, Pili-Pili	Lakes Edward, Kivu Ndalaga	*Cyclostephanos damasii* (Hustedt) Stoermer & Håkansson
Surirella congolensis Cocquyt & J.C. Taylor	Cocquyt and Taylor 2015	8		6–9	Tshopo	Yangubu	Lomami river	*Iconella congolensis* (Cocquyt & J.C. Taylor) Cocquyt & J.C. Taylor
Surirella cuspidata f. *constricta* Hustedt*	Hustedt 1949	155	15	11	North-Kivu	Karisimbi, Gando	crater pond pond	
Surirella ebalensis Cocquyt & J.C. Taylor	Cocquyt and Taylor 2015	2		1–5	Tshopo	Yangubu	Lomami river	*Iconella ebalensis* (Cocquyt & J.C. Taylor) Cocquyt & J.C. Taylor
Surirella propinqua Hustedt*	Hustedt 1949	153	14	5–6	North-Kivu	Karisimbi	lake	*Iconella propinqua* (Hustedt) Cocquyt & R. Jahn
Surirella symoensii Cholnoky*	Cholnoky 1970	56	2	8	Zambia	Bwalya Mponda	Lake Chali	
Synedra bananaensis Kufferath*	Kufferath 1956	49	3	8	Bas-Congo	Banana	ocean – brackish-water	
Synedra famelica var. enflata Zanon*	Zanon 1938	586–587		11	North-Kivu, Uganda	Karisimbi, Mufumbiru, Nya-Mwindhja	puddle at 3900 m, peat bog at 2160 m, puddle at 1500 m	*Fragilaria strangulata* f. *inflata* (Zanon) Hustedt
Synedra strangulata Zanon*	Zanon 1938	587		14	North-Kivu	Karisimbi	puddle at 3900 m	*Fragilariforma strangulata* (Zanon) D.M. Williams & Round

* : taxon status uncertain '(unassessed) in DiatomBase (30 September 2019);
**: taxon not found in DiatomBase (30 September 2019);
***: taxon status unaccepted (synonym) in DiatomBase (30 September 2019).

Rusizi River divides its plain in two parts, the river forming the border between DR Congo and Burundi.

We have not included the research conducted on diatoms of Lake Tanganyika because this ancient lake, located on the territory of four African countries (DR Congo, Burundi, Tanzania and Zambia), does not fall within the scope of this paper. Moreover, there are a number of reports regarding this lake which have been produced in the last decades (e.g. Cocquyt 1998, 2006).

Very little research has been done on freshwater algae from the remaining part of DR Congo (see also Taylor and Cocquyt 2015). For Kongo Central (called Bas-Congo in the colonial time and between 1997 and 2015, and Bas-Zaïre between 1965 and 1997) of note are the publications of Kufferath who reported eight taxa near Mateba Island (Kufferath 1956a) and 44 taxa, of which eleven species and two forms were new to science, at Banana Beach (Kufferath 1956b) (for details see Table 1): one *Coscinodiscus* Ehrenberg, one *Craspedodiscus* Ehrenberg, one *Melosira* C. Agardh, nine *Nitzschia* and one *Synedra*. It should be noted that some marine species are included in the results of these surveys, which is not surprising as the two localities are close to the mouth of the Congo River into the Atlantic Ocean. In 1948, Kufferath reported on the plankton of the Congo River near Makanza, formerly called New Antwerp, halfway between Kisangani and Kinshasa in the Equateur province. Among the 25 taxa Kufferath (1948) reported one new *Nitzschia* species (Table 1). He named this species after André Capart (1914–1991), who was the Director of the Royal Belgian Institute of Natural Sciences between 1958 and1978. Therefore the specific epithet should be written as *capartii*. In the second half of the 20th century Cholnoky published three works on tropical African diatoms. Besides diatoms from Mount Kenya (Cholnoky 1960) and the Rwenzori mountains in Uganda (Cholnoky 1964), he studied the diatoms from the Bangweulu swamps (Cholnoky 1970) and reported on 92 specific and infraspecific taxa including three new species, one *Achnanthes*, one *Pinnularia* and one *Surirella* (Table 1). Although these swamps are located in Zambia we include these here as the swamps are situated in the upper Congo River basin and close to the border with DR Congo. Two decades later, Compère (1989) described a new *Stauroneis* from a fishpond in Kinshasa (Table 1).

The first investigation of the Tshopo province was carried out in the mid 1950's (Demalsy 1957) on diatoms growing epiphytically on *Azolla* Lamarck (aquatic ferns of the family Salviniaceae) in the vicinity of Yangambi. The dominant genera were *Eunotia*, *Cocconeis* and *Achnanthes*; the other genera mentioned are: *Bacillaria* Ehrenberg, *Caloneis*, *Coscinodiscus* Ehrenberg, *Cyclotella* Kützing ex Brébisson, *Diatoma* Bory, *Diploneis* (Ehrenberg) Cleve, *Epithemia* Kützing, *Frustulia* Rabenhorst, *Gomphonema*, *Gyrosigma* Hassall, *Cymbella*, *Navicula*, *Nitzschia*, *Pleurostaurum* (Rabenhorst) C. Janisch, *Pinnularia*, *Stauroneis*, *Surirella*, *Synedra* and some other centric diatoms. Diatom research in the Tshopo province was started again at the end of the 20th century, as is shown in the publication record. The Congo River as well as localities downstream the Lindi River, a major tributary of the Congo river, the Tshopo River and several small rivers and ponds in Kisangani were studied by Golama (1991, 1992, 1996), who

reported 278 diatom taxa excluding desmids (group of green algae) and euglenophytes. In the same period a new *Gomphonema* species, *G. zairense* Compère, was described from the Tshopo River (Compère 1995) (Table 1).

Two decades later, renewed interest in diatom research in the region of Kisangani and Yangambi was initiated by the Boyekoli Ebale Congo 2010 expedition, an expedition that covered 250 km of the Congo River between Kisangani and Bumba and downstream some of its major tributaries (e.g. Cocquyt et al. 2013, 2016; Cocquyt and Taylor 2015). This research resulted in the description of several new diatom species belonging to the genera *Cavinula* D.G. Mann & Stickle, *Eunotia*, *Gomphonema*, *Navicula* and *Iconella* Jurilj (as *Surirella*) (for details see Table 1). *Cavinula lilandae* Cocquyt & M. de Haan (Cocquyt et al. 2013), a diatom from sandy substrata, for example, was described from a stream near the village of Lilanda located close to the western border of the Yangambi Biosphere Reserve. *Gomphonema grande* B. Karthick, Kociolek, J.C. Taylor & Cocquyt (Karthick et al. 2016) and *Navicula nielsfogedii* J.C. Taylor & Cocquyt (Taylor et al. 2016a) were described from an epiphytic sample taken in the Lomami River about 33 km as the crow flies from its confluence with the Congo River. This *N. nielsfogedii*, which may be conspecific with *N. fuerbornii* f. *africana* Foged described from Ghana (Foged 1966), has a distribution that is not restricted to the Congo, but to tropical and sub-tropical Africa (Taylor et al. 2016). The genus *Eunotia* is not only abundant in the acid streams and rivers from the Congo basin, but it is also a very diverse genus. Up to the present four new taxa have been described from the Yangambi Biosphere Reserve and its surroundings: *E. pierrefuseyi* (J.C. Taylor & Cocquyt) J.C. Taylor and Cocquyt, *E. leonardii* J.C. Taylor & Cocquyt, *E. rudis* Cocquyt & M. de Haan and *Geissleria lubiluensis* Cocquyt & Lokele (Table 1) (Cocquyt et al. 2016; Taylor et al. 2016b; Cocquyt and Lokele 2019; Taylor and Cocquyt 2019). Moreover, *Eunotia enigmatica* L.F. Costa & C.E. Wetzel a species recently described from the Amazon basin (Costa et al. 2017a, b) and another South American species, *Encyonopsis frequentis* Krammer (Krammer 1997) were observed in the Congo basin (Cocquyt et al. 2019).

However, what is not apparent from the above cited publications is that diatom research was also conducted in the region of Kisangani, Tshopo province, in the decades between the publication of the paper by Demalsy (1957) and those of Golama (1991, 1992, 1996). In the 1980's several students completed their theses on diatoms at the University of Kisangani (UNIKIS): Golama in 1980, Dhed'a in 1981, Mbuyu and Mwilambwe in 1983, Kasereka, Kwere and Mbiya in 1984 (Table 2). The results of Golama on diatoms of the Lindi River and the Simi-Simi pond, and of Dhed'a, on diatoms of the Kabondo River and ponds near Botumbe, were published in the "Annales de la Faculté des Sciences de Kisangani", the local journal of the University of Kisangani (Golama et al. 1983). A total of 21 genera were reported: *Asterionella* Hassall, *Caloneis*, *Ceratoneis* Ehrenberg, *Cocconeis*, *Coscinodiscus* (mentioned as *Cosnodiscus*), *Cylindrotheca* Rabenhorst, *Cymbella*, *Diatoma*, *Epithemia*, *Eunotia*, *Fragilaria*, *Frustulia*, *Gomphonema*, *Gyrosigma*, *Navicula*, *Nitzschia*, *Pinnularia*, *Rhopalodia*, *Surirella*, *Synedra*, *Tabellaria* Ehrenberg ex Kützing (Golama et al. 1983). The Lindi River and the Simi-Simi pond were the most diverse each with 16 genera; 7 genera were reported from ponds near Botumbe, 5 from the Kabondo River and 3 from a pond at Lumbulumbu.

A pond (étang du Grand-séminaire) in Kisangani, dominated by *Closterium* Nitzsch ex Ralfs (Desmidiales), was also investigated. It is located 4.5 km from the old road to Buta in the north of the city. Mbuyu (Table 2) reported twelve diatom genera in samples from the dry and the wet season in 1983. *Surirella* was only observed in the wet season, while *Amphipleura* Kützing, *Cymbella*, *Epithemia*, *Fragilaria*, *Melosira*, *Navicula*, *Nitzschia*, *Pinnularia*, *Rhoicosphenia*, *Synedra* and *Tabellaria* were observed both in the dry and the wet season. Kasereka (Table 2) studied the algal flora of the Djubudjubu River, where he mentioned the following diatom genera from 27 samples taken between 10 March and 3 May 1984: *Asterionella*, *Nitzschia* in the plankton, *Fragilaria*, *Gomphonema*, *Navicula* and *Pinnularia* in the benthos, *Cocconeis*, *Cymbella*, *Fragilaria*, *Gomphonema*, *Navicula*, *Nitzschia*, *Pinnularia*, *Surirella* and *Synedra* in the epilithon. Diatoms of the genera *Gomphonema* and *Navicula* were the most abundant. Kwere (Table 2) reported on algae present in the purification ponds of the water treatment plant of the Régideso in Kisangani. Seven diatom genera were mentioned, *Navicula*, *Nitzschia* and *Pinnularia* were dominant, *Asterionella*, *Fragilaria*, *Gomphonema*, *Melosira*, *Surirella* and *Synedra* were also recorded. Mbiya (Table 2) studied the algal flora of the Makiso River in the urban subregion of Kisangani. In epilithic samples eight genera were reported (*Cocconeis*, *Cymbella*, *Gomphonema*, *Navicula*, *Nitzschia*, *Pinnularia*, *Surirella* and *Synedra*) and only four were found in the benthos (*Navicula*, *Nitzschia*, *Pinnularia*, and *Synedra*).

Golama and Richell-Maurer (1983) reported on fish stomach contents from several fish species captured in the Lindi and the Congo River near Kisangani. *Melosira* was found to be dominant in the stomach contents of *Citharinus* sp., a tropical African lutefish, and *Labeo* sp., a genus of carp, while *Cymbella* and *Navicula* were found in *Distichodus* sp., an African ray-finned fish. In addition to diatoms belonging to these three genera, 15 other genera were reported: *Amphora*, *Amphipleura*, *Arcella* Ehrenberg, *Cocconeis*, *Caloneis*, *Cymatopleura*, *Cylindrotheca*, *Diatoma*, *Fragilaria*, *Gomphonema*, *Gyrosigma*, *Nitzschia*, *Pinnularia*, *Surirella* and *Synedra*.

The Boyekoli Ebale Congo 2010 expedition, together with initiatives taken by the VLIR–UOS at the University of Kisangani and the FORETS project at Yangambi, encouraged a number of students to choose diatom related subjects for their theses. In 2013, two students investigated the diatoms of some fish ponds at NgeneNgene, about 20 km from the city center of Kisangani. One thesis concentrated on the diatoms in the phytoplankton (Mosunga), the other on the benthos and the epiphyton (Mukinzi) (Table 2). These two students tried to delineate taxa within diatom genera. However, as the available literature or diatom floras for tropical Africa were scarce or not available to the students, a name could not be given to most of the taxa. In the phytoplankton samples 27 taxa were reported belonging to *Asterionella*, *Aulacoseira* Thwaites, *Cyclotella*, *Cymbella*, *Encyonema* Kützing, *Eunotia*, *Fragilariforma* D.M. Williams & Round, *Frustulia*, *Gomphonema*, *Navicula*, *Nitzschia*, *Pinnularia*, *Sellaphora* Mereschkowsky, *Stenopterobia* (Brébisson) Van Heurck and *Surirella*. For the benthos and epiphyton a total of 13 taxa were reported (12 for the benthos, 9 epiphytic on *Nymphaea lotus* L. and 6 epiphytic on *Azolla pinnata* R. Brown). Most were the same genera as reported in the plankton, however *Asterionella* and *Cymbella* were not present in the periphytic samples while *Cymatopleura* was present but not in the plankton.

Table 2. List of diatom-related theses authored by students in DR Congo with the academic year of submission, the student's full name and affiliation (UNIKIS: Université de Kisangani; IFA: Institut Facultaire des Sciences Agronomiques de Yangambi; UOB: Université officielle de Bukavu), the academic degree and the title of the dissertation. A bachelor`s dissertation from the Thomas More University of Applied Sciences (Thomas More) in Belgium is added. A translation of the original French/Dutch title into English is given in italics. (*: not yet submitted).

Year	Institution	Full name	Degree	Title thesis
1980	UNIKIS	Anicet Golama Swana Kaketa	licentiate	Étude comparative de la flore algologique de la rivière Lindi et de l'étang de Simi-Simi (Haut-Zaïre) en relation avec quelques facteurs du milieu. *Comparative study of the algal flora of the Lindi river and the Simi-Simi pond (Upper Zaire) in relation with some environmental factors.*
1981	UNIKIS	Benoît Dhed'a Djailo	licenciate	Inventaire algologique des étangs de Botumbe et de la rivière Kabondo. *Algological inventory of the ponds of Botumbe and the Kabondo River.*
1983	UNIKIS	Mwilambwe Mbuyu Wa Kibwe	licenciate	Flore algale des réservoirs d'eau douce, étude des algues d'un étang à Kisangani. *Algal flora of freshwater reservoirs, study of algae of a pond in Kisangani.*
1984	UNIKIS	Mbiya Mutombo Mudima	licenciate	Contribution à l'étude de la flore algale d'une rivière de la sous-région urbaine de Kisangani: Makiso. *Contribution to the study of the algal flora of a river in the suburban region of Kisangani: Makiso.*
1984	UNIKIS	Kasereka Katswangene	licenciate	Contribution à l'étude de la flore algale d'une petite rivière de la sous-région urbaine de Kisangani: Djubudjubu I. *Contribution to the study of the algal flora of a small river in the suburban region of Kisangani: Djubudjubu I.*
1984	UNIKIS	Kwere Kwere Mughania	licenciate	Étude des algues des bassins d'épuration de l'usine de traitement des eaux à la Régideso Kisangani. *Study of the algae of the water purification basins of the water treatment plant at the Régideso Kisangani.*
2013	UNIKIS	Julienne Mukinzi Manyumba	licentiate	Contribution à l'étude des diatomées benthiques et périphytiques des quelques étangs de Ngene-Ngene aux environs de Kisangani (R.D. Congo). *Contribution to the study of benthic and periphytic diatoms of some ponds at Ngene-Ngene in the surrounding of Kisangani (DR Congo)*
2013	UNIKIS	Solange Mosunga Boamba	licentiate	Étude sur la composition des diatomées phytoplanctoniques des étangs de Ngene-Ngene situés en milieu périphérique de Kisangani. *Study on the composition of phytoplankton diatoms in ponds at Ngene-Ngene located in the peripheral area of Kisangani.*
2014	UOB	S. Ombeni	licentiate	Evaluation de la qualité de l'eau de la rivière Nyamuhinga (l'un des affluents Nord-Ouest du Lac Kivu) par les indices diatomiques. *Assessment of the water quality of the Nyamuhinga River (one of the northwestern tributaries of Lake Kivu) using diatom indices.*
2018	UOB	MwamiBantu Muliri Cédric-Dubois	bachelor	Diversité algale et caractéristiques physico-chimiques des eaux thermales de la rivière Mayi ya Moto, Nyangezi, Sud-Kivu. *Algal diversity and physico-chemical characteristics of the thermal waters of the Mayi ya Moto River, Nyangezi, South-Kivu.*
2019	UNIKIS	Alain Okito Mosindo	master	Étude des diatomées épiphytiques isolées des herbiers et plantes aquatiques fraîches de la région de Yangambi en République Démocratique du Congo (RDC). *Study of epiphytic diatoms isolated from herbarium materials and fresh aquatic plants collected in the region of Yangambi in the Democratic Republic of the Congo (DRC).*
2019	Thomas More	Zoë Madder	bachelor	Een onderzoek naar de evolutie van waterkwaliteit in de regio Eala, Kisangani en Yangambi (DR Congo) doorheen de 20ste eeuw. *A study of the evolution of water quality in the Eala, Kisangani and Yangambi region (DR Congo) throughout the 20th century.*
2019*	IFA	Nelly Asele Yapeti	bachelor	Identification des diatomées du cours d'eau Makiso dans la région de Kisangani en saison sèche et saison des pluies. *Identification of the diatoms of the Makiso watercourse in the region of Kisangani in the dry season and the rainy season.*
2019*	IFA	Francis Nzanzu Vosi	bachelor	La flore des diatomées du cours d'eau Lotuli dans la région de Yangambi en saison sèche et saison des pluies. *The diatom flora of the Lotuli River in the region of Yangambi during the dry season and the rainy season.*
2019*	IFA	Daniel Mabele Boyoma	bachelor	Identification des diatomées du cours d'eau Loile dans la région de Yangambi en saison sèche et saison des pluies. *Identification of diatoms from the Loile River in the Yangambi region in the dry and the rainy season.*
2019*	UNIKIS	Dorcas Basuma Sakina	licentiate	Identification des diatomées du cours d'eau Lokwae dans la région de Kisangani en saison sèche et saison des pluies. *Identification of the diatoms of the Lokwae watercourse in the region of Kisangani in the dry season and the rainy season.*

Year	Institution	Full name	Degree	Title thesis
2019*	UNIKIS	Anastasie Batchangondua Beyanga	licentiate	Influence de la saison sur la flore diatomique d'un cours d'eau. Cas de la rivière Masindula dans la région de Yangambi. *Influence of the season on the diatom flora of a watercourse. Case of the Masindula River in the Yangambi region.*
2019*	UNIKIS	Jean Claude Makambo Tindya	licentiate	Influence de la saison sur la flore diatomique d'un cours d'eau. Cas de la rivière Lokombe dans la région de Yangambi. *Influence of the season on the diatom flora of a watercourse. Case of the Lokombe River, in the region of Yangambi.*
2019*	UNIKIS	Bienfait Nzanzu Vivuya	licentiate	Influence de la saison sur la flore diatomique d'un cours d'eau. Cas de la rivière Losa dans la région de Yangambi. *Influence of the season on the diatom flora of a watercourse. Case of the Losa River in the region of Yangambi.*
2019*	UNIKIS	Jules Abani Sifa Zolianse	master	Analyse de l'impact de l'anthropisation et saisonnier sur la diversité de diatomées dans la rivière Kabondo (Province de la Tshopo, R.D. Congo). *Analysis of the human impact and seasonality on the diversity of diatoms in the Kabondo River (Tshopo Province, DR Congo).*
2019*	UNIKIS	Nathalie Longonya	master	Variations spatio-saisonnière et l'influence des activités anthropiques sur le développement de peuplement algale (diatomées) de la rivière Yoko 1 à la Réserve Forestière de la Yoko. *Spatio-seasonal variations and the influence of human activities on the development of algal (diatoms) communities of the Yoko 1 River at the Yoko Forest Reserve.*
2019*	UNIKIS	Marie-Claire Lissasi Songowali	master	Variations spatio-saisonnière et l'influence des activités anthropiques sur le développement de peuplement algale (diatomées) de la rivière Yoko 2 à la Réserve Forestière de la Yoko. *Spatio-seasonal variations and the influence of human activities on the development of algal (diatoms) communities of the Yoko 2 River at the Yoko Forest Reserve.*
2020*	UNIKIS	Edit Lokele Ndjombo	PhD	Etude des diatomées de quelques cours d'eau de Yangambi, dans le district de la Tshopo. *Study on diatoms from some rivers at Yangambi, Thopo district.*

Okito studied diatoms present on herbarium material of aquatic plants collected during the 20th century in the Central Forest phytogeographic region (VI) according to the classification of Robyns (Robyns 1948; Bamps 1968) and kept at the Herbarium of Yangambi (YBI) (Table 2). In a similar fashion to the students Mosunga and Mukinzi, Okito tried to distinguish the different species, without, however, giving a name to most of them. This resulted in 104 specific and infra specific taxa, belonging to 34 genera with *Eunotia*, *Frustulia* and *Desmogonium* Ehrenberg as most dominant. The other observed genera were *Achnanthes*, *Achnanthidium* Kützing, *Actinella* F.W. Lewis, *Amphora*, *Aulacoseira*, *Bacillaria*, *Brachysira* Kützing, *Caloneis*, *Cavinula*, *Cocconeis*, *Cyclotella*, *Cymbopleura* (Krammer) Krammer, *Diploneis*, *Encyonema*, *Encyonopsis* Krammer, *Fragilaria*, *Fragilariforma*, *Frustulia*, *Gomphonema*, *Luticola* D.G. Mann, *Neidium*, *Nitzschia*, *Orthoseira* Thwaites, *Placoneis* Mereschkowsky, *Planothidium* Round & Bukhtiyarova, *Pinnularia*, *Sellaphora*, *Stauroneis*, *Stenopterobia*, *Surirella* and *Ulnaria* (Kützing) Compère. A professional bachelor thesis at the Thomas More University of Applied Sciences, Geel, Belgium, was written by Madden on epiphytic diatoms growing on a restricted number of *Nymphaea lotus* herbarium specimens from the same phytogeographic region (VI) (Table 2). The sampled herbarium specimens are from the collections of the herbarium of the Meise Botanic Garden (BR). This student reported on about 180 taxa belonging to 42 genera. In addition to the genera given by Okito, she also observed *Craticula* Grunow, *Diadesmis* Kützing, *Eolimna* Lange-Bertalot & W. Schiller, *Fallacia* A.J. Stickle & D.G. Mann, cf. *Fistulifera* Lange-Bertalot, *Geissleria* Lange-Bertalot & Metzeltin, *Halamphora* (Cleve) Levkov, *Humidophila* (Lange-Bertalot & Werum) Lowe, Kociolek, Johansen, Van de Vijver, Lange-Bertalot & Kopalová, *Iconella*, *Mayamaea* Lange-Bertalot, *Navicula*, *Nupela* Vyverman & Compère, *Staurosira* Ehrenberg, *Staurosirella* D.M. Williams & Round.

During the academic year 2017–2018 several other students started studying diatoms in rivers in the Tshopo province. Although most are not finished at the time of publication of the present paper, the preliminary titles of these theses (bachelor, licentiate or master level) are included in Table 2.

Algological investigations, other than on Lake Kivu, continue in the South Kivu province through student theses (Table 2). Muliri (Table 2) for example reported on 18 diatom genera from the thermal water of the Mayi ya Moto River. From the genera cited (*Achnanthes*, *Actinella*, *Aulacoseira*, *Bacillaria*, *Cocconeis*, *Cyclotella*, *Diadesmis*, *Diatoma*, *Encyonopsis*, *Fragilaria*, *Fragilariforma*, *Melosira*, *Navicula*, *Nitzschia*, *Stephanodiscus*, *Synedra*, *Tabellaria* and *Thalassiosira* Cleve) we can conclude that more recent literature (e.g., Round et al. 1990, and subsequent later taxonomic publications) is already being used. For example the genera *Diadesmis* and *Encyonopsis* are used which were before lumped with the genera *Navicula* and *Cymbella* respectively.

Up to now a total of 106 new diatoms (specific and infraspecific taxa) have been described from DR Congo, with a peak (51 taxa) at the end of the 1940's (Fig. 1). Of the 21 genera (s.l.), *Nitzschia* is by far the genus with the highest numbers of new taxa described from DR Congo (40), followed by *Pinnularia* (12) (Fig. 2). *Navicula* s.l. has 15 taxa, but includes at least two *Craticula*, one *Cavicula*, one *Geissleria*, one *Luticola* and one *Mayamaea* species. Although the genus *Eunotia* is well represented in the acid rivers of DR Congo, it only comes in fourth place with 7 new species described. However, the renewed interest in the diatom biodiversity in DR Congo will certainly increase the number of new diatom species to be discovered, including several *Eunotia* as evidenced by ongoing investigations (unpubl. data). Of interest are the similarities and differences with the neo-tropical (South America) diatom flora as evidenced by the presence of *Eunotia enigmatica* L.F. Costa & C.E. Wetzel and *Encyonopsis frequentis* Krammer (Cocquyt et al. 2019) in DR Congo.

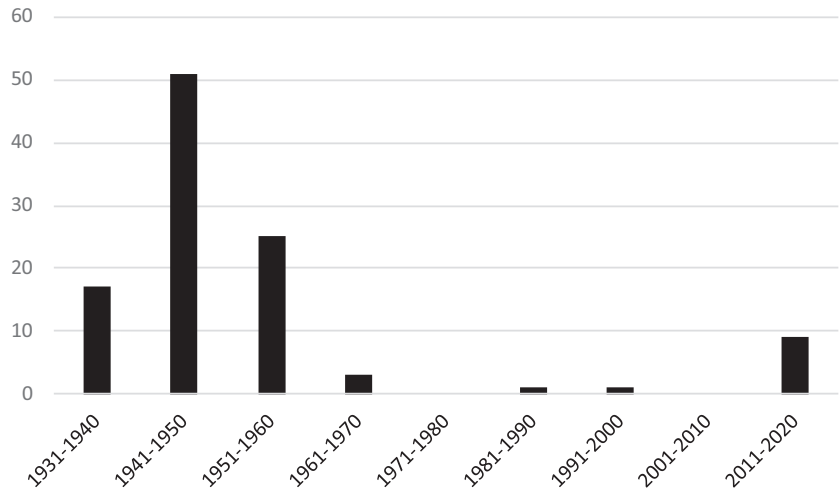

Figure 1. Number of new diatom taxa (specific and infraspecific) described from DR Congo per decade.

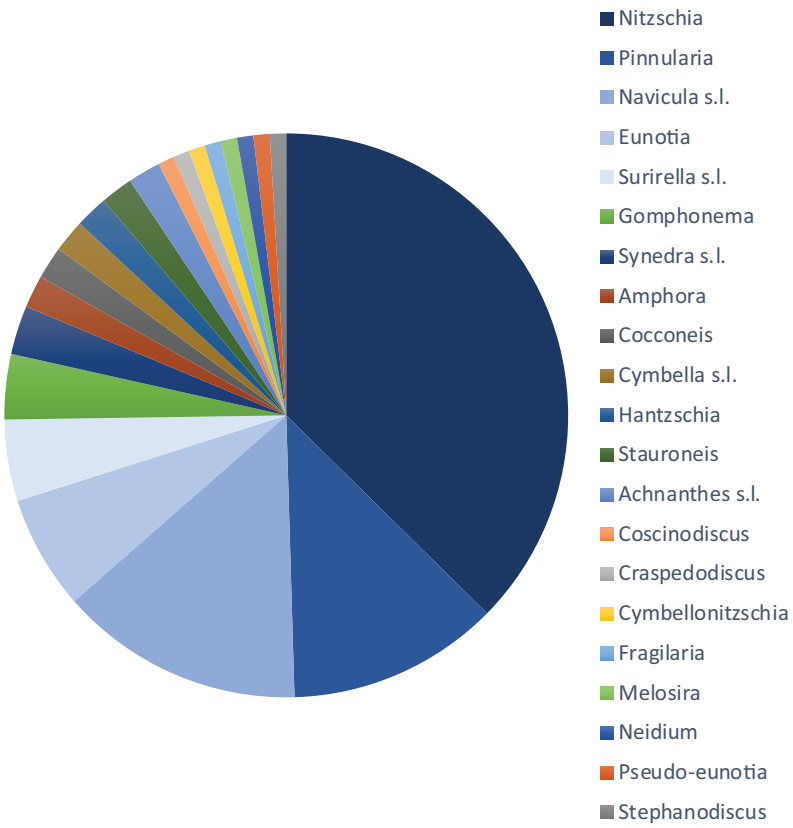

Figure 2. Pie diagram showing the relative abundance of the 21 genera (s.l.) to which the newly described species and infraspecific taxa from the DR Congo belong, *Nitzschia* being the most important, followed by *Pinnularia* and *Navicula* s.l.

It is worth noting that almost all of the new diatoms (see Table 1) described from DR Congo have the taxon status uncertain (unassessed) in DiatomBase. Only twelve taxa have the taxon status accepted; these include nine species described from DR Congo in the 21st century (Cocquyt et al. 2013; Cocquyt and Taylor 2015; Cocquyt et al. 2016; Karthick et al. 2016; Taylor et al. 2016a, b; Cocquyt and Lokele 2019) as well as *Eunotia pseudoflexuosa* Hustedt, *Nitzschia elliptica* Hustedt and *Pinnularia tropica* Hustedt. All three aforementioned species were described in a publication in which Hustedt described a total of 50 new taxa from the "Parc national Albert" (Hustedt 1949). Although *Nitzschia epiphyticoides* Hustedt was thoroughly studied (Cocquyt et al. 2012) it still has the status uncertain (unassessed) in DiatomBase (Kociolek et al. 2019).

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