PhytoKeys 155: 1–14 (2020)
doi: 10.3897/phytokeys.155.54224
http://phytokeys.pensoft.net

RESEARCH ARTICLE

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Typification and taxonomic remarks on five species names in *Cytisus* (Fabaceae)

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Academic editor: Patrick Herendeen | Received 12 May 2020 | Accepted 16 June 2020 | Published 7 August 2020

Citation: Domina G, Bartolucci F, Mráz P, Peruzzi L, Conti F, Šída O, Galasso G (2020) Typification and taxonomic remarks on five species names in *Cytisus* (Fabaceae). PhytoKeys 155: 1–14. https://doi.org/10.3897/phytokeys.155.54224

Abstract

This paper deals with the typification and taxonomy of five Mediterranean *Cytisus* species. *Cytisus affinis*, *C. candidus*, and *C. spinescens* nom. illeg., non Sieber ex Spreng. were described from Sicily by Karel Bořivoj Presl, *Cytisus spinescens* was described from Apulia (southern Italy) by Curt Polycarp Joachim Sprengel, and *C. villosus* was described from southern France by Pierre André Pourret (1788). Lectotypes are here designated for Presl and Sprengel's names. A neotype is designated for *C. villosus*. The taxonomic revision of these five names confirmed that *C. villosus* Pourr. (= *Cytisus affinis* C.Presl) is the name to be used for the species occurring in the large part of the Mediterranean countries. *Cytisus spinescens* Sieber ex Spreng. (≡ *C. candidus* C.Presl = *C. spinescens* C.Presl, nom. illeg.) is the correct name for the amphi-adriatic species occurring in peninsular Italy, and along the NE coast of the Adriatic Sea. This species does not occur in Sicily and reference to this latter region in the protologues of both *C. spinescens* C.Presl and *C. candidus* C.Presl is a misinterpretation due, possibly, to exchange of labels.

Keywords

Cytisus, *Leguminosae*, Mediterranean flora, nomenclature, Presl

Introduction

The Italian vascular flora includes 17 native *Cytisus* L. species and subspecies (Bartolucci et al. 2018) belonging to seven sections (Cristofolini and Troia 2006), and *C. striatus* (Hill) Rothm., a naturalised alien in Liguria (Galasso et al. 2018). Half of these taxa are widespread in the Mediterranean region and occur in a large portion of Italy (e.g., *C. hirsutus* L. and *C. villosus* Pourr.); other taxa show a limited distribution and occur only in a few Italian regions (e.g., *C. pseudoprocumbens* Markgr.), or are narrow endemics (e.g., *Cytisus aeolicus* Guss. confined to the Aeolian Islands, Conte et al. 1998).

Several names in *Cytisus*, published during the 19th and 20th centuries, still lack a nomenclatural type and there are even doubts about the taxonomic position for some of these names (Peruzzi et al. 2015, 2019). Among them, there are three species described from Sicily by Karel Bořivoj Presl (1794–1852, standard botanical form C.Presl from Carl, Carel or Carolus) from Sicily, namely *C. affinis* C.Presl, *C. candidus* C.Presl, and *C. spinescens* C.Presl. These taxa were described only very briefly, in the form of footnotes within a list of taxa occurring in Sicily (Presl 1826: XIX). No locality was specified in the protologues. These names, as well as the related ones *C. spinescens* Sieber ex Spreng. and *C. villosus* Pourr., are typified here and their taxonomic relationship is discussed.

This contribution is part of the large project aimed at typifying all taxa described from Italy and recognising their *loci classici* in order to serve as a basis for further taxonomic studies (Domina et al. 2012; Passalacqua et al. 2014; Peruzzi et al. 2015, 2019; Brundu et al. 2017).

Material and methods

We performed a survey of the original material in the herbaria PR (National Museum, Prague) and PRC (Charles University, Prague) (acronyms according to Thiers 2019+), hosting the Presl's Sicilian collections (Stafleu and Cowan 1983). Further material has been searched in the main Italian and European herbaria that could host duplicates and/or the original material of *C. spinescens* Sieber ex Spreng. and *C. villosus* Pourr.: B, BM, BOLO, FI, G, K, MA, MAF-POURRET, NAP, P, PAD, PAL, RO, W, and WU. The articles of the *International Code of Nomenclature for algae*, *fungi*, *and plants* (herafter ICN) cited through the text follow Turland et al. (2018).

Typification of the names *Cytisus affinis*, *C. candidus* and *C. spinescens* described by K. B. Presl, with a note on his gatherings

***Cytisus affinis* C.Presl, Fl. Sicul.: XIX. 1826. [October 1826]**

= *C. villosus* Pourr., Hist. & Mém. Acad. Roy. Sci. Toulouse 3: 317. 1788.

Ind. Loc. "[Sicilia]".

Type (lectotype, here designated): Italy. [The label written by K.B. Presl] *Cytisus affinis* Presl. / In apricis regionis collinae Siciliae ad Panormum; in insula Capri ad Neapolim, etc., May 1817, *s.coll.* [*C. Presl*] *s.n.* (PRC 450903!, Fig. 1A); other original material PR 375413!) (Fig. 1B).

***Cytisus candidus* C.Presl, Fl. Sicul.: XIX. 1826. [October 1826]**

≡ [after typification, see below] *C. spinescens* Sieber ex Spreng., Syst. Veg., ed. 16 3: 225. 1826. [January–March 1826]

Ind. Loc.: "[Sicilia]".

Type (lectotype, here designated): Italy. [The label written by K.B. Presl] *Cytisus candidus* Presl. / Mons Garganus Apulia / collegit Sieber // [printed label of F.W. Sieber: Plantae Neapolitanae et Apulae] *Cytisus spinosus*, Dec. Stachelicter Bohnenbaum. Auf felsigten nakten Stellen der Südseite des Berges Gargano, May 1812, *F.W. Sieber s.n.* (PR 375660!, Fig. 1C; isolectotypes PRC 454917! [Fig. 1D], JE 00021324 [digital photo!], W 333912 [digital photo!, the plant in the left bottom corner and the plant in the right top corner] [Fig. 2B]).

***Cytisus spinescens* C.Presl, Fl. Sicul.: XIX. 1826. [October 1826] nom. illeg. (Art. 53.1. of the ICN)**

= *Cytisus spinescens* Sieber ex Spreng.
≡ *Chamaecytisus spinescens* Rothm., Feddes Repert. Spec. Nov. Regni Veg. 53(2): 143. 1944. [1 June 1944]

Ind. Loc.: "[Sicilia]".

Type (lectotype, here designated): Italy. [The label written by K.B. Presl] *Cytisus spinescens* Presl non Spr. / Insula Capri et in Sicilia, a Schleichero et collegit Sieber. // [The label written by L. Thomas] *Cytisus nanus* Willd seu nova species / Calabre, s.d., *s.coll.* [*L. Thomas*] *s.n.* (PR 375417!, Fig. 2A; isolectotypes PRC 450971! [Fig. 2C], PRC 452282! [Fig. 2D], W 333912 [digital photo!, the plant in the right bottom corner] [Fig. 2B]).

Note. During his professional life, K.B. Presl worked simultaneously as curator of Prague National Museum collections [at that time Patriotic Museum in Bohemia] (1823–1846) and in various positions in other Prague institutions (Maiwald 1904: 180; Skočdopolová 1995). At the beginning of his career, he taught economic botany in the garden of Count of Malabaila de Canal (from 1826), later at the Faculty of Medicine (from 1829) and Philosophy (from 1833). As noted by Skočdopolová (1995), Presl frequently transferred herbarium specimens from Museum collections to his office at the

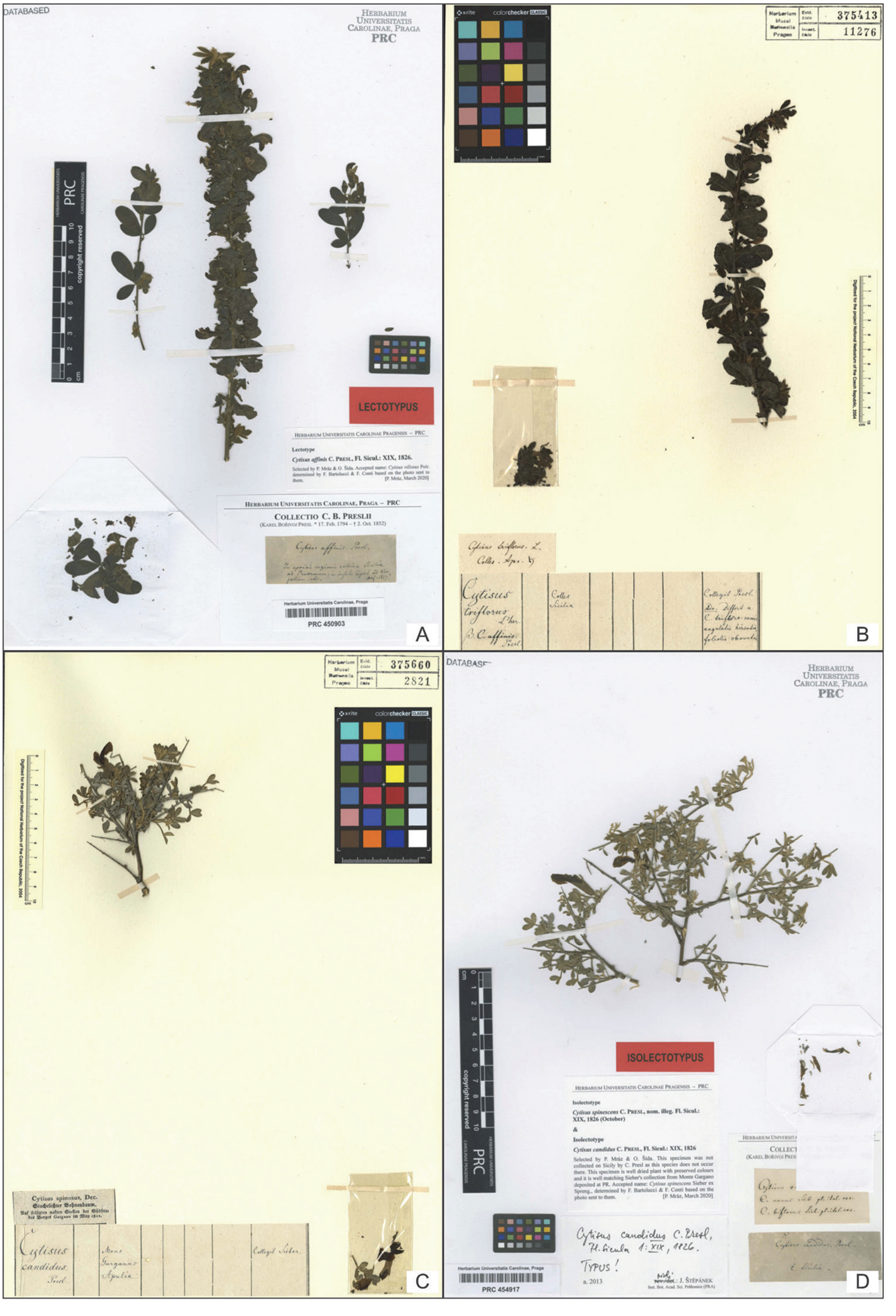

Figure 1. A The specimen of *Cytisus affinis* C.Presl (PRC 450903) here designated as lectotype of the name **B** The specimen of *C. affinis* C.Presl (PR 375413) **C** The specimen (PR 375660) here designated as lectotype of the names *C. candidus* C.Presl and *C. spinescens* Sieber ex Spreng. **D** The specimen of *C. candidus* C.Presl (PRC 454917) here designated as isolectotype of the name (all photos reproduced with permission).

university because of more suitable conditions for his work. For this reason, K.B. Presl's collections, including types, are variously distributed between today's herbaria PR and PRC. After a detailed search for original material of the above mentioned names, we found seven specimens deposited in PR and PRC putatively belonging to different gatherings and identified as three distinct taxa. We found two specimens of *C. affinis* C.Presl (PRC 450903 [Fig. 1A], PR 375413 [Fig. 1B]) collected by the author in Sicily in 1817. The specimen deposited in PRC (Fig. 1A) bears a Presl's label encompassing the species name and rather detailed locality, all written in italics, typical for his own collection (Domina and Štěpánek 2009). The specimen in PR (Fig. 1B) bears a label cut out from a specimen folder used at that time in C.M. Sternberg's herbarium, including the species name (at varietal rank, "Cytisus triflorus L'her. β. C. affinis Presl."), locality, collector and a short diagnosis against *C. triflorus* L'Hér. In addition, there is attached a small label from Presl's exsiccata collection "Flora sicula", suggesting that duplicates of this collection were distributed in the past and can be found elsewhere. Both specimens look very similar in respect of phenology and form of preparation and although they differ in the month of collection (May versus April), this likely originates from labelling of specimens in different times, and both specimens could be part of a single gathering. Both specimens are original material. They bear the name "*Cytisus affinis* Presl" written by himself, and in this case it seems unquestionable that the name *C. affinis* is based on specimens collected by Presl in Sicily. In any case, bearing two different dates, we prudentially consider them as two different gatherings. As the specimen in PRC [Fig. 1A] is more complete, we designate it as the lectotype of the name. From the morphological study of this specimen it is obvious that it agrees with the short original description, so that it can be stated that *C. affinis* C.Presl is a heterotypic synonym of *C. villosus* Pourr. Interestingly, in the PR label this taxon is subordinate to *Cytisus triflorus* L'Hér., and Presl himself later recognised *C. affinis* C.Presl as a synonym of *C. triflorus* [written without name's authority], a species currently accepted under the name *C. villosus* Pourr. (see below), in his unpublished and undated second volume of *Flora Sicula*.

More problematic are the specimens belonging to the original material of *Cytisus candidus* and *C. spinescens*. We have found one specimen belonging to *Cytisus candidus* in PR (PR 375660!) [Fig. 1C] and one in PRC (PRC 454917!) [Fig. 1D], both showing well preserved colours. In PR and PRC, we have also found three specimens belonging to *C. spinescens*: (PR 375417 [Fig. 2A], PRC 450971 [Fig. 2C], and PRC 452282 [Fig. 2D] showing very brownish tint caused probably by very slow drying.

In addition, in W there is a sheet (W333912 photo!) [Fig. 2B] bearing four specimens with four labels bearing different names and collected in several localities of peninsular Italy: *Cytisus spinosus* DC. (two specimens from the Gargano), *C. ramosissimus* Ten. from the mountains near Castellammare, and *C. nanus* Willd. from Calabria. Although all specimens from PR and PRC bear Presl's handwritten identifications, the plants belong to the same taxon and all agree with the protologues of both Presl's *C. candidus* and *C. spinescens*. More specifically, both names were allegedly based on material originated from Sicily, as can be deduced from (i) descriptions of both taxa included in *Flora Sicula* (Presl 1826), and (ii) specification about the locality of

Figure 2. A The specimen PR 375417 here designated as lectotype of *Cytisus spinescens* C.Presl, *nom. illeg.* **B** The herbarium sheet W 333912 bearing on the right bottom corner the isolectotype here designated of *C. spinescens* C.Presl and on the right top and on the left bottom corners the isolectotypes of *C. candidus* C.Presl **C** The specimen PRC 450971 here designated as isolectotype of *C. spinescens* C.Presl, *nom. illeg.* **D** The specimen PRC 452282 here designated as isolectotype of *C. spinescens* C.Presl, *nom. illeg.* (all photos reproduced with permission).

C. candidus being collected in two carbonate promontories near Palermo ("Habitat in regione collina in saxosis apricis sterilibus ad promontorium Zafferana una vire, altera vire in monte Pellegrino", see Presl, undated, unpub. msc. *Flora Sicula* vol. 2) or in Sicily in general (Presl's annotations on two specimens deposited in PRC "E[x] Sicilia"; PRC 454917 and PRC 450971). Importantly, from the taxonomic point of view, both *Cytisus candidus* and *C. spinescens* C.Presl, are heterotypic synonyms of *C. spinescens* Sieber ex Spreng. (see below), a taxon which, besides Presl's records from *Flora Sicula*, has never been reported from Sicily (Bartolucci et al. 2018). In fact, *C. spinescens* Sieber ex Spreng. is a taxon confined solely to the Italian peninsula (northwards to Latium, Umbria and Marche) and to the NE coast of the Adriatic Sea. In addition to the doubtful location (Sicily), it has become obvious from the elements specified below that these specimens were not collected by Presl himself, but by Franz Wilhelm Sieber (1789–1844) and by Charles-François-Louis-Alexandre [Luigi] Thomas (1784–1823) (cf. Burdet 1978; see also an annotation to the Table 1), respectively. We hypothesise that these discrepancies in locations and collectors have likely originated from dividing and postponing the labelling of these specimens by Presl himself. Such a mistake has previously been documented in *Asplenium lepidum* C.Presl, which was allegedly collected by him in Bohemia, but actually by Anton Rochel (1770–1847) in the region of Banat (currently in Romania and Serbia) (P. Mráz, unpublished data).

In the case of *Cytisus candidus*, the specimen PR 375660 (Fig. 1C) bears, in addition to Presl's label, also Sieber's original label of "*Cytisus spinosus* DC." from his exsiccata collection "Plantae Neapolitanae et Apulae". As stated on both labels, it was collected in Gargano, where this species (currently *C. spinescens* Sieber ex Spreng.) occurs (Fenaroli 1970; Bartolucci et al. 2018). Interestingly, Sieber's original label is missing in the specimen found in PRC (PRC 454917, Fig. 1D), which bears two labels written by Presl only (Table 1). We found Sieber's duplicates of this gathering also in JE (JE 00021324 Photo!) and W (W 333912 photo!, plant on the left bottom, Fig. 2B). Importantly, both these specimens bear Sieber's exsiccata labels and the plants show the same colour and character as the specimens housed at PR (Fig. 1C) and PRC (Fig. 1D). We here selected the specimen at PR (PR 375660), bearing the original label from Sieber's "Plantae Neapolitanae et Apulae" collection, as the lectotype of *C. candidus* C.Presl. The specimen PRC 454917, as well as the duplicates in JE and W, are therefore isolectotypes of *C. candidus* C.Presl.

The three remaining specimens (PR 375417 [Fig. 2A], PRC 450971 [Fig. 2C], and PRC 452282 [Fig. 2D]) are again morphologically very homogeneous and were consistently identified by Presl as "*Cytisus spinescens* Presl", although labelled as being collected from three different sites (see Table 1). Very important in this respect is the sheet W 333912 (Fig. 2B), with the specimen in the right bottom corner "*Cytisus nanus* Willd." collected by Thomas in Calabria. Importantly, a similar label showing the same plant name and locality accompanies the specimen PR 375417 (Fig. 2A), whose plant shows similar / identical habitus as the one at W. The same can be argued for the specimens from PRC (PRC 450971 [Fig. 2C], and PRC 452282 [Fig. 2D]), albeit missing Thomas' label. On the contrary, one of the PRC specimens (PRC 452282)

Table 1. Overview of elements involved in the nomenclatural history of four *Cytisus* taxa described by K.B. Presl and K.P.J. Sprengel from Italy and their taxonomic interpretation.

Barcode and nomenclatural type	Identification and morphology of specimen	Presl's identification	Label(s)	Notes
PRC 450903 (Fig. 1A) **lectotype of *C. affinis* C.Presl**	*C. villosus* Pourr.	*C. affinis* C.Presl	"Cytisus affinis Presl. / In apricis regionis collinae Siciliae / ad Panormum, in insula Capri ad Nea- / polium, etc. Maj. 1817"	Standard Presl's label from his own herbarium
PR 375413 (Fig. 1B) **other original material (syntype) of *C. affinis* C.Presl**	*C. villosus* Pourr.	*C. affinis* C.Presl	"Cytisus / ~~triflorus~~ L'Her. / β C. affinis / Presl. // Colles Siciliae // Collegit Presl. / Adn. Differt a C. trifloro ramis angulatis hirsutis foliolis obovatis"	Large Presl's label cut out from the specimen folder used in Sternberg's herbarium
			"Cytisus triflorus. L. / Colles. Apr."	Presl's label from his exsiccata collection *Plantae Siculae*, written in 1817 or early after
PR 375660 (Fig. 1C) **lectotype of *C. candidus* C.Presl, lectotype of *C. spinescens* Sieber ex Spreng.**	*C. spinescens* Sieber ex Spreng., well dried plants with preserved colours, well matching Sieber's collection from Gargano	*C. candidus* C.Presl	"Cytisus / candidus / Presl. // Mons Garganus Apulia // Collegit Sieber"	Large Presl's label cut out from the specimen folder used in Sternberg's herbarium
			"Cytisus spinosus, Dec. / Stachelichter Bohnenbaum. / Auf felsigten Stellen de Südseite / des Berges Gargano im May 1812"	Sieber's label from his exsiccata collection *Plantae Neapolitanae et Apulae*, printed in 1812 or early after
PRC 454917 (Fig. 1D) **isolectotype of *C. candidus* C.Presl, isolectotype of *C. spinescens* Sieber ex Spreng.**	*C. spinescens* Sieber ex Spreng., well dried plants with preserved colours, well matching Sieber's collection from Gargano	*C. candidus* C.Presl	"Cytisus candidus Presl fl. sic. / C. nanus Sieb. pl. ital. exs. / C. biflorus Sieb. pl. ital. exs."	Presl's handwritten label, which is very similar to the label on PRC 452282 (Fig. 2D) and was presumably written in 1832 or later. Reference to Sieber's collection from Capri, also noted on specimen PR 375417 (Fig. 2A). Reference to *C. nanus* was probably wrongly ascribed to Sieber and, in fact, it refers to the specimen of L. Thomas
			"Cytisus candidus Presl. / E Sicilia."	Presl's handwritten label
PR 375417 (Fig. 2A) **lectotype of *C. spinescens* C.Presl, nom. illeg.**	*C. spinescens* Sieber ex Spreng., bleached and brownish plants, well matching Thomas' collection from Calabria	*C. spinescens* C.Presl	"Cytisus / spinescens / Presl / non Spr. // Insula / Capri et / in Sicilia // A Schleichero / et collegit Sieber"	Large Presl's label cut out from the specimen folder used in Sternberg's herbarium written in 1826 or later. K.B. Presl referred to Schleicher, not to Thomas. J. C. Schleicher (1768–1834) was contemporary and also competitor of AbrahamThomas (1740–1824, father), Abraham Louis Emmanuel Thomas (1788–1859, son), Charles-François-Louis-Alexandre Thomas (1784–1823, son). Thomas' family owned horticultural business in Bex, Switzerland (Moret, 1993, 1999), where was also active J.C. Schleicher. Gathering collected by one of Thomas was most probably sent to Prague by Schleicher (reference to Sprengel's publication given)
			"Cytisus nanus Willd / seu nova species / Calabre"	Handwritten label probably by Ch.F.L.A. Thomas, but not entirely sure if written by him or by his brother A.L.E. Thomas. Based on the note on duplicate specimen kept in Wien (W 333912, Fig. 2B). According to Burdet (1978), the label is more probably written by A.L.E. Thomas, although presumably collected by Ch.F.L.A. Thomas, who worked in Calabria

Barcode and nomenclatural type	Identification and morphology of specimen	Presl's identification	Label(s)	Notes
PRC 450971 (Fig. 2C) **isolectotype of *C. spinescens* C.Presl, nom. illeg.**	*C. spinescens* Sieber ex Spreng., bleached and brownish plants, well matching Thomas' collection from Calabria	*C. spinescens* C.Presl	"Cytisus spinescens. Presl / E Sicilia."	Presl's handwritten label; the annotations "fl. sic. 1825" and "C. argyreus Rchb. 1830" in pencil probably written by Kosteletzky were added later
PRC 452282 (Fig. 2D) **isolectotype of *C. spinescens* C.Presl, nom. illeg.**	*C. spinescens* Sieber ex Spreng., bleached and brownish plants, well matching Thomas' collection from Calabria	*C. spinescens* C.Presl	"Cytisus spinescens Presl fl. sic. (1825) / C. spinosus Sieb. pl. ital. exs., Günther / herb. / C. argyreius Reichenb. (1830)"	Presl's handwritten label from 1832 or later [reference to Reichenbach's publication given]
			"Cytisus spinosus, Dec. / Stachelichter Bohnenbaum. / Auf felsigten Stellen de Südseite / des Berges Gargano im May 1812"	Sieber's label from his exsiccate collection *Plantae Neapolitanae et Apulae*, printed in 1812 or early after
PRC 455779	*C. spinescens* Sieber ex Spreng., glabrescent morphotype	–	"Cytisus biflorus. Tenore. / Zweiblüthiger Bohnenbaum / Auf der Insel Capri, den 6. April 1812."	Sieber's label from his exsiccate collection *Plantae Neapolitanae et Apulae* and with Presl's annotation 'Sieber', printed in 1812 or early after

bears Sieber's label of his "Plantae Neapolitanae et Apulae" collection (the same of *C. candidus* in PR 375660 [Fig. 1C] and W 333912 [Fig. 2B, plant on the left bottom]). Because this label is missing on *C. candidus* specimen from PRC (PRC 454917, Fig. 1D), we hypothesise that Sieber's label attached to the specimen of *C. spinescens* C.Presl (PRC 452282, Fig. 2D) emerged from a mistake and was, in fact, exchanged with that of *C. candidus* (PRC 454917, Fig. 1D). Since the specimen PR 375417 [Fig. 2A] contains the best preserved plant and bears both Presl's identification label and original label by Thomas, we designate it as the lectotype of the illegitimate name *C. spinescens* C.Presl. Consequently, we consider the specimens in PRC (Figs. 2C, 2D) and W (Fig.2B, the plant in the right bottom corner) as duplicates of Thomas' collection from Calabria, and hence isolectotypes.

A possible scenario leading to the current "messy" state is as follows. During the work on his *Flora Sicula* (between 1817 and 1825–1826), K. B. Presl had access to five gatherings of *Cytisus* from Italy. Two of them (*C. affinis* C.Presl) were part of his own herbarium and were collected by him in Sicily, another two (one by Sieber, one by Thomas) were part of Prague National Museum collections and came from Italian mainland. The fifth is a Sieber's gathering from Capri Island (Campania, southern Italy) and bears Presl's annotation 'Sieber'. It is deposited in PRC (PRC 455779) with no duplicate in PR. Our hypothesis is that Presl divided the museum specimens and transferred fragments to his own herbarium, and vice versa, donating duplicates of his own collection from Sicily to the Museum. We suppose also that during this "fragmentation" of specimens, he probably did not annotate carefully these fragments, and this may be the main reason for the chaotic situation concerning these collections.

Based on the morphology of the specimens of Presl's *C. candidus* and *C. spinescens*, which agrees with the short original descriptions, we conclude that both names are synonyms of *C. spinescens* Sieber ex Spreng. Because *C. spinescens* C.Presl was described about seven months later than *C. spinescens* Sieber ex Spreng. (Stafleu and Cowan 1983, 1985), and because both names are based on different types (see also below), Presl's name is a later and heterotypic homonym of *C. spinescens* Sieber ex Spreng., illegitimate according to Art. 53.1 of the ICN. Consequently, Presl's name should not be used as an accepted name as it is currently treated in *The Plant List* (2019) or in the *International Legume Database* (Roskov et al. 2006) and in *Euro+Med Plantbase* (Euro+Med 2006). Concerning the name *C. spinescens* C.Presl, it is noteworthy that in his unpublished second volume of *Flora Sicula*, Presl wrote that its provenance was unclear for him ('*locus specialis mihi amplius non constat*') and unclear was for him also the status of *C. spinescens* Sieber ex Spreng. with respect to *C. candidus* ('Quid vero *C. spinescens* Spreng. … est … An species sequens?' [the next species in the manuscript is *C. candidus*]).

Typification of the names *Cytisus spinescens* Sieber ex Spreng. and *C. villosus* Pourr.

Cytisus spinescens Sieber ex Spreng., Syst. Veg., ed. 16 3: 225. 1826. [January–March 1826]

≡ *Spartium spinescens* (Sieber ex Spreng.) Bertol., Fl. Ital. 7(3): 345. 1850. [June 1850]
≡ [after typification] *Cytisus candidus* C.Presl

Ind. Loc. "Mons Garganus Apul." Puglia.

Type (lectotype, here designated): Italy. [The label written by K.B. Presl] *Cytisus candidus* Presl. / Mons Garganus Apulia / collegit Sieber // [printed label of F.W. Sieber: Plantae Neapolitanae et Apulae] Cytisus spinosus, Dec. Stachelicter Bohnenbaum. Auf felsigten nakten Stellen der Südseite des Berges Gargano, May 1812, *F.W. Sieber. s.n.* (PR 375660!, Fig. 1C; isolectotype PRC 454917! [Fig. 1D], JE 00021324 [digital photo!], W 333912 [digital photo!, the plant in the left bottom corner and the plant in the right top corner] [Fig. 2B]).

Note. As Sprengel based his description on the exsiccata series collected and issued by F.W. Sieber, the best solution for typification would be to choose the specimen from Sieber's collection seen by Sprengel himself. Unfortunately, after the death of his son, Sprengel's rich herbarium was divided into many parts and sold in small portions to different specialists and institutions (Stafleu and Cowan 1985). The largest part, containing the collections of many botanists and among them also those by Sieber, was bought by B in 1890 (Urban 1891), and subsequently destroyed during World War II. We found unequivocal duplicates of this F.W.Sieber's collection in herbaria PR, W and JE, and as shown above also in PRC, although incorrectly labelled later by Presl. It is interesting to note that Presl based his later homonym *C. spinescens* on a different gathering (Thomas' collection), while he described *C. candidus* on a F.W.Sieber's gathering. As the above designated lectotype of *C. candidus* belongs, without any doubt, also to the original material of *C. spinescens* Sieber ex Spreng, we designate it also as the lectotype of the latter name. *Cytisus candidus* C.Presl thus becomes a homotypic synonym of the prioritary name *C. spinescens* Sieber ex Spreng.

This brings also another nomenclatural consequence: when treating *C. spinescens* Sieber ex Spreng. as a member of the separate genus *Chamaecytisus* Link, the correct name is *Chamaecytisus spinescens* Rothm. This is because Rothmaler (1944) based his intended "new combination" on Presl's illegitimate name, and thus accidentally published a replacement name (Art 58.1 of the ICN), which prevents making the combination based on legitimate Sprengel's epithethon.

***Cytisus villosus* Pourr., Hist. & Mém. Acad. Roy. Sci. Toulouse 3: 317. 1788.**

≡ [after typification] *Cytisus triflorus* L'Hér., non Lam., nom. illeg.

Ind. Loc. "Aux environs de Narbonne, à Fontlaurier". France

Type (neotype, here designated): Algeria. In montibus prope Algeriam, *s.d.*, R. L. Desfontaines, *s.n.* (G 00007761 [digital photo!] image: https://www.ville-ge.ch/musinfo/bd/cjb/chg/adetail.php?id=30955).

Note. We did not find any original material for this name either in MAF (MAF-Pourret collection), and P (the general collection and the special Pourret's collection named "*Chloris narbonensis*"), where Pierre André Pourret's (1754–1818) collections are mainly kept (Stafleu and Cowan 1983), or in other relevant herbaria (BM, FI, MPU, and UPS; see Stafleu and Cowan 1983: 368). It seems, therefore, that the original material for this name is lost. This possibility is not surprising giving Pourret's dramatic escape from France to Spain in 1789 and his forced exile (Galibert 1856), followed by several war events (Stafleu and Cowan 1983: 368). Because the original material of *C. villosus* is lost, we have decided to choose a neotype represented by the specimen G00007761 housed at G-DC. This specimen has been previously selected by Cristofolini and Fumeaux (Cristofolini and Troia 2006) as the lectotype of *C. triflorus* L'Hér. [1791]; an illegitimate name (a later homonym of *C. triflorus* Lam. [1786]) being conspecific with *C. villosus* Pourr. (see Polhill 1978; Cristofolini and Troia 2006). Importantly, as *Cytisus triflorus* L'Hér. has been accepted as the conserved type for the generic name *Cytisus* Desf., nom. cons. (Appendix III of the ICN), it becomes automatically a homotypic synonym of *Cytisus villosus* Pourr. – which is the accepted name of the generitype of this genus.

Acknowledgements

We thank Cécile Aupic (P), Jiří Hadinec (PRC), Anton Igersheim (W), José Pizarro (MAF), Christophe Randin (LAU), and other curators of herbaria listed in Material and Methods section for their help with searching for the original material;

to Alena Richterová (National Library, Praha) for her help in searching for Presl's unpublished manuscript. This work was supported by the "Progetto di Ricerca di Rilevante Interesse Nazionale" (PRIN) "PLAN.T.S. 2.0 – towards a renaissance of PLANt Taxonomy and Systematics" lead by the University of Pisa, under the grant number 2017JW4HZK (Principal Investigator: Lorenzo Peruzzi). Work of OŠ was supported by Ministry of Culture of the Czech Republic (DKRVO 2019–2023/4.I.b, National Museum, 00023272), that of PM by statutory funds of Charles University

References

Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, Astuti G, Bacchetta G, Ballelli S, Banfi E, Barberis G, Bernardo L, Bouvet D, Bovio M, Cecchi L, Di Pietro R, Domina G, Fascetti S, Fenu G, Festi F, Foggi B, Gallo L, Gubellini L, Gottschlich G, Guiggi A, Iamonico D, Iberite M, Jiménez-Mejías P, Lattanzi E, Martinetto E, Masin RR, Medagli P, Passalacqua NG, Peccenini S, Pennesi R, Pierini B, Poldini L, Prosser F, Raimondo FM, Marchetti D, Roma-Marzio F, Rosati L, Santangelo A, Scoppola A, Scortegagna A, Selvaggi A, Selvi F, Soldano A, Stinca A, Wagensommer RP, Wilhalm T, Conti F (2018) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 179–303. https://doi.org/10.1080/11263504.2017.1419996

Brundu G, Peruzzi L, Domina G, Bartolucci F, Galasso G, Peccenini S, Raimondo FM, Albano A, Alessandrini A, Banfi E, Barberis G, Bernardo L, Bovio M, Brullo S, Brunu A, Camarda I, Carta L, Conti F, Croce A, Iamonico D, Iberite M, Iiriti G, Longo D, Marsili S, Medagli P, Mariotti MG, Pennesi R, Pistarino A, Salmeri C, Santangelo A, Scassellati E, Selvi F, Stinca A, Vacca G, Villani M, Wagensommer RP, Passalacqua NG (2017) At the intersection of cultural and natural heritage: Distribution and conservation of the type localities of the Italian endemic vascular plants. Biological Conservation 214: 109–118. https://doi.org/10.1016/j.biocon.2017.07.024

Burdet HM (1978) Cartulae ad botanicorum graphicem. XIV. Candollea 33: 409–454.

Conte L, Troìa A, Cristofolini G (1998) Genetic diversity in *Cytisus aeolicus* Guss. (*Leguminosae*), a rare endemite of the Italian flora. Plant Biosystems 132(3): 239–249. https://doi.org/10.1080/11263504.1998.10654208

Cristofolini G, Troìa A (2006) A reassessment of the sections of the genus *Cytisus* Desf. (*Cytiseae*, *Leguminosae*). Taxon 55(3): 733–746. https://doi.org/10.2307/25065647

Domina G, Štěpánek J (2009) Typification of the name *Orobanche canescens* C.Presl (*Orobanchaceae*) with taxonomic notes. Candollea 64: 31–37.

Domina G, Giusso Del Galdo G, Gargano D, Labra M, Peccenini S, Peruzzi L, Raimondo FM (2012) The Italian loci classici census. Taxon 61(1): 1351–1353. https://doi.org/10.1002/tax.616031

Euro+Med (2006) Euro+Med PlantBase - the information resource for Euro-Mediterranean plant diversity. http://ww2.bgbm.org/EuroPlusMed/ [accessed 10.01.2020]

Fenaroli L (1970) Florae Garganicae Prodromus. Webbia 24(2): 435–578. https://doi.org/10.1080/00837792.1970.10669916

Galasso G, Domina G, Adorni M, Ardenghi NMG, Bonari G, Buono S, Cancellieri L, Chianese G, Ferretti G, Fiaschi T, Forte L, Guarino R, Labadessa R, Lastrucci L, Lazzaro L, Magrini S, Minuto L, Mossini S, Olivieri N, Scoppola A, Stinca A, Turcato C, Nepi C (2018) Notulae to the Italian alien vascular flora: 5. Italian Botanist 5: 45–56. https://doi.org/10.3897/ib.5.25910

Galibert L (1856) Biographie de Pierre-André Pourret. Narbonne, Imprimerie D'Emmanuel Caillard.

Maiwald V (1904) Geschichte der Botanik in Böhmen. Wien, C. Fromme. https://doi.org/10.5962/bhl.title.9667

Moret J-L (1993) Le commerce de graines et de plantons forestiers de la famille Thomas, de Bex (VD, Suisse). Bulletin du Cercle Vaudois de Botanique 22: 121–131. https://www.patrinum.ch/record/18250?ln=en

Moret J-L (1999) Note sur les catalogues de vente de plantes de la famille Thomas, de Bex (VD, Suisse). Bulletin du Cercle Vaudois de Botanique 86: 191–198.

Passalacqua NG, Banfi E, Galasso G (2014) Banca dati delle piante endemiche italiane: protologhi e loci classici. In: Alessandrello A (Ed) Al Museo per scoprire il mondo. La ricerca scientifica e le esposizioni. Museo Civico di Storia Naturale di Milano 2010–2013. Natura 104: 33–38.

Peruzzi L, Domina G, Bartolucci F, Galasso G, Peccenini S, Raimondo FM, Albano A, Alessandrini A, Banfi E, Barberis G, Bernardo L, Bovio M, Brullo S, Brundu G, Brunu A, Camarda I, Carta L, Conti F, Croce A, Iamonico D, Iberite M, Iiriti G, Longo D, Marsili S, Medagli P, Pistarino A, Salmeri C, Santangelo A, Scassellati E, Selvi F, Soldano A, Stinca A, Villani M, Wagensommer RP, Passalacqua NG (2015) An inventory of the names of vascular plants endemic to Italy, their loci classici and types. Phytotaxa 196(1): 1–217. https://doi.org/10.11646/phytotaxa.196.1.1

Peruzzi L, Galasso G, Domina G, Bartolucci F, Santangelo A, Alessandrini A, Astuti G, D'Antraccoli M, Roma-Marzio F, Ardenghi NMG, Barberis G, Conti F, Bernardo L, Peccenini S, Stinca A, Wagensommer RP, Bonari G, Iamonico D, Iberite M, Viciani D, Del Guacchio E, Gusso del Galdo G, Lastrucci L, Villani M, Brunu A, Magrini S, Pistarino A, Brullo S, Salmeri C, Brundu G, Clementi M, Carli E, Vacca G, Marcucci R, Banfi E, Longo D, Di Pietro R, Passalacqua NG (2019) An inventory of the names of native, non-endemic vascular plants described from Italy, their loci classici and types. Phytotaxa 410(1): 1–215. https://doi.org/10.11646/phytotaxa.410.1.1

Polhill RM (1978) Proposal to conserve and retypify the name *Cytisus* (*Leguminosae*). Taxon 27(5/6): 556–559. https://doi.org/10.2307/1219931

Pourret M (1788) Extrait de la Chloris narbonensis. Histoire et Mémoires de l'Academie Royale des Sciences, Inscriptions et Belles Lettres de Toulouse 3: 297–334. https://bibdigital.rjb.csic.es/viewer/1525864/?offset=#page=1&viewer=picture&o=bookmark&n=0&q=

Presl CB (1826) Flora sicula, exibens plantas vasculosas in Sicilia aut sponte crescentes aut frequentissime cultas, secundum systema naturale digestas. Tomus primus. Pragae, A. Borrosch. https://books.google.it/books?id=ZMwZAAAAYAAJ&printsec=frontcover&dq=in

title:Flora+intitle:sicula+inauthor:presl&hl=it&sa=X&ved=0ahUKEwjVgbr2jb3nAhVL2KQKHflzDFQQ6AEIKTAA#v=onepage&q&f=false

Presl CB (Undated) Manuscript intendit as a continuation of his first volume of Flora sicula. Presl's personal legacy deposited under the inventory number 41 in the Archive of National Museum, Praha.

Roskov YR, Bisby FA, Zarucchi JL, Schrire BD, White RJ (2006) ILDIS world database of legumes: draft checklist, version 10. ILDIS, Reading. [Cd-Rom] https://ildis.org/LegumeWeb10.01.shtml [accessed 11.10.2019]

Rothmaler WHP (1944) Die Gliederung der Gattung *Cytisus* L. Feddes Repertorium Specierum Novarum Regni Vegetabilis 53(2): 137–150. https://doi.org/10.1002/fedr.19440530208

Skočdopolová B (1995) Historie herbářů Tadeáše Haenkeho a jejich zpracování v Preslově díle Reliquiae Haenkeanae [History of the herbarium collections of T. Haenke, and their evaluation in Presl, Reliquiae Haenkeanae]. Zprávy Československé Botanické Společnosti při Československé Akademii Věd 30: 161–166.

Stafleu FA, Cowan RS (1983) Taxonomic literature, ed. 2, vol. 4. Utrecht, Bohn, Scheltema & Holkema. https://doi.org/10.5962/bhl.title.48631

Stafleu FA, Cowan RS (1985) Taxonomic literature, ed. 2, vol. 5. Utrecht, Bohn, Scheltema & Holkema. https://doi.org/10.5962/bhl.title.48631

The Plant List (2019) The Plant List. A working list of all plant sepcies. Version 1.1. http://www.theplantlist.org/ [accessed 11.10. 2019]

Thiers B (2019+) Index herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's virtual herbarium. http://sweetgum.nybg.org/science/ih/ [accessed 15.06.2019]

Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Kusber W-H, Li D-Z, Marhold K, May TW, McNeill J, Monro AM, Prado J, Price MJ, Smith GF (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Glashütten, Koeltz Botanical Books [Regnum Vegetabile 159]. https://doi.org/10.12705/Code.2018

Urban J (1891) Der Königl. botanische Garten und botanische Museum zu Berlin in den Jahren 1878–1892. Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 14(suppl. 32): 9–64. https://www.biodiversitylibrary.org/item/672#page/664/mode/1up

PhytoKeys 155: 15–32 (2020)
doi: 10.3897/phytokeys.155.53460
http://phytokeys.pensoft.net

RESEARCH ARTICLE

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A dated phylogeny of the genus *Pennantia* (Pennantiaceae) based on whole chloroplast genome and nuclear ribosomal 18S–26S repeat region sequences

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Academic editor: James W. Byng | Received 21 April 2020 | Accepted 13 July 2020 | Published 7 August 2020

Citation: Maurin KJL (2020) A dated phylogeny of the genus *Pennantia* (Pennantiaceae) based on whole chloroplast genome and nuclear ribosomal 18S–26S repeat region sequences. PhytoKeys 155: 15–32. https://doi.org/10.3897/phytokeys.155.53460

Abstract

Pennantia, which comprises four species distributed in Australasia, was the subject of a monographic taxonomic treatment based on morphological characters in 2002. When this genus has been included in molecular phylogenies, it has usually been represented by a single species, *P. corymbosa* J.R.Forst. & G.Forst., or occasionally also by *P. cunninghamii* Miers. This study presents the first dated phylogenetic analysis encompassing all species of the genus *Pennantia* and using chloroplast DNA. The nuclear ribosomal 18S–26S repeat region is also investigated, using a chimeric reference sequence against which reads not mapping to the chloroplast genome were aligned. This mapping of off-target reads proved valuable in exploiting otherwise discarded data, but with rather variable success. The trees based on chloroplast DNA and the nuclear markers are congruent but the relationships among the members of the latter are less strongly supported overall, certainly due to the presence of ambiguous characters in the alignment resulting from low coverage. The dated chloroplast DNA phylogeny suggests that *Pennantia* has diversified within the last 20 My, with the lineages represented by *P. baylisiana* (W.R.B.Oliv.) G.T.S.Baylis, *P. endlicheri* Reissek and *P. corymbosa* diversifying within the last 9 My. The analyses presented here also confirm previous molecular work based on the nuclear internal transcribed spacer region showing that *P. baylisiana* and *P. endlicheri*, which were sometimes considered synonyms, are not sister taxa and therefore support their recognition as distinct species.

Keywords

chimeric mapping reference, chloroplast DNA, internal transcribed spacer, Next Generation Sequencing, off-target reads, *Torricellia*

Introduction

Pennantia J.R.Forst. & G.Forst. is the sole genus of the family Pennantiaceae J.Agardh, a member of Apiales that comprises four species in Australasia (Gardner and de Lange 2002, Fig. 1). *Pennantia endlicheri* Reissek is a forest tree endemic to Norfolk Island, a small volcanic remnant located about 1400 km east of Australia's mainland. *Pennantia baylisiana* (W.R.B.Oliv.) G.T.S.Baylis (Three Kings Kaikomako/Kaikōmako Manawa Tāwhi) is a small tree originally known in the wild by only one plant, discovered in 1945 on Great Island/Manawa Tawhi (Three Kings Islands/Manawatāwhi, New Zealand, Baylis 1977) and thought to be female. However, cuttings of the plant were induced to produce seeds in cultivation (Beever and Davidson 1999, Gardner et al. 2004) and later the wild individual was observed seeding (Wright 1989). It is nowadays planted throughout New Zealand in both residential and botanic gardens (Gardner and de Lange 2002; pers. obs.) from cuttings of the original tree and from the seeds they produced (de Lange et al. 2010). *Pennantia baylisiana* was regarded by Sleumer (1970) as synonymous with *P. endlicheri*, a view disputed by Baylis (1977, 1989); more recently, Gardner and de Lange (2002) maintained *P. baylisiana* on morphological grounds, while Mabberley (2017) still considered it a synonym of *P. endlicheri*. *Pennantia corymbosa* J.R.Forst. & G.Forst. is a tree endemic to the main islands of New Zealand (North Island, South Island and Stewart Island) and some outlying islands. It is a heteroblastic tree of coastal and lowland forests with a divaricating juvenile form (Dawson and Lucas 2012). *Pennantia cunninghamii* Miers is an Australian endemic tree of subtropical to warm-temperate rainforest of the east coast. Miers (1852) initially placed this species in a monotypic section, *P.* sect. *Dermatocarpus* Miers, because of its fruits, which are different from those of *P. corymbosa* and *P. endlicheri*. In Miers' time, *P. baylisiana* had not yet been collected, and even though it has similar fruits to *P. cunninghamii*, Gardner and de Lange (2002) maintained *P.* sect. *Dermatocarpus* on the basis of other morphological traits that distinguish *P. cunninghamii* from the other members of the genus, which they placed in *P*. sect. *Pennantia*.

The placement of Pennantiaceae within Apiales has been a matter of debate. Their morphology is consistent with Apiales in the inferior position of their ovary and their low number of carpels (Nicolas and Plunkett 2014). On the molecular phylogenetics side, studies have mostly sampled *P. corymbosa* alone (Chandler and Plunkett 2004; Qiu et al. 2010) or with *P. cunninghamii* (Kårehed 2001, 2003; Winkworth et al. 2008; Nicolas 2009; Nicolas and Plunkett 2009, 2014; Tank and Donoghue 2010; Byng et al. 2014; Magallón et al. 2015; Li et al. 2019); Keeling et al. (2004), however, provided a phylogeny of the four species based on the nuclear ribosomal internal transcribed spacer (ITS) region. On one hand, analyses of nuclear markers proved rather ambiguous, sometimes showing that *Pennantia* falls among close sisters to Apiales, namely Dipsacales or Aquifoliales (Chandler and Plunkett 2004; Nicolas 2009), sometimes that it falls among Apiales (Keeling et al. 2004). On the other hand, sequence data from plastid (e.g. Kårehed 2001; Li et al. 2019) and mitochondrial genes (albeit with poor support, Qiu et al. 2010) placed them sister to the rest of the Apiales; this conclusion was strongly supported by studies that built a phylogeny combining both plastid genes and nuclear markers (e.g. Chandler and Plunkett 2004; Magallón et al. 2015).

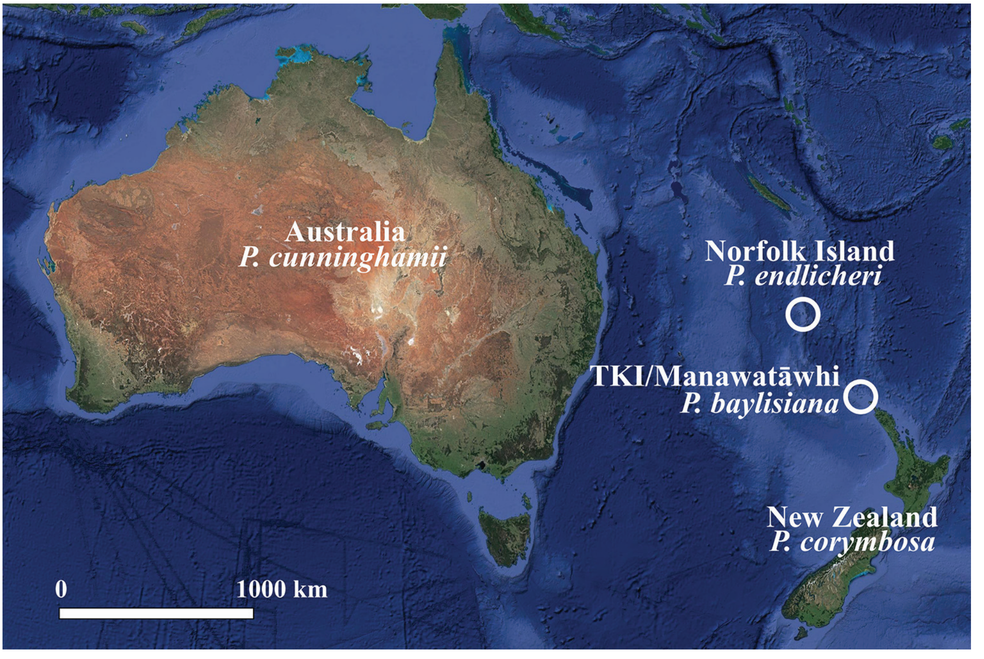


Figure 1. General distribution of the four *Pennantia* species. TKI = Three Kings Islands. Generated in QGIS 3.0.1 from Google Satellite data obtained through the XYZ Tiles tool (https://mt1.google.com/vt/lyrs=s&x={x}&y={y}&z={z}).

This study has three goals. (1) To propose the first molecular phylogeny that samples all four species of *Pennantia* for whole plastid DNA sequences, dated using two Apiales fossils and one secondary calibration. (2) To present and evaluate the relevance of a method I used to generate sequence data for nuclear markers at low marginal cost from the shotgun sequencing of genomic DNA: I mapped reads that were unmapped to the chloroplast DNA reference sequence ("off-target reads") against a chimeric 18S–26S nuclear ribosomal DNA repeat region reference sequence to build the sequences for a nuclear DNA phylogeny. (3) To use both the chloroplast DNA and nuclear DNA phylogenies to further examine proposals made by Gardner and de Lange (2002) regarding the relationships among the four *Pennantia* species based on morphological features alone, which have also been assessed by Keeling et al. (2004) using nuclear ribosomal sequences alone.

Methods

Sampling plan

Gardner and de Lange (2002) showed that all four *Pennantia* species are well defined morphologically, and that they have no morphologically divergent populations, a claim which still appears unchallenged today; therefore, it is reasonable in such a group to assume that morphological coherence is an accurate indication of monophyly within each species, and hence only one sample per species was considered. For the chloroplast DNA phylogeny, I also included representatives of five families of Apiales, and four closely related orders according to recent whole-plastid DNA phylogenies of land plants as an outgroup (e.g. Magallón et al. 2015, Li et al. 2019). I included newly generated sequences of the apialean families Araliaceae Juss. (6 species), Pittosporaceae R.Br. (1 species) and Torricelliaceae Hu (2 species), and of the order Asterales (1 species), along with previously published sequences downloaded from GenBank of two other families of Apiales, Apiaceae Lindl. and Torricelliaceae, and of three other orders, Aquifoliales, Dipsacales and Paracryphiales (1 species each); see Table 1 for details. I was not able to generate nor could I find whole-plastid DNA sequences for the remaining two families of Apiales, Griseliniaceae Takht. and Myodocarpaceae Doweld. For the nuclear DNA phylogeny, newly generated sequences of the 18S–26S repeat region for *Pennantia* were obtained from the same samples used to generate the chloroplast DNA sequences. The sequences newly generated for this study were obtained either from field collections that were dried in silica gel and processed in the lab within three months of collection (Maurin collections in Table 1), or from herbarium specimens. I was not able to obtain sequences of the 18S–26S nuclear DNA repeat region from Torricelliaceae. The sampling plan for chloroplast DNA and the 18S–26S nuclear DNA repeat region is given in Table 1. At the time of submission of this paper, a whole chloroplast DNA sequence purported to be of *Torricellia angulata* Oliv. was available on GenBank (accession NC031509/KX648359); it was disregarded because it appears to derive from a member of Rosales. A second *Torricellia* chloroplast genome sequence (NC040944), from *T. tiliifolia* DC., was included.

DNA extraction

DNA from the samples of *Pennantia corymbosa*, *Raukaua anomalus* (Hook.) A.D.Mitch., Frodin & Heads and *Schefflera digitata* J.R.Forst. & G.Forst. was extracted using a CTAB-based protocol (Doyle and Dickson 1987) modified as in Smissen and Heenan (2007) to include a phenol:chloroform extraction and recovery using spin columns (Zymo IIC, Zymo Research, Orange County, California). The DNA of the other samples was extracted following the DNA tissue protocol of the Maxwell 16 instrument (Promega, Madison, Wisconsin) and further purified by phenol/chloroform extraction and recovery in spin columns. Detailed step-by-step protocols are available upon request. The DNA concentration of the extracts was measured using the Qubit (Thermo Fisher Scientific, Waltham, Massachusetts) dsDNA high-sensitivity assay protocol.

Library preparation and sequencing

Genomic DNA libraries of *Pennantia corymbosa*, *Raukaua anomalus* and *Schefflera digitata* were prepared using Illumina Nextera DNA Library Prep kits, following the

Table 1. Sampling plan of this study, with voucher information and GenBank accession numbers. Samples sorted alphabetically by order name then species name. CANB = Australian National Herbarium (CANB), Canberra, Australia; CHR = Allan Herbarium (CHR), Lincoln, New Zealand; P = Herbarium of the Muséum National d'Histoire Naturelle, Paris, France. Newly generated sequences were formatted for submission to GenBank using the tool GB2Sequin (Lehwark and Greiner 2019).

Order	Family	Species	Distribution	Source of plant material or sequence	Herbarium accession #	Voucher or publication	Markers	GenBank accession #
Apiales	Araliaceae	*Cheirodendron bastardianum* (Decne.) Frodin	Marquesas Islands	P	P02800554	Perlman 19764	Chloroplast	MT385071
	Apiaceae	*Daucus carota* L.	Native to temperate Europe and south-west Asia	GenBank	–	Ruhlman et al. (2006)	Chloroplast	DQ898156
	Torricelliaceae	*Melanophylla alnifolia* Baker	Madagascar	P	P02529054	Ranirison 966	Chloroplast	MT385073
	Torricelliaceae	*Melanophylla modestei* G.E. Schatz, Lowry & A.-E. Wolf	Madagascar	P	P06233571	Bernard 1700	Chloroplast	MT385074
	Pennantiaceae	*Pennantia baylisiana* (W.R.B.Oliv.) G.T.S.Baylis	Three Kings Islands/ Manawatāwhi (Great Island/ Manawa Tawhi)	CHR	CHR 655088	Maurin 87	Chloroplast	MT385075
							Nuclear	MT434778
				GenBank	–	Rotherdam et al. (unpubl.)	Nuclear	EF660531
	Pennantiaceae	*Pennantia corymbosa* J.R.Forst. & G.Forst.	New Zealand's main islands and some neighbouring offshore islands	CHR	CHR 649661	Maurin 45	Chloroplast	MT385076
							Nuclear	MT434779
				GenBank	–	Rotherdam et al. (unpubl.)	Nuclear	EF635468
	Pennantiaceae	*Pennantia cunninghamii* Miers	East coast of Australia	CANB	CANB869762	Purdie 9229	Chloroplast	MT385077
							Nuclear	MT434780
				GenBank	–	Rotherdam et al. (unpubl.)	Nuclear	EF635470
	Pennantiaceae	*Pennantia endlicheri* Reissek	Norfolk Island	CANB	CBG8703383	Telford 10450	Chloroplast	MT385078
							Nuclear	MT434781
				GenBank	–	Rotherdam et al. (unpubl.)	Nuclear	EF635469
	Pittosporaceae	*Pittosporum eugenioides* A.Cunn.	North and South Islands of New Zealand	CHR	CHR 553618	Courtney, *s.n.*	Chloroplast	MT385079
	Araliaceae	*Raukaua anomalus* (Hook.) A.D.Mitch., Frodin & Heads	New Zealand's main islands	CHR	CHR 649673	Maurin 57	Chloroplast	MT385080
	Araliaceae	*Raukaua edgerleyi* (Hook.f.) Seem.	New Zealand's main islands	CHR	CHR 655508	Maurin 103	Chloroplast	MT385081
	Araliaceae	*Raukaua simplex* (G.Forst.) A.D.Mitch., Frodin & Heads	New Zealand's main islands, Auckland Islands	CHR	CHR 437312	Sykes 42/87	Chloroplast	MT385082
	Araliaceae	*Schefflera actinophylla* (Endl.) Harms	Northern and north-eastern coast of Australia	CANB	CANB874342	Lepschi 7083	Chloroplast	MT385083
	Araliaceae	*Schefflera digitata* J.R.Forst. & G.Forst.	New Zealand's main islands	CHR	CHR 649676	Maurin 60	Chloroplast	MT385084
	Torricelliaceae	*Torricellia tiliifolia* DC.	China, eastern Himalaya	GenBank	–	Yao et al. (2019)	Chloroplast	NC040944
Aquifoliales	Aquifoliaceae	*Ilex paraguariensis* A.St.-Hil.	South America	GenBank	–	Cascales et al. (2017)	Chloroplast	KP016928
Asterales	Argophyllaceae	*Corokia cotoneaster* Raoul	New Zealand's main islands	CHR	CHR 655097	Maurin 96	Chloroplast	MT385072
Dipsacales	Caprifoliaceae	*Dipsacus asper* Wallich ex Candolle	China, south-east Asia	GenBank	–	Park et al. (2018)	Chloroplast	MH074864
Paracryphiales	Paracryphiaceae	*Quintinia verdonii* F.Muell.	Eastern Australia	GenBank	–	Yao et al. (2019)	Chloroplast	MK397891

manufacturer's instructions (Reference Guide, #15027987 v01, January 2016) except that I halved the quantities of reagents and the target amount of input DNA. Libraries of the other samples were prepared using Illumina TruSeq Nano DNA Library Prep kits, according to the manufacturer's instructions (Reference Guide, # 15041110 Rev. D, June 2015), again using halved reagent quantities and target input DNA; genomic DNA was fragmented using a Covaris ME220 Focused-ultrasonicator (settings: 75 s duration – 40 W peak power – 25% duty factor – 50 cycles per burst). The concentration and size range of libraries were measured with a LabChip GX Touch HT (Perkin Elmer). Libraries were enriched for chloroplast DNA using a custom MYBaits kit (Arbor Biosciences, Ann Arbor) modified from Stull et al. (2013) as detailed in Smissen et al. (in press) using the manufacturer's instructions (version 3.02, July 2016 or version 4.01, April 2018). Illumina HiSeq shotgun sequencing was carried out by Otago Genomics using paired end 2 × 125 bp reads.

Chloroplast DNA assembly and annotation

Reads were first trimmed using Trimmomatic v. 0.38 (Bolger et al. 2014) with the following settings: ILLUMINACLIP:[path/to/NexteraPE-PE.fa for *Pennantia corymbosa*, *Raukaua anomalus* and *Schefflera digitata*, TruSeq3-PE-2.fa for the others]:1:30:10 SLIDINGWINDOW:10:20 MINLEN:40. The reads of the Pennantiaceae and Torricelliaceae samples were then mapped to *Torricellia tiliifolia* (NC040944), the closest sequence to *Pennantia* available in GenBank at the time the mappings were performed (July 2019) that was both verified and published. Mapping was performed with BWA, using the BWA-MEM algorithm (Li 2013). The quality of the best resulting sequence, *P. cunninghamii*, was then improved (in terms of coverage, HQ% and number of ambiguous bases) by remapping its reads against a consensus sequence from the initial mapping against the *Torricellia* sequence. Finally, reads from all the other samples were mapped against the remapped *P. cunninghamii* sequence. The same process was followed for Araliaceae with the sequence of *Schefflera actinophylla* (Endl.) Harms, first mapped to the GenBank reference *Schefflera heptaphylla* (L.) Frodin (NC029764), *Pittosporum eugenioides* A.Cunn. first mapped to *Torricellia tiliifolia* (NC040944), and *Corokia cotoneaster* Raoul first mapped to *Llerasia caucana* (S.F.Blake) Cuatrec. (NC034821).

The resulting sequences, except *Melanophylla modestei* G.E. Schatz, Lowry & A.-E. Wolf, were of good overall quality (Suppl. material 1: Table S1): on average the HQ% was 98.4 (range: 93.7 – 99.9) and the percentage of ambiguous bases was 1.2% (range: 0.2% – 6.2%). Mean coverage ranged from 124 to 10,804. The *Melanophylla modestei* sequence was of lesser quality, with HQ% 63.6 and mean coverage of 16.5. However, its percentage of ambiguous bases was still low (4.8%), with the vast majority of them located outside the coding regions used in the phylogenetic analysis. The sequences were annotated by (1) aligning the improved references to the GenBank references used to map their reads against with the MAFFT algorithm v. 7.388 (Katoh et al. 2002, Katoh and

Standley 2013) plugin in Geneious Prime 2019.2.1, (2) transferring the annotations of the GenBank references to the improved references, and (3) aligning the other sequences to their corresponding improved references, again with MAFFT within Geneious Prime, and transferring the annotations across. Annotations were manually checked.

18S–26S nuclear ribosomal DNA repeat region assembly and annotation

In the absence of a complete 18S–26S nuclear ribosomal DNA repeat region for Apiales, I built a chimeric 18S–26S nuclear DNA repeat region from several GenBank sequences. I concatenated the 18S rRNA sequence of *Melanophylla alnifolia* Baker (AJ236002), the ITS1, 5.8 S RNA, and ITS2 sequences of *Pennantia cunninghamii* (EF635470), and the 26S rRNA sequence of *Pittosporum fairchildii* Cheeseman (AF479192), in that order. The structure of the resulting chimeric 18S–26S nuclear DNA repeat region is provided in Suppl. material 1: Fig. S1. I then mapped the off-target reads from the chloroplast DNA mappings of the shotgun sequencing data of my herbarium and fresh samples to this chimeric nuclear DNA reference.

The quality of the resulting assemblies was rather variable. There was no clear relationship between the number of reads available to map and the number of reads actually mapped to the chimeric reference (Suppl. material 1: Table S2). The mapping of the two *Melanophylla* species failed; the mapping of the four sequences of *Pennantia* was satisfactory for *P. baylisiana*, *P. cunninghamii* and *P. endlicheri* (HQ% > 86% and ambiguities < 7%), but less so for *P. corymbosa* (HQ% = 51.0%, and ambiguities = 29.1%). Because of the variable quality of my newly reconstructed 18S–26S nuclear DNA repeat region sequences, I aligned them together with the longest sequences of the 18S–26S nuclear DNA repeat region available on GenBank for the four *Pennantia* species, as a control of the identity of my newly generated sequences for the phylogenetic analyses. Some statistics regarding these sequences discussed later in the paper were obtained with MEGA X (Kumar et al. 2018).

Data partitioning

Sixty protein-coding sequences (CDS, 46,051 sites) from the long and short single copy regions were used for the chloroplast DNA analyses (see list in Suppl. material 1: Table S3); coding rRNA, which was located in the inverted repeats, was not considered. CDS were partitioned into 1st + 2nd codon position on the one hand (30,701 sites), and 3rd codon position on the other hand (15,350 sites). For the nuclear DNA analyses, the 18S–26S nuclear DNA repeat region alignment represented 810 sites, partitioned as ITS1 + ITS2 on the one hand (538 sites), a portion of 18S rRNA + whole 5.8S rRNA + a portion of 26S rRNA on the other hand (272 sites). The markers were aligned in Geneious Prime using the MAFFT plugin, and the alignments were manually checked.

Phylogenetic analyses and chloroplast DNA tree calibration

Phylogenetic analyses were conducted with the BEAST suite v. 2.5.2 (Bouckaert et al. 2019). Each of the four partitions was assigned its own evolutionary model using bModelTest (Bouckaert and Drummond 2017) to average the best-fitted nucleotide models. A relaxed clock with rates drawn from an exponential distribution (Drummond et al. 2006) was associated to each partition. The MCMC chains were run for 250 million generations and sampled once every 25,000 generations for chloroplast DNA, and for 50 million generations sampled once every 5,000 generations for nuclear DNA. The influence of tree prior choice on the phylogeny and dating was assessed by repeating the analysis under both the Yule model (Yule 1925) and the Birth-Death model (Gernhard 2008). These analyses were run on the CIPRES platform (Miller et al. 2010). The proper convergence of the chains and the determination of the burnin that would maximise their effective sample size (ESS) was examined with Tracer v. 1.7.1 (Rambaut et al. 2018); the ESS of a parameter represents the number of effectively independent samples from the posterior distribution of the parameter, and therefore how strong its estimation is: values above 200 are considered satisfactory (BEAST Developers 2017). Three independent runs per analysis (i.e. per combination of Birth-Death or Yule model with chloroplast DNA or nuclear DNA) were started from different seeds and combined with LogCombiner v. 2.5.2 (Bouckaert et al. 2019). The combined sampled trees from each analysis were then summarised in TreeAnnotator v. 2.5.2 (Bouckaert et al. 2019) with their selected burnin.

The chloroplast DNA phylogeny was calibrated using two fossils and one secondary calibration. Firstly, I assigned the age of the earliest confirmed fossils of *Torricellia*, which are ca. 48 My old (Manchester et al. 2017), to the minimum crown age of Torricelliaceae, using an offset exponential distribution (Mean = 20.0, Offset = 48.0), resulting in a wide prior with a 2.5% quantile of 48.5 My, a 97.5% quantile of 122 My, and a mean of 68 My. Secondly, I assigned the age of *Paleopanax oregonensis* Manchester fossils, which are considered from the Middle Eocene (Manchester 1994), to the minimum crown age of Araliaceae, following Magallón et al. (2015) and Li et al. (2019); I used an offset exponential distribution (Mean = 20.0 and Offset = 37.8), resulting in a wide prior with a 2.5% quantile of 38.3 My, a 97.5% quantile of 112 My, and a mean of 57.8 My. Finally, the estimated age of Apiales in recent Angiosperm-wide phylogenies (Magallón et al. 2015, Li et al. 2019) is about 80–81 My old, with a maximum interval of about [70,95] My; I therefore assigned an offset lognormal distribution with M = 33.0, S = 0.2, and Offset = 48.0 to the crown age of the Apiales species, resulting in a prior with a 2.5% quantile of 69.9 My, a 97.5% quantile of 95.9 My, and a mean of 81.0 My.

The robustness of the Bayesian inference of tree topology for the phylogenies resulting from both the chloroplast DNA and the nuclear DNA sequence data was assessed with a maximum likelihood approach. RAxML v. 8.2.12 (Stamatakis 2014) was run on CIPRES with the following settings for both phylogenies: GTRGAMMA model, rapid bootstrap analysis with search for best scoring tree (-f a -x) with 1,000 bootstrap replicates. The chloroplast DNA phylogeny was rooted by fixing the four non-Apiales sequences as outgroups, while no outgroup was set for the nuclear DNA phylogeny.

Finally, the six resulting trees (chloroplast DNA or nuclear DNA, with BEAST2/Birth-Death model, BEAST2/Yule model or RAxML) were first formatted in FigTree v. 1.4.4 (Rambaut 2018) and then refined in Inkscape v. 0.92.3. Given the much larger number of sites in the chloroplast DNA dataset compared to the nuclear DNA dataset, a combined analysis was not conducted as its results would have been skewed towards what was observed with chloroplast DNA alone; moreover, the topologies of both phylogenies were congruent. The detailed settings and parameters used for the phylogenetic analyses are in the BEAST2 and RAxML files provided in Suppl. material 2.

Results

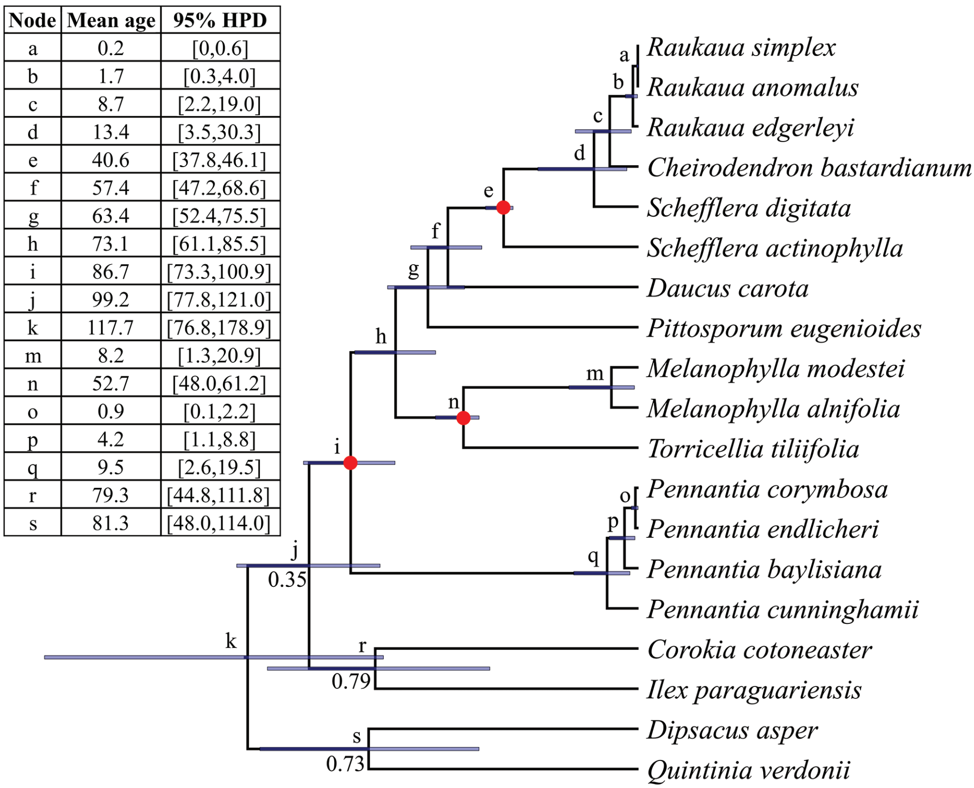
Dated chloroplast DNA phylogeny

The combination of the chains run under the Birth-Death model or the Yule model resulted in an Effective Sample Size (ESS) > 200 for all their parameters. The tree had the same topology and was very well supported within the ingroup Apiales under both models, all the node posterior probabilities (PP) being equal to 1. Moreover, the same topology was obtained for the chloroplast DNA tree built with RAxML, with 100% bootstrap support within Apiales. The tree resulting from the Birth-Death model is shown in Fig. 2, and the trees resulting from the Yule model and the RAxML analysis in Suppl. material 1: Fig. S2 and Fig. S3 respectively.

In the phylogeny presented in Fig. 2, the relationships between the families of Apiales that were included in the analysis conformed to contemporary ideas about the relationships among Apiales families (Stevens 2017). Here, the crown age of *Pennantia* was estimated at 9.5 My, with an HPD of [2.6,19.5] My. Within *Pennantia*, the Australian species *P. cunninghamii* was sister to the rest of the genus. Then, *P. baylisiana*, from the Three Kings Islands/Manawatāwhi, was sister to a clade formed by the New Zealand species *P. corymbosa* and the Norfolk Island species *P. endlicheri*.

Undated 18S–26S nuclear DNA repeat region phylogeny

The chains yielded an ESS far greater than 200 even before they were combined under both the Birth-Death model and the Yule model. The resulting tree showed the same topology with comparable PP under both models, although the PP under the Yule model tended to be slightly lower than under the Birth-Death model. The topology of the tree produced from the RAxML analysis was congruent with the topology of the BEAST2 trees, with bootstrap values of 100% except for the node placing the two samples of *P. corymbosa* and *P. endlicheri* as sister to each other (bootstrap = 88%). For consistency with the chloroplast DNA phylogeny, I draw conclusions regarding the



Node	Mean age	95% HPD
a	0.2	[0,0.6]
b	1.7	[0.3,4.0]
c	8.7	[2.2,19.0]
d	13.4	[3.5,30.3]
e	40.6	[37.8,46.1]
f	57.4	[47.2,68.6]
g	63.4	[52.4,75.5]
h	73.1	[61.1,85.5]
i	86.7	[73.3,100.9]
j	99.2	[77.8,121.0]
k	117.7	[76.8,178.9]
m	8.2	[1.3,20.9]
n	52.7	[48.0,61.2]
o	0.9	[0.1,2.2]
p	4.2	[1.1,8.8]
q	9.5	[2.6,19.5]
r	79.3	[44.8,111.8]
s	81.3	[48.0,114.0]

Figure 2. Dated chloroplast DNA BEAST 2 phylogeny of *Pennantia*, under the Birth-Death model. Mean node age and 95% HPD (in My) is given in the table embedded in the figure under the corresponding letter code. 95% HPD is also represented by blue bars. All node posterior probabilities are equal to 1 except if indicated otherwise. The calibrated nodes (see text) are indicated by red dots.

nuclear DNA phylogeny primarily by examining the Birth-Death model tree (Fig. 3), while providing the Yule model and RAxML trees in Suppl. material 1: Fig. S4 and Fig. S5 respectively. In the absence of suitable outgroup sequences, the RAxML nuclear DNA tree was rooted to make *P. cunninghamii* sister to the other species of *Pennantia*, in accordance with the topology of the chloroplast DNA tree presented in this study and of the ITS tree of Keeling et al. (2004).

The percentage of identical sites between the two samples of each species was ≥ 98.7%. There were relatively few parsimony-informative sites in the nuclear DNA alignment: only 35 out of 538 (6.5%) sites in the ITS1/ITS2 partition and 0 out of 272 in the rRNA partition. The two samples of each species were recovered as sisters, usually with strong support: PP = 1 for *P. cunninghamii* and *P. baylisiana*, PP = 0.97 for *P. corymbosa*, but PP = 0.75 only for *P. endlicheri*. Moreover, the topology of this tree was congruent with that of the tree based on chloroplast DNA (Fig. 2), with strong support (PP = 0.99) for the clade *P. corymbosa* + *P. endlicheri* but weak support for the clade *P. corymbosa* + *P. endlicheri* + *P. baylisiana* (PP = 0.64), although the latter had 100% bootstrap support in the RAxML analysis. This phylogeny was also congruent with the one reported by Keeling et al. (2004), built with

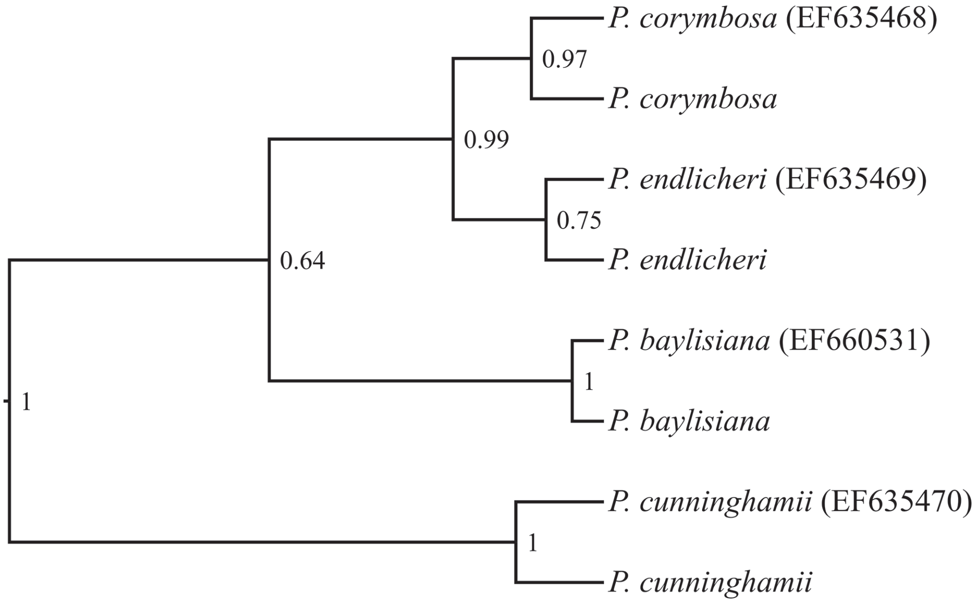


Figure 3. Undated 18S–26S nuclear DNA repeat region BEAST 2 phylogeny of *Pennantia*, under the Birth-Death model. The tree was rooted to make *P. cunninghamii* sister to the other species of *Pennantia*, in accordance with the chloroplast DNA tree and the ITS tree of Keeling et al. (2004). Node posterior probability is shown next to the corresponding node. The sequences downloaded from GenBank have their accession number in round brackets; the others were generated from the samples used in this study.

the maximum likelihood option of PAUP* 4.0b (Swofford 2002), and showing comparable bootstrap values for equivalent nodes in the case of the present RAxML analysis.

Discussion

Congruence between chloroplast and nuclear DNA phylogenies

Phylogenies based on chloroplast DNA markers and the 18S–26S nuclear DNA repeat region indicate the same relationships among the four species of *Pennantia*. They are also congruent with the ITS phylogeny of Keeling et al. (2004), confirming the relationships they inferred among the four species. The relatively low support values that were observed for some clades in the 18S–26S nuclear DNA repeat region could result from the limited amount of variation of this region, or more probably from the loss of sites during the phylogenetic analyses due to the presence of ambiguities: the sequences I generated from the samples of *P. endlicheri* and *P. corymbosa* have a percentage of ambiguities of 16.3% and 6.9% respectively (while all the other sequences have ≤ 0.5% of ambiguities), after trimming the sequences. Conflicting tree topologies did not seem to be in play in this case given the paucity of parsimony-informative sites in this 18S–26S nuclear DNA repeat region.

Crown age of Pennantiaceae and age of its most recent common ancestor (MRCA) with Torricelliaceae

The age of the MRCA of Pennantiaceae and Torricelliaceae (which is the crown age of Apiales) was estimated about 86.7 My, with an HPD of [73.3,100.9] My. This mean estimate is consistent with some of the previous dated phylogenies that include this MRCA: 73.6 My (Li et al. 2019), 80.8 My (Magallón et al. 2015) and 91.39 My (Tank et al. 2015); however, it is more recent than the 117.0 My indicated by Nicolas and Plunkett (2014), which might be explained by their use of an Araliaceae fossil about the same age as the one I used to date a node that is internal to Araliaceae.

The mean crown age of Pennantiaceae was estimated to be 9.5 My with an HPD of [2.6,19.5] My, which is slightly older than the previous estimate for *Pennantia* of 6.6 My with an HPD of ca. [1.6,15.8] My suggested by Nicolas and Plunkett (2014). The fact that I used more conservative priors than they did for the MRCAs of Araliaceae and Torricelliaceae may explain my older estimates. The difference in priors on the crown age of Araliaceae was mentioned above. Moreover, their priors were tightly constrained around old ages compared to mine, e.g. for the crown age of Torricelliaceae they used a prior with a 95% HPD of [55.8,58.7] My, while my prior had a 95% HPD of [48.5,122] My. I allowed the possibility for relatively older posterior dates than the estimated age of the fossils so as to account better for the fact that fossils can only represent the youngest possible age of the clade to which they are associated; older fossils might yet exist and be discovered. Nevertheless, the results of both sets of analyses suggest that *Pennantia* diversified within the last 20 My. The present analysis also shows that the diversification of the ancestors of the extant New Zealand, Three Kings Islands/Manawatāwhi and Norfolk Island species is much more recent, starting about 4.2 Mya with an HPD of [1.1,8.8] My.

Relationships within *Pennantia*

The phylogenies presented here significantly supported *Pennantia baylisiana* being a distinct species to *Pennantia endlicheri*, corroborating the conclusions Keeling et al. (2004) made from their ITS region phylogeny of the four species of *Pennantia*. Gardner and de Lange (2002) suggested that the closest relative of *P. baylisiana* may be *P. endlicheri* (p. 671) but maintained *P. baylisiana* distinct from *P. endlicheri* on morphological grounds: e.g. domatia developed and bearing trichomes in the former but hardly developed and glabrous in the latter. The chloroplast DNA phylogeny strongly supported the distinction between these species since they are not sister taxa, as it placed *P. baylisiana* sister to the clade *P. endlicheri* + *P. corymbosa* with a PP of 1. In the nuclear DNA phylogeny, this node only had a PP of 0.64 but is strongly supported (bootstrap = 100%) in the phylogeny of Keeling et al. (2004). Characters shared between *P. endlicheri* and *P. corymbosa* that are not found in the two other species of the genus include the presence of uncinate trichomes (rather sparse and restricted to inflorescence axes in *P. endlicheri*) and a stigmatic ring being made of three distinct stigmas (Gardner and de Lange 2002).

The present phylogenies also supported the placement by Miers (1852) of *Pennantia cunninghamii* in a monotypic section *Dermatocarpus*, which was maintained by Gardner and de Lange (2002) on morphological grounds. *P. cunninghamii* indeed has unique morphological features compared to the rest of the genus. For example, its domatia form pits while those of the other species are pockets (although shallow and sometimes absent in *P. endlicheri*), and its ovary is longitudinally ridged and thus appears to be formed by three carpels while the ovary of the other species is barrel-shaped and barely furrowed. Here, the results of the phylogeny based on chloroplast sequences were consistent with this infrageneric classification, placing *P. cunninghamii* sister to all the other *Pennantia* species with a posterior probability of 1. The nuclear DNA phylogeny presented here, in the absence of outgroups to *Pennantia*, does not explicitly support this idea, but it is consistent with it. The sister group relationship between *P. cunninghamii* and the rest of the genus was well supported by the ITS phylogeny of Keeling et al. (2004, bootstrap values ≥ 96%).

Conclusions

The analysis of chloroplast genome sequences supports previous phylogenetic results based on nuclear DNA in suggesting that *Pennantia cunninghamii* is sister to the rest of the genus. Moreover, it strongly supports previous nuclear DNA analyses in placing *P. baylisiana* as sister to the clade *P. endlicheri* + *P. corymbosa* rather than sister to *P. endlicheri* alone, with which it has sometimes been considered conspecific (e.g. Mabberley 2017). This is consistent with previous studies based on morphology, which concluded that *P. baylisiana* should be recognised as a distinct species. The dated phylogeny presented here suggests that *Pennantia* diversified within the last 20 My, and possibly as recently as 2.6 My ago. It also suggests that divergences among the ancestors of the three species of section *Pennantia*, now distributed on Norfolk Island, Three Kings Islands/Manawatāwhi and the main islands of New Zealand, happened over the last 9 My and as recently as 0.1 My ago. However, the island endemism of each *Pennantia* species and the lack of close outgroups and of information about ancestral distribution areas prevents the inference of confident biogeographical scenarios regarding the origin of the distribution of the extant species. Finally, this study has shown that the use of a chimeric reference sequence to utilise off-target reads from target enrichment libraries that are usually discarded can provide useful data for phylogenetic analysis. Although the quality of such mappings can be quite variable, as demonstrated here, the low marginal cost of this procedure makes it worth exploring in genome-based research using shotgun sequencing techniques.

Acknowledgments

I would like to thank Chris Lusk and Rob Smissen for commenting on the draft manuscripts; Peter de Lange and Porter Lowry II for commenting on the submitted manuscript; Otari Native Botanic Garden, the Pukemokemoke Bush Trust, the Department of Conservation, the Maungatautari Ecological Island Trust and the iwi Waikato Tainui, Ngāti Rangi and Mōkai Pātea for sampling permits and agreements in New Zealand; the herbaria CHR, CANB and P for leaf samples. This research is supported by the Royal Society of New Zealand – Te Apārangi through Marsden contract 16-UOW-029; and the Faculty of Science and Engineering of the University of Waikato through FSEN Student Trust Fund (# P102218 SoS/PG Support).

References

Baylis G (1977) *Pennantia baylisiana* (Oliver) Baylis comb. nov. New Zealand Journal of Botany 15(2): 511–512. https://doi.org/10.1080/0028825X.1977.10432558

Baylis G (1989) *Pennantia baylisiana* (W. Oliver) Baylis. New Zealand Botanical Society Newsletter 15: 13. https://doi.org/10.1080/0028825X.1977.10432558

BEAST Developers (2017) Effective Sample Size (ESS) | BEAST Documentation. Available from: https://beast.community/ess_tutorial [accessed April 9, 2020]

Beever R, Davidson G (1999) *Pennantia baylisiana* project. Auckland Botanical Society Journal 54.

Bolger AM, Lohse M, Usadel B (2014) Trimmomatic: A flexible trimmer for Illumina sequence data. Bioinformatics (Oxford, England) 30(15): 2114–2120. https://doi.org/10.1093/bioinformatics/btu170

Bouckaert RR, Drummond AJ (2017) bModelTest: Bayesian phylogenetic site model averaging and model comparison. BMC Evolutionary Biology 17(1): 42. https://doi.org/10.1186/s12862-017-0890-6

Bouckaert R, Vaughan TG, Barido-Sottani J, Duchêne S, Fourment M, Gavryushkina A, Heled J, Jones G, Kühnert D, De Maio N, Matschiner M, Mendes FK, Müller NF, Ogilvie HA, du Plessis L, Popinga A, Rambaut A, Rasmussen D, Siveroni I, Suchard MA, Wu C-H, Xie D, Zhang C, Stadler T, Drummond AJ (2019) BEAST 2.5: An advanced software platform for Bayesian evolutionary analysis. PLoS Computational Biology 15(4): e1006650. https://doi.org/10.1371/journal.pcbi.1006650

Byng JW, Bernardini B, Joseph JA, Chase MW, Utteridge TM (2014) Phylogenetic relationships of Icacinaceae focusing on the vining genera. Botanical Journal of the Linnean Society 176(3): 277–294. https://doi.org/10.1111/boj.12205

Cascales J, Bracco M, Garberoglio MJ, Poggio L, Gottlieb AM (2017) Integral phylogenomic approach over *Ilex* L. species from southern South America. Life (Chicago, Ill.) 7: 47. https://doi.org/10.3390/life7040047

Chandler G, Plunkett G (2004) Evolution in Apiales: Nuclear and chloroplast markers together in (almost) perfect harmony. Botanical Journal of the Linnean Society 144(2): 123–147.

Dawson J, Lucas R (2012) Field Guide to New Zealand's Native Trees. Craig Potton.

de Lange PJ, Heenan PB, Norton DA, Rolfe JR, Sawyer JWD (2010) Threatened Plants of New Zealand. Canterbury University Press, Christchurch, 471pp.

Doyle JJ, Dickson EE (1987) Preservation of plant samples for DNA restriction endonuclease analysis. Taxon 36(4): 715–722. https://doi.org/10.2307/1221122

Drummond AJ, Ho SY, Phillips MJ, Rambaut A (2006) Relaxed phylogenetics and dating with confidence. PLoS Biology 4(5): e88. https://doi.org/10.1371/journal.pbio.0040088

Gardner RO, de Lange PJ (2002) Revision of *Pennantia* (Icacinaceae), a small isolated genus of Southern Hemisphere trees. Journal of the Royal Society of New Zealand 32(4): 669–695. https://doi.org/10.1080/03014223.2002.9517715

Gardner RO, de Lange PJ, Davidson G (2004) Fruit and seed of *Pennantia baylisiana* (Pennantiaceae). New Zealand Botanical Society Newsletter 76: 21–23.

Gernhard T (2008) The conditioned reconstructed process. Journal of Theoretical Biology 253(4): 769–778. https://doi.org/10.1016/j.jtbi.2008.04.005

Kårehed J (2001) Multiple origin of the tropical forest tree family Icacinaceae. American Journal of Botany 88(12): 2259–2274. https://doi.org/10.2307/3558388

Kårehed J (2003) The family Pennantiaceae and its relationships to Apiales. Botanical Journal of the Linnean Society 141(1): 1–24. https://doi.org/10.1046/j.1095-8339.2003.00110.x

Katoh K, Standley DM (2013) MAFFT multiple sequence alignment software version 7: Improvements in performance and usability. Molecular Biology and Evolution 30(4): 772–780. https://doi.org/10.1093/molbev/mst010

Katoh K, Misawa K, Kuma K, Miyata T (2002) MAFFT: A novel method for rapid multiple sequence alignment based on fast Fourier transform. Nucleic Acids Research 30(14): 3059–3066. https://doi.org/10.1093/nar/gkf436

Keeling D, Gardner R, de Lange P (2004) An inferred molecular phylogeny from nrDNA ITS sequences for *Pennantia* (Pennantiaceae). New Zealand Botanical Society Newsletter 76: 24–27.

Kumar S, Stecher G, Li M, Knyaz C, Tamura K (2018) MEGA X: Molecular evolutionary genetics analysis across computing platforms. Molecular Biology and Evolution 35(6): 1547–1549. https://doi.org/10.1093/molbev/msy096

Lehwark P, Greiner S (2019) GB2sequin-A file converter preparing custom GenBank files for database submission. Genomics 111(4): 759–761. https://doi.org/10.1016/j.ygeno.2018.05.003

Li H (2013) Aligning sequence reads, clone sequences and assembly contigs with BWA-MEM. arXiv preprint arXiv:1303.3997.

Li H-T, Yi T-S, Gao L-M, Ma P-F, Zhang T, Yang J-B, Gitzendanner MA, Fritsch PW, Cai J, Luo Y, Wang H, van der Bank M, Zhang S-D, Wang Q-F, Wang J, Zhang Z-R, Fu C-N, Yang J, Hollingsworth PM, Chase MW, Soltis DE, Soltis PS, Li D-Z (2019) Origin of angiosperms and the puzzle of the Jurassic gap. Nature Plants 5(5): 461–470. https://doi.org/10.1038/s41477-019-0421-0

Mabberley DJ (2017) Mabberley's plant-book: a portable dictionary of plants, their classification and uses. No.Ed. 4. Cambridge University Press, Cambridge, UK. https://doi.org/10.1017/9781316335581

Magallón S, Gómez-Acevedo S, Sánchez-Reyes LL, Hernández-Hernández T (2015) A metacalibrated time-tree documents the early rise of flowering plant phylogenetic diversity. The New Phytologist 207(2): 437–453. https://doi.org/10.1111/nph.13264

Manchester SR (1994) Fruits and seeds of the Middle Eocene nut beds flora, Clarno Formation, Oregon. Paleoutographica Americana 58: 1–205.

Manchester SR, Collinson ME, Soriano C, Sykes D (2017) Homologous fruit characters in geographically separated genera of extant and fossil Torricelliaceae (Apiales). International Journal of Plant Sciences 178(7): 567–579. https://doi.org/10.1086/692988

Miers J (1852) On some genera of the Icacinaceæ. Annals & Magazine of Natural History 9: 481–492. https://doi.org/10.1080/03745485609495623

Miller MA, Pfeiffer W, Schwartz T (2010) Creating the CIPRES Science Gateway for inference of large phylogenetic trees. Ieee, 1–8. https://doi.org/10.1109/GCE.2010.5676129

Nicolas AN (2009) Understanding evolutionary relationships in the Angiosperm order Apiales based on analyses of organellar DNA sequences and nuclear gene duplications. PhD thesis. Virginia Commonwealth University

Nicolas AN, Plunkett GM (2009) The demise of subfamily Hydrocotyloideae (Apiaceae) and the re-alignment of its genera across the entire order Apiales. Molecular Phylogenetics and Evolution 53(1): 134–151. https://doi.org/10.1016/j.ympev.2009.06.010

Nicolas AN, Plunkett GM (2014) Diversification times and biogeographic patterns in Apiales. Botanical Review 80(1): 30–58. https://doi.org/10.1007/s12229-014-9132-4

Park I, Yang S, Kim WJ, Noh P, Lee HO, Moon BC (2018) Authentication of herbal medicines *Dipsacus asper* and *Phlomoides umbrosa* using DNA barcodes, chloroplast genome, and sequence characterized amplified region (SCAR) Marker. Molecules (Basel, Switzerland) 23(7): 1748. https://doi.org/10.3390/molecules23071748

Qiu Y, Li L, Wang B, Xue J, Hendry TA, Li R, Brown JW, Liu Y, Hudson GT, Chen Z (2010) Angiosperm phylogeny inferred from sequences of four mitochondrial genes. Journal of Systematics and Evolution 48(6): 391–425. https://doi.org/10.1111/j.1759-6831.2010.00097.x

Rambaut A (2018) FigTree version 1.4.4. Computer program distributed by the author. Available from: http://tree.bio.ed.ac.uk/software/figtree/ [accessed November 27, 2018]

Rambaut A, Drummond AJ, Xie D, Baele G, Suchard MA (2018) Posterior summarization in Bayesian phylogenetics using Tracer 1.7. Systematic Biology 67(5): 901–904. https://doi.org/10.1093/sysbio/syy032

Ruhlman T, Lee S-B, Jansen RK, Hostetler JB, Tallon LJ, Town CD, Daniell H (2006) Complete plastid genome sequence of *Daucus carota*: Implications for biotechnology and phylogeny of angiosperms. BMC Genomics 7(1): 222. https://doi.org/10.1186/1471-2164-7-222

Sleumer H (1970) The identity of *Plectomirtha* Oliv. with Pennantia JR & G. Forster (Icacinaceae). Blumea 18: 217–218.

Smissen R, Heenan P (2007) DNA fingerprinting supports hybridisation as a factor explaining complex natural variation in *Phormium* (Hemerocallidaceae). New Zealand Journal of Botany 45(2): 419–432. https://doi.org/10.1080/00288250709509723

Smissen RD, Breitwieser I, de Lange PJ (in press) *Pseudognaphalium* (Asteraceae) diversity in New Zealand revealed by DNA sequences with notes on the phylogenetic relationships of plants from the Hawaiian Islands referred to *Pseudognaphalium sandwicensium*. Plant Systematics and Evolution.

Stamatakis A (2014) RAxML version 8: A tool for phylogenetic analysis and post-analysis of large phylogenies. Bioinformatics (Oxford, England) 30(9): 1312–1313. https://doi.org/10.1093/bioinformatics/btu033

Stevens P (2017) Apiales. Angiosperm Phylogeny Website. Version 14. Available from: http://www.mobot.org/MOBOT/research/APweb/orders/apialesweb.htm [accessed April 4, 2020]

Stull GW, Moore MJ, Mandala VS, Douglas NA, Kates H-R, Qi X, Brockington SF, Soltis PS, Soltis DE, Gitzendanner MA (2013) A targeted enrichment strategy for massively parallel sequencing of angiosperm plastid genomes. Applications in Plant Sciences 1(2): 1200497. https://doi.org/10.3732/apps.1200497

Swofford D (2002) PAUP*: Phylogenetic Methods Using Parsimony (* and other methods), version 4.0b. Sinauer, Sunderland, Massachusetts.

Tank DC, Donoghue MJ (2010) Phylogeny and phylogenetic nomenclature of the Campanilidae based on an expanded sample of genes and taxa. Systematic Botany 35(2): 425–441. https://doi.org/10.1600/036364410791638306

Tank DC, Eastman JM, Pennell MW, Soltis PS, Soltis DE, Hinchliff CE, Brown JW, Sessa EB, Harmon LJ (2015) Nested radiations and the pulse of angiosperm diversification: Increased diversification rates often follow whole genome duplications. The New Phytologist 207(2): 454–467. https://doi.org/10.1111/nph.13491

Winkworth RC, Lundberg J, Donoghue MJ (2008) Toward a resolution of Campanulid phylogeny, with special reference to the placement of Dipsacales. Taxon 57: 53–65.

Wright A (1989) *Pennantia baylisiana* fruiting on Great Island. New Zealand Botanical Society Newsletter 15: 16.

Yao G, Jin J-J, Li H-T, Yang J-B, Mandala VS, Croley M, Mostow R, Douglas NA, Chase MW, Christenhusz MJ, Soltis DE, Soltis PS, Smith SA, Brockington SF, Moore MJ, Yi T-S, Li D-Z (2019) Plastid phylogenomic insights into the evolution of Caryophyllales. Molecular Phylogenetics and Evolution 134: 74–86. https://doi.org/10.1016/j.ympev.2018.12.023

Yule GU (1925) II. A mathematical theory of evolution, based on the conclusions of Dr. J. C. Willis, F. R. S. Philosophical Transactions of the Royal Society of London. Series B, Containing Papers of a Biological Character 213(402–410): 21–87. https://doi.org/10.1098/rstb.1925.0002

Supplementary material 1

Figs S1–S5; Tables S1–S3

Author: Kévin J. L. Maurin

Data type: figures and tables

Link: https://doi.org/10.3897/phytokeys.155.53460.suppl1

Supplementary material 2

BEAST2 and RAxML files

Author: Kévin J. L. Maurin

Data type: molecular data

Link: https://doi.org/10.3897/phytokeys.155.53460.suppl2

PhytoKeys 155: 33–51 (2020)
doi: 10.3897/phytokeys.155.53833
http://phytokeys.pensoft.net

RESEARCH ARTICLE

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Two new species and a new species record of *Aglaia* (Meliaceae) from Indonesia

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Academic editor: Marc Appelhans | Received 1 May 2020 | Accepted 8 July 2020 | Published 7 August 2020

Citation: Pannell CM, Schnitzler J, Muellner-Riehl AN (2020) Two new species and a new species record of *Aglaia* (Meliaceae) from Indonesia. PhytoKeys 155: 33–51. https://doi.org/10.3897/phytokeys.155.53833

Abstract

Two new species of *Aglaia* from Indonesia are described, *Aglaia monocaula* restricted to West Papua, and *Aglaia nyaruensis* occurring on Borneo (Kalimantan, Brunei, Sabah and Sarawak). A phylogenetic analysis using nuclear ITS and ETS, and plastid *rps15-ycf1* sequence data indicates that the two new species of *Aglaia* are also genetically distinct. *Aglaia monocaula* belongs to section *Amoora*, while *A. nyaruensis* is included in section *Aglaia*. A dichotomous key, drawings and three-locus DNA barcodes are provided as aids for the identification of the two new species of *Aglaia*. In addition, the geographic range of *Aglaia mackiana* (section *Amoora*) is expanded from a single previously known site in Papua New Guinea to West Papua, Indonesia.

Keywords

Aglaia, conservation status, Indonesia, Meliaceae, phylogeny, taxonomy

Introduction

The classification of the family Meliaceae continues to be refined (Muellner et al. 2003, 2005, 2009a, b, Muellner and Mabberley 2008, Pennington and Muellner

* Joint first authorship.

2010, Köcke et al. 2015, Clarkson et al. 2016, Gama et al. 2020) and new taxa are still being discovered and described (e.g., Pannell 2004, 2019). *Aglaia* Lour. is the largest genus of the family, and, with at least 120 arborescent species, presents more taxonomic problems in species delimitation than any other genus of the family (Pannell 1992, 1995, 1998a, b, 2004, Muellner et al. 2005, 2008a). *Aglaia* forms an important component of the moist tropical forest in the Indomalesian region. The distribution range comprises the tropics of southeastern Asia from Sri Lanka and India to Australia (Queensland, Northern Territory, and Western Australia) and eastwards to the island of Samoa in Polynesia and north to the Mariana (Saipan, Roti, and Guam) and Caroline Islands (Palau and Ponape) in Micronesia (Pannell 1992). A monograph of the entire genus throughout its range has been published (Pannell 1992), of the Malesian species, including New Guinea, in Flora Malesiana (Pannell 1995), and of the Bornean species in the Tree Flora of Sabah and Sarawak (Pannell 2007).

From the 1990s, the genus received increasing scientific focus due to its bioactivity potential (Muellner et al. 2005, and references therein), including inhibiting activity against Ebola-, corona-, Zika-, Chikungunya- and hepatitis E-viruses (Müller et al. 2018, 2020). A recent research call in the field of “Biodiversity and Health”, funded by the German Federal Ministry of Education and Research, has led to a surge of interest in the taxonomic investigation of plant groups of potential interest for the future development of new antiinfective compounds. A taxonomic survey of *Aglaia* in Indonesia in the course of this research program has led to the discovery of two new species. We here describe these two new species from Indonesia. In addition, we report a new record of *Aglaia* from Indonesia, previously known only from Papua New Guinea.

Materials and methods

Morphology

The two new species are described based on field observations and examination of herbarium specimens at BO, FHO, K, L, and A, using morphological characters that distinguish them from all other species in the genus *Aglaia*. Descriptions were written from herbarium specimens. Measurements were made with a tape-measure and calipers. The structure of the indumentum and its distribution was observed and described under a dissecting microscope at magnifications of more than 20×. Flowers were rehydrated by boiling in tap water. They were placed on a glass slide covered with 1 mm graph paper for scale and dissected, measured and described under a dissecting microscope. Additional information on locality, habitat, ecology, plant form, bark and wood characters and fruits was collected in the field and taken from herbarium labels. Conservation threat assessment followed IUCN Categories and Criteria (IUCN 2012).

DNA extraction, amplification, and sequencing

Total genomic DNA was extracted for representative samples of each species of *Aglaia* described herein (Table 1) using a Macherey-Nagel NucleoSpin Plant II kit. The protocol was modified by adding 40 ul β-mercaptoethanol and 2% polyvinylpyrrolidone (PVP). ITS was amplified either as a whole using the primer combination 17SE_m/26SE_m (Grudinski et al. 2014) or, if this failed, adding two internal primers (F1_ITS/R1_ITS, Muellner et al. 2005) to amplify the first and second part of the ITS region separately. ETS was amplified using the primers 18S_ETS (Baldwin and Markos 1998) and a newly designed primer, 18S_MEL [5'-GTG TGA GTG ATT GGA T-3'; this study]. The plastid region *rps15-ycf1* was amplified using the primer pair rps15-IGSR/ycf1-IGSR (Prince 2015).

For all amplifications, we used the Phusion High-Fidelity DNA Polymerase (New England BioLabs, Ipswich, MA, United States) according to the manufacturer's protocol. Annealing temperature for ITS (whole region or in two parts) and ETS was 51.5 °C, and for *rps15-ycf1* 51 °C. PCR products were cleaned using the NucleoSpin Extract II Kit (Macherey-Nagel, Düren, Germany). Sequencing reactions and analyses were run by LGC Genomics (Berlin, Germany).

All sequences were assembled and edited using Geneious (v7.06, Kearse et al. 2012). Consensus sequences were aligned using MUSCLE (v.3.8.31 Edgar 2004) as implemented in Geneious, and all alignments were thoroughly checked and further refined manually. For ITS, sequences were explored for the presence of several structural motifs, allowing for the detection of pseudogenes: the conserved angiosperm motif GGCRY–(4 to 7n)–GYGYCAAGGAA (Liu and Schardl 1994); the conserved (C1–C6) and variable (V1–V6) domains determined for plant ITS2 sequences (Hershkovitz and Zimmer 1996); and the conserved angiosperm motif 5´-GAATTGCAGAATCC-3´ within the 5.8S rRNA gene (Jobes and Thien 1997). Secondary structure predictions were confirmed by hemi-compensatory base changes and full compensatory base changes that preserved the predicted folding pattern. Sequences for the new species were deposited in GenBank (http://www.ncbi.nlm.nih.gov/; Table 1). Voucher information, geographic origin, and GenBank accession numbers for all samples included in this study are provided in Suppl. material 1: Table S1.

Phylogenetic analyses

Newly generated sequences of ITS were combined with the data from Muellner et al. (2008b) and an improved and reduced version of the data matrix used in Grudinski et

Table 1. Voucher information and GenBank accession numbers for *Aglaia monocaula* and *A. nyaruensis*.

Taxon	Locality	Voucher	ITS	ETS	*rps15-ycf1*
A. monocaula	West Papua	Polak 1221 (FHO)	MT439806	MT439713	MT409504
A. nyaruensis	Kalimantan	Sidiyasa et al. 1422 (L)	MT439808	MT439716	MT409506
	Kalimantan	G. Laman et al. 1397 (A)	MT439807	MT439715	MT409505
	Brunei	Muellner et al. 2039 (K,BRUN)	KF212126	MT439714	–

al. (2014), which included representatives of all sections of *Aglaia* and outgroups. The best-fit model of nucleotide substitution, as determined using the Akaike information criterion (AIC) in jModelTest 2.1.10 (Darriba et al. 2012), was GTR+G for ITS and *rps15-ycf1*, and GTR+G+I for ETS. Phylogenetic analyses for each individual marker and combined datasets (both nuclear markers, all markers) were performed using MrBayes v3.2.7 (Huelsenbeck and Ronquist 2001, Ronquist and Huelsenbeck 2003) with four runs (six Markov chains each) for 20–25 million generations (depending on the marker), sampling every 10,000 steps. In the combined analyses, datasets were partitioned according to the genetic markers with model parameters being unlinked across the partitions. Efficient chain mixing and convergence of the runs to the same posterior distribution, as well as the adequacy of sampling (using the Effective Sample Size [ESS] diagnostic) were evaluated by examining the log files in Tracer v1.7 (Rambaut et al. 2018). For each analysis, a majority-rule consensus tree was constructed after excluding the first 20% of samples as burn-in.

Results and discussion

Taxonomy

Section *Amoora*

1. *Aglaia monocaula* C.M. Pannell, sp. nov.
urn:lsid:ipni.org:names:77210863-1
Fig. 1

Diagnosis. ***Aglaia monocaula*** resembles *Aglaia flavida*, from which it differs through being a smaller, unbranched tree with reticulation subprominent and no indumentum on the lamina of the lower surface of the leaflets. It is unique in the genus in having a dark blackish-brown, slightly swollen, region at the base of the petiolules.

Holotype. Indonesia. **West Papua**: Kecamatan Ayfat, neighborhood of Ayawasi, fr. 12 Feb. 1995, *K. Yumte* 126 (L)

Tree, 3–10 m high, *unbranched*, with a terminal tuft of spirally inserted leaves; bole 4 cm in diameter; latex white. Twigs greyish-brown with large orange-brown pustules, densely covered with orange-brown and dark brown compact stellate hairs at the apex, glabrescent on older wood.

Leaves 47–70 cm long, 28–32 cm wide; petiole 11–30 cm long; the petiole, rachis and petiolules with few to numerous hairs like those on the twigs, glabrescent. Leaflets 15, the laterals opposite or subopposite, coriaceous, lamina 7–16 cm long 2–5.5 cm wide, elliptical, slightly up-curved at the margins, cuneate at the slightly asymmetrical base, tapering to an acuminate apex, the acumen obtuse and 10–12 mm long; lateral

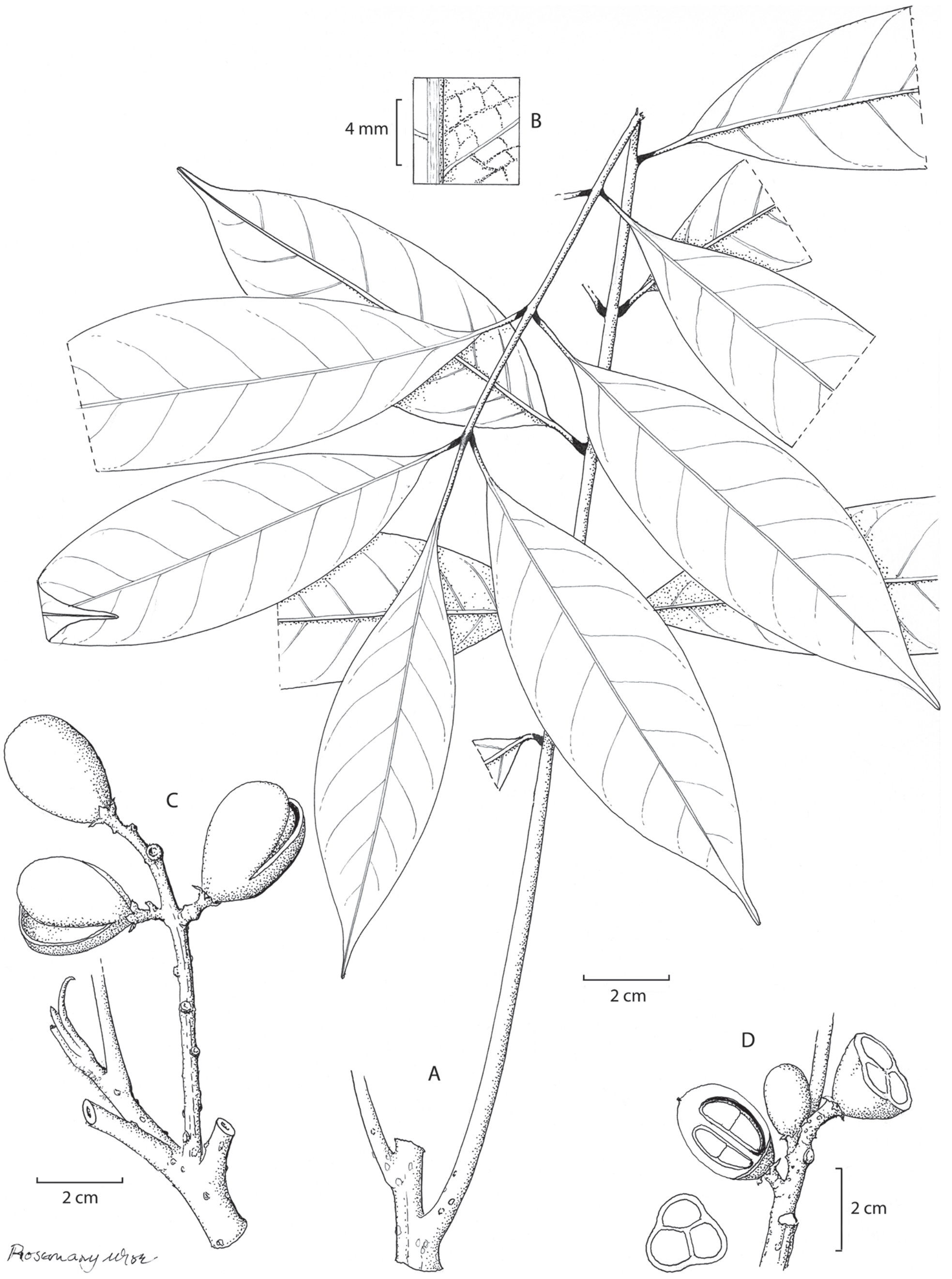

Figure 1. *Aglaia monocaula* Pannell **A** habit **B** detail of lower surface of the leaflet **C** apical shoot subtending infructescence in a leaf axil **D** part of the infructescence with fruits cut transversely to show the three seeds and longitudinally to show the junction between the two peltate cotyledons typical of the genus *Aglaia* (Drawn by Rosemary Wise, edited by Alexandra Muellner-Riehl).

veins 5–14, ascending and curved upwards near the margin, not anastomosing, lateral veins and reticulation subprominent; midrib prominent below with sparse stellate scales, absent from lower leaflet surface, upper and lower leaflet surfaces minutely rugulose; petiolules 10–15 mm on lateral leaflets, slender, 20–40 mm long on terminal leaflet, all with a dark blackish-brown, slightly swollen, region at the base of the petiolules.

Inflorescences not seen.

Infructescence 11 cm long, 7 cm wide; peduncle 6 cm long, the peduncle and fruit stalks with few to numerous hairs like those on the twigs, glabrescent. Fruits 2.8 cm long, 1.8 cm wide, ovoid, pericarp bright scarlet or pinkish-red, inner pericarp white, dehiscent with three locules each containing 1 seed; seed white where attached to the central axis of the fruit by a large hilum, aril orange.

Distribution. Known only from the area around Ayawasi village in West Papua.

Ecology. Primary open forest on limestone ridge to 600 m, with an abundant growth of moss. Fruits eaten by kuskus.

Use. Wood used for house beams.

Vernacular. sapa sai (K.Yumte)

Etymology. The specific epithet of *Aglaia monocaula* refers to the unbranched habit of this small tree.

Conservation. This species is known from only two fruiting specimens collected near Ayawasi village and is therefore assessed to be Data Deficient (provisional). Further collecting and monitoring is necessary to allow more conclusive estimations about the rareness and vulnerability of the species. However, the collections seen were made 24 and 25 years ago, so the likelihood of obtaining further material from this species is not great.

Additional specimen. Indonesia. **West Papua**: top ridge of limestone hills south of Ayawasi village, fr., 1 May 1996, *Polak* 1221 (FHO)

Notes. This new species is represented by two fruiting specimens of monocaul trees that have leaves with a long petiolule on the terminal leaflet.

Section *Aglaia*

2. *Aglaia nyaruensis* C.M. Pannell, sp. nov.

urn:lsid:ipni.org:names:77210864-1

Fig. 2

Diagnosis. *Aglaia nyaruensis* resembles *A. foveolata*, from which it differs in its smooth leaflet lower surface, with the lateral veins and reticulation not prominent. These characters, combined with numerous pits on the leaflet upper and lower surfaces, make this species unique in the genus.

Holotype. Indonesia. **Kalimantan**: Central, Nyaru Menteng Arboretum, off km 28 road to Sampit, alt. 50m, fl., 28 Jan 1995, *K. Sidyasa* with *Ambriansyah*, *Arifin & Priyono* 1422 (holotype BO; isotypes K, L).

Tree, 10–22 m high, bole 8 m, diameter 20 cm, outer bark smooth, greyish or greyish-brown, shallowly fissured and lenticellate, inner bark pink, brownish-green

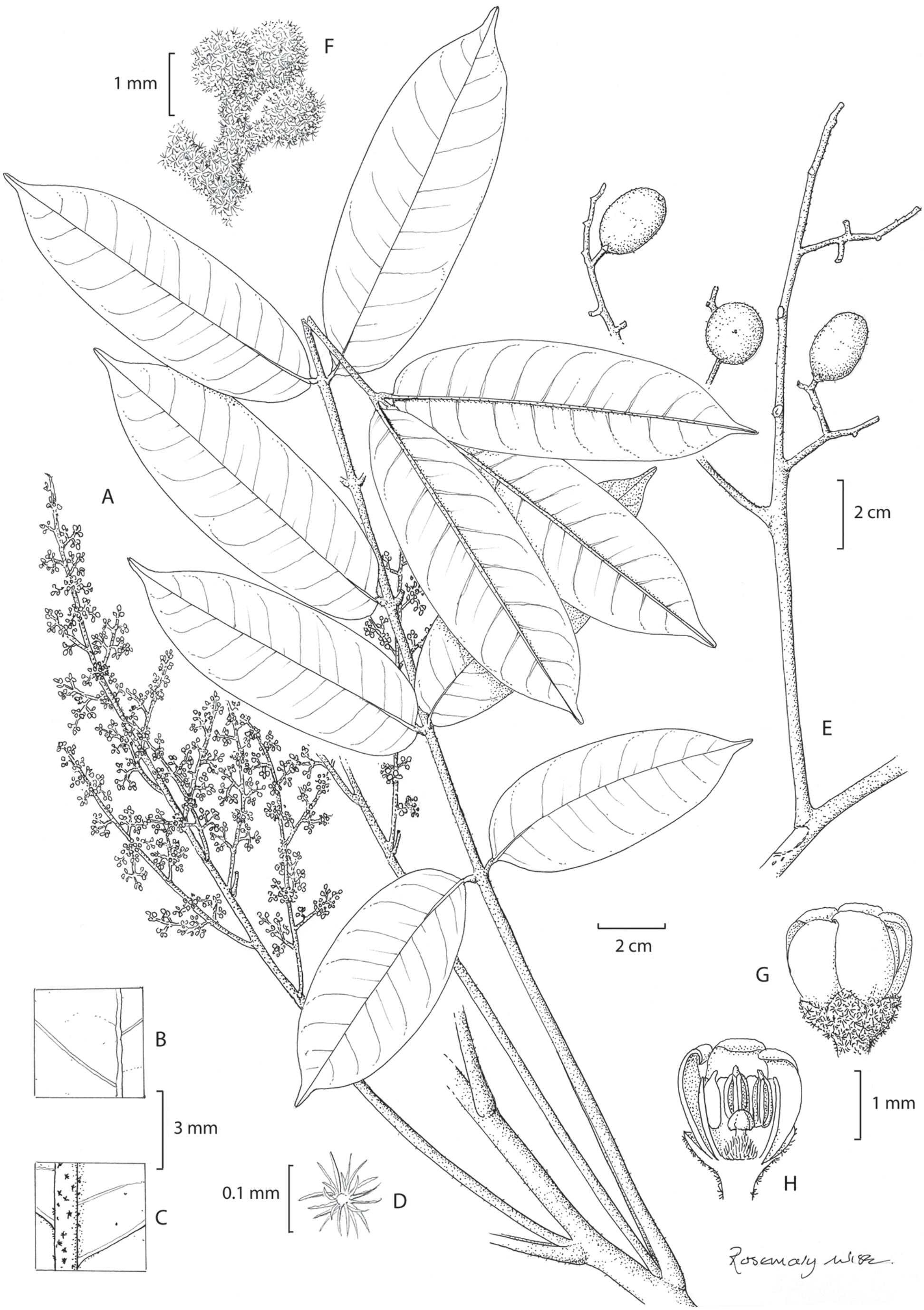

Figure 2. *Aglaia nyaruensis* Pannell **A** habit with male inflorescence **B** detail of upper leaflet surface **C** detail of lower leaflet showing distribution of indumentum **D** stellate hair **E** immature infructescence **F** male flower buds, densely covered with stellate hairs **G** male flower **H** half male flower (Drawn by Rosemary Wise, edited by Alexandra Muellner-Riehl).

or brown and fibrous, sapwood pale yellow, heartwood white; latex white or absent. Young twigs densely covered with reddish-brown stellate hairs and scales.

Leaves 25–31(–60) cm long, 14–21(–34) cm wide; petiole 7–9 cm long, the petiole, rhachis and petiolules densely covered with reddish-brown stellate hairs. Leaflets 11–15, the laterals subopposite, lamina 5.5–11.0 cm long 2.5–4.0 cm wide, narrowly oblong or elliptical, pale brownish-green when dry, rounded to cordate at the asymmetrical base, acuminate at apex with the acute acumen narrow and to 15 mm long; lateral veins 10–15, ascending and curved upwards near the margin, anastomosing some distance from the margin and with further reticulation between this and the margin of the leaflet, with shorter lateral veins in between. Midrib prominent below, lateral veins and reticulation not raised and barely visible in dried leaflets, the midrib on the upper surface of leaflet with numerous pale brown stellate hairs and scales, the midrib on the lower surface densely covered with reddish brown stellate hairs and scales, numerous on the lower leaflet surface when young, glabrescent, becoming sparse on the mature lamina near the midrib and absent from the rest of both surfaces of the lamina, with numerous pits on both surfaces; petiolules to 3 mm long on lateral leaflets to 10 mm long on terminal leaflet.

Male inflorescence 20 cm long, 10 cm wide; peduncle 8–9 cm long, the peduncle, rachis and first branches densely covered with reddish-brown stellate hairs and scales; higher orders of inflorescence branches with numerous reddish-brown stellate hairs and scales. Male flower 2 mm long, 2 mm wide; pedicel 1 mm long, the calyx and pedicel densely covered with reddish-brown stellate hairs and scales; calyx cup-shaped, deeply divided into five rounded lobes, petals 5, 1.75 mm long, 1 mm wide, yellow, obovate; staminal tube 1.5 mm long, 1.5 mm wide, obovoid with a wide mouth 1.5 mm across, anthers 6, 0.75 mm long, 0.25 mm wide, inserted half way down the tube inside and protruding through the aperture; ovary 0.5 mm long, 0.5 mm wide, ovoid, densely covered with brown stellate hairs and scales on the outside, with two locules each containing one vestigial ovule. Female flowers not seen.

Infructescence 24 cm long, 26 cm wide, peduncle 8 cm; peduncle rachis and branches densely covered with reddish-brown stellate hairs and scales. Young fruits 2 cm long, 1.5 cm wide, ellipsoid, reddish-orange, densely covered with reddish-brown stellate hairs and scales.

Distribution. One record each from Kalimantan, Brunei, Sabah and Sarawak.

Ecology. Peat swamp forest, swampy forest on white sand, on ultrabasic soil or on yellow-brown sandy soil over Tertiary clays, with deep litter and abundant humus and living roots. Altitude to 400 m.

Vernacular name. Jalongan sasak (Bejang b. Sitam).

Etymology. The specific epithet of *Aglaia nyaruensis* refers to the type locality, Nyaru Menteng in Kalimantan.

Conservation (provisional). This species is known from one locality each in Kalimantan, Brunei, Sabah and Sarawak and is therefore considered to be Vulnerable.

Additional specimens. Malaysia. **Sarawak:** Sibu, Haman Forest Reserve, c. 3 m alt, fr 18 June 1958, *Bejang b. Sitam* 9169 (K); **Sabah:** Sandakan, Bt Tawai Forest Reserve, 400 m alt., young flowers 26 June 1996, *S. Diwol & L. Madani* SAN

135187 (K). Brunei, **Belait:** Sungai Liang, Andalau Forest Reserve Compartment 5, 4°38'41"N, 114°30'20"E, 30 m alt., sterile, 8 March 2004, *A.N. Muellner*, *C.M. Pannell*, *G. Challen*, *Jangurun*, *Muhd Yussof*, *Ibrahim* ANM2039 (K).

New record for West Papua, Indonesia

Aglaia mackiana **Pannell, Kew Bull. 52(3): 715. 1997.**
Fig. 3

Remark. Previously known only from the type locality in Papua New Guinea, this tall tree species in section *Amoora*, has the largest fruits recorded for the genus *Aglaia*. Collections from West Papua are of immature fruits and flower buds.

Distribution. Indonesia, two records from West Papua. In Papua New Guinea, known only from the type locality in Chimbu Province.

Ecology. Primary lowland forest on the coastal plain and to 450 m altitude; canopy 25–45 m high; associate species include *Celtis*, *Sterculia*, *Pometia*, *Ficus*, *Oncospermum*, and sundry Rubiaceae. Canopy tree to 45 m tall, branching above; bole c. 1 m diameter, buttressed below; bark tan, smooth, somewhat round flaky; fruits 12–16 cm diameter, light brown, lactiferous, 3-lobed. In Papua New Guinea, the fruit either dehisces on the tree and the seeds fall to the ground or the whole fruit falls from the tree and dehisces on impact with the ground. The seeds are swallowed whole by the Dwarf Cassowary and defaecated at up to 1000 m from the parent trees (Mack 1995a, b; Pannell 1997). A fruit bat (probably *Dobsonia moluccensis*) carries seeds shorter distances, reportedly less than 100 m, away from the parent tree. Germination is semi-hypogeal, within a few days of deposition of seeds; the two large cotyledons persist at ground level for up to two years after germination.

Vernacular. 'sapa peka' (Wanda Ave 4394)

Etymology. Named after Andrew Mack, who discovered this species in the course of his field work on the Dwarf Cassowary.

Conservation. This species is known from only three localities, two in Papua and one in Papua New Guinea. It is therefore assessed to be Data Deficient (provisional). Further collecting and monitoring is necessary to allow more conclusive estimations about the rareness and vulnerability of the species. However, the collections seen were made 24, 25, 27, and 28 years ago, so the likelihood of obtaining further material from this species is not great.

Additional specimens. Indonesia. **West Papua:** surroundings of Ayawasi, 1°09'S, 132°12'E, c. 450m, fruit, 30 April 1996, *Wanda Ave* 4394 (L); Sarmi, coastal plain, 1–3 km N of Sewan on the Waske River. 2°4'S, 138°46'E, 10–20 m, fr., 3 June 1993 *McDonald and Ismail* 3786 (BO, L, K). Papua New Guinea. **Chimbu Province:** Crater Mountain Biological Research Station, 145043–45'S, 6'05–58'E, leaves only, 1992, Mack 699 (FHO! holotype); same locality, ?1995, fruit only, Ross Sinclair RS 105 (FHO!); same locality, seeds only, 18 Aug. 1995, Mack s.n. (FHO!); same locality, fallen male inflorescences only, no date, Mack 297 (A):

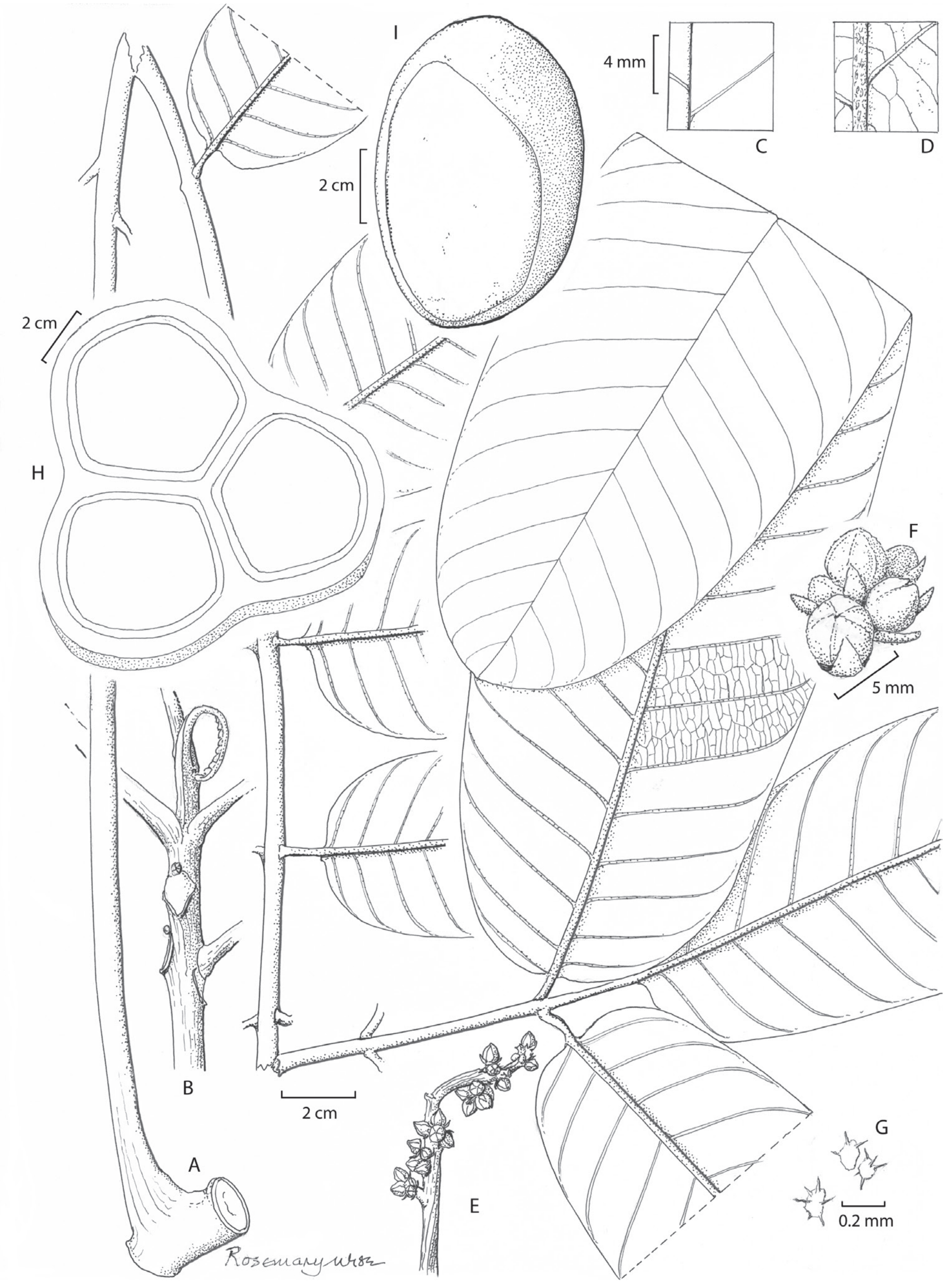

Figure 3. *Aglaia mackiana* **A** leaf with attachment to twig **B** apex of shoot **C** detail of upper leaflet surface **D** detail of lower leaflet surface **E** immature inflorescence **F** flower buds **G** peltate scales **H** transverse section of immature fruit with three seeds **I** seed, with large hilum and intact aril (Drawn by Rosemary Wise, edited by Alexandra Muellner-Riehl).

New species inserted into a truncated version of the existing key to the species of *Aglaia* in Malesia

To accommodate the three species the following couplets (in bold, labelled (i) and (ii), can be inserted into the existing key to Malesian *Aglaia* by Pannell (1995, pp. 201–212)]

1a	Leaf always a single blade	**2**
1b	Leaves trifoliolate or imparipinnate	**7**
7a (1)	Leaflets with few or no hairs or scales on the lower surface, the reticulation continuous and subprominent on one or both surfaces	**8**
7b	Leaflets with at least some scales or hairs on the lower surface, although these may be few and difficult to see, reticulation not continuous and subprominent on either surface, or if subprominent, then with indumentum on lower surface of leaflet	**10**
8a (7)	Leaflets with reticulation subprominent on the lower surface	**8a (i) & (ii)**
8a(i)	Tree branched, leaflets 2–7, fruits indehiscent	**66. *A. cumingiana***
8a(ii)	Tree unbranched, leaflets 15, fruits dehiscent	***A. monocaula***
8b	Leaflets with reticulation subprominent on both surfaces	**9**
10a (7)	Leaflets linear-lanceolate or narrowly elliptical, most being at least 5 times longer than wide	**11**
10b	Leaflets ovate, elliptical, oblong, obovate, lanceolate or oblanceolate, most less than 5 times longer than wide	**14**
14a (10)	Indumentum dense, of white or pale brown hairs or scales which totally conceal the lower surface of leaflet	**15**
14b	Indumentum reddish-brown or, if pale, not totally concealing the lower surface of leaflet	**20**
20a (14)	Lower surface of leaflet so densely covered with reddish-brown or orange brown hairs or scales, that the surface is not or barely visible between them	**21**
20b	Hairs or scales absent from the lower surface or, when present, the lower surface of leaflet readily visible between them	**24**
24a (20)	Indumentum of peltate scales, sometimes with stellate scales interspersed	**25**
24b	Indumentum of stellate hairs or scales; peltate scales absent	**69**
25a (24)	Indumentum of peltate scales only	**26**
25b	Indumentum of peltate and stellate scales (or with at least some of the scales with a long fimbriate margin)	**60**
26a (25)	Scales densely covering lower surface of leaflet	**27**
26b	Scales ± absent to numerous on lower surface of leaflet	**31**
31a (26)	Scales few to numerous on lower surface of leaflet	**32**
31b	Scales ± absent from lower surface of leaflet but may densely cover the midrib below and immediately adjacent to it and occasionally on the lateral veins	**46**
46a (31)	Scales densely covering the midrib on lower surface of leaflet and immediately adjacent to the midrib, occasionally also on the lateral veins	**47**

46b	Scales ± absent from lower surface of leaflet	**54**
47a (46)	Scales large (many 0.2 mm across), orange-brown, reddish-brown or almost white, with a tendency to flake off	**48**
47b	Scales less than 0.2 mm across or if larger, then dark reddish-brown or purplish-brown and adhering closely to the leaflet	**50**
50a (47)	Anthers and/or staminal tube with simple white hairs	**51**
50b	Anthers and staminal tube without hairs	**52**
52a (50)	Leaflets with purplish-brown fimbriate peltate scales densely covering the midrib below and ± absent from the rest of the lower surface of the leaflet	**34. *A. glabrata***
52b (50)	Leaflets with dark reddish-brown peltate scales numerous on the midrib below	**53**
53a (52)	Leaflets 7–23, stellate scales absent	**53a (i) & (ii)**
53a(i)	Leaflets 11–23, 50–88 cm long, 36–54 cm wide, fruits dehiscent, at least 12.5 cm long and 10 cm wide	***A. mackiana***
53a (ii)	Leaflets (7-)9–13(-15), 5–18.5 cm long, 1.5–4.5 cm wide, fruits indehiscent, 1.5–3 cm long, 2–3.5 cm wide	**33. *A. scortechinii***
53b	Leaflets 3–5(-7), some stellate scales interspersed among the peltate scales.	**50. *A. odoratissima***
69a (24)	Leaflets with few to densely covered with stellate hairs or scales on the lower surface; when sparse, some hairs or scales occur evenly distributed between the veins and their presence visible with the naked eye	**70**
69b	Leaflets without or with few hairs on the lower surface, with scales visible only with a lens or densely covered with hairs on the midrib only, few and unevenly scattered on the rest of the lower surface	**88**
88a (69)	Lower surface of leaflet with numerous stellate or peltate scales	**89**
88b	Leaflets with hairs or scales few on the lower surface between the veins when mature, but sometimes densely covering the midrib	**93**
93a (88)	Stellate hairs or scales more than 0.15 mm in diam., numerous on or densely covering the midrib, sometimes also on the lateral veins, almost absent elsewhere	**94**
93b	Stellate hairs or scales either very small, less than 0.15 mm in diameter, or almost totally absent from the midrib below and from the rest of the lower surface of leaflet	**109**
94a (93)	Leaves ± sessile or with a short peduncle of not more than 1 cm; the basal part of leaflets much smaller than the rest and subrotund	**61. *A. subsessilis***
94b	Leaves not sessile, the basal leaflets only slightly smaller than the rest and of similar shape	**95**
95a (94)	Reticulation subprominent on lower surface and often on upper surface of leaflet	**96**
95b	Reticulation may be visible, but not subprominent	**97**
97a (96)	Petals 3, densely covered with stellate scales on the outside; fruits dehiscent	**9. *A. lepidopetala***

97b	Petals 5, without scales on the outside, fruits indehiscent	**98**
98a (97)	Tree unbranched; leaflets shiny	**69. *A. coriacea***
98b	Tree branched; leaflets not shiny	**99**
99a (98)	Fruit c. 0.5 cm in diameter, with few stellate scales	**64. *A. aherniana***
99b	Ripe fruit 1 cm or more in diameter, with dense indumentum	**100**
100a (99)	Leaflet apex with a parallel-sided acumen	**101**
100b	Leaflet apex with a tapering acumen	**102**
101a (100)	Leaflets coriaceous	**42. *A. forbesii***
101b	Leaflets not coriaceous	**101b (i) & (ii)**
101b(i)	lateral veins subprominent	**40. *A. leptantha***
101b(ii)	lateral veins not raised	**43a *A. nyaruensis***

Markers and trees

The final lengths of our alignments were 1006 bp (ITS), 515 bp (ETS), and 600 bp (*rps15-ycf1*). The results of our phylogenetic analyses of the combined nuclear data were largely congruent with the infrageneric relationships of Grudinski et al. (2014). Individual analysis of the plastid data, however, resulted in a largely unresolved tree (tree not shown). Furthermore, the combination of all markers led to an overall decrease of resolution and support as compared to the nuclear dataset (partly due to the high degree of missing data in the *rps15-ycf1* data). Given that we did not find any strongly supported disagreements between the plastid and nuclear data, we here present only the results of the analyses of the combined nuclear (ITS and ETS) dataset (Fig. 4). Both new species were found to be phylogenetically well supported. *Aglaia monocaula* was found to be closely related to other members of section *Amoora* (*A. meridionalis*, *A. australiensis*) from Australia. All samples of *A. nyaruensis* formed a strongly supported clade (pp = 0.99), with an accession of *A. elliptica* from Kalimantan as sister species. Both species belong to section *Aglaia* and have an indumentum of stellate hairs and scales.

DNA barcodes

Three-locus DNA barcodes (Table 1) are provided as aids for the identification of the two new species of *Aglaia*. On purpose, we did not use the 2-locus combination of *rbcL* and *matK* as originally recommended by the CBOL Plant Working Group (Hollingsworth et al. 2009a) or other previously recommended chloroplast markers, as previous phylogenetic and barcoding studies provided evidence for their insufficient taxonomic resolution at species level in the Meliaceae (e.g., Muellner et al. 2003, Muellner et al. 2011). ITS was proposed by Kress et al. (2005) as potential barcoding region, and has repeatedly been suggested as additional marker in case resolution with plastid markers was not sufficient in the group under investigation (Chase et al. 2005; Hollingsworth et al. 2009b; also compare the review by Shneyer 2009; and many others since then).

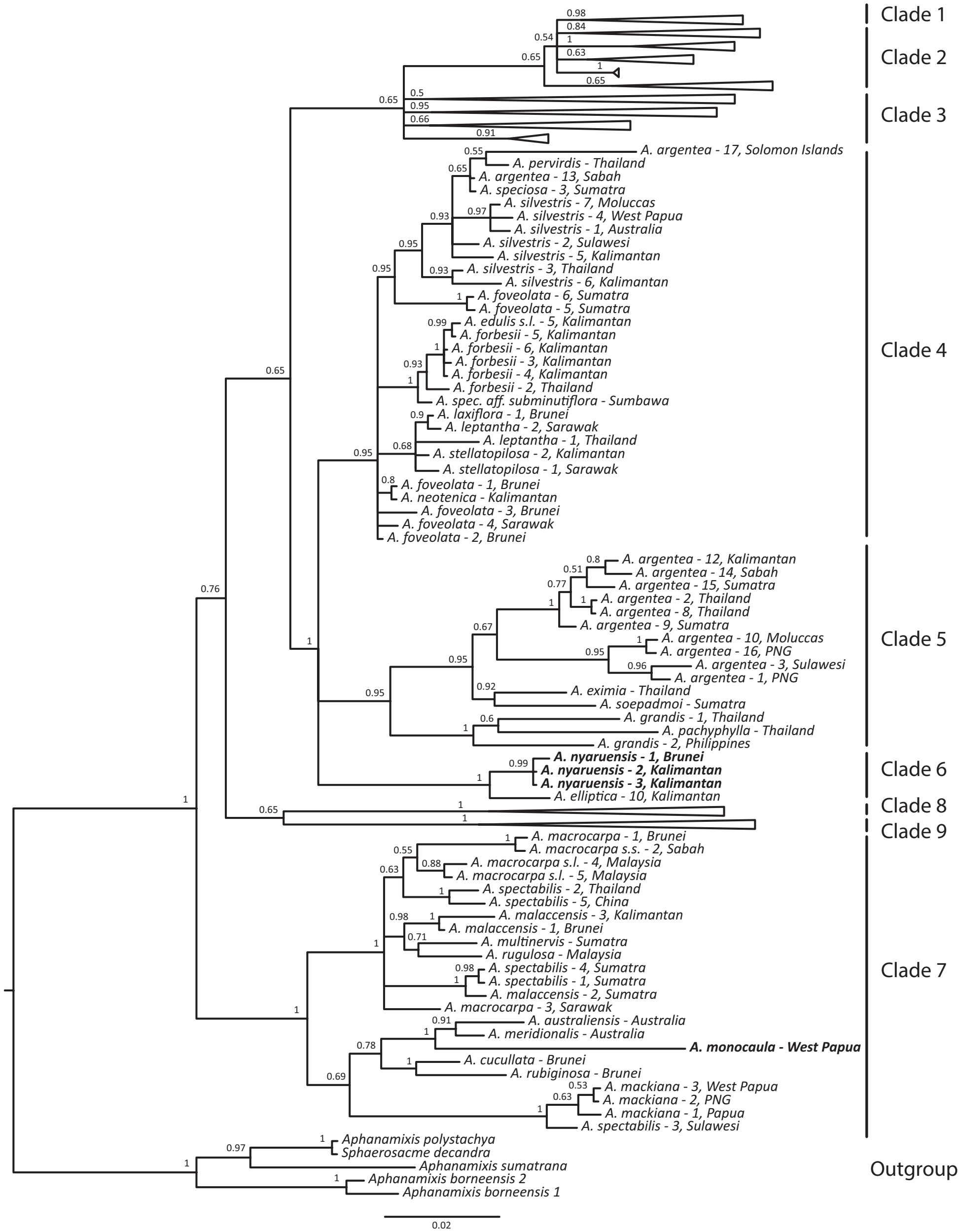

Figure 4. Majority-rule consensus tree of the combined nuclear dataset (ITS and ETS). Node values indicate Bayesian posterior probabilities. Clade numbers on the right refer to the clades identified by Grudinski et al. (2014). Clades outside the focus of this study were collapsed. Accessions of the new species (*A. nyaruensis* and *A. monocaula*) are highlighted in bold.

In previous phylogenetic studies of *Aglaia*, ITS has so far been shown to constitute the most informative DNA region out of all markers investigated (e.g., Muellner et al. 2005, Grudinski et al. 2014). Recently, Dong et al. (2012) and Dong et al. (2015)

found that parts of the plastid gene *ycf1* were very variable across flowering plants, indicating that this marker might be a useful barcode region. Finally, tests across several Meliaceae genera indicated that ETS might be another useful, i.e. informative, marker.

Acknowledgements

We would like to thank the directors and curators of the following herbaria for permission to remove samples from herbarium specimens for DNA extraction and sequencing: Naturalis, Leiden (L), Royal Botanic Gardens, Kew (K), Harvard University Herbaria (A), Smithsonian Institution, Washington (US), Daubeny Herbarium, University of Oxford (FHO), living collections and Herbarium of the University of Vienna (WU) and L for a loan received and processed by the National Botanic Gardens of Ireland (DBN); Claudia Krüger for assistance in DNA laboratory work; Rosemary Wise for the detailed botanical illustration of the species; and David Kenfack as well as an additional anonymous reviewer and the editors for useful comments on the manuscript. Financial support for this study was provided by the project "Indonesian Plant Biodiversity and Human Health – BIOHEALTH" (BMBF grant no. 16GW0120K) to Alexandra N. Muellner-Riehl. Jan Schnitzler is currently supported by the German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig funded by the German Research Foundation (DFG – FZT 118).

References

Baldwin BG, Markos S (1998) Phylogenetic Utility of the External Transcribed Spacer (ETS) of 18S-26S rDNA: Congruence of ETS and ITS Trees of *Calycadenia* (Compositae). Molecular Phylogenetics and Evolution 10(3): 449–463. https://doi.org/10.1006/mpev.1998.0545

Chase MW, Salamin N, Wilkinson M, Dunwell JM, Kesanakurthi RP, Haidar N, Savolainen V (2005) Land plants and DNA barcodes: Short-term and long-term goals. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 360(1462): 1889–1895. https://doi.org/10.1098/rstb.2005.1720

Clarkson JJ, Pennington TD, Chase MW, Haynes G, Engstrand R, Kaye M, Michalak I, Muellner-Riehl AN (2016) Phylogenetic relationships in *Trichilia* (Meliaceae) based on ribosomal ITS sequences. Phytotaxa 259(1): 6–17. https://doi.org/10.11646/phytotaxa.259.1.4

Darriba D, Taboada GL, Doallo R, Posada D (2012) jModelTest 2: More models, new heuristics and parallel computing. Nature Methods 9(8): 772. https://doi.org/10.1038/nmeth.2109

Dong W, Liu J, Yu J, Wang L, Zhou S (2012) Highly Variable Chloroplast Markers for Evaluating Plant Phylogeny at Low Taxonomic Levels and for DNA Barcoding. PLoS One 7(4): e35071. https://doi.org/10.1371/journal.pone.0035071

Dong W, Xu C, Li C, Sun J, Zuo Y, Shi S, Cheng T, Guo J, Zhou S (2015) ycf1, the most promising plastid DNA barcode of land plants. Scientific Reports 5(1): 8348. https://doi.org/10.1038/srep08348

Edgar RC (2004) MUSCLE: Multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research 32(5): 1792–1797. https://doi.org/10.1093/nar/gkh340

Gama RL, Muellner-Riehl AN, Demarco D, Pirani JR (2020) Evolution of reproductive traits in the mahagony family (Meliaceae). Journal of Systematics and Evolution.

Grudinski M, Pannell CM, Chase MW, Ahmad JA, Muellner-Riehl AN (2014) An evaluation of taxonomic concepts of the widespread plant genus *Aglaia* and its allies across Wallace's Line (tribe Aglaieae, Meliaceae). Molecular Phylogenetics and Evolution 73: 65–76. https://doi.org/10.1016/j.ympev.2014.01.025

Hershkovitz MA, Zimmer EA (1996) Conservation patterns in angiosperm rDNA ITS2 sequences. Nucleic Acids Research 24(15): 2857–2867. https://doi.org/10.1093/nar/24.15.2857

Hollingsworth PM, Forrest LL, Spouge JL, Hajibabaei M, Ratnasingham S, van der Bank M, Chase MW, Cowan RS, Erickson DL, Fazekas AJ, Graham SW, James KE, Kim K-J, Kress WJ, Schneider H, van AlphenStahl J, Barrett SCH, van den Berg C, Bogarin D, Burgess KS, Cameron KM, Carine M, Chacon J, Clark A, Clarkson JJ, Conrad F, Devey DS, Ford CS, Hedderson TAJ, Hollingsworth ML, Husband BC, Kelly LJ, Kesanakurti PR, Kim JS, Kim Y-D, Lahaye R, Lee H-L, Long DG, Madrinan S, Maurin O, Meusnier I, Newmaster SG, Park C-W, Percy DM, Petersen G, Richardson JE, Salazar GA, Savolainen V, Seberg O, Wilkinson MJ, Yi D-K, Little DP (2009a) A DNA barcode for land plants. Proceedings of the National Academy of Sciences of the United States of America 106(31): 12794–12797. https://doi.org/10.1073/pnas.0905845106

Hollingsworth ML, Clark AA, Forrest LL, Richardson J, Pennington RT, Long DG, Cowan R, Chase MW, Gaudeul M, Hollingsworth PM (2009b) Selecting barcoding loci for plants: Evaluation of seven candidate loci with species-level sampling in three divergent groups of land plants. Molecular Ecology Resources 9(2): 439–457. https://doi.org/10.1111/j.1755-0998.2008.02439.x

Huelsenbeck JP, Ronquist F (2001) MrBayes: Bayesian inference of phylogenetic trees. Bioinformatics (Oxford, England) 17(8): 754–755. https://doi.org/10.1093/bioinformatics/17.8.754

IUCN (2012) IUCN Red List Categories and Criteria - version 3.1, (2nd edn). IUCN, Gland and Cambridge, 32 pp. https://portals.iucn.org/library/node/10315

Jobes DV, Thien LB (1997) A conserved motif in the 5.8S ribosomal RNA (rRNA) gene is a useful diagnostic marker for plant internal transcribed spacer (ITS) sequences. Plant Molecular Biology Reporter 15(4): 326–334. https://doi.org/10.1023/A:1007462330699

Kearse M, Moir R, Wilson A, Stones-Havas S, Cheung M, Sturrock S, Buxton S, Cooper A, Markovitz S, Duran C, Thierer T, Ahton B, Meintjes P, Drummoned A (2012) Geneious Basic: An integrated and extendable desktop software platform for the organization and analysis of sequence data. Bioinformatics (Oxford, England) 28(12): 1647–1649. https://doi.org/10.1093/bioinformatics/bts199

Köcke AV, Muellner-Riehl AN, Cáceres O, Pennington TD (2015) *Cedrela ngobe* (Meliaceae), a new species from Panama and Costa Rica. Edinburgh Journal of Botany 72(2): 225–233. https://doi.org/10.1017/S0960428615000098

Kress WJ, Wurdack KJ, Zimmer EA, Weigt LA, Janzen DH (2005) Use of DNA barcodes to identify flowering plants. Proceedings of the National Academy of Sciences of the United States of America 102(23): 8369–8374. https://doi.org/10.1073/pnas.0503123102

Liu J-S, Schardl CL (1994) A conserved sequence in internal transcribed spacer 1 of plant nuclear rRNA genes. Plant Molecular Biology 26(2): 775–778. https://doi.org/10.1007/BF00013763

Mack A (1995a) Seed dispersal by the Dwarf Cassowary, *Casuarius bennettii* in Papua New Guinea. Ph.D. dissertation, University of Miami. https://www.researchgate.net/publication/34803848_Seed_dispersal_by_the_Dwarf_Cassowary_Casuarius_bennetti_in_Papua_New_Guinea#fullTextFileContent

Mack A (1995b) Distance and non-randomness of dispersal by the Dwarf Cassowary, *Casuarius bennettii*. Ecography 18(3): 286–295. https://doi.org/10.1111/j.1600-0587.1995.tb00131.x

Muellner AN, Mabberley DJ (2008) Phylogenetic position and taxonomic disposition of *Turraea breviflora* Ridl. (Meliaceae), a hitherto enigmatic species. Blumea 53(3): 607–616. https://doi.org/10.3767/000651908X607549

Muellner AN, Samuel R, Johnson SA, Cheek M, Pennington TD, Chase MW (2003) Molecular phylogenetics of Meliaceae (Sapindales) based on nuclear and plastid DNA sequences. American Journal of Botany 90(3): 471–480. https://doi.org/10.3732/ajb.90.3.471

Muellner AN, Samuel R, Chase MW, Pannell CM, Greger H (2005) *Aglaia* (Meliaceae): An evaluation of taxonomic concepts based on DNA data and secondary metabolites. American Journal of Botany 92(3): 534–543. https://doi.org/10.3732/ajb.92.3.534

Muellner AN, Samuel R, Chase MW, Coleman A, Stuessy TF (2008a) An evaluation of tribes and of generic relationships in Melioideae (Meliaceae) based on nuclear ITS ribosomal DNA. Taxon 57(1): 98–106.

Muellner AN, Pannell CM, Coleman A, Chase MW (2008b) The origin and evolution of Indomalesian, Australasian and Pacific island biotas: Insights from *Aglaieae* (Meliaceae, Sapindales). Journal of Biogeography 35(10): 1769–1789. https://doi.org/10.1111/j.1365-2699.2008.01935.x

Muellner AN, Pannell CM, Greger H (2009a) Genetic diversity and geographic structure in *Aglaia elaeagnoidea* (Meliaceae, Sapindales), a morphologically complex tree species, near the two extremes of its distribution. Blumea 54(1–3): 207–216. https://doi.org/10.3767/000651909X476175

Muellner AN, Pennington TD, Chase MW (2009b) Molecular phylogenetics of Neotropical Cedreleae (mahogany family, Meliaceae) based on nuclear and plastid DNA sequences reveal multiple origins of "*Cedrela odorata*". Molecular Phylogenetics and Evolution 52(2): 461–469. https://doi.org/10.1016/j.ympev.2009.03.025

Muellner AN, Schaefer H, Lahaye R (2011) Evaluation of DNA barcodes for economically important timber species of the mahogany family (Meliaceae). Molecular Ecology Resources 11(3): 450–460. https://doi.org/10.1111/j.1755-0998.2011.02984.x

Müller C, Schulte FW, Lange-Grünweller K, Obermann W, Madhugiri R, Pleschka S, Ziebuhr J, Hartmann R, Grünweller A (2018) Broad-spectrum antiviral activity of the eIF4A inhibitor silvestrol against corona- and picornaviruses. Antiviral Research 150: 123–129. https://doi.org/10.1016/j.antiviral.2017.12.010

Müller C, Obermann W, Schulte FW, Lange-Grünweller K, Oestereich L, Elgner F, Glitscher M, Hildt E, Singh K, Wendel HG, Hartmann RK, Ziebuhr J, Grünweller A (2020) Comparison of broad-spectrum antiviral activities of the synthetic rocaglate CR-31-B (–) and the eIF4A-inhibitor Silvestrol. Antiviral Research 175: 104706. https://doi.org/10.1016/j.antiviral.2020.104706

Pannell CM (1992) A taxonomic monograph of the genus *Aglaia* Lour. (Meliaceae). Kew Bulletin Additional Series XVI. HMSO, London, United Kingdom, viii + 1–379.

Pannell CM (1995) *Aglaia*. In: Mabberley DJ, Pannell CM, Sing AM (Authors), Meliaceae. Flora Malesiana I(12): 194–314. Foundation Flora Malesiana, Leiden, Netherlands. https://www.semanticscholar.org/paper/Flora-Malesiana%3A-Series-I.-Spermatophyta-Volume-12%2C-Mabberley-Pannell/f7bfe88a821e26ccb1289d502b9988b7a3011490

Pannell CM (1997) A new, cassowary-dispersed, species of *Aglaia* (Meliaceae, section *Amoora*) from Papua New Guinea. Kew Bulletin 52(3): 715–717. https://doi.org/10.2307/4110302

Pannell CM (1998a) Taxonomy, ecology and reproductive biology of *Aglaia* (Meliaceae). In: Hopkins HCF, Huxley CR, Pannell CM, Prance GT, White F (Eds) The biological monograph: The importance of field studies and functional syndromes for taxonomy and evolution of tropical plants, A Festschrift for Frank White. Royal Botanic Gardens Kew, London, United Kingdom, 59–77. https://link.springer.com/article/10.2307/2666614

Pannell CM (1998b) Species delimitation in *Aglaia*. In: Hopkins HCF, Huxley CR, Pannell CM, Prance GT, White F (Eds) The biological monograph, The importance of field studies and functional syndromes for taxonomy and evolution of tropical plants, A Festschrift for Frank White. Royal Botanic Gardens Kew, London, United Kingdom, 124–127. https://link.springer.com/article/10.2307/2666614

Pannell CM (2004) Three new species, two new subspecies and five new combinations at the subspecific level in *Aglaia* Lour. (Meliaceae). Kew Bulletin 59(1): 87–94. https://doi.org/10.2307/4111078

Pannell CM (2007) *Aglaia* (Meliaceae). In: Soepadmo E, et al (Eds) Tree Flora of Sabah and Sarawak 6: 24–107. https://www.nhbs.com/3/series/tree-flora-of-sabah-and-sarawak?qtview=154602

Pannell CM (2019) *Aglaia mabberleyi* Pannell (Meliaceae), a new species from Borneo. Gardens' Bulletin (Singapore) 71(Suppl. 2): 189–195. https://doi.org/10.26492/gbs71(suppl.2).2019-02

Pennington TD, Muellner AN (2010) A monograph of *Cedrela*. DH Books, Sherborne, UK, 1–112. https://www.nhbs.com/a-monograph-of-cedrela-book

Prince LM (2015) Plastid primers for angiosperm phylogenetics and phylogeography. Applications in Plant Sciences 3(6): 1400085. https://doi.org/10.3732/apps.1400085

Rambaut A, Drummond AJ, Xie D, Baele G, Suchard MA (2018) Posterior summarization in Bayesian phylogenetics using Tracer 1.7. Systematic Biology 67(5): 901–904. https://doi.org/10.1093/sysbio/syy032

Ronquist F, Huelsenbeck JP (2003) MRBAYES 3: Bayesian phylogenetic inference under mixed models. Bioinformatics (Oxford, England) 19(12): 1572–1574. https://doi.org/10.1093/bioinformatics/btg180

Shneyer VS (2009) DNA barcoding is a new approach in comparative genomics of plants. Russian Journal of Genetics 45(11): 1267–1278. https://doi.org/10.1134/S1022795409110027

Supplementary material 1

Table S1. Voucher information, origin, and GenBank accession numbers for all species included in this study

Authors: Caroline M. Pannell, Jan Schnitzler, Alexandra N. Muellner-Riehl

Data type: molecular data

Explanation note: New GenBank accessions (this study) are highlighted in bold.

Link: https://doi.org/10.3897/phytokeys.155.53833.suppl1

PhytoKeys 155: 53–85 (2020)
doi: 10.3897/phytokeys.155.51072
http://phytokeys.pensoft.net

RESEARCH ARTICLE

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Zapałowicz's *Conspectus florae Galiciae criticus*: Clarification of publication dates for nomenclatural purposes and bibliographic notes

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Academic editor: S. Knapp | Received 12 February 2020 | Accepted 20 May 2020 | Published 7 August 2020

Citation: Paszko B, Nikel A, Mueller-Bieniek A, Paul W (2020) Zapałowicz's *Conspectus florae Galiciae criticus*: Clarification of publication dates for nomenclatural purposes and bibliographic notes. PhytoKeys 155: 53–85. https://doi.org/10.3897/phytokeys.155.51072

Abstract

Work on the catalogue of type specimens of vascular plants deposited in the KRAM herbarium has highlighted uncertainties and errors in references to place of valid publication of numerous taxa described by Hugo Zapałowicz in his *Conspectus florae Galiciae criticus – Krytyczny przegląd roślinności Galicyi* (1904–1914). Zapałowicz published his work in an excerpt series, a serial publication and a multi-volume book, with much duplication amongst these three different forms. Despite the importance of this work, no studies have clarified the dates of publication of its various parts, as relevant to the nomenclature of numerous new taxa of Central European vascular plants described therein: 94 species and hybrids, 10 subspecies and more than 2000 other infraspecific taxa. Here, the publication dates of the component parts of Zapałowicz's work are clarified and discussed. Archival sources that made it possible to determine publication dates of these works are described in detail.

Keywords

bibliography, botanical nomenclature, history of publication, Hugo Zapałowicz, priority, taxonomic botanical literature, verification

Introduction

An eminent Polish naturalist, Hugo Zapałowicz (Fig. 1), was born on 15 November 1852 in Laibach (now Ljubljana in Slovenia) and died 20 November 1917 in Perovsk (now Kyzylorda in Kazakhstan). After graduating from high school, Zapałowicz studied law and in 1876 was awarded a doctorate at the Faculty of Law, Jagiellonian University, Kraków. Following this, Zapałowicz worked as a military lawyer, but botany, taken up early in his life, was his major passion. In 1894, Zapałowicz became a Member of the Academy of Arts and Sciences in Kraków (AAS, since 1920: Polish AAS – PAAS; in Polish, respectively: Akademia Umiejętności – AU, Polska Akademia Umiejętności – PAU) and, for a long time, had been co-operating with the Museum of the Physiographic Commission of the AAS, studying its abundant herbarium. Zapałowicz retired in 1905, after a 35 years law career, but returned to the military during World War I. Imprisoned by Russian troops, he died as a prisoner of war. Throughout his life, Zapałowicz devoted all of his leisure time to investigating the flora of the Carpathian Mountains and Galicia (today mostly the territory of western Ukraine and south-eastern Poland, Eastern Europe) (Rouppert 1918; Hryniewiecki 1953; Zdebska 1978–1979; Zdebski 1978–1979; Majkowska 2006).

In 1904, Zapałowicz began publishing his most distinguished work in the field of botany, titled *Conspectus florae Galiciae criticus – Krytyczny przegląd roślinności Galicyi* (1904–1914) [= A critical review of the flora of Galicia] (hereafter, the *Conspectus*). The *Conspectus* was a multipart work that appeared over 11 years and was published in three forms: as an excerpt series, a serial publication and a multi-volume book. The excerpts were written in French, whereas the serial and books were written in Polish; in all three forms, Latin was used for species description and taxonomic remarks. Although unfinished, the *Conspectus* is a monumental work that provided the first (but incomplete) enumeration of the vascular plants (1222 species in 52 families, including addenda) of Galicia, including descriptions of new taxa (49 species, 50 hybrids, 10 subspecies and more than 2000 other infraspecific taxa). Entries in the *Conspectus* include accepted names, selected synonyms (basionyms where appropriate), detailed Latin descriptions of most taxa, taxonomic notes, localities of herbarium specimens studied and regional distributions; taxonomic keys were not included. The *Conspectus* was issued as a book in three volumes; a projected 4th volume was never published. Volume 1 covers pteridophytes, monocotyledons and gymnosperms (Polypodiaceae-Coniferae) and Volumes 2 and 3 cover dicotyledons, including families from Betulaceae to Caryophyllaceae. Content that would have appeared in Volume 4 was published only in serial form, covering dicotyledon families from Papaveraceae to Violaceae. The work was based almost entirely on the herbarium collection housed at the Museum of the Physiographic Commission of the AAS in Kraków, including the author's own collection (Zapałowicz 1904, 1906b), currently housed at the KRAM herbarium (with some duplicates at KRA).

We identified 65 different publication events related to the *Conspectus*, including numerous duplicate nomenclaturally-redundant publications. These events comprise a 30 part excerpt series (representing 32 publication events), a 30 part serial publication and a three volume book. All but one of them were published under the same Polish title. Stafleu and Cowan (1988) listed the *Conspectus* (no. 18.599) under its alterna-

Figure 1. Hugo Zapałowicz (1852–1919). Image from http://www.cotg.pttk.pl/newsy/img/zapalowicz.jpg [Accessed September 2019].

tive Latin title, even though the Latin title was included in only 33 of the publication events (for details see Appendix I).

The 30 individual parts that make up the *Conspectus* were published separately in a Polish journal, *Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności*, *Dział B. Nauki Biologiczne* (*Seria 3*) (hereafter, the *Rozprawy*). The content of the first 21 parts of the *Rozprawy* was brought together and re-published in a three volume book, along with Addenda, Corrigenda and Index generum sections at the end of each volume. The 30 excerpts (selections) were published in advance of the serial publications and the books in an international monthly journal, *Bulletin International de l'Académie des Sciences de Cracovie*: *Classe des Sciences Mathématiques et Naturelles* (Vols. 1904–1909) and its successor, *Bulletin International de l'Académie des Sciences de Cracovie*: *Classe des Sciences Mathématiques et Naturelles*; *Série B. Sciences Naturelles* (Vols. 1910–1914) (hereafter, the *Bulletin*). Parts 1 to 21 of the *Conspectus* were published in the *Rozprawy* and in book form and excerpts from them were published in the *Bulletin*. Parts 22 to 30 were published in the *Rozprawy* and excerpts from them were published in the *Bulletin*.

Zapałowicz's names in the *Conspectus* were usually published twice and sometimes even three times, but none of these duplicate or triplicate publications indicated that the name had already been published elsewhere. A few of Zapałowicz's names, for example, *Carex* × *bogdanensis*, *C.* × *paczoskii* and *C.* × *raciborskii*, were published exclusively in the Addenda sections at the end of book volumes. Zapałowicz's names of new taxa, published in each of the various forms of the *Conspectus*, meet the conditions of the International Code of Nomenclature (ICN) for valid and effective publication (Art. 29, 30 of ICN; Turland et al. 2018). Zapałowicz's new names also meet the conditions for valid publication (Art. 32 of ICN; Turland et al. 2018); all are accompanied by Latin (rarely also French, exceptionally Polish) descriptions and/or diagnoses. Due to the multiple and mostly redundant instances of publication of Zapałowicz's work, however, there is chaos in the citations of the correct place of publication of his names in the taxonomic literature, including in Stafleu and Cowan (1988), authoritative online botanical nomenclature databases of taxon names and nomenclatural acts (International Plant Names Index (IPNI), Tropicos (Missouri Botanical Garden 2019)), as well as in the primary literature (Mitka and Starmühler 2000; Optasyuk and Shevera 2011; Ziman et al. 2015; Wacławska-Ćwiertnia and Mitka 2016; Barberá et al. 2018). Stafleu and Cowan (1988) assessed the status of Zapałowicz's book volumes as "Reprinted and to be cited from Rozpr. Akad. Umiej. Krakow ser. B". However, based on dates of publication of volumes of the *Rozprawy* that included papers presented at the AAS meetings in 1906, 1908 and 1911, we concluded that, in several cases, material published in book form could have appeared simultaneously or prior to that published in the journal. IPNI (2019) usually variously cites the *Bulletin* or book form of the *Conspectus* as the correct place of publication of Zapałowicz's names; rarely IPNI cites both sources (e.g. for "*Silene berdaui* Zapał., Bull. Acad. Cracovie 1911. B, 286; Consp. Fl. Galic. Crit. iii. 182 (1911)") or even a secondary source is cited as a second place of publication (e.g. for "*Thlaspi tatrense* Zapał., Bull. Acad. Cracovie 1913, B. 431; Just's Bot. Jahresb. xli. II. 176").

Duplicate (or multiple) publication, in whole or in part, is problematic in the context of botanical nomenclature. The verification of the dates of Zapałowicz's publications is critical because of the principle of priority: the earliest place and date of valid publication of a new name is the correct one and later redundant publication(s) of names has(ve) no nomenclatural standing. Therefore, we undertook ancillary bibliographic studies to clarify the correct dates of publication for each of Zapałowicz's works. As an addition to Taxonomic Literature II (Stafleu and Cowan 1988) records, the dates of publication of the component parts of Zapałowicz's *Conspectus* are here confirmed or revised. We also verified the data available in IPNI related to Zapałowicz's names of species and nothospecies (IPNI 2019), including verification of a few names published outside the *Conspectus*.

Material and methods

We reviewed materials housed in the Jagiellonian Library (the *Rozprawy*, Vols. 4B–14B; the bookselling catalogue of the Spółka Wydawnicza Polska [= Polish Publishing Company] in the collection Documents of Everyday Life, Vols. 1904–1912; the bookselling catalogue of Gebethner and Co. Publishing House, digital copies accessed via Jagiellonian Digital Library, Vols. 1904–1911; accession books of the Jagiellonian Library from 1904–1914 in the collection of the Manuscript Section), in the Scientific Library of the PAAS and Polish Academy of Sciences (PAS) (the *Rozprawy*, Vols. 4B to 14B; the *Bulletin*, Vols. 1904–1914) and in the library of the W. Szafer Institute of Botany, PAS (the *Rozprawy*, Vols. 4B–14B; the *Bulletin*, Vols. 1904–1914), all located in Kraków, Poland. Additionally, we reviewed the following library collections: Ernst Mayr Library of the Museum of Comparative Zoology at Harvard University, Smithsonian Libraries and the LuEsther T. Mertz Library of the New York Botanical Garden (the *Bulletin*, Vols. 1904–1909, 1911–1914; digital copies accessed via the Biodiversity Heritage Library (BHL, biodiversitylibrary.org), September 2019). We consulted additional libraries in several countries for the presence in their depositories of wrappers (i.e. temporary covers usually disposed of by the binders) of the fascicles of the *Rozprawy* from volumes 4B–14B.

We follow journal abbreviations provided in the database BPH Online (Hunt Institute for Botanical Documentation 2019). If a title is given in two languages, the second title is preceded by a dash (–). Titles (generally English translations) in square brackets and preceded by the equals sign [=] were determined by us, not the original author. For the Polish "zeszyt" of the *Rozprawy*, we generally use the English equivalent "fascicle" and, for the French "livraison" of the *Bulletin*, we use "issue".

Results and discussion

Determination of publication dates

A multilingual international journal, the *Bulletin* and a Polish-language journal, the *Rozprawy*, were edited by the AAS and both consisted of papers presented at the meetings of the Class of Mathematics and Natural Sciences of the AAS. We first searched for explicit evidence about the publication dates (imprint date) of these journals within them. In the *Bulletin*, the publication date of each issue, precisely to the day, is specified in the work itself. The *Rozprawy* volumes, apart from the imprint date at the foot of the title page, labelled each paper according to the date of presentation at the AAS meeting (Suppl. material 1: Table S1). These presentation dates cannot be accepted as publication dates according to Article 31.1 of the ICN (Turland et al. 2018; Turland 2019). In such situations, it becomes necessary to seek additional information to determine the dates of effective publication. The actual years of publication of the *Rozprawy* volumes may vary from the imprint years at the foot of the title page, since books published in December (and sometimes even November) commonly bear the imprint of the following year and books published in January or February occasionally bear the imprint of the preceding year.

External sources

In cases where the original work either does not provide information on the precise date of publication or the date it bears is suspected of being inaccurate, we pursued additional evidence, external to the work itself. The newly-published editions of the AAS were recorded and advertised by its Bibliographic Commission in the bibliographic indexes published in two journals. The monthly reports were listed in the section entitled *Bibliografia* [= Bibliography] in the journal *Sprawozdania z Czynności i Posiedzeń Akademii Umiejętności w Krakowie* [= Reports on the AAS's Activities and Meetings (Kraków)] (hereafter, the *Spraw. AU*). The annual reports were published in the journal *Rocznik Akademii Umiejętności w Krakowie* [= AAS Annual (Kraków)] (hereafter, the *Rocznik AU*). In the former journal, the publications most frequently were dated to the nearest month; rarely a range of dates was given (e.g. August–October 1905). In the latter journal, the publications were recorded from 1 May to 30 April of the following year. These records are a rich source of bibliographical information about the publications of the AAS, including signature size, publication prices and, in the case of journals, the table of contents with page numbers. In addition, the notification of the new publications at the sessions of the Class of Mathematics and Natural Sciences of the AAS were noted in years 1912–1914 in the section *Sprawozdania z posiedzeń* [= Reports from the meetings].

All Zapałowicz's works considered here were printed at the Jagiellonian University Printing House (currently Jagiellonian University Press); therefore, we searched the printing house's 1904–1914 bill books, which are preserved in the Archives of the Jagiellonian University (ref. codes DUJ 185–DUJ 193), to determine the date of the printing of the *Rozprawy* volumes in years 1904–1914. We found that bills were usually passed from the printing house to the AAS three times per year and dozens of bills for several journals of the AAS were written with the same date. We also checked handwritten minutes of meetings of the Class of Mathematics and Natural Sciences of the AAS from the years 1904–1914, which are housed at the Archives of Science of the PAS and the PAAS, to determine the publication dates of the individual fascicles that comprise volumes of the Rozprawy in years 1904–1914.

The publications of the AAS were distributed by the Spółka Wydawnicza Polska [= Polish Publishing Company] and Gebethner and Co. Publishing House (Stachowska 1973; Gruca 1993). Therefore, we searched their bookselling catalogues, reference copies of which are stored in the collection Documents of Everyday Life of the Jagiellonian Library.

Finally, dates of receipt or accession of the published journal by institutions, societies or museums provide absolute evidence of the latest date that a particular work was published. We searched the accession books of the Jagiellonian Library for dates of receipt of the *Rozprawy* in years 1904–1914. We also located such information for the Tromsø Museum library, which published similar reports in the journal *Tromsø Museum Aarsberetning* [= Tromsø Museum Reports].

Discussion on particular series

1A. *Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles – Anzeiger der Akademie der Wissenschaften in Krakau. Mathematisch-Naturwissenschftliche Klasse* (Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math.) (1901–1909); continued, in part, by

1B. *Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles – Anzeiger der Akademie der Wissenschaften in Krakau*: *Mathematisch-Naturwissenschftliche Klasse*. *Reihe B. Biologische Wissenschaften* (Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Sér. B, Sci. Nat.) (1910–1918)

This journal was characterised by frequent title changes at the turn of the 19th and 20th centuries. Initially, there were two international journals founded and administered by Polish scientists in which botanical papers were published. These were a French-language journal, *Bulletin International de l'Académie des Sciences de Cracovie* (1890–1901) and a German-language journal, *Anzeiger der Akademie der Wissenschaften in Krakau* (1890–1901). These two journals were merged in 1902 and the new multilingual journal with a bilingual title was published until 1909. At the same time, the journal was divided into classes; botanical papers went into *Classe des Sciences Mathématiques et Naturelles – Mathematisch-Naturwissenschaftliche Klasse*. Beginning in 1910, the journal was divided into two series; botany was included in *Série B. Sciences Naturelles – Reihe B. Biologische Wissenschaften*. These two series consisted of research summaries (some of them up to two signatures long) that were intended for an international audience. The *Bulletin* was an important platform for Polish scientists for quick dissemination of their scientific research results abroad (Stachowska 1973). In the case of Zapałowicz, a subset of his nomenclatural and taxonomic novelties was excerpted from the Rozprawy prior to publication and printed in the *Bulletin*.

The *Bulletin* used the years of the covered AAS meetings as volume numbers and its issues were numbered starting at one in each year. In all cases except Volume 1907, published in 1907, the volume number (year) preceded the year of its completion (e.g. Volume 1905 was issued in 1906). Each volume consisted of papers presented during a calendar year at ten monthly meetings of the Class of Mathematics and Natural Sciences of the AAS. Consequently, its volumes each comprised ten issues, appearing after every meeting and each issue comprised papers presented there. Beginning in 1910, the issues were printed in 16-page signatures (in *octavo*), with total pages per issue being multiples of 16 (16, 32, 48 etc.). Given this, the published papers could be divided between two adjacent signatures that were published separately. In issues of volumes 1904 to 1909, the date is given on the last text page of the issue, whereas in issues of volumes from 1910 to 1914, the date is given on the verso of the front wrapper. In the *Bulletin*, the title-page date of the volume represents the data of completion of the multipart work, whereas the individual parts were published on earlier dates. In the *Bulletin*, date research is easiest with sets in which the issue wrappers were preserved by the binders, either bound in place or sometimes at the end of a volume. However, the wrappers were often discarded when a volume was complete and sent for binding. In many libraries, no wrappers have been preserved, for example, in the Library of the PAAS and PAS and in the Jagiellonian Library. In the library of the W. Szafer Institute of Botany PAS, however, the wrappers are bound at the end of a volume and some unbound issues in the original wrappers are also housed there. Copies available online in the Biodiversity Heritage Library include the complete issue wrappers bound in place.

The 30 excerpts from Zapałowicz's work, written in French and Latin, were issued in the *Bulletin* in years 1904 (Vol. 1904, Issue 4) to 1914 (Vol. 1914, Issue 4B). Two parts (23 and 27) were further subdivided between two adjacent signatures and published separately (for details see Suppl. material 1: Table S1). The first part was titled *Uwagi krytyczne nad roślinnością Galicyi – Remarques critiques sur la flore de la Galicie*, while the following ones, from the second to the thirtieth, were titled *Krytyczny przegląd roślinności Galicyi – Revue critique de la flore de la Galicie*, with accompanying part numbers in Roman numerals (see Appendix I).

In the excerpts, Zapałowicz published 72 new names of species and nothospecies and more than 80 names of infraspecific taxa, accompanied almost always by Latin descriptions and/or diagnoses. In one case, *Gypsophila paniculata* L. subsp. *lithuanica* Zapał., there is only a short diagnosis in French but, because the publication dates to before 1935, this French diagnosis does not preclude valid publication of that name. For a list of taxa published in the excerpts, see Suppl. material 1: Table S1. Zapałowicz's work published in the *Bulletin* preceded its publication in serial form in the *Rozprawy* (see below) and, therefore, publication dates of names that first appeared in the *Bulletin* are the relevant ones for nomenclatural purposes.

2. *Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności*, *Dział B. Nauki Biologiczne* (*Seria 3*) (Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol.) (1901–1919)

This Polish journal ran from 1901 to 1919 in its third series, as volumes 1B–18B or volumes 41B–58B of the journal as a whole. Here, we use the former numbering. Each volume of the journal comprised full-text versions of the selected papers presented during a particular calendar year at the meetings of the Class of Mathematics and Natural Sciences of the AAS. Papers accepted for publication in the journal, were printed in 16-page signatures (in *octavo*) with continuous pagination. Zapałowicz's work was issued there in 30 parts in Polish with Latin descriptions/diagnoses and taxonomical remarks. The parts were published in volumes 4B to 14B(1) and titled *Conspectus florae Galiciae criticus – Krytyczny przegląd roślinności Galicyi* with respective part number (see Appendix I and Suppl. material 2: Table S2).

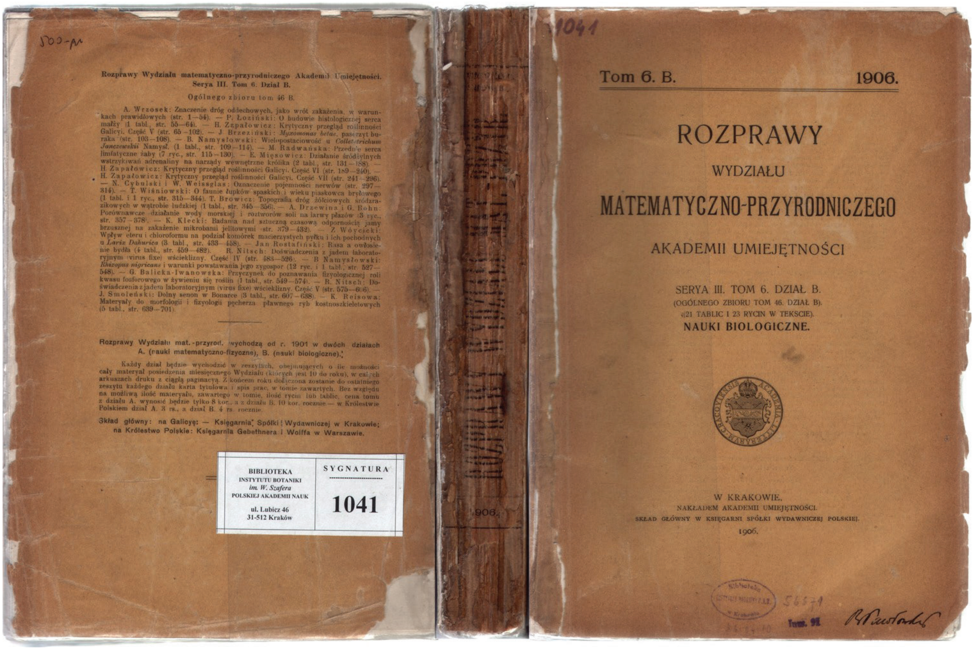

Figure 2. The illustration of binding of Volume 6B of the *Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności*, *Dział B. Nauki Biologiczne* (*Seria 3*) showing its book spine and the outside covers, with the 1906 date at the foot of the front cover. Copy from the library of the W. Szafer Institute of Botany, Polish Academy of Sciences (Kraków, Poland).

Information for subscribers provided by the journal itself, on the preserved wrappers of some full year's volumes, i.e. 1B, 2B, 3B, 4B, 6B (see Fig. 2), 7B and 8B, on their outside back covers, indicated that its volumes would be published in fascicles. The number of these fascicles was never determined, suggesting it varied from one year to another. This information is absent on the wrappers from Volume 12B onwards, which suggests that this practice had been abandoned. Moreover, on these wrappers, the contents of the preceding volumes were listed, followed by the content of the current volume (see Fig. 2), where sometimes division into fascicles was indicated. In Volume 8B, no information on its division into fascicles is presented on its outside back cover. The information about division into fascicles might also have been determined from the individual covers (fascicle wrappers) of the relevant separate fascicles, but few of them have survived.

Although the *Rozprawy* was, at least in several years, published and sent to subscribers in fascicles, the basic sale unit was the journal volume, one per year. After a volume had been completed, it was no longer available in fascicles. The paperback or hardcover copies from the period 1904–1914, to which we had access, do not contain any information that allows recognition of their division into fascicles and their arrangement (except in part volumes 7B and 8B – see Suppl. material 3: Table S3). As there was no fixed schedule for fascicle publication, their frequency of publication is unknown. Our library research showed that some libraries probably received complete volumes of this journal, rather than individual fascicles, because we found only the original paperback volume wrappers in those collections. For example, the library of the W. Szafer Institute of Botany PAS has several volumes of the *Rozprawy* in the original wrappers (Fig. 2) and the British Library houses volumes of the *Rozprawy* with wrappers bound at the end of volumes. Thus, the fascicle compositions and their exact dates of publication are difficult to establish with confidence. The only date is the year (imprint year) provided at the foot of the title page of the complete year volume.

An annotated bibliography of literature relating to botany published by the AAS and PAAS was compiled by Köhler (2004). However, the actual publication dates of volumes of the *Rozprawy* given by him are inaccurate (for details see Suppl. material 2: Table S2). Thus far, there have been a few studies dealing with publication dates of the parts of Zapałowicz's *Conspectus* issued in the *Rozprawy*. Recently, Wacławska-Ćwiertnia and Mitka (2016) and Paszko et al. (2020) attempted to establish the date of publication for Parts 12 and 13 of the *Conspectus* that appeared in Volume 8B of the *Rozprawy* with imprint year 1909. Based on the bibliographic information from the *Spraw. AU*, Volume 8B was issued in March 1909 (Suppl. material 2: Table S2). Therefore, in the case of this volume, the year provided at its title page is reliable. Wacławska-Ćwiertnia and Mitka (2016) located a copy of Volume 8B at the Jagiellonian Library (ref. no. 284061/III, not 28061/III as given in their paper). This copy of Volume 8B is the only one of these published in 1904–1914 that preserves the original front wrappers (partly damaged) of Fascicles 1 and 3 (see fig. 4 in Paszko et al. 2020). However, no precise (day) dates are provided on these two fascicles; they are dated only 1908 and 1909, respectively. According to the contents listed on its wrapper, Fascicle 1 included eight papers, amongst them Parts 12 and 13 of the *Conspectus* (Zapałowicz 1909a, b). Volume 2 of the book version of the *Conspectus* (Zapałowicz 1908; see below), which comprises the text of these two parts, also bears the imprint year 1908. As none of this information clarifies which source was published first, Wacławska-Ćwiertnia and Mitka (2016) searched the 1908 bill book of the Jagiellonian University Printing House (ref. code DUJ 188). They concluded, based on review of three printers' receipts from 1908, that three fascicles of Volume 8B of the *Rozprawy* were published in 1908. Fascicle 1 was dated by Wacławska-Ćwiertnia and Mitka (2016) as 5 May 1908. Paszko et al. (2020) considered this inference improbable, because Part 13 of the *Conspectus* was presented at the meeting of the AAS only one day earlier, on 4 May 1908. In addition, Paszko et al. (2020) found, based on the table of contents presented on the verso of the front wrapper of Fascicle 1 and the known number of pages of its last article, that Fascicle 1 comprised 256 pages in sixteen 16-page signatures. These 16 signatures were billed by the printers on two different dates in 1908, 5 May (signatures nos. 1–10 on receipt no. 2404) and 7 August (signatures nos. 11–16 on receipt no. 2577) (Suppl. material 3: Table S3). Thus, Paszko et al. (2020) concluded that the first fascicle could not have been published on the date suggested by Wacławska-Ćwiertnia and Mitka (2016).

The exact date of these fascicles notwithstanding, Paszko et al. (2020) confirmed the order in which the two publications in question had been distributed. They traced information confirming that Fascicle 1 of Volume 8B of the *Rozprawy*, as defined above, was available for sale as early as July–August 1908 in the bookshop of Gebethner and Co. Publishing House, based on its publisher's catalogue (Świszczowski 1908a), which also provides the table of contents of this fascicle. Recommendation 31A of the ICN helps here, by advising that the date on which the publisher or publisher's agent delivers printed matter to one of the usual carriers for distribution to the public should be accepted as its date of effective publication (Turland et al. 2018; Turland 2019). Thus, the date of effective publication for Fascicle 1 of Volume 8B of the *Rozprawy* is July–August 1908. Based on the bibliographic information from the *Spraw. AU*, Volume 2 of the *Conspectus* was published in August–October 1908 and was available for sale at Gebethner and Co. in September–October 1908 (Świszczowski 1908b). Therefore, Paszko et al. (2020) confirmed that Parts 12 and 13 of the *Conspectus* were effectively published in the *Rozprawy*.

We have made efforts to determine the publication dates of other volumes of the *Rozprawy*, i.e. Vols. 4B–14B(1). Searches were conducted in several secondary sources (see Suppl. material 2: Table S2), that help determine true dates of publications of these volumes. The *Spraw. AU* is the best source of evidence for the publication dates of the complete volumes of the *Rozprawy* for nomenclatural purposes. We have uncovered considerable evidence that the issuing of volumes of the *Rozprawy* was often delayed. All complete volumes were published at the beginning of the following year (often in March, rarely later), except Volume 14B, which was published in two parts. We found that, in six cases, the imprint years for complete volumes of the *Rozprawy* (and thus the effective publication dates for several parts of the *Conspectus* published there) are not the true dates of publication in this journal; Volumes 4B, 6B, 7B, 11B, 12B and 13B bore the imprint of the preceding year. In most volumes of *Rozprawy* (4B, 5B, 6B–8B (in part) and 10B–14B), the date ranges from the *Spraw. AU* are indicated by us as the publication dates of these journal volumes (see Suppl. material 2: Table S2). The publication of some the volumes of the *Rozprawy* was announced in the Meeting Report section in the *Spraw. AU* (Vols. 11B–14B), but these dates fall within the period known from the Bibliographic section (see Appendix I and Suppl. material 2: Table S2).

We have been unable to find dated fascicle wrappers of the *Rozprawy*, except for Fascicles 1 and 3 of Volume 8B, mentioned above. We still have little knowledge of how the published fascicles of the *Rozprawy* were disseminated to subscribers. We found, as mentioned above, that some fascicles of the volumes of the *Rozprawy* (Vols. 6B–8B) were available for sale in the bookshop of Gebethner and Co. Publishing House, based on its publisher's catalogue (see Appendix I and Suppl. material 2: Table S2). We determined that Parts 5, 6, 7 (p.p.), 8–10, 12 and 13 of the *Conspectus* from the *Rozprawy* were available for readers in fascicles, prior to the whole appearing in print as a journal volume. Thus, the dates of effective publication for these parts are based on Gebethner and Co. catalogue (for details see Suppl. material 2: Table S2).

In a search for precise information regarding the dates of publication of the subsequent parts of the *Conspectus* published in the *Rozprawy*, we looked through bill books for years 1904–1914 of the Jagiellonian University Printing House (ref. codes DUJ 185–DUJ 193) (see Suppl. material 3: Table S3). We found that signatures were printed throughout the whole calendar year; however, the final ones were printed and postpress operations were carried out at the beginning of the following year (see Suppl. material 3: Table S3 for details).

We found that up to two months from the date of publication given in the *Spraw. AU*, the complete volumes of the *Rozprawy* were entered into the inventory of the Jagiellonian Library: Volume 5B on 19 November 1906, Volume 6B on 23 May 1907 and Volume 7B on 7 May 1908. For the Tromsø Museum, we obtained this type of information from the reports in the journal *Tromsø Museum Aarsberetning* available online, but these dates are later than those for the Jagiellonian Library. In both places, the complete volumes are indexed; however, the precise date (to the day) is limited to a short period of time; in the case of Jagiellonian Library, it covers only the years presented above. The receipt dates are the latest dates of possible publication, but they confirm the earlier dates given in the *Spraw. AU* (see Suppl. material 2: Table S2).

3. *Conspectus florae Galiciae criticus – Krytyczny przegląd roślinności Galicyi* (3 Vols) (1906–1911), publication in book form

Three volumes of the *Conspectus* were completed and issued in 1906, 1908 and 1911 (Zapałowicz 1906b, 1908, 1911b). The publication process of the fourth volume was interrupted by the outbreak of the World War I and it was never published (Köhler 2015). The first 21 parts of the *Conspectus* from the serial form in the *Rozprawy* were brought together and published in three volumes. They were reprinted (or preprinted in some cases) with pagination that differed from that used in the *Rozprawy*. The volumes are supplemented by Addenda, Corrigenda and Index generum sections at the end of each volume. The Addenda sections include omitted species with numbers, additional infraspecific forms, new names, a few new species descriptions and additional distribution data. Volume 1 covers Parts 1–7 and the Addenda and Corrigenda to Volume 1, Volume 2 covers Parts 8–13 and the Addenda and Corrigenda to Volumes 1 and 2 and Volume 3 covers Parts 14–21 and the Addenda and Corrigenda to Volumes 1, 2 and 3.

We determined, based on bibliographic data available in the *Spraw. AU*, that the volumes of the *Conspectus* were already available for readers during the following periods: August–October 1906 (Volume 1), August–October 1908 (Volume 2) and November 1911 (Volume 3). The dates given in the publisher's catalogue of Gebethner and Co. Publishing House are the same or later (Świszczowski 1906, 1908b, 1912). From this, we conclude that the imprint dates at the foot of the title pages were provided correctly in these three volumes. The *Spraw. AU* revealed precise dates of publication for Zapałowicz's books of the *Conspectus* (Suppl. material 4: Table S4).

Volume 4, which covers parts 22–30 along with further addenda, was not effectively published nor distributed widely. Two printed copies, both lacking covers and title pages, were traced by Köhler (2015), one at the Library of the Jagiellonian University (ref. no. 80990 II) and one at the Library of the Nicolaus Copernicus University at Toruń (ref. no. DT 003208), Poland. Köhler (2015) identified these books as Zapałowicz's 4th volume based on the signature mark "H. Zapałowicz T. IV." ("T" standing for Polish "Tom" = volume) printed on the bottom of the first page of each signature (see fig. 9 in Köhler 2015). A digitised version of Toruń copy has been available online since 11 March 2015 in Djvu format from the collections of Kujawsko-Pomorska Biblioteka Cyfrowa [= Kujawsko-Pomorska Digital Library] (http://www.kpbc.ukw.edu.pl/dlibra). This electronic material does not constitute effective publication, because it was not published in Portable Document Format (PDF) and does not have an International Standard Serial Number (ISSN) or an International Standard Book Number (ISBN) (see Article 29.1 of the ICN, Knapp et al. 2011; Turland et al. 2018). From a practical point of view, this affects only those names that were introduced (or their descriptions amended) in the Addenda sections of this volume, as they were published nowhere else.

In the prefaces to Zapałowicz's books (Zapałowicz 1906b, 1908, 1911b), there are notes that each volume represents the collective reprint from the relevant volumes of the *Rozprawy*. This is almost always true with regard to their contents; however, we detected a small paragraph (11 text lines) related to *Dianthus armeria* L. var. *dubius* Zapał. (Zapałowicz 1911b: 109) that appeared in Volume 3, but is missing at the respective place in the *Rozprawy* (Zapałowicz 1911a: 682). This may suggest that the respective signatures in the *Rozprawy* and the book were printed simultaneously. Alternatively, the book signatures may have been printed sometimes even before those for the *Rozprawy*, which may explain why the text noted above is missing in the *Rozprawy*, even though the journal was supposed to be the original publication.

We paid special attention to "reprints" from the journal with possible earlier appearance dates than those of the *Rozprawy*. Our research revealed that more than half of the material in book form (Zapałowicz 1906b, 1908, 1911b) appeared earlier in serial form in the *Rozprawy*. This situation concerns 13 parts (i.e. Parts 1–3, 8–17) of the book, which we considered to be reprints. Seven parts appeared earlier in book form (i.e. Parts 5–7, 18–21) and these parts are considered by us to be original. The publication dates of Part 4 (Zapałowicz 1906a) are the same for both sources; we therefore recommend that both be cited for names published in Part 4 (for details, see Suppl. material 4: Table S4).

As mentioned above, some of Zapałowicz's names, supplementing those from serial form in the *Rozprawy*, were published exclusively at the ends of book volumes of the *Conspectus* in addenda to the current and the previously-issued volumes. These names must be cited from the relevant book volume of the *Conspectus* (Zapałowicz 1906b, 1908, 1911b).

Conspectus florae Galiciae criticus and other sources online

Zapałowicz's works are available for readers via the Polona website (polona.pl). The Biodiversity Heritage Library (BHL) (www.biodiversitylibrary.org) has digitised several of the volumes of the *Bulletin*, together with the covers accompanying each issue. Other sources are available as follows: the *Rozprawy* in the Wielkopolska Digital Library (www.wbc.poznan.pl), the *Spraw. AU* in the Silesian Digital Library (www.sbc.org.pl), the journal *Rocznik AU* on the RCIN platform (rcin.org.pl) and Gebethner and Co. publisher's catalogue titled *Katalog Nowych Książek* [= Catalogue of New Books] in the Jagiellonian Digital Library (jbc.bj.uj.edu.pl/dlibra).

Updates to the International Plant Names Index (IPNI) database

The IPNI database provides nomenclatural information (spelling, author, types and first place and date of publication) for the scientific names of vascular plants. However, not all information concerning Zapałowicz's names is accurate in its current version. Entries of Zapałowicz's names at species rank (including hybrids) in IPNI are corrected here and the hope is expressed that the current inventory may be useful for fixing them.

A search of names in IPNI brought to light more than one hundred plant names for species and hybrids described by Zapałowicz (IPNI 2019) (for details, see Table 1). Amongst these records, we have identified 14 duplicate IPNI entries that are records of the same names with two different bibliographic citations. They probably derived from more than one of the three original source databases (Index Kewensis, the Gray Card Index and the Australian Plant Names Index) that had been combined in the late 1990s to create IPNI (Croft et al. 1999). It seems that the deduplication process conducted by the IPNI team in early 2016 (Nic Lughadha et al. 2016) was not fully successful, especially in cases when we deal with multiple data sources for Zapałowicz's names. After our processing of the mentioned IPNI entries, we obtained 98 names at species rank (including hybrids). We have searched for their first place and date of publication. Two names, *Rorippa* × *wimmeri* Zapał. and *Viola berdaui* Zapał., omitted in IPNI, are added by us. One name, *Viola* × *roxolanica* attributed to Zapałowicz, must be deleted. This taxon was described by Błocki (Deutsche Bot. Monatsschr. 5: 147. 1887) at species rank, then Zapałowicz transferred it to a hybrid category. Therefore, it must be cited as *Viola* × *roxolanica* Błocki (pro sp.). In total, we obtained 99 names at species rank (including hybrids), attributed to Zapałowicz, including one combination (*Rumex carpaticus* (Zapał.) Zapał.). Most of these names, 94 out of 99, are attributed to the *Conspectus*. Corrections are here provided for more than 60% of the respective IPNI entries. We have checked their name spelling (four corrections), authorships (three corrections), associated bibliographical details (63 corrections) and journal names (or their abbreviations; for details, see Table 1).

Table 1. The inventory of bibliographic data covering Zapałowicz's names of species and hybrids in the International Plant Names Index (IPNI) database. Species and nothospecies names, authorship and place of their publications were corrected, where necessary, according to the rules of the Shenzen Code (Turland & al. in Regnum Veg. 159. 2018). Major source corrections are indicated by the word "yes". The list of taxa names with associated basic bibliographical details was extracted on 10 July 2019 from the IPNI database. Duplicated names are marked for deletion.

No.	Taxon name	Authorship	Bibliographic information from the current IPNI database	Source correction needed	Revised bibliographic information by the present authors	Remarks
The IPNI entries attributed to Hugo Zapałowicz						
1	***Aconitum ×berdaui***	Zapał.	*Aconitum × berdaui* Zapał., Consp. Fl. Galic. Crit. 2: 229 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1908(3): 143. 1908	
2	***Aconitum ×bucovinense***	Zapał.	*Aconitum bucovinense* Zapał., Consp. Fl. Galic. Crit. ii. 230 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1908(3): 144. 1908	
3	***Alsine zarencznyi***	Zapał.	*Alsine zarencznyi* Zapał., Consp. Fl. Galic. Crit. iii. 25 (1911).	yes		Duplicate entry to be deleted.
			Alsine zarenczyni Zapał., Bull. Int. Acad. Sci. Cracovie, Cl. Sci.Math., Ser. B, Sci. Nat. 1910, 168.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1910(3B): 168. 1910	Spelling in IPNI incorrect: "*zarenczyni*" should be changed to "*zarencznyi*"
4	***Alyssum borysthenicum***	Zapał.	*Alyssum borysthenicum* Zapał., Bull. Acad. Cracovie 1912, B, 710.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(7B): 710. 1912	
5	***Alyssum brodense***	Zapał.	*Alyssum brodense* Zapał., Bull. Acad. Cracovie 1912, B, 711.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(7B): 711. 1912	
6	***Arabis besseri***	Zapał.	*Arabis besseri* Zapał., Bull. Acad. Cracovie 1912, B. 17.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(2B): 17. 1912	
7	***Arabis ×calcigena***	Zapał.	*Arabis calcigena* Zapał., Bull. Acad. Cracovie 1912, B. 21, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(2B): 21. 1912	
8	***Arabis ×decipiens***	Zapał.	*Arabis decipiens* Zapał., Bull. Acad. Cracovie 1912, B. 20, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(2B): 20. 1912	
9	***Arabis ×kotulae***	Zapał.	*Arabis kotulae* Zapał., Bull. Acad. Cracovie 1912, 11. 21, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(2B): 21. 1912	
10	***Arabis ×saccata***	Zapał.	*Arabis saccata* Zapał., Bull. Acad. Cracovie 1912, B. 22, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(2B): 22. 1912	
11	***Atriplex polonicum***	Zapał.	*Atriplex polonicum* Zapał., Consp. Fl. Galic. Crit. ii. 169 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1907(10): 1080. 1907	
12	***Bromus janczewskii***	Zapał.	*Bromus janczewskii* Zapał., Bull. Acad. Cracovie 1904, 306.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1904(6): 306. 1904	
			Bromus janczewskii Zapał., Consp. Fl. Galic. Crit. i. 73 (1906).	yes		Duplicate entry to be deleted.
13	***Bunias dubia***	Zapał.	*Bunias dubia* Zapał., Bull. Acad. Cracovie 1913, B. 446; Just's Bot. Jahresb. xli. II. 169.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1913(7B): 446. 1913	
14	***Calamagrostis kotulae***	Zapał.	*Calamagrostis kotulae* Zapał., Bull. Acad. Cracovie 1904, 163.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1904(3): 163. 1904	
			Calamagrostis kotulae Zapał., Consp. Fl. Galic. Crit. i. 23 (1906).	yes		Duplicate entry to be deleted.

No.	Taxon name	Authorship	Bibliographic information from the current IPNI database	Source correction needed	Revised bibliographic information by the present authors	Remarks
15	***Cardamine ×dubia***	Zapał.	*Cardamine dubia* Zapał., Bull. Acad. Cracovie 1912, B, 13, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(1B): 13. 1912	
16	***Cardamine ×tatrensis***	Zapał.	*Cardamine tatrensis* Zapał., Bull. Acad. Cracovie 1912, B, 12, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(1B): 12. 1912	
17	***Carex ×bogdanensis***	Zapał.	*Carex bogdanensis* Zapał., Consp. Fl. Galic. Crit. iii. 233 (1911), hybr.		Consp. fl. Galic. crit. 3. 233. 1911	
18	***Carex ×paczoskii***	Zapał.	*Carex paczoskii* Zapał., Consp. Fl. Galic. Crit. iii. 234 (1911), hybr.		Consp. fl. Galic. crit. 3. 234. 1911	
19	***Carex ×raciborskii***	Zapał.	*Carex raciborskii* Zapał., Consp. Fl. Galic. Crit. iii. 233 (1911), hybr.		Consp. fl. Galic. crit. 3. 233. 1911	
20	***Cerastium ciarcanense***	Zapał.	*Cerastium ciarcanense* Zapał., Bull. Acad. Sc. Cracovie, Ser. B. 1910, 436.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1910(6B): 436. 1910	
			Cerastium ciarcanense Zapał., Consp. Fl. Galic. Crit. iii. 90 (1911).	yes		Duplicate entry to be deleted.
21	***Cerastium pietrosuanum***	Zapał.	*Cerastium pietrosuanum* Zapał., Bull. Acad. Sc. Cracovie, Ser. B. 1910, 436.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1910(6B): 436. 1910	
			Cerastium pietrosuanum Zapał., Consp. Fl. Galic. Crit. iii. 95 (1911).	yes		Duplicate entry to be deleted.
22	***Cerastium raciborskii***	Zapał.	*Cerastium raciborskii* Zapał., Bull. Acad. Sc. Cracovie, Ser. B. 1910, 433.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1910(6B): 434. 1910	
			Cerastium raciborskii Zapał., Consp. Fl. Galic. Crit. iii. 84 (1911).	yes		Duplicate entry to be deleted.
23	***Cerastium ×tatrense***	Zapał.	*Cerastium tatrense* Zapał., Bull. Acad. Sc. Cracovie, Ser. B. 1910, 437.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1910(6B): 437. 1910	
			Cerastium tatrense Zapał., Consp. Fl. Galic. Crit. iii. 97 (1911), hybr.	yes		Duplicate entry to be deleted.
24	***Crocus babiogorensis***	Zapał.	*Crocus babiogorensis* Zapał., Consp. Fl. Galic. Crit. i. 185 (1906).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1906(5): 326. 1906	
25	***Delphinium nacladense***	Zapał.	*Delphinium nacladense* Zapał., Consp. Fl. Galic. Crit. ii. 202 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1908(3): 142. 1908	
26	***Dianthus euponticus***	Zapał.	*Dianthus euponticus* Zapał., Consp. Fl. Gallic. Crit. iii. 141 (1911); et in Bull. Acad Crac. 1911, B. 10.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1911(1B): 10. 1911	Spelling of the abbreviation in IPNI incorrect: "Gallic." changed to "Galic."
27	***Dianthus ×lacinulatus***	Zapał.	*Dianthus lacinulatus* Zapał., Consp. Fl. Galic. Crit. iii. 161 (1911); et in Bull. Acad. Crac. 1911, B. 163, hybr.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1911(3B): 163. 1911	
28	***Dianthus polonicus***	Zapał.	*Dianthus polonicus* Zapał., Consp. Fl. Galic. Crit. iii. 122 (1911); et in Bull. Acad. Crac. 1911, B. 7.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1911(1B): 7. 1911	
29	***Dianthus ×zarencznianus***	Zapał.	*Dianthus zarencznianus* Zapał., Consp. Fl. Galic. Crit. iii. 149 (1911); et in Bull. Acad. Crac. 1911, B. 162, hybr.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1911(3B): 162. 1911	

No.	Taxon name	Authorship	Bibliographic information from the current IPNI database	Source correction needed	Revised bibliographic information by the present authors	Remarks
30	***Diplotaxis polonica***	Zapał.	*Diplotaxis polonica* Zapał., Bull. Acad. Cracovie 1913, 11. 273; Just's Bot. Jahresb. 1913, xli. II. 171.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1913(5B): 273. 1913	
31	***Erysimum hungaricum***	Zapał.	*Erysimum hungaricum* Zapał., Bull. Acad. Cracovie 1913, II. 49; Just's Bot. Jahresb. 1913, xli. II. 172.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1913(3B): 49. 1913	
32	***Euphrasia carpatica***	Zapał.	*Euphrasia carpatica* Zapał., Spraw. Komis. Fizjogr. xxiv. 270 (1889).		Spraw. Komis. Fizjogr. 24: 270. 1889; Roślinna szata Gór Pokucko-Marmaroskich 270. 1889	Roślinna szata... is separate from Spraw. Komis. Fizjogr. 24
			Euphrasia carpatica Zapał., Spraw. Komis. Fizjogr. xlii. II. 6 (1908).	yes		Duplicate entry to be deleted.
33	***Festuca ×czarnohorensis***	Zapał.	*Festuca czarnohorensis* Zapał., Consp. Fl. Gallic. Crit. 3: 230 (1911).		Consp. fl. Galic. crit. 3. 230. 1911	Spelling of the abbreviation in IPNI incorrect: "Gallic." changed to "Galic."
34	***Festuca hackeliana***	Zapał.	*Festuca hackeliana* Zapał., Consp. Fl. Galic. Crit. iii. 231 (1911).		Consp. fl. Galic. crit. 3. 231. 1911	
35	***Festuca makutrensis***	Zapał.	*Festuca makutrensis* Zapał., Consp. Fl. Galic. Crit. iii. 229 (1911).	yes		Duplicate entry to be deleted. *Festuca makutrensis* in Consp. fl. Galic. crit. 3. 229. 1911 is also recorded with the phrase "m. (n. sp.)", that is confusing for this name.
			Festuca makutrensis Zapał., Kosmos xxxv. 782–786 (1910); cf. Bot. Centralbl. cxvi. 420.		Kosmos (Lvov) 35: 783. 1910	
36	***Festuca pietrosii***	Zapał.	*Festuca pietrosii* Zapał., Bull. Acad. Cracovie 1904, 304.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1904(6): 304. 1904	
			Festuca pietrosii Zapał., Consp. Fl. Galic. Crit. i. 63 (1906); ii. 306 (1908).	yes		Duplicate entry to be deleted.
37	***Festuca ×pocutica***	Zapał.	*Festuca pocutica* Zapał., Consp. Fl. Galic. Crit. iii. 230 (1911), hybr.		Consp. fl. Galic. crit. 3. 230. 1911	
38	***Festuca polesica***	Zapał.	*Festuca polesica* Zapał., Bull. Acad. Cracovie 1904, 303.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1904(6): 303. 1904	
			Festuca polesica Zapał., Consp. Fl. Galic. Crit. i. 62 (1906).	yes		Duplicate entry to be deleted.
39	***Festuca polonica***	Zapał.	*Festuca polonica* Zapał., Bull. Acad. Cracovie 1904, 302.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1904(6): 302. 1904	
			Festuca polonica Zapał., Consp. Fl. Galic. Crit. i. 60 (1906).	yes		Duplicate entry to be deleted.
40	***Heliosperma arcanum***	Zapał.	*Heliosperma arcanum* Zapał., Consp. Fl. Galic. Crit. iii. 203 (1911).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1911(6B): 498. 1911	
41	***Hesperis carpatica***	Zapał.	*Hesperis carpatica* Zapał., Spraw. Komis. Fizjogr. xxiv. (1889) 106.	yes	Spraw. Komis. Fizjogr. 24: 106. 1889; Roślinna szata Gór Pokucko-Marmaroskich 106. 1889	Roślinna szata... is separate from Spraw. Komis. Fizjogr. 24
42	***Hesperis pontica***	Zapał.	*Hesperis pontica* Zapał., Bull. Acad. Cracovie 1912, B, 1158.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(9B): 1183. 1912	

No.	Taxon name	Authorship	Bibliographic information from the current IPNI database	Source correction needed	Revised bibliographic information by the present authors	Remarks
43	***Hieracium zapalowiczii***	Uechtr. ex Zapał.	*Hieracium zapalowiczii* Uchtr. ex Zapał., Kosmos xxxv. 782–786 (1910); cf. Bot. Centralbl. cxvi. 420.	yes	Spraw. Komis. Fizjogr. 39: 37. 1906	Description from Uechtritz's letter quoted (without the species name) in Spraw. Komis. Fizjogr. 24: 234–235. 1889 (and thus in the separate Roślinna szata Gór Pokucko-Marmaroskich 234–235. 1889). The name, ascribed by Zapałowicz to Uechtritz, appeared for the first time in Spraw. Komis. Fizjogr. 39: 37. 1906 with indication of description in the former source.
44	***Iris pontica***	Zapał.	*Iris pontica* Zapał., Consp. Fl. Galic. Crit. i. 191 (1906).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1906(5): 326. 1906	
45	***Isatis ciesielskii***	Zapał.	*Isatis ciesielskii* Zapał., Bull. Acad. Cracovie 1913, B. 447; Just's Bot. Jahresb. 1913, xli. II. 173.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1913(7B): 447. 1913	
46	***Isatis kamienskii***	Zapał.	*Isatis kamienskii* Zapał., Bull. Acad. Cracovie 1913, B. 447.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1913(7B): 447. 1913	
47	***Muscari pocuticum***	Zapał.	*Muscari pocuticum* Zapał., Consp. Fl. Galic. Crit. i. 164 (1906).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1906(2): 100. 1906	
48	***Papaver corona-sancti-stephani***	Zapał.	*Papaver corona-sti-stephani* Zapał., Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 620 (1911).		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1911(8B): 620. 1911	Original abbreviation "sti" expanded into "sancti" in accordance with Art. 60.14 of ICN
49	***Poa janczewskii***	Zapał.	*Poa janczewskii* Zapał., Consp. Fl. Galic. Crit. i. 292 (1906).	yes	Spraw. Komis. Fizjogr. 39: 34. 1906	Zapałowicz in Consp. fl. Galic. crit. 1. 292. 1906 provided proper citation with page number to "Sprawozd. Kom. fiz. 1905 str. [page] 34".
50	***Poa rodnensis***	Zapał.	*Poa rodnensis* Zapał., Consp. Fl. Galic. Crit. ii. 302 (1908).	yes	Spraw. Komis. Fizjogr. 42: 62. 1908	Zapałowicz in Consp. fl. Galic. crit. 2. 302. 1908 provided imprecise citation to Sprawozd. Kom. fiz. vol. XLII, II).
51	***Polygonum ×asperulum***	Zapał.	*Polygonum asperulum* Zapał., Consp. Fl. Galic. Crit. ii. 145 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1907(6): 631. 1907	
52	***Polygonum ×janoviense***	Zapał.	*Polygonum janoviense* Zapał., Consp. Fl. Galic. Crit. ii. 131 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1907(6): 631. 1907	
53	***Pulsatilla ×janczewskii***	Zapał.	*Pulsatilla janczewskii* Zapał., Consp. Fl. Galic. Crit. ii. 244 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1908(5): 448. 1908	
54	***Pulsatilla ×tarnoviensis***	Zapał.	*Pulsatilla tarnoviensis* Zapał., Consp. Fl. Galic. Crit. ii. 245 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1908(5): 449. 1908	
55	***Ranunculus ×gilibertii***	Zapał.	*Ranunculus gilibertii* Zapał., Consp. Fl. Galic. Crit. ii. 289 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1908(5): 449. 1908	
56	***Ranunculus ×klukii***	Zapał.	*Ranunculus klukii* Zapał., Consp. Fl. Galic. Crit. ii. 289 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1908(5): 449. 1908	
57	***Rorippa cracoviensis***	Zapał.	*Rorippa cracoviensis* Zapał., Bull. Acad. Cracovie 1912, B, 345.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(4B): 345. 1912	Original spelling of the genus name "*Roripa*" used by Zapałowicz corrected to "*Rorippa*".

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58	***Rorippa ×oslawiensis***	Zapał.	*Rorippa oslawiensis* Zapał., Bull. Acad. Cracovie 1912, B, 347, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(4B): 347. 1912	Original spelling of the genus name "*Roripa*" used by Zapałowicz corrected to "*Rorippa*".
59	***Rorippa ×podolica***	Zapał.	*Rorippa podolica* Zapał., Bull. Acad. Cracovie 1912, B, 346, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(4B): 346. 1912	Original spelling of the genus name "*Roripa*" used by Zapałowicz corrected to "*Rorippa*".
60	***Rorippa ×sodalis***	Zapał.	*Rorippa sodalis* Zapał.,Bull. Acad. Cracovie 1912, B, 347, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(4B): 347. 1912	Original spelling of the genus name "*Roripa*" used by Zapałowicz corrected to "*Rorippa*".
61	***Rorippa ×viaria***	Zapał.	*Rorippa viaria* Zapał., Bull. Acad. Cracovie 1912, B, 346, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(4B): 346. 1912	Original spelling of the genus name "*Roripa*" used by Zapałowicz corrected to "*Rorippa*".
62	***Rorippa ×wimmeri***	Zapał.	[absent]		Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 12B(52B): 179. 1912 [Feb. 1913]	Original spelling of the genus name "*Roripa*" used by Zapałowicz corrected to "*Rorippa*".
63	***Rorippa ×wislokiensis***	Zapał.	*Rorippa wislokiensis* Zapał., Bull. Acad. Cracovie 1912, B, 348, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1912(4B): 348. 1912	Original spelling of the genus name "*Roripa*" used by Zapałowicz corrected to "*Rorippa*".
64	***Rumex ×babiogorensis***	Zapał.	*Rumex babiogorensis* Zapał., Consp. Fl. Galic. Crit. ii. 116 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1907(4): 254. 1907	
65	***Rumex ×błockii***	Zapał.	*Rumex blockii* Zapał., Consp. Fl. Galic. Crit. ii. 111 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 292. 1907 [Jan.–Febr. 1908]	
66	***Rumex carpaticus***	(Zapał.) Zapał.	*Rumex carpaticus* Zapał., Consp. Fl. Galic. Crit. ii. 118 (1908)		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1907(4): 253. 1907	Authority citation in IPNI should be corrected. This name is a combination based on *Rumex arifolius* All. α [var.] *carpaticus* Zapał. (Spraw. Komis. Fizjogr. 24: 285. 1889; Roślinna szata Gór Pokucko-Marmaroskich 285. 1889).
			Rumex carpaticus Zapał., Sprawozd. Akad. Umiejętn. Krakow. xlv. III. 153 (1911).	yes		Duplicate entry to be deleted.
67	***Salix ×cracoviensis***	Zapał.	*Salix cracoviensis* Zapał., Consp. Fl. Galic. Crit. ii. 78 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 230. 1907 [Jan.–Febr. 1908]	
68	***Salix ×janczewskii***	Zapał.	*Salix janczewskii* Zapał., Consp. Fl. Galic. Crit. ii. 67 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 219. 1907 [Jan.–Febr. 1908]	
69	***Salix ×kotuliana***	Zapał.	*Salix kotuliana* Zapał., Consp. Fl. Galic. Crit. ii, 68 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 220. 1907 [Jan.–Febr. 1908]	
70	***Salix ×pocutica***	Zapał.	*Salix pocutica* Zapał., Consp. Fl. Galic. Crit. ii. 33 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 185. 1907 [Jan.–Febr. 1908]	
71	***Salix ×polesica***	Zapał.	*Salix polesica* Zapał., Consp. Fl. Galic. Crit. ii. 76 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 228. 1907 [Jan.–Febr. 1908]	

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72	***Salix ×rehmanii***	Zapał.	*Salix rehmani* Zapał., Consp. Fl. Galic. Crit. ii. 41 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 193. 1907 [Jan.–Febr. 1908]	In accordance with Art. 60.8 of ICN, the specific epithet "*rehmani*" is corrected to "*rehmanii*".
73	***Salix ×sandomiriensis***	Zapał.	*Salix sandomiriensis* Zapał., Consp. Fl. Galic. Crit. ii. 75 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 228. 1907 [Jan.–Febr. 1908]	
74	***Salix ×sarmatica***	Zapał.	*Salix sarmatica* Zapał., Consp. Fl. Galic. Crit. ii. 56 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 208. 1907 [Jan.–Febr. 1908]	
75	***Salix tatrorum***	Zapał.	*Salix tatrorum* Zapał., Consp. Fl. Galic. Crit. ii. 65 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1907(2): 59. 1907	
76	***Salix ×vistulensis***	Zapał.	*Salix vistulensis* Zapał., Consp. Fl. Galic. Crit. ii. 77 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 229. 1907 [Jan.–Febr. 1908]	
77	***Salix ×volhyniensis***	Zapał.	*Salix volhyniensis* Zapał., Consp. Fl. Galic. Crit. ii. 75 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 227. 1907 [Jan.–Febr. 1908]	
78	***Salix ×wołoszczakii***	Zapał.	*Salix woloszczakii* Zapał., Consp. Fl. Galic. Crit. ii. 40 (1908).	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 7B(47B): 193. 1907 [Jan.–Febr. 1908]	
79	***Silene berdaui***	Zapał.	*Silene berdaui* Zapał., Bull. Acad. Cracovie 1911. B, 286; Consp. Fl. Galic. Crit. iii. 182 (1911).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1911(5B): 286. 1911	
80	***Silene jundzillii***	Zapał.	*Silene jundzillii* Zapał., Bull. Acad. Cracovie 1911, B, 287; Consp. Fl. Galic. Crit. iii. 197.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1911(5B): 287. 1911	
81	***Silene lituanica***	Zapał.	*Silene lituanica* Zapał., Bull. Acad. Cracovie 1911, B, 285; Consp. Fl. Galic. Crit. iii. 181.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1911(5B): 285. 1911	
82	***Silene subleopoliensis***	Zapał.	*Silene subleopoliensis* Zapał., Bull. Acad. Cracovie 1911. B, 286; Consp. Fl. Galic. Crit. iii. 183.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1911(5B): 286. 1911	
83	***Sisymbrium roxolanicum***	Zapał.	*Sisymbrium roxolanicum* Zapał., Bull. Acad. Cracovie 1913, B, 48.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1913(2B): 48. 1913	
84	***Thalictrum ×andrzejowskii***	Zapał.	*Thalictrum andrzejowskii* Zapał., Consp. Fl. Galic. Crit. ii. 297 (1908).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1908(5): 450. 1908	
85	***Thlaspi tatrense***	Zapał.	*Thlaspi tatrense* Zapał., Bull. Acad. Cracovie 1913, B. 431; Just's Bot. Jahresb. xli. II. 176.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1913(7B): 443. 1913	
86	***Thlaspi trojagense***	Zapał.	*Thlaspi trojagense* Zapał., Bull. Acad. Cracovie 1913, B. 444; Just's Bot. Jahresb. xli. II. 176.	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1913(7B): 444. 1913	
87	***Trisetum tarnowskii***	Zapał.	*Trisetum tarnowskii* Zapał., Bull. Acad. Cracovie 1904, 167.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1904(3): 167. 1904	
			Trisetum tarnowskii Zapał., Consp. Fl. Galic. Crit. i. 35 (1906).	yes		Duplicate entry to be deleted.

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88	***Tulipa bessarabica***	Zapał.	*Tulipa bessarabica* Zapał., Consp. Fl. Galic. Crit. i. 167 (1906).	yes	Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. 1906(2): 101. 1906	
89	***Viola ×babiogorensis***	Zapał.	*Viola babiogorensis* Zapał., Bull. Acad. Cracovie 1914 B. 461, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1914(4B): 461. 1914	
90	***Viola ×berdaui***	Zapał.	[absent]		Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 14B(1)(54B(1)): 235. 1914 [Oct.–Dec. 1914]	
91	***Viola ×bessarabica***	Zapał.	*Viola bessarabica* Zapał., Bull. Acad. Cracovie 1914 B. 459, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1914(4B): 459. 1914	
92	***Viola decorata***	Zapał.	*Viola decorata* Zapał. ex Zablocki, in Rosl. Polsk., Pl. Polon. Exsicc. Ser. II. Cent. II. 13 (1934), in obs., pro syn.	yes	Rozpr. Wydz. Mat.-Przyr. Akad. Umiejętn., Dział B, Nauki Biol., (Ser. 3) 14B(1) (54B(1)): 258. 1914 [Oct.–Dec. 1914]	Authority citation in IPNI should be corrected. This name should be attributed to Zapałowicz and recorded as *Viola decorata* Zapał.
93	***Viola jagellonica***	Zapał.	*Viola jagellonica* Zapał., Bull. Acad. Cracovie 1914 B. 455.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1914(4B): 455. 1914	
94	***Viola ×mielnicensis***	Zapał.	*Viola mielnicensis* Zapał., Bull. Acad. Cracovie 1914 B. 463, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1914(4B): 463. 1914	
95	***Viola ×mira***	Zapał.	*Viola mira* Zapał., Bull. Acad. Cracovie 1914 B. 460, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1914(4B): 460. 1914	
96	***Viola ×prutensis***	Zapał.	*Viola prutensis* Zapał., Bull. Acad. Cracovie 1914 B. 464, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1914(4B): 464. 1914	
97	***Viola ×sanensis***	Zapał.	*Viola sanensis* Zapał., Bull. Acad. Cracovie 1914 B. 462, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1914(4B): 462. 1914	
98	***Viola ×sokalensis***	Zapał.	*Viola sokalensis* Zapał., Bull. Acad. Cracovie 1914 B. 460, hybr.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1914(4B): 460. 1914	
99	***Viola zarencznyi***	Zapał.	*Viola zarencznyi* Zapał., Bull. Acad. Cracovie 1914 B. 457.		Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math., Ser. B, Sci. Nat. 1914(4B): 457. 1914	
The IPNI entry incorrectly attributed to Zapałowicz						
1	***Viola roxolanica***		*Viola roxolanica* Zapał., Bull. Acad. Cracovie 1914 B. 458, hybr.	yes		Entry to be deleted.
	Viola roxolanica	Błocki	*Viola roxolanica* Błocki, Deutsche Bot. Monatsschr. v. (1887) 147; et in Oest. Bot. Zeitschr. xxxviii. (1888) 15.			In accordance with Art. 50.1 of ICN when a taxon at the rank of species or below is transferred from the non-hybrid category to the hybrid category at the same rank (Art. H.10 Note 1), or vice versa, the authorship remains unchanged. This name is attributed to Błocki (Deutsche Bot. Monatsschr. 5: 147. 1887) and should be recorded as *Viola ×roxolanica* Błocki (pro sp.).

Acknowledgements

This study was financed from the statutory fund of the W. Szafer Institute of Botany of the Polish Academy of Sciences. The research is a contribution to the ongoing catalogue of type specimens of vascular plants deposited in KRAM (W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków, Poland). Part of data was obtained from the OZwRCIN Project, co-realised by the Institute in the years 2018–2021, implemented by the Operational Programme Digital Poland for 2014−2020, co-financed by the European Original Development Fund. Special thanks go to Dr. Jeffery M. Saarela (Canadian Museum of Nature, Ottawa) and an anonymous Reviewer for thorough and insightful remarks and suggestions on the manuscript. The authors are grateful to the staff of the British Library for checking and scanning for them the volume wrappers of the *Rozprawy*.

References

Barberá P, Romero-Zarco C, Aedo C (2018) Taxonomic revision of *Trisetum* sect. *Trisetum* (Poaceae: Pooideae: Aveninae) from Eurasia and North Africa. Annals of the Missouri Botanical Garden 103(3): 350–392. https://doi.org/10.3417/2018067

Croft J, Cross N, Hinchcliffe S, Nic Lughadha E, Stevens PF, West JG, Whitbread G (1999) Plant names for the 21st century: The International Plant Names Index, a distributed data source of general accessibility. Taxon 48(2): 317–324. https://doi.org/10.2307/1224436

Gruca A (1993) Spółka Wydawnicza Polska (1890–1916). Wydawnictwo krakowskich konserwatystów [= Polish Publishing Company (1890–1916). Publishing House of Polish Conservatists]. Universitas, Kraków. [in Polish]

Hryniewiecki B (1953) Hugo Zapałowicz (1852–1917) w setną rocznicę urodzin. Pour le centenaire de naissance. Acta Societatis Botanicorum Poloniae 22(2): 445–456. https://doi.org/10.5586/asbp.1953.029 [in Polish with French summary]

Hunt Institute for Botanical Documentation (2019) BPH Online. http://www.huntbotanical.org/databases/show.php?1 [accessed: October 2019]

IPNI [International Plant Names Index] (2019) [Zapałowicz Hugo] http://www.ipni.org/, https://beta.ipni.org/a/11990-1 [accessed July 2019]

Knapp SD, McNeill J, Turland NJ (2011) Changes to publication requirements made at the XVIII International Botanical Congress in Melbourne – what does e-publication mean for you? The New Phytologist 192(3): 569–573. https://doi.org/10.1111/j.1469-8137.2011.03914.x

Köhler P (2004) Bibliografia botaniki w Towarzystwie Naukowym Krakowskim, Akademii Umiejętności i Polskiej Akademii Umiejętności. Bibliography of botany at the Academic Society of Cracow, Academy of Sciences and Letters, and the Polish Academy of Sciences and Letters (1818–1952–2000). W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

Köhler P (2015) Zagadka IV tomu "Krytycznego przeglądu roślinności Galicyi" Hugona Zapałowicza. – The riddle of the 4th volume of 'Conspectus florae Galiciae criticus' by Hugo Zapałowicz. Wiadomości Botaniczne 59(3–4): 160–175 [in Polish] https://pbsociety.org.pl/default/wp-content/uploads/2016/04/wb.2015.022_ev_s.pdf [accessed: 1 September 2019]

Majkowska R [Ed.] (2006) Poczet członków Akademii Umiejętności i Polskiej Akademii Umiejętności w latach 1872–2000 [= Members of the Academy of Arts and Sciences and the Polish Academy of Arts and Sciences in 1872–2000]. Akademia Umiejętności, Kraków, 231 pp. [in Polish]

Missouri Botanical Garden (2019) Tropicos. http://www.tropicos.org/Home.aspx [accessed: 1 September 2019]

Mitka J, Starmühler W (2000) Phenetic variability of *Aconitum lasiocarpum* (Rchb.) Gáyer (Ranunculaceae): Extension of taxonomic and geographic borders. Acta Societatis Botanicorum Poloniae 69(2): 145–155. https://doi.org/10.5586/asbp.2000.020

Nic Lughadha E, Govaerts R, Belyaeva I, Black N, Lindon H, Allkin R, Magill RE, Nicolson N (2016) Counting counts: Revised estimates of numbers of accepted species of flowering plants, seed plants, vascular plants and land plants with a review of other recent estimates. Phytotaxa 272(1): 82–88. https://doi.org/10.11646/phytotaxa.272.1.5

Optasyuk OM, Shevera MV (2011) Typification of the species of Salicaceae Lindl. described from the territory of Ukraine. Ukrainian Botanical Journal 68(5): 723–729. [in Ukrainian with English abstract]

Paszko B, Paul W, Nikel A, Musiał L (2020) Typifications, a new synonym and new distribution data in *Ficaria* (Ranunculaceae). Phytotaxa 432(2): 144–154. https://doi.org/10.11646/phytotaxa.432.2.4

Rouppert K (1918) Dr. Hugo Zapałowicz. Pamiętnik Towarzystwa Tatrzańskiego 36: 33–38. [in Polish]

Stachowska K (1973) Z działalności wydawniczej Polskiej Akademii Umiejętności. Starania o upowszechnienie za granicą polskiej myśli naukowej w latach 1873–1952. Rocznik Biblioteki Naukowej PAU i PAN w Krakowie 19: 39–71. [= Publishing activity of the Academy of Arts and Sciences. Promotion of the achievements of Polish Science abroad in years 1873–1952] [in Polish]

Stafleu FA, Cowan RS (1988) Taxonomic literature: a selective guide to botanical publications and collections with dates, commentaries and types (Vol. 7. W-Z. 2nd ed.). Scheltema and Holkema, Utrecht. https://doi.org/10.5962/bhl.title.48631

Świszczowski F [Ed.] (1906) Katalog Nowych Książek: miesięcznik bibliograficzny Księgarni G. Gebethnera i Spółki w Krakowie [= Catalogue of New Books: bibliographic monthly journal of G. Gebethner & Co. Publishing House in Kraków] 2(12): 113–120. [in Polish] https://jbc.bj.uj.edu.pl/dlibra/publication/343922/edition/328470#structure

Świszczowski F [Ed.] (1908a) Katalog Nowych Książek. Miesięcznik Bibliograficzny Księgarni G. Gebethnera i Spółki w Krakowie [= Catalogue of New Books: bibliographic monthly journal of G. Gebethner & Co. Publishing House in Kraków] 4(9–10): 77–88. [in Polish] https://jbc.bj.uj.edu.pl/dlibra/publication/343922/edition/328470#structure

Świszczowski F [Ed.] (1908b) Katalog Nowych Książek: miesięcznik bibliograficzny Księgarni G. Gebethnera i Spółki w Krakowie [= Catalogue of New Books: bibliographic monthly journal of G. Gebethner & Co. Publishing House in Kraków] 4(11–12): 89–104. [in Polish] https://jbc.bj.uj.edu.pl/dlibra/publication/343922/edition/328470#structure

Świszczowski F [Ed.] (1912) Katalog Nowych Ks iążek: miesięcznik bibliograficzny Księgarni G. Gebethnera i Spółki w Krakowie [= Catalogue of New Books: bibliographic monthly journal of G. Gebethner & Co. Publishing House in Kraków] 9(1–2): 1–20. [in Polish] https://jbc.bj.uj.edu.pl/dlibra/publication/343922/edition/328470#structure

Turland N (2019) The Code decoded. A user's guide to the International Code of Nomenclature for algae, fungi, and plants (2nd ed.). Pensoft, Sofia, 196 pp. https://doi.org/10.3897/ab.e38075

Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Kusber WH, Li DZ, Marhold K, May TW, McNeill J, Monro AM, Prado J, Price MJ, Smith GF [Eds] (2018) International Code of Nomenclature for Algae, Fungi, and Plants (Shenzhen Code) Adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile 159. Koeltz Botanical Books, Glashütten. https://doi.org/10.12705/Code.2018

Wacławska-Ćwiertnia K, Mitka J (2016) Typification of Zapałowicz's names in *Aconitum* section *Aconitum*. PhytoKeys 58: 119–126. https://doi.org/10.3897/phytokeys.58.7110

Zapałowicz H (1904 [21 Apr. 1904]) Uwagi krytyczne nad roślinnością Galicyi. – Remarques critiques sur la flore de la Galicie. Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1904(3): 162–169. [in French and Latin]

Zapałowicz H (1906a) Conspectus florae Galiciae criticus (pars IV). – Krytyczny przegląd roślinności Galicyi (część IV). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 5B: 83–110. [in Polish and Latin]

Zapałowicz H (1906b) Conspectus florae Galiciae criticus (Vol. 1). – Krytyczny przegląd roślinności Galicyi (Tom 1). Akademia Umiejętności, Kraków, 296 pp. [in Polish and Latin]

Zapałowicz H (1908) Conspectus florae Galiciae criticus (Vol. 2). – Krytyczny przegląd roślinności Galicyi (Tom 2). Akademia Umiejętności, Kraków, 311 pp. [in Polish and Latin]

Zapałowicz H (1909a) Conspectus florae Galiciae criticus (pars XII). – Krytyczny przegląd roślinności Galicyi (część XII) [= A critical review of the flora of Galicia (part XII)]. Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 8B: 41–90. [in Polish and Latin]

Zapałowicz H (1909b) Conspectus florae Galiciae criticus (pars XIII). – Krytyczny przegląd roślinności Galicyi (część XIII) [= A critical review of the flora of Galicia (part XIII)]. Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 8B: 187–256. [in Polish and Latin]

Zapałowicz H (1911a) Conspectus florae Galiciae criticus (pars XVII). – Krytyczny przegląd roślinności Galicyi (część XVII) [= A critical review of the flora of Galicia (part XVII)]. Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 10B: 671–682. [in Polish and Latin]

Zapałowicz H (1911b) Conspectus florae Galiciae criticus (Vol. 3). – Krytyczny przegląd roślinności Galicyi (Tom 3). Akademia Umiejętności, Kraków, 246 pp. [in Polish and Latin]

Zdebska D (1978–1979) Prace Hugona Zapałowicza w zakresie botaniki. Karpaty 13–14: 22–25. [= Hugo Zapałowicz's publications in the field of botany] [in Polish]

Zdebski J (1978–1979) Hugon Zapałowicz (1852–1917). Zarys biografii. Karpaty 13–14: 3–8. [= Biography outline] [in Polish]

Ziman SN, Shyian NN, Bulakh EV (2015) Types of the taxa of genus *Aconitum* (Ranunculaceae) described from Ukraine. Ukrainian Botanical Journal 72(4): 325–333. [in Ukrainian with English abstract] https://doi.org/10.15407/ukrbotj72.04.325

Appendix I

A list of 65 publication events related to Zapałowicz's *Conspectus florae Galiciae criticus – Krytyczny przegląd roślinności Galicyi* taking into account the division into three sources. Dates of effective publication for nomenclatural purposes are recorded in square brackets.

Excerpt series in the *Bulletin*

1. Zapałowicz H (1904 [21 Apr. 1904]) Uwagi krytyczne nad roślinnością Galicyi. – Remarques critiques sur la flore de la Galicie. Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1904(3): 162–169 (in French and Latin).
2. Zapałowicz H (1904 [5 Jul. 1904]) Krytyczny przegląd roślinności Galicyi. Część II. – Revue critique de la flore de la Galiciae (II partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1904(6): 302–307 (in French and Latin).
3. Zapałowicz H (1904 [15 Nov. 1904]) Krytyczny przegląd roślinności Galicyi. Część III. – Revue critique de la flore de la Galiciae (III partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1904(8): 394–395 (in French and Latin).
4. Zapałowicz H (1905 [16 Jun. 1905]) Krytyczny przegląd roślinności Galicyi. Część IV. – Revue critique de la flore de la Galiciae (IV partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1905(5): 286 (in French and Latin).
5. Zapałowicz H (1906 [15 Mar. 1906]) Krytyczny przegląd roślinności Galicyi. Część V. – Revue critique de la flore de la Galiciae (V partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1906(2): 100–101 (in French).
6. Zapałowicz H (1906 [25 Jun. 1906]) Krytyczny przegląd roślinności Galicyi. Część VI. – Revue critique de la flore de la Galiciae (VI partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1906(5): 326–327 (in French and Latin).
7. Zapałowicz H (1906 [19 Oct. 1906]) Krytyczny przegląd roślinności Galicyi. Część VII. – Revue critique de la flore de la Galiciae (VII partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1906(7): 603 (in French).
8. Zapałowicz H (1907 [12 Mar. 1907]) Krytyczny przegląd roślinności Galicyi. Część VIII. – Revue critique de la flore de la Galiciae (VIII partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1907(2): 59–60 (in French and Latin).
9. Zapałowicz H (1907 [15 May 1907]) Krytyczny przegląd roślinności Galicyi. Część IX. – Revue critique de la flore de la Galiciae (IX partie). Bulletin Inter-

national de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1907(4): 253–254 (in French and Latin).

10. Zapałowicz H (1907 [10 Aug. 1907]) Krytyczny przegląd roślinności Galicyi. Część X. – Revue critique de la flore de la Galiciae (X partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1907(6): 631–632 (in French and Latin).
11. Zapałowicz H (1907 [28 Dec. 1907]) Krytyczny przegląd roślinności Galicyi. Część XI. – Revue critique de la flore de la Galiciae (XI partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1907(10): 1079–1080 (in French and Latin).
12. Zapałowicz H (1908 [12 Mar. 1908]) Krytyczny przegląd roślinności Galicyi. Część XII. – Revue critique de la flore de la Galiciae (XII partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1908(3): 141–145 (in French and Latin).
13. Zapałowicz H (1908 [3 Jun. 1908]) Krytyczny przegląd roślinności Galicyi. Część XIII. – Revue critique de la flore de la Galiciae (XIII partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1908(5): 448–450 (in French and Latin).
14. Zapałowicz H (1908 [14 Sept. 1908]) Krytyczny przegląd roślinności Galicyi. Część XIV. – Revue critique de la flore de la Galiciae (XIV partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles 1908(7): 603 (in French and Latin).
15. Zapałowicz H (1910 [12 Apr. 1910]) Krytyczny przegląd roślinności Galicyi. Część XV. – Revue critique de la flore de la Galiciae (XV partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1910(3B): 168–172 (in French).
16. Zapałowicz H (1910 [29 Jul. 1910]) Krytyczny przegląd roślinności Galicyi. Część XVI. – Revue critique de la flore de la Galiciae (XVI partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1910(6B): 433–438 (in French and Latin).
17. Zapałowicz H (1910 [10 Sep. 1910]) Krytyczny przegląd roślinności Galicyi. Część XVII. – Revue critique de la flore de la Galiciae (XVII partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1910(7B): 607 (in French).
18. Zapałowicz H (1911 [9 Feb. 1911]) Krytyczny przegląd roślinności Galicyi. Część XVIII. – Revue critique de la flore de la Galiciae (XVIII partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1911(1B): 7–11 (in French and Latin).
19. Zapałowicz H (1911 [12 Apr. 1911]) Krytyczny przegląd roślinności Galicyi. Część XIX. – Revue critique de la flore de la Galiciae (XIX partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1911(3B): 162–163 (in French and Latin).

20. Zapałowicz H (1911 [26 Jun. 1911]) Krytyczny przegląd roślinności Galicyi. Część XX. – Revue critique de la flore de la Galiciae (XX partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1911(5B): 285–289 (in French and Latin).
21. Zapałowicz H (1911 [27 Jul. 1911]) Krytyczny przegląd roślinności Galicyi. Część XXI. – Revue critique de la flore de la Galiciae (XXI partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1911(6B): 497–499 (in French and Latin).
22. Zapałowicz H (1911 [25 Nov. 1911]) Krytyczny przegląd roślinności Galicyi. Część XXII. – Revue critique de la flore de la Galiciae (XXII partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1911(8B): 620–622 (in French and Latin).
23. Zapałowicz H (1912 [26 Feb. 1912]) Krytyczny przegląd roślinności Galicyi. Część XXIII. – Revue critique de la flore de la Galiciae (XXIII partie) [1st part]. Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1912(1B): 12–16 (in French and Latin).
24. Zapałowicz H (1912 [20 Mar. 1912]) Krytyczny przegląd roślinności Galicyi. Część XXIII. – Revue critique de la flore de la Galiciae (XXIII partie) [2nd part]. Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1912(2B): 17–22 (in Latin).
25. Zapałowicz H (1912 [13 Jun. 1912]) Krytyczny przegląd roślinności Galicyi. Część XXIV. – Revue critique de la flore de la Galiciae (XXIV partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1912(4B): 345–348 (in French and Latin).
26. Zapałowicz H (1912 [9 Nov. 1912]) Krytyczny przegląd roślinności Galicyi. Część XXV. – Revue critique de la flore de la Galiciae (XXV partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1912(7B): 710–716 (in French and Latin).
27. Zapałowicz H (1913 [12 Jan. 1913]) Krytyczny przegląd roślinności Galicyi. Część XXVI. – Revue critique de la flore de la Galiciae (XXVI partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1912(9B): 1158 (in French and Latin).
28. Zapałowicz H (1913 [15 Mar. 1913]) Krytyczny przegląd roślinności Galicyi. Część XXVII. – Revue critique de la flore de la Galiciae (XXVII partie) [1st part]. Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1913(2B): 48 (in French and Latin).
29. Zapałowicz H (1913 [24 Apr. 1913]) Krytyczny przegląd roślinności Galicyi. Część XXVII. – Revue critique de la flore de la Galiciae (XXVII partie) [2nd

part]. Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1913(3B): 49–50 (in Latin).
30. Zapałowicz H (1913 [30 Jun. 1913]) Krytyczny przegląd roślinności Galicyi. Część XXVIII. – Revue critique de la flore de la Galiciae (XXVIII partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1913(5B): 273–274 (in French and Latin).
31. Zapałowicz H (1913 [10 Oct. 1913]) Krytyczny przegląd roślinności Galicyi. Część XXIX. – Revue critique de la flore de la Galiciae (XXIX partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1913(7B): 443–448 (in French and Latin).
32. Zapałowicz H (1914 [23 May 1914]) Krytyczny przegląd roślinności Galicyi. Część XXX. – Revue critique de la flore de la Galiciae (XXX partie). Bulletin International de l'Académie des Sciences de Cracovie. Classe des Sciences Mathématiques et Naturelles. Série B. Sciences Naturelles 1914(4B): 455–464 (in French and Latin).

Serial form in the *Rozprawy*

33. Zapałowicz H (1904 [Aug.–Oct. 1905]) Conspectus florae Galiciae criticus [pars I]. – Krytyczny przegląd roślinności Galicyi [część I]. Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 4B(44B): 74–113 (in Polish and Latin).
34. Zapałowicz H (1904 [Aug.–Oct. 1905]) Conspectus florae Galiciae criticus (pars II). – Krytyczny przegląd roślinności Galicyi (część II). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 4B(44B): 153–196 (in Polish and Latin).
35. Zapałowicz H (1904 [Aug.–Oct. 1905]) Conspectus florae Galiciae criticus (pars III). – Krytyczny przegląd roślinności Galicyi (część III). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 4B(44B): 305–341 (in Polish and Latin).
36. Zapałowicz H (1906 [Aug.–Oct. 1906]) Conspectus florae Galiciae criticus (pars IV). – Krytyczny przegląd roślinności Galicyi (część IV). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 5B(45B): 83–110 (in Polish and Latin).
37. Zapałowicz H (1906 [Dec. 1906]) Conspectus florae Galiciae criticus (pars V). – Krytyczny przegląd roślinności Galicyi (część V). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 6B(46B): 65–102 (in Polish and Latin).
38. Zapałowicz H (1906 [Dec. 1906]) Conspectus florae Galiciae criticus (pars VI). – Krytyczny przegląd roślinności Galicyi (część VI). Rozprawy Wydziału

Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 6B(46B): 189–239 (in Polish and Latin).
39. Zapałowicz H (1906 [Dec. 1906 (pp. 241–288) / Mar. 1907 (pp. 289–296)]) Conspectus florae Galiciae criticus (pars VII). – Krytyczny przegląd roślinności Galicyi (część VII). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 6B(46B): 241–296 (in Polish and Latin).
40. Zapałowicz H (1907 [Jan.–Febr. 1908]) Conspectus florae Galiciae criticus (pars VIII). – Krytyczny przegląd roślinności Galicyi (część VIII). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 7B(47B): 153–236 (in Polish and Latin).
41. Zapałowicz H (1907 [Jan.–Febr. 1908]) Conspectus florae Galiciae criticus (pars IX). – Krytyczny przegląd roślinności Galicyi (część IX). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 7B(47B): 265–302 (in Polish and Latin).
42. Zapałowicz H (1907 [Jan.–Febr. 1908]) Conspectus florae Galiciae criticus (pars X). – Krytyczny przegląd roślinności Galicyi (część X). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 7B(47B): 587–631 (in Polish and Latin).
43. Zapałowicz H (1907 [Mar. 1908]) Conspectus florae Galiciae criticus (pars XI). – Krytyczny przegląd roślinności Galicyi (część XI). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 7B(47B): 685–703 (in Polish and Latin).
44. Zapałowicz H (1909 [Jul.–Aug. 1908]) Conspectus florae Galiciae criticus (pars XII). – Krytyczny przegląd roślinności Galicyi (część XII). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 8B(48B): 41–90 (in Polish and Latin).
45. Zapałowicz H (1909 [Jul.–Aug. 1908]) Conspectus florae Galiciae criticus (pars XIII). – Krytyczny przegląd roślinności Galicyi (część XIII). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 8B(48B): 187–256 (in Polish and Latin).
46. Zapałowicz H (1909 [Apr.–May 1909]) Conspectus florae Galiciae criticus (pars XIV). – Krytyczny przegląd roślinności Galicyi (część XIV). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 8B(48B): 331–336 (in Polish and Latin).
47. Zapałowicz H (1911 [Jan. 1911]) Conspectus florae Galiciae criticus (pars XV). – Krytyczny przegląd roślinności Galicyi (część XV). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 10B(50B): 173–211 (in Polish and Latin).
48. Zapałowicz H (1911 [Jan. 1911]) Conspectus florae Galiciae criticus (pars XVI). – Krytyczny przegląd roślinności Galicyi (część XVI). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 10B(50B): 353–408 (in Polish and Latin).

49. Zapałowicz H (1911 [Jan. 1911]) Conspectus florae Galiciae criticus (pars XVII). – Krytyczny przegląd roślinności Galicyi (część XVII). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 10B(50B): 671–682 (in Polish and Latin).
50. Zapałowicz H (1911 [Mar. 1912]) Conspectus florae Galiciae criticus (pars XVIII). – Krytyczny przegląd roślinności Galicyi (część XVIII). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 11B(51B): 1–34 (in Polish and Latin).
51. Zapałowicz H (1911 [Mar. 1912]) Conspectus florae Galiciae criticus (pars XIX). – Krytyczny przegląd roślinności Galicyi (część XIX). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 11B(51B): 67–89 (in Polish and Latin).
52. Zapałowicz H (1911 [Mar. 1912]) Conspectus florae Galiciae criticus (pars XX). – Krytyczny przegląd roślinności Galicyi (część XX). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 11B(51B): 121–157 (in Polish and Latin).
53. Zapałowicz H (1911 [Mar. 1912]) Conspectus florae Galiciae criticus (pars XXI). – Krytyczny przegląd roślinności Galicyi (część XXI). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 11B(51B): 265–280 (in Polish and Latin).
54. Zapałowicz H (1911 [Mar. 1912]) Conspectus florae Galiciae criticus (pars XXII). – Krytyczny przegląd roślinności Galicyi (część XXII). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 11B(51B): 443–456 (in Polish and Latin).
55. Zapałowicz H (1912 [Feb. 1913]) Conspectus florae Galiciae criticus (pars XXIII). – Krytyczny przegląd roślinności Galicyi (część XXIII). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 12B(52B): 1–49 (in Polish and Latin).
56. Zapałowicz H (1912 [Feb. 1913]) Conspectus florae Galiciae criticus (pars XXIV). – Krytyczny przegląd roślinności Galicyi (część XXIV). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 12B(52B): 157–180 (in Polish and Latin).
57. Zapałowicz H (1912 [Feb. 1913]) Conspectus florae Galiciae criticus (pars XXV). – Krytyczny przegląd roślinności Galicyi (część XXV). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 12B(52B): 211–239 (in Polish and Latin).
58. Zapałowicz H (1912 [Feb. 1913]) Conspectus florae Galiciae criticus (pars XXVI). – Krytyczny przegląd roślinności Galicyi (część XXVI). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 12B(52B): 547–565 (in Polish and Latin).
59. Zapałowicz H (1913 [Apr. 1914]) Conspectus florae Galiciae criticus (pars XXVII). – Krytyczny przegląd roślinności Galicyi (część XXVII). Rozprawy

Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 13B(53B): 29–49 (in Polish and Latin).
60. Zapałowicz H (1913 [Apr. 1914]) Conspectus florae Galiciae criticus (pars XXVIII). – Krytyczny przegląd roślinności Galicyi (część XXVIII). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 13B(53B): 115–125 (in Polish and Latin).
61. Zapałowicz H (1913 [Apr. 1914]) Conspectus florae Galiciae criticus (pars XXIX). – Krytyczny przegląd roślinności Galicyi (część XXIX). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 13B(53B): 311–339 (in Polish and Latin).
62. Zapałowicz H (1914 [Oct.–Dec. 1914]) Conspectus florae Galiciae criticus (pars XXX). – Krytyczny przegląd roślinności Galicyi (część XXX). Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności, Dział B. Nauki Biologiczne (Seria 3) 14B(1)(54(1)): 209–270 (in Polish and Latin).

Book form

63. Zapałowicz H (1906 [Aug.–Oct. 1906]) Conspectus florae Galiciae criticus, Vol. 1. – Krytyczny przegląd roślinności Galicyi, Tom 1. Akademia Umiejętności, Kraków, 1–296 (in Polish and Latin).
64. Zapałowicz H (1908 [Aug.–Oct. 1908]) Conspectus florae Galiciae criticus, Vol. 2. – Krytyczny przegląd roślinności Galicyi, Tom 2. Akademia Umiejętności, Kraków, 1–311 (in Polish and Latin).
65. Zapałowicz H (1911 [Nov. 1911]) Conspectus florae Galiciae criticus, Vol. 3. – Krytyczny przegląd roślinności Galicyi, Tom 3. Akademia Umiejętności, Kraków, 1–246 (in Polish and Latin).

Supplementary material 1

Table S1

Authors: Beata Paszko, Agnieszka Nikel, Aldona Mueller-Bieniek, Wojciech Paul

Data type: bibliographic data, species data

Explanation note: Bibliographic details of the 30 excerpts of Zapałowicz's series *Krytyczny przegląd roślinności Galicyi – Revue critique de la flore de la Galicie published in Bulletin International de l'Académie des Sciences de Cracovie*.

Link: https://doi.org/10.3897/phytokeys.155.51072.suppl1

Supplementary material 2

Table S2

Authors: Beata Paszko, Agnieszka Nikel, Aldona Mueller-Bieniek, Wojciech Paul

Data type: bibliographic data

Explanation note: Bibliographic details of the 30 individual parts of Zapałowicz's series *Conspectus florae Galiciae criticus*. – *Krytyczny przegląd roślinności Galicyi published in the Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności*, *Dział B. Nauki Biologiczne* (*Seria 3*).

Link: https://doi.org/10.3897/phytokeys.155.51072.suppl2

Supplementary material 3

Table S3

Authors: Beata Paszko, Agnieszka Nikel, Aldona Mueller-Bieniek, Wojciech Paul

Data type: bibliographic data

Explanation note: Receipts for the Academy of Arts and Sciences provided by the Jagiellonian University Printing House for printing subsequent signatures of the *Rozprawy Wydziału Matematyczno-Przyrodniczego Akademii Umiejętności*, *Dział B. Nauki Biologiczne* (*Seria 3*).

Link: https://doi.org/10.3897/phytokeys.155.51072.suppl3

Supplementary material 4

Table S4

Authors: Beata Paszko, Agnieszka Nikel, Aldona Mueller-Bieniek, Wojciech Paul

Data type: bibliographic data

Explanation note: Bibliographic details of Zapałowicz's *Conspectus florae Galiciae criticus – Krytyczny przegląd roślinności Galicyi* (3 Vols).

Link: https://doi.org/10.3897/phytokeys.155.51072.suppl4

PhytoKeys 155: 87–139 (2020)
doi: 10.3897/phytokeys.155.51966
http://phytokeys.pensoft.net

CHECKLIST

A peer-reviewed open-access journal
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An annotated checklist of the vascular flora of South and North Nandi Forests, Kenya

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Academic editor: Ricarda Riina | Received 13 March 2020 | Accepted 19 June 2020 | Published 7 August 2020

Citation: Melly DK, Kipkoech S, Muema BW, Kamau P, Malombe I, Hu G, Wang Q-F (2020) An annotated checklist of the vascular flora of South and North Nandi Forests, Kenya. PhytoKeys 155: 87–139. https://doi.org/10.3897/phytokeys.155.51966

Abstract

We compiled a checklist of the flora of South and North Nandi forests based on literature, online databases, herbarium collections and floristic field surveys. A combination of general walk-over surveys and plotless landscape sampling for plant collection and sight observation was used. We recorded 628 plant species representing 118 families and 392 genera, which almost double the latest results of the previous most recent survey. We found 61 species of ferns and fern allies and 567 species of seed plants, representing 9.98% of the total plant species in Kenya. Herbs were the majority (50.2%) of life forms followed by shrubs (16.5%). We report unique populations of three species out of 19 species that are widespread in Africa, but restricted to Nandi and Kakamega Forests in Kenya. Four of the recorded species are threatened globally and 16 exotic plant species were found. The recent description of one new species and two new records for Kenya from these forests, together with the comprehensive checklist is of crucial importance to the conservation of these unique ecosystems. Our results are essential to forest managers, community forest associations, conservationists, students and research scientists in Kenya and globally for implementing critical decisions for the conservation of this vital biodiversity resource.

Keywords

Biodiversity, conservation, floristic survey, inventory, Nandi County

Introduction

Tropical rainforests support more than half of the world's species (Armstrong 2016; McFarland 2018), although they constitute only 7% of Earth's land area. Nevertheless, no other land community sustains such a high species diversity and ecological complexity like tropical rainforests (Lewis 2006). As a result, they are very critical and essential in biodiversity conservation. Tropical forest ecosystems are crucial, because they act as reservoirs of biodiversity, they are sources of timber and medicinal plants, they also act as carbon sinks and play a critical role in watershed protection (Russo and Kitajima 2016; Maua et al. 2018a). Due to their diversity, tropical rainforests provide habitat for more than half of the world's known terrestrial plant and animal species (Lewis 2006; McFarland 2018). Globally, most forests experience enormous fragmentation as the human population increases; hence more land is needed to cater for human needs (Mitchell et al. 2006). Tropical forests are at the forefront of species extinction crises due to widespread habitat loss and alteration (Mwavu and Witkowski 2009; Vuyiya et al. 2014; Tanui 2015; Mutoko et al. 2015). Between 2000 and 2012, "the world has been losing about 0.43% of its remaining tropical rainforests per year (Lewis 2006; McFarland 2018). Moreover, it is estimated that only 2.5% of the surface area of Earth is covered by rainforests, or approximately 8% of the land on Earth consists of rainforests (Pariona 2018). If this rate of loss persists, one-third of all remaining tropical rainforests will be primarily altered in the next 30 years (Althof 2005). Forests like North Nandi and South Nandi are diminishing due to the increased demand for their useful products and services (Mutoko et al. 2015). The tropical rainforests have received increasing attention both globally and locally due to their importance, with numerous efforts and calls for its proper assessment, management, conservation and documentation of their biodiversity status in a bid to prevent them from being wiped out.

Kenya has the most diverse forests in East Africa (Peltorinne 2004). They harbour over 6,000 species of higher plants, including 2,000 trees and shrubs (KIFICON 1994a; MEWNR 2015; Zhou et al. 2017). Although they are highly fragmented, these forests are biologically rich and harbour high concentrations of endemic species of animals and plants (Peltorinne 2004).

The Nandi Forests are within Nandi County in Western Kenya and occupy an area currently covered by three sub-counties, namely; Nandi Central, Nandi South and Kabiyet (Ehrich et al. 2007). They are enriched by Afromontane forest elements from the Rift Valley escarpment (Fischer et al. 2010). These two forests have been classified as semi-humid and as a nature reserve (Kigomo 1987). In the years from the 1980s and earlier, Kenya's indigenous forest coverage was about 2% (Wass 1995) and agricultural communities occupied most of the remaining areas. Some parts of the Nandi forests constitute a lowland rainforest-like Kakamega Tropical Rainforest (MEWNR 2015).

A careful review of the literature available for North Nandi and South Nandi Forests indicates that only a few floristic studies have been done in the past. Most plant species have not been fully documented and, if there is any documentation, it focuses on tree species (Koros et al. 2016). Previous research on these forests includes ethnobotany studies, which recorded 56 plant species in 30 families that are useful in treating reproductive disorders (Pascaline et al. 2011). The list of tree species in North Nandi forest, used in the study by Diamond and Fayad (1979) while undertaking their Avifauna studies, had 56 species. An inventory by KIFCON (1994 a, b), that concentrated on the total standing volume of tree species, recorded 79 species in South Nandi and 65 species in North Nandi. A team from the National Museums of Kenya, who surveyed the biodiversity of these forests, recorded 125 plant species in South Nandi and 171 plant species in North Nandi (Musila et al. 2011). Finally, Maua et al. (2018a) found 128 plant species belonging to 105 genera and 55 families that are used as Non-Timber Forest Products (NTFPs) by households adjacent to South Nandi Forest.

The socioeconomic factors influencing the dependence of households on non-timber forest products in South Nandi Forest were addressed by Maua et al. (2018b). The most recent study about the floristic structure and plant composition in Nandi Forests (Girma et al. 2015) found 321 plant species in 92 families and 243 genera.

Other studies focused on the ecology, species distribution and composition, as well as the management of these forests by different stakeholders (Njunge and Mugo 2011; Mbuvi et al. 2015; Tanui 2015; Koros et al. 2016).

This study fills the existing knowledge gap by reporting on the indigenous flora of Nandi forests located near the remaining Kakamega Rainforest in Kenya. Our aim is to provide the first comprehensive, detailed checklist of the flora situated in this important biodiversity area to help in conservation and management, as well as determine the plant species composition and structure of North and South Nandi Forests of Kenya.

Material and methods

Study site and current vegetation status

Nandi Forests (Fig. 1) are situated on the top of Nandi escarpment in the Rift Valley Province of Kenya to the east of Kakamega Forest (KIFCON 1994a; 1994b). It comprises of two forests; North Nandi to the north of Kapsabet town and measures about 10,501 ha (KIFCON 1994b) and it stretches for more than 30 km from north to south. It is seldom more than 5 km wide or less than 3 km wide for a considerable part of its length (KIFCON 1994b) while South Nandi Forest is situated to the south of North Nandi Forest and covers 19,502 ha (KIFCON 1994a). North Nandi Forest, together with the Kakamega Forest and South Nandi Forest, is one of the three forests in western Kenya, southeast of Mount Elgon (Schifter et al. 1998). North Nandi forest is found in Nandi North District between 00°12.38'–00°25.10'N latitude and 34°57.58'–35°01.05'E longitude. South Nandi Forest is situated in Nandi South District between latitude 00°34'N and 35°25'E (Maua et al. 2018b). The elevation of Nandi Forests is between 1695 and 2145 m. The mean annual rainfall is 1800 to 2000 mm, with peaks in April/May and August/September. (Mitchell et al. 2006; Lung and Schaab 2010; Maua et al. 2018b).

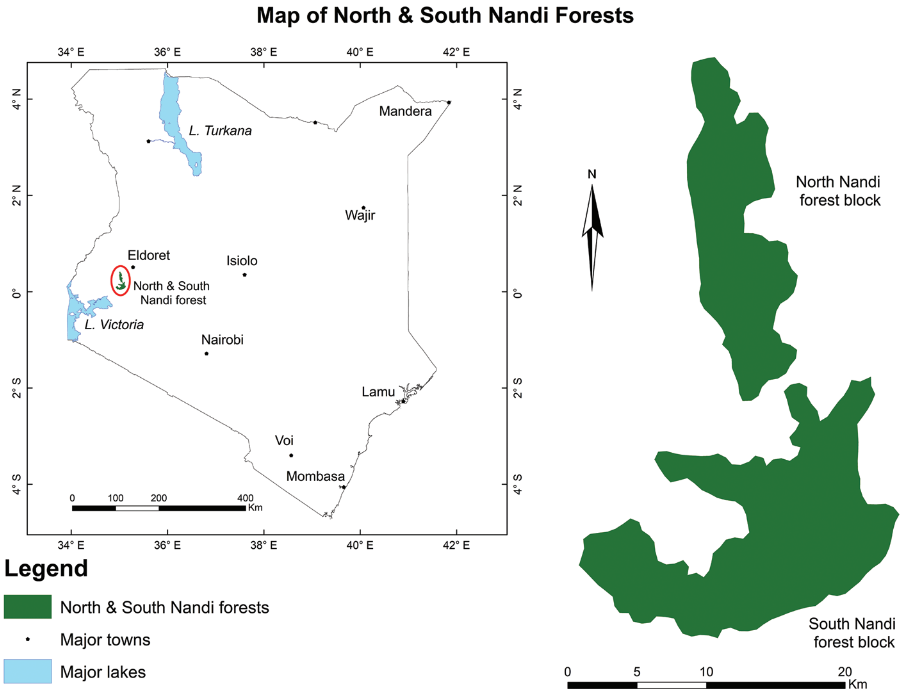

Figure 1. Location of North and South Nandi forests of Kenya.

The mean annual temperature ranges between 17 °C and 20 °C, with the mean maximum and minimum of 25 °C and 11 °C, respectively (KIFCON 1994a). The soils of the North Nandi Forest are derived from undifferentiated basement system rocks and are well-drained, deep and red to yellowish-red friable sandy clays (KIFCON 1994a). The most common tree species communities of Nandi Forests are: *Diospyros abyssinica-Heinsenia diervilleoides*, *Trilepisium madagascariense-Solanum mauritianum* and *Turraea holstii-Ehretia cymose*. Some of the dominant vascular plant species present includes *Croton macrostachyus*, *Celtis africana*, *Strombosia scheffleri*, *Syzygium guineense*, *Tabernaemontana stapfiana*, *Casearia battiscombei*, *Croton magalocarpus*, *Macaranga capensis* and *Neoboutonia macrocalyx* (Girma et al. 2015; KIFCON 1994a).

Floristic surveys, specimen collection and identification

Floristic surveys and specimen collections were conducted between November 2016 and April 2019. The botanical team consisted of botanists from the National Museums of Kenya and the Sino-Africa Joint Research Center (SAJOREC). Our study covered the entire forest from 40 sites within the two forests, 20 in South Nandi and 20 in North Nandi Forest. A combination of general walk-over survey method (Filgueiras et al. 1994) and a plotless landscape defined sampling methods for plant specimen collection and sight observation was used to aid the characterisation of the vegetation (Hall and Swaine 1981). Plant specimens bearing flowers or fruit were collected and identified. The habit, habitat, elevation and collector details were recorded. The samples were then preserved by pressing. All the plant specimens collected are stored at the East Africa Herbarium (EA) and Wuhan Botanical Garden (HIB).

All vascular plant specimens, that were previously collected from the entire former Nandi District and particularly North and South Nandi Forests, were compiled from 43 herbarium specimens in the East Africa Herbarium at the National Museums of Kenya. Additionally, the species collected in the previous decades are reported in this checklist. These were obtained by searching the locality "Nandi District" records in literature (FTEA 1952–2012, Beentje et al. 1994, Agnew and Agnew 1994; Agnew 2013). These botanical references were also used to identify the specimens that we collected. The state of endemism was evaluated by searching all the vascular plants recorded, including existing endemics cited in literature in the Global Biodiversity Information Facility (GBIF) (www.gbif.org). The conservation status of all the vascular plant species collected was assessed using the criteria from the International Union for Conservation of Nature (IUCN 2019) (https://www.iucnredlist.org/).

Habitat description for each species was based on our field observations. For those species that we collected more than one specimen, maximum and minimum altitude ranges are recorded in the checklist. For the herbarium specimens, their habitats were not restricted to the Nandi Forests, since some of the species had wide distribution ranges. The life form information was obtained from field observations and botanical literature. They were categorised as trees (main trunk over 3 m tall, shrubs (0.5–3 m plants with woody stems branching near the ground), climbers (with twinning herbaceous or woody stems) and herbs (< 0.5 m, or < 1 m without persistent woody stems).

Plant taxonomic circumscription and authorities for each taxon were checked in the African Plant Database (https://www.ville-ge.ch/musinfo/bd/cjb/africa/index.php?langue=an) and Catalogue of Life, 2019 Annual Checklist (http://www.catalogueoflife.org/) and further verified using the International Plant Names Index'( ). Herbarium acronyms followed Thiers (2016).

Checklist

A comprehensive checklist of the vascular plant taxa of the Nandi Forests is enumerated below. Families are grouped in lycophytes, monilophytes, gymnosperms and angiosperms. Families in lycophytes and monilophytes follow the PPG I system (PPG I 2016), those in gymnosperms are based on Christenhusz et al. (2011) and families in angiosperms are based on the APG IV system (Chase et al. 2016). Recently-described species and new floristic records for Kenya are indicated in the checklist. Asterisk (*) before the name indicates the introduced species. The conservation status of vulnerable taxa is shown at the end of the taxon.

Results and discussion

Families, genera and species diversity

The current list contains 628 vascular plant taxa representing 118 families and 392 genera. Out of the total species recorded, 43 species were obtained from herbarium specimens at the National Museums of Kenya. Lycophytes and monilophytes comprised 61 species. Seed plants included 567 species, representing 9.98% of the 6,293 total vascular plant species in Kenya recorded by the Flora of Tropical East Africa. Angiosperms represent 90.12% of the total species collected in Nandi Forests (357 genera, 566 species), followed by monilophytes with 9.4% (33 genera, 59 species), lycophytes with 0.3% (1 genus, 2 species) and gymnosperms with 0.2% (1 genus, 1 species).

The top five species-rich families of vascular plants in this checklist were Asteraceae, Orchidaceae, Fabaceae, Poaceae and Lamiaceae (Table 1). The top five species-rich genera were *Asplenium* (Aspleniaceae), *Cyperus* (Cyperaceae), *Polystachya* (Orchidaceae), *Solanum* (Solanaceae), *Ficus* (Moraceae), *Impatiens* (Balsaminaceae) and *Plectranthus* (Lamiaceae) (Table 1).

Plants life forms

The majority of the plants were herbs comprising 50.2% of the total plant species, followed by shrubs, trees, climbers, epiphytes, shrubs or small trees, lianas and subshrubs (Table 2).

Plant species of special concern

Exotic species

We recorded 16 introduced or exotic plant species (3.02%) belonging to 13 genera and eight families (Table 3). These plants represented 2.5% of the total plants collected in

Table 1. Top 10 species-rich families and genera of North and South Nandi forest.

Top 10 Genera			Top 10 Species-rich families		
Family	**Genus**	**Species**	**Family**	**Genera**	**Species**
Aspleniaceae	*Asplenium*	20	Asteraceae	36	50
Cyperaceae	*Cyperus*	10	Orchidaceae	17	37
Orchidaceae	*Polystachya*	8	Fabaceae	21	31
Solanaceae	*Solanum*	8	Poaceae	19	30
Moraceae	*Ficus*	7	Lamiaceae	14	28
Balsaminaceae	*Impatiens*	7	Cyperaceae	9	26
Lamiaceae	*Plectranthus*	7	Rubiaceae	18	23
Orchidaceae	*Bulbophyllum*	6	Aspleniaceae	1	20
Asparagaceae	*Chlorophytum*	5	Acanthaceae	10	18
Poaceae	*Eragrostis*	5	Euphorbiaceae	10	14

Table 2. Life forms of plants species of North and South Nandi forests.

Life form	Species	Percentage of species recorded (%)
Herbs	316	50.2
Shrubs	104	16.5
Trees	81	12.9
Climbers	59	9.4
Epiphytes	34	5.4
Shrub or small trees	28	4.4
Lianas	6	0.9
Subshrubs	2	0.3

Nandi Forests. The families with more species were Fabaceae (4), Asteraceae (3) and Solanaceae (3). All these plants originated from eight different regions (Table 3). Most of the introduced species were from South America (7), Central and South America (2) (Table 3).

Widespread taxa restricted in Kenya to Nandi and Kakamega Forests

The checklist contains 19 species that are widespread in Africa but are restricted in Kenya to the Kakamega and Nandi Forests (Table 4). Other than the species in Table 4, one species *Alchornea hirtella* Benth. is also widespread in Africa. Still, in Kenya, it is restricted to Kakamega, Nandi and the Coastal forests.

Threatened species

A total of four species; *Arachniodes webbiana* (A. Braun) Schelpe (Dryopteridaceae), *Agelanthus pennatulus* (Sprague) Polhill & Wiens (Loranthaceae), *Prunus africana* (Hook. f.) Kalkman (Rosaceae) and *Cissus humbertii* Robyns & Lawalrée (Vitaceae) were found to be vulnerable globally, 234 species were of least concern. In comparison, 392 vascular plant species in this checklist have not been evaluated (Source: IUCN 2019); these represent 0.6% of the total plant species recorded for North and South Nandi forests. The high percentage (62.22%) of the plants that have not been assessed in Nandi Forests call for the need for assessment to conserve those species that are of special concern.

New floristic records

During the fieldwork of December 2016, we found a new species of *Zehneria* (Wei et al. 2017) from South Nandi Forest. In subsequent field collections, 2017 and 2018, we collected the first record of *Coccinia subsessiliflora* Cogn. (Melly et al. 2019) for Kenya, a widespread species in tropical Africa. *Nervilia lilacea* Jum. & H. Perrier (Orchidaceae) (Jing Tian et al. 2019) is also a new record for Kenya and is the only record for the northern hemisphere.

Table 3. List of exotic plant species in North and South Nandi Forests.

Family	Species	Native/Origin
Apocynaceae	*Gomphocarpus physocarpus* E. Mey.	Southern Africa
Asteraceae	*Acanthospermum glabratum* (DC.) Wild	South America
Asteraceae	*Ageratum conyzoides* L.	South America
Asteraceae	*Tagetes minuta* L.	South America
Fabaceae	*Caesalpinia decapetala* (Roth) Alston	India & Southeast Asia
Fabaceae	*Senna didymobotrya* (Fresen.) H. S. Irwin & Barneby	Tropical Africa
Fabaceae	*Senna obtusifolia* (L.) H. S. Irwin & Barneby	Tropical America
Fabaceae	*Senna septemtrionalis* (Viv.) H. S. Irwin & Barneby	Mexico & Central America
Myrtaceae	*Eucalyptus saligna* Sm.	Australia
Passifloraceae	*Passiflora edulis* Sims	South America
Phytolaccaceae	*Phytolacca octandra* L.	South America
Solanaceae	*Cestrum aurantiacum* Lindl.	Tropical America from Guatemala to Venezuela
Solanaceae	*Physalis peruviana* L.	South America
Solanaceae	*Solanum mauritianum* Scop.	South America
Verbenaceae	*Lantana camara* L.	Central & South America
Verbenaceae	*Lantana trifolia* L.	Central & South America

Table 4. Taxa restricted to Kakamega and Nandi forests in Kenya, but widespread in Africa.

Family	Species	Life form
Acanthaceae	*Pseuderanthemum ludovicianum* (Büttner) Lindau	Herb
Amaranthaceae	*Sericostachys scandens* Gilg & Lopr.	Shrub
Athyriaceae	*Diplazium velaminosum* (Diels) Pic. Serm	Herb
Celastraceae	*Salacia cerasifera* Wele. Ex Oliv.	Shrub
Celastraceae	*Simirestis brianii* N. Hallé	Shrub
Cucurbitaceae	*Coccinia barteri* (Hook. f.) Keay	Climber
Cucurbitaceae	*Coccinia subsessiliflora* Cogn.	Climber
Cucurbitaceae	*Momordica cissoides* Benth.	Climber
Cucurbitaceae	*Zehneria longiflora* G. W. Hu & Q. F. Wang	Climber
Lamiaceae	*Achyrospermum parviflorum* S. Moore	Herb
Lamiaceae	*Clerodendrum formicarum* Gűrke	Shrub
Lamiaceae	*Clerodendrum melanocrater* Gürke	Shrub
Orchidaceae	*Bulbophyllum encephalodes* Summerh.	Epiphyte
Orchidaceae	*Nervilia lilacea* Jum. & H. Perrier	Herb
Passifloraceae	*Adenia bequaertii* Robyns & Lawalrée	Climber
Passifloraceae	*Adenia cissampeloides* (Planch. ex Hook.) Harms	Climber
Proteacae	*Protea madiensis* Oliv.	Shrub
Sapotaceae	*Synsepalum cerasiferum* (Welw.) T. D. Penn.	Tree
Vitaceae	*Cissus humbertii* Robyns & Lawalrée	Climber

Checklist

Besides the taxon name, each record includes information about habit, habitat, elevation (m), representative herbarium vouchers. Vulnerable species are labeled as such. Herbaria: EA (East African Herbarium, Kenya), HIB (Herbarium of Wuhan Botanical Garden, China). Collecting teams: FOKP (Flora of Kenya Project) and Sino Africa Joint Investigation Team (SAJIT).

LYCOPHYTES

F1. Lycopodiaceae

1 Genus, 2 species

Huperzia dacrydioides **(Baker) Pic. Serm.** Epiphyte. Upland forest, 1928–2364 m. FOKP 1468 (EA, HIB), FOKP 1494 (EA, HIB).

Huperzia gnidioides **(L. f.) Trevis.** Epiphyte. Wet upland forest, 1925 m. FOKP 1461 (EA, HIB).

MONILOPHYTES

F2. Aspleniaceae

1 Genus, 20 species

Asplenium abyssinicum Fée. Herb. Under upland forest, 2342 m. FOKP 1493 (EA, HIB).

Asplenium aethiopicum **(Burm. f.) Bech.** Perennial herb. Dry and moist forest, moist bushland on tree, 1872–2052 m. FOKP 1318 (EA, HIB), FOKP 1440 (EA, HIB), SAJIT 006956, (EA, HIB).

Asplenium boltonii **Hook. ex Schelpe.** Perennial herb. Dry and moist forest, moist bushland on tree, 2052 m. FOKP 1362 (EA, HIB).

Asplenium bugoiense **Hieron.** Herb. Moist upland forest, 1989 m. FOKP 1366 (EA, HIB), FOKP 1402 (EA, HIB).

Asplenium ceii **Pic. Serm.** Herb. Dense shade in moist forests, 1974–1989 m. FOKP 1393 (EA, HIB).

Asplenium elliottii **C. H. Wright.** Perennial herb. Dense shade in moist forests, 1975–2050 m. FOKP 1359 (EA, HIB), FOKP 1490 (EA, HIB).

Asplenium erectum **Bory ex Willd.** Herb. Dense shade, seasonally moist forest, 1971–2125 m. FOKP 1387 (EA, HIB), FOKP 1363 (EA, HIB).

Asplenium friesiorum **C. Chr.** Herb. Moist upland forest, 1925 m. FOKP 1463 (EA, HIB).

Asplenium gemmiferum **Schrad.** Perennial herb. Dense shade of Moist forests, 1810–2397 m. FOKP 1492 (EA, HIB), SAJIT 006962 (EA, HIB), Melly 0305 (EA).

Asplenium hypomelas **Kuhn.** Herb. In moist montane forests, generally along the rivers, 1927–2007 m. FOKP 1426 (EA, HIB), FOKP 1443 (EA, HIB).

Asplenium lividum **Mett. ex Kuhn.** Perennial herb. Moist forest, 1000–2550 m. Gillet 16698 (EA).

Asplenium macrophlebium **Baker.** Herb. Moist forest, 1000–1850 m. Faden and Rathbun 69/2118 (EA).

Asplenium mannii **Hook.** Epiphytic herb. Moist intermediate and montane forest, 2036–2087 m. FOKP 1508 (EA, HIB).

***Asplenium megalura* Hieron.** Perennial herb. moist intermediate and montane forests, 1893–1969 m. FOKP 1437 (EA, HIB), SAJIT 006942 (EA, HIB).

***Asplenium protensum* Schrad.** Herb. Moist upland forest, 1975 m. FOKP 1365 (EA, HIB), FOKP 1368 (EA, HIB), FOKP 1434 (EA, HIB).

***Asplenium sandersonii* Hook.** Herb. Montane moist forest, occasionally in moister spots in dry forests, 1975 m. FOKP 1665 (EA, HIB).

***Asplenium smedsii* Pic. Serm.** Epiphyte. Moist montane forest, 2010–2257 m. FOKP 1401 (EA, HIB) FOKP 1433 (EA, HIB), FOKP 1472 (EA, HIB).

***Asplenium stuhlmannii* Hieron.** Epiphyte. Moist montane forest, 2010 m. FOKP 1533 (EA, HIB), FOKP 1608 (EA, HIB).

***Asplenium theciferum* (Kunth) Mett.** Perennial herb. Moist upland forest, 1920 m. FOKP 1319 (EA, HIB).

***Asplenium thunbergii* Kunze.** Herb. Dense shade of Moist forests, 1961 m. FOKP 1412 (EA, HIB).

F3. Athyriaceae

3 Genera, 3 species

***Athyrium scandicinum* (Willd.) C. Presl.** Herb. Montane forests extending along the streams, 2016–2063 m. FOKP 1521 (EA, HIB), FOKP 1681 (EA, HIB).

***Deparia boryana* (Willd.) M. Kato.** Herb. Moist upland forest, 1966–2007 m. FOKP 1424 (EA, HIB).

***Diplazium velaminosum* (Diels) Pic. Serm.** Herb. Along streams in upland evergreen forest, 1927 m. FOKP 1454 (EA, HIB).

F4. Blechnaceae

1 Genus, 1 species

***Blechnum attenuatum* (Sw.) Mett.** Herb. Moist montane forest, 1929 m. FOKP 1471 (EA, HIB).

F5. Cyatheaceae

1 Genus, 1 species

***Alsophila manniana* (Hook.) R. M. Tryon.** Tree. Form dense stand in steep, forested valleys along rivers, roadsides, 1991 m. Mabberley 19 (EA).

F6. Cystopteridaceae

1 Genus, 1 species

***Cystopteris fragilis* (L.) Bernh.** Herb. Upland forest, 2016 m. FOKP 1520 (EA, HIB).

F7. Dennstaedtiaceae

1 Genus, 1 species

***Hypolepis sparsisora* (Schrad.) Kuhn. Herb.** Common in open areas at high altitudes, 1996 m. FOKP 1562 (EA, HIB).

F8. Didymochlaenaceae
1 Genus, 1 species

***Didymochlaena truncatula* (Sw.) J. Sm.** Herb. Wet forests, 2019 m. FOKP 1403 (EA, HIB), FOKP 1404 (EA, HIB).

F9. Dryopteridaceae
4 Genera, 6 species

***Arachniodes webbiana* (A. Braun) Schelpe**. Herb. Wet upland forests, 2393 m. FOKP 1491 (EA, HIB). Vulnerable.

***Ctenitis cirrhosa* (Schumach.) Ching**. Herb. Wet upland forests, 2005–2193 m. FOKP 1399 (EA, HIB), FOKP 1442 (EA, HIB), FOKP 1516 (EA, HIB).

***Dryopteris pentheri* (Krasser) C. Chr.** Herb. Shades of moist forests and roadside banks in ditches, 1993 m. FOKP 1416 (EA, HIB).

***Dryopteris schimperiana* (Hochst.) C. Chr.** Herb. Riverine forest, 2008 m. FOKP 1417 (EA).

***Dryopteris manniana* (Hook.) C. Chr.** Herb. Moist upland forest, 1995 m. FOKP 1428 (EA).

***Polystichum sinense* (Christ) Christ.** Herb. Shady moist forest, along the streams, 2391 m. FOKP 1473 (EA, HIB).

F10. Hymenophyllaceae
1 Genus, 2 species

***Crepidomanes chevalieri* (Christ) Ebihara & Dubuisson.** Herb. Found on tree trunks in upland forest, 2036 m. FOKP 1509 (EA, HIB).

***Crepidomanes melanotrichum* (Schltdl.) J. P. Roux.** Herb. Usually on tree trunks, often in wet places in dry forests, 2036–2387 m. FOKP 1476 (EA, HIB), FOKP 1510 (EA, HIB).

F11. Lomariopsidaceae
1 Genus, 1 species

***Nephrolepis undulata* (Afzel. ex Sw.) J. Sm.** Herb. Moist thickets, 2041 m. FOKP 1635 (EA, HIB).

F12. Marattiaceae
1 Genus, 1species

***Ptisana fraxinea* (Sm.) Murdock.** Herb. Upland forest, 1989 m. FOKP 1370 (EA, HIB).

F13. Polypodiaceae
4 ***Genera***, 4 species

Lepisorus excavatus **(Bory ex Willd.) Ching.** Epiphyte. Upland forest, moist, riverine forest, 1849–2140 m. FOKP 1358 (EA, HIB), FOKP 1639 (EA, HIB), FOKP 1648 (EA, HIB).

Loxogramme abyssinica **(Baker) M. G. Price.** Herb. Dry and wet upland forest, 1873–1895m. FOKP 1351 (EA, HIB), SAJIT 006941 (EA, HIB).

Pleopeltis macrocarpa **(Bory ex Willd.) Kaulf.** Herb. Dry or moist, riverine forest, 1893–2040 m. FOKP 1361 (EA, HIB), SAJIT 006940 (EA, HIB).

Hovenkampia schimperiana **(Mett. ex Kuhn) Li Bing Zhang & X. M. Zhou.** Herb. Locally common on rocks and trees in riverine and moist intermediate forests, 600–2125 m. FOKP 1618 (EA, HIB).

F14. Pteridaceae
7 Genera, 10 species

Aleuritopteris farinosa **(Forsk.) Fée.** Herb. Upland forest, 2180 m. FOKP 1505 (EA, HIB).

Cheilanthes bergiana **Schltdl.** Herb. Moist banks in upland forest, 1966 m. FOKP 1397 (EA, HIB), FOKP 1398 (EA, HIB), FOKP 1522 (EA, HIB).

Cheilanthes viridis **(Forssk.) Sw.** Herb. On banks, path sides, forest margins, among rocks in woodland, 1982 m. FOKP 1553 (EA, HIB).

Coniogramme africana **Hieron.** Herb. Moist forest, 2013 m. FOKP 1408 (EA, HIB).

Doryopteris concolor **(Langsd. & Fisch.) Kuhn.** Herb. Dry and wet forest, 2043 m. FOKP 1378 (EA, HIB), SAJIT 007022 (EA, HIB).

Doryopteris kirkii **(Hook.) Alston.** Herb. Dry and wet forest, 2009 m. FOKP 1375 (EA, HIB).

Haplopteris volkensii **(Hieron.) E. H. Crane.** Herb. Moist upland forest, 2016 m. FOKP 1519 (EA, HIB).

Pellaea calomelanos **(Sw.) Link.** Herb. On the rock crevices or on roadside banks I full sun, 2125–2148 m. FOKP 1606 (EA, HIB), SAJIT 006611 (EA, HIB).

Pteris dentata **Forssk.** Herb. Upland forest, moist areas, 1996–2019 m. FOKP 1391 (EA, HIB), FOKP 1563 (EA, HIB), FOKP 1627 (EA, HIB).

Pteris pteridioides **(Hook.) Ballard.** Herb. Upland forest, moist areas, 1996–2019 m. FOKP 1388 (EA, HIB).

F15. Tectariaceae
2 Genera, 2 species

Arthropteris orientalis **(J. F. Gmel.) Posth.** Herb. Partial shade on rocks or ground, rarely epiphytic, in dry or moist forests or thickets, 2140 m. FOKP 1336 (EA, HIB), Sangai573 (EA).

Tectaria gemmifera **(Fée) Alston.** Herb. Upland forest, 1864 m. Melly 0247 (EA).

F16. Thelypteridaceae
4 Genera, 5 species

Christella dentata **(Forssk.) Brownsey & Jermy.** Herb. Common along streams and other wet places in the forests, 1864 m. FOKP 1326 (EA, HIB).
Cyclosorus gueinziana **(Mett.) J. P. Roux.** Herb. Riverine, moist roadside banks, 1864 m. FOKP 1332 (EA, HIB).
Cyclosorus interruptus **(Willd.) H. Itô.** Herb. Marshes and swamps, 1864–1995 m. FOKP 1327 (EA, HIB), FOKP 1438 (EA, HIB), FOKP 1586 (EA, HIB).
Pneumatopteris unita **(Kunze) Holttum.** Herb. Along streams in moist forest, 1771 m. Melly 0277 (EA).
Pseudocyclosorus pulcher **(Bory ex Willd.) Holttum.** Herb. Shaded moist forest floors and next to streams, 1927 m. FOKP 1449 (EA, HIB).

GYMNOSPERMS

F17. Podocarpaceae
1 Genus, 1 species

Podocarpus latifolius **(Thunb.) R. Br. ex Mirb.** Tree. Upland rainforest, 900–3150 m. Geesteranus 4984 (EA).

ANGIOSPERMS

F18. Achariaceae
1 Genera, 1 species

Rawsonia lucida **Harv. & Sond.** Tree. Moist or riverine forest, 1951 m. Melly 0060 (EA).

F19. Acanthaceae
10 Genera, 18 species

Acanthopale pubescens **(Lindau ex Engl.) C.B. Clarke.** Shrub. Wet Forest, 1762–1947 m. Melly 0069 (EA), Melly 0270 (EA), Bamps 6475 (EA), SAJIT 006935 (EA, HIB), SAJIT 006997 (EA, HIB).
Acanthus eminens **C.B. Clarke**. Shrub. Upland forest, 1924 m. Melly 0101 (EA).
Acanthus polystachius **Delile.** Perennial herb. Forest clearings, wooded grassland, 2005 m. Melly 0122 (EA).

***Acanthus pubescens* (Thoms. ex Oliv.) Engl.** Shrub. Forest edges, wet grasslands, rocky hills, 1830 m. Hill 698 (EA).

***Barleria ventricosa* Nees.** Herb. Under forests, edges and disturbed areas, 1941 m. Melly 0239 (EA).

***Brillantaisia vogeliana* (Nees) Benth.** Herb. Forest undergrowth, 2005 m. FOKP 1514 (EA, HIB).

***Brillantaisia owariensis* P. Beauv.** Herb. Wet lowland and montane forests, often along streams or in damp places, riverine or along river banks, swampy forest, 750–1850 m. Dale 3208 (EA).

***Dyschoriste radicans* Nees.** Herb. Common along roadsides, 2015 m. FOKP 1644 (EA, HIB).

***Isoglossa punctata* (Vahl) Brummitt & Wood.** Herb. Locally common in montane rain forest, 1350–2400 m. FOKP 1495 (EA).

***Justicia betonica* L.** Herb. Grassland, Wet forests, riversides, 700–2220 m. Tweedie 2985 (EA).

***Justicia pinguior* C.B. Clarke.** Herb. Common in wooded grasslands, 2149 m. FOKP 1690 (EA).

***Justicia flava* (Forssk.) Vahl.** Herb. Wooded grassland, 1951 m. Melly 0006 (EA).

***Mimulopsis arborescens* C.B. Clarke.** Tree. Upland forest, 1973 m. Cock 009 (EA).

***Mimulopsis solmsii* Schweinf.** Woody herb. Upland forest, 1986 m. Melly 0116 (EA).

***Pseuderanthemum ludovicianum* (Büttner) Lindau.** Woody herb. Riverine, forest undergrowth, 1740 m. Melly 0312 (EA).

***Thunbergia alata* Bojer ex Sims.** Herb. Forest edge, bushland, thicket, 1995 m. Melly 0134 (EA).

***Thunbergia paulitschkeana* Beck.** Herb. In forest margin, grassland of upland forest 1904–2017 m. Melly 0117 (EA), SAJIT 007014 (EA, HIB).

***Thunbergia usambarica* Lindau.** Herb. Upland forest on the forest edges, 1881–2073 m. FOKP 1654 (EA, HIB), Williams and Piers 594 (EA), SAJIT 006943 (EA, HIB), SAJIT 006983 (EA, HIB), SAJIT 006987 (EA, HIB), SAJIT 007026 (EA, HIB).

F20. Alismataceae

1 Genus, 1 species

***Alisma plantago-aquatica* L.** Herb. Wet places, especially by streamsides, 1884–2052 m. FOKP 1538 (EA, HIB), SAJIT 006639 (EA, HIB), SAJIT 006947 (EA, HIB).

F21. Amaranthaceae

3 Genera, 4 species

***Achyranthes aspera* L.** Annual or perennial herb. Disturbed dry places, 1778 m. Melly 0269 (EA).

***Cyathula cylindrica* Moq.** Herb. Bushland, 1936 m. Melly 0097 (EA).

***Cyathula uncinulata* (Schrad.) Schinz.** Herb. Forest margins, hedges, roadside, stream banks, 2026 m. FOKP 1394 (EA), SAJIT 006662 (EA, HIB).

***Sericostachys scandens* Gilg & Lopr.** Shrub. Moist riverine, forest edge, 1733 m. Melly 0299 (EA).

F22. Amaryllidacaee

2 Genera, 2 species

***Crinum kirkii* Baker.** Herb. Grassland, 1900 m. Ekkens 2731 (EA).

***Scadoxus multiflorus* (Martyn) Raf.** Herb. Rocky places in forest edges, riverine forest, 2002–2052 m. FOKP 1642 (EA, HIB), SAJIT 007081 (EA, HIB).

F23. Anacardiaceae

1 Genus, 2 species

***Searsia longipes* (Engl.) Moffett.** Tree. Wooded grassland, 1964 m. FOKP 1574 (EA).

***Searsia pyroides* (Burch.) Moffett.** Shrub or small tree. Bushland, wooded grassland, dry forest margins, along stream banks, 2004–2058 m. FOKP 1560 (EA, HIB), FOKP 1601 (EA, HIB).

F24. Annonaceae

2 Genera, 2 species

***Artabotrys likimensis* De Wild.** Shrub or Liana. Evergreen rainforest, 1884–1973 m. Battiscombe 570 (EA), Melly 0055 (EA), Melly 0107 (EA), SAJIT 006678 (EA, HIB), SAJIT 006937 (EA, HIB).

***Monanthotaxis schweinfurthii* (Engl. & Diels) Verdc.** Shrub or Liana. Evergreen forest, often riverine, 1830–1966 m. Dale 3171 (EA), FOKP 1661 (EA, HIB).

F25. Apiaceae

1 Genus, 1 species

***Heteromorpha arborescens* var. *abyssinica* (Hochst. ex A. Rich.) H. Wolff.** Shrub or tree. Evergreen bushland or riverine, dry forest on edges, rocky grassland, 1150–2650 m. Melly 0197 (EA).

F26. Apocynaceae

11 Genera, 13 species

***Carissa spinarum* L.** Shrub. Forest margins, bushland, wooded grassland, thickets, especially in rocky places, 2120 m. Melly 0202 (EA).

***Cynanchum altiscandens* K. Schum.** Climber. Upland forest edges, 2014 m. FOKP 1647 (EA).

***Funtumia africana* (Benth.) Stapf.** Tree. Moist upland forest, 1625 m. SAJIT 006680 (EA, HIB).

*****Gomphocarpus physocarpus* E. Meyer.** Shrub. Forest edge, disturbed places, seasonal swampy grassland and roadsides, 1769–1920m. FOKP 1671 (EA, HIB), Melly 0280 (EA).

***Landolphia buchananii* (Hallier f.) Stapf.** Liana or scandent shrub. Riverine forest, relict montane evergreen forest, 1977–2143 m. Melly 0180 (EA), SAJIT 006630 (EA, HIB), FOKP 1545 (EA, HIB).

***Mondia whitei* (Hook. f.) Skeels.** Climber. Upland forest, 2026 m. FOKP 1718 (EA, HIB).

***Oncinotis tenuiloba* Stapf.** Climber. Riverine forests margins, 1888 m. Melly 0246 (EA).

***Pergularia daemia* (Forssk.) Chiov.** Twinning herb. Upland forest, 2057–2071 m. SAJIT 006629 (EA, HIB), SAJIT 007031 (EA, HIB).

***Periploca linearifolia* Quart.-Dill. & A. Rich.** Climber. Upland forest on road sides, 2010–2186 m. Melly 0127 (EA), SAJIT 006609 (EA, HIB), SAJIT 006934 (EA, HIB), FOKP 1506 (EA, HIB).

***Tabernaemontana stapfiana* Britten.** Tree. Moist disturbed forest, 1921 m. SAJIT 006934 (EA, HIB).

***Vincetoxicum anomalum* (N.E. Br.) Meve & Liede.** Climber. Upland forest, 2118–2148 m. SAJIT 006604 (EA, HIB), SAJIT 006932 (EA, HIB), Melly 0192 (EA).

***Vincetoxicum heterophylla* (A. Rich.) Vatke.** Climber. Upland forest on forest Margins, 1996 m. SAJIT 007016 (EA, HIB).

***Vincetoxicum sylvaticum* (Decne.) Kuntze.** Climber. Rare in bushland, 1920–1967 m. FOKP 1307 (EA, HIB), FOKP 1662 (EA, HIB).

F27. Araceae

2 Genera, 3 species

***Culcasia falcifolia* Engl.** Climber. Upland forest, 1944–2026 m. SAJIT 006636 (EA, HIB), FOKP 1381 (EA, HIB), Melly 0057 (EA).

***Culcasia scandens* P. Beauv.** Herb. Rainforest, riverine or swamp forest, 1965 m. Agnew and Musumba 8592 (EA).

***Sauromatum venosum* (Dryand. ex Aiton) Kunth.** Herb. Upland forest, uncommon in savannah, 2019–2056 m. FOKP 1631 (EA, HIB), SAJIT 007030 (EA, HIB).

F28. Araliaceae

5 Genera, 6 species

***Astropanax abyssinicus* (Hochst. ex A. Rich.) Seem.** Tree. Wet upland forest, 1981 m. FOKP 1384 (EA, HIB).

***Astropanax volkensii* (Harms) Lowry, G. M. Plunkett, Gostel & Frodin.** Tree. Wet or dry upland forest, 1896–1965 m. Melly 0102 (EA), FOKP 1395(EA, HIB).

***Cussonia spicata* Thunb.** Tree. Riverine, grassland forest, 2327 m. FOKP 1484 (EA, HIB).

***Heteromorpha arborescens* var. *abyssinica* (Hochst. ex Rich.) H. Wolff.** Shrub. In montane and riverine woodland, in forest margins and in secondary regrowth, 2140 m. FOKP 1638 (EA, HIB).

***Polyscias fulva* (Hiern) Harms.** Tree. Moist upland forest, 2026–2334 m. Melly 0194 (EA), FOKP 1487 (EA, HIB).

***Schefflera myriantha* (Baker) Drake** Tree. Upland forest, 1997 m. SAJIT 007018 (EA, HIB).

F29. Asparagaceae

5 Genera, 11 species

***Asparagus africanus* Lam.** Shrub. Forest edges, bushy woodland, grassland, 1995 m. FOKP 1377 (EA).

***Asparagus racemosus* Willd.** Woody Climber or scrambling shrub. Forest margins, drier bushland, 1945 m. Melly 0220 (EA).

***Chlorophytum blepharophyllum* Schweinf. ex Baker.** Herb. Locally common in burnt grassland, 1828 m. Battiscombe K657 (EA).

***Chlorophytum cameronii* (Baker) Kativu.** Herb. Highland grassland, often on rocky slopes, 1706 m. Hill 1(EA).

***Chlorophytum comosum* (Thunb.) Jacques.** Herb. Shady wet places in forest, locally found in burnt grassland, 1828–1967 m. FOKP 1664 (EA, HIB), Gillett 16716 (EA).

***Chlorophytum gallabatense* Schweinf. ex Baker.** Herb. Grassland, open woodlands and shallow soils, after first rains, 1676 m. Hill 740 (EA).

***Chlorophytum nubicum* (Baker) Kativu.** Herb. Upland grasslands, 1676 m. Hill 692(EA).

***Dracaena laxissima* Engl.** Shrub. Upland forest, 1818–1991 m. Melly 0114 (EA), Melly 0260 (EA).

***Dracaena steudneri* Engl.** Shrub. Moist upland forest, 2087 m. FOKP 1777 (EA, HIB).

***Ledebouria revoluta* (L. f.) Jessop.** Herb. Upland forest, 1900–2009 m. Ekkens 2454, FOKP 1569 (EA, HIB).

***Ornithogalum gracillimum* R. E. Fr.** Herb. Grassland, 2125 m. FOKP 1616 (EA, HIB).

F30. Asphodelaceae

1 Genus, 1 species

***Aloe elgonica* Bullock.** Shrub. Shallow soils or in pockets on rocky slopes, 2133 m. G650 (EA), Reynold 7522 (EA).

F31. Asteraceae

36 Genera, 50 species

****Acanthospermum glabratum* (DC.) Wild.** Herb. Grassland, 1995 m. FOKP 1554 (EA, HIB).

***Acmella caulirhiza* Delile.** Herb. Swampy or seasonally wet sites, river banks, forest margins, cultivated areas, 2058 m. Melly 0155 (EA).

***Adenostemma caffrum* DC.** Herb. Wet grounds and swamps especially in disturbed sites, 1050–2300 m. Hill 151(EA), FOKP 1419 (EA, HIB).

***Ageratina adenophora* (Spreng.) R. M. King & H. Rob.** Shrub. Riverine, swampy sites, 2183 m. FOKP 1504 (EA, HIB).

*****Ageratum conyzoides* L.** Herb. Weed in cultivation, pioneer on disturbed land, grassland, 1808 m. Melly 0027 (EA).

***Artemisia afra* Jacq. ex Willd.** Woody herb or shrub. Burnt areas, upland bushland edges, 1889 m. Melly 0244 (EA).

***Baccharoides dumicola* (S. Moore) Isawumi, El-Ghazaly & B. Nord.** Shrubby herb or small shrub. Wet grassland, mashes, riverine, 1967 m. FOKP 1669 (EA, HIB).

***Baccharoides lasiopus* (O. Hoffm.) H. Rob.** Herb. Upland forest on the edges, 1864–2058 m. FOKP 1330, Melly 0037 (EA), Melly 0157 (EA), SAJIT 006664 (EA, HIB).

***Berkheya spekeana* Oliv.** Herb. Wooded grassland, 2149 m. FOKP 1684 (EA, HIB).

***Bidens kilimandscharica* (O. Hoffm.) Sherff.** Herb. Upland forest edges, 1962 m. Melly 0002 (EA).

***Blumea axillaris* (Lam.) DC.** Herb. Local by streamsides and naturally disturbed places, 1920 m. FOKP 1323 (EA, HIB).

***Cineraria deltoidea* Sond.** Herb. Hillside, shrubland, roadsides, forest edges and cliffs, 1835 m. Melly 0021 (EA).

***Conyza hochstetteri* Sch.Bip. ex A. Rich.** Herb. Very common in disturbed grassland, 1987 m. FOKP 1585 (EA, HIB).

***Conyza schimperi* Sch. Bip. ex A. Rich.** Herb. Upland grassland, especially on impeded drainage, 1864 m. FOKP 1339 (EA, HIB).

***Crassocephalum montuosum* (S. Moore) Milne-Redhead.** Herb. Upland forest, valley, 1950 m. Kamau 278 (EA).

***Crassocephalum picridifolium* (DC.) S. Moore.** Herb. Swamps and river edges, 2026 m. SAJIT 006663 (EA, HIB).

***Crassocephalum rubens* (Juss. ex Jacq.) S. Moore.** Herb. Disturbed, often cultivated ground, 1677 m. 492 (EA).

***Crassocephalum vitellinum* (Benth.) S. Moore.** Herb. Upland forest, farming land, 1966 m. SAJIT 007032 (EA, HIB).

***Crepis rueppellii* Sch. Bip.** Herb. Highland grassland, 1600–3200 m. FOKP 1643 (EA, HIB).

***Dichrocephala integrifolia* (L. f.) Kuntze.** Herb. Disturbed wet habitats, 1880–1958 m. SAJIT 007037 (EA, HIB), Melly 0105 (EA).

***Distephanus biafrae* (Oliv. & Hiern) H. Rob**. Scrambling low shrub. Locally common in bushland in Western Kenya, 1040–2400 m. Dale 1012 (EA).

***Erigeron trilobus* (Decne.) Boiss.** Herb. Common in disturbed places in dry grassland, bushland, 1846–2001 m. Melly 0032 (EA), Melly 0132 (EA).

***Gamochaeta purpurea* (L.) Cabrera.** Herb. In gardens, arable cultivation, 1999 m. FOKP 1576 (EA, HIB).

***Gerbera viridifolia* (DC.) Sch. Bip.** Shrub. Upland forest, on roadsides, 1500–2100 m. Gilbert and Mesfin 6704 (EA).

***Guizotia scabra* (Vis.) Chiov.** Herb. Upland grassland, 2183 m. FOKP 1498 (EA, HIB).

***Gymnanthemum amygdalinum* (Delile) Sch. Bip. ex Walp.** Herb. Disturbed cultivated area, hillside, bushland, 1872 m. Melly 0031 (EA).

***Gymnanthemum auriculiferum* (Hiern) Isawumi.** Shrub or tree. Forest margins, riverine, lakeshores, bushland derived from disturbed upland forests, 1920 m. FOKP 1320 (EA).

***Gymnanthemum urticifolium* (A. Rich.) H. Robinson.** Shrub. Forest edges, 2026 m. Tweedie 1371 (EA, HIB).

***Helichrysum argyranthum* O. Hoffm.** Shrub. Upland forest, streamsides, 2026 m. SAJIT 006644 (EA, HIB).

***Helichrysum forskahlii* (J. F. Gmel.) Hilliard & B. L. Burtt.** Herb. Rocky grassland, 1200–3500 m. FOKP 1614 (EA).

***Helichrysum globosum* Sch. Bip.** Herb. Upland grassland, 1920 m. FOKP 1321 (EA, HIB).

***Helichrysum pedunculatum* Hilliard & B. L. Burtt.** Herb. Grassland, 1985 m. FOKP 1598 (EA, HIB).

***Kleinia abyssinica* (A. Rich.) A. Berger.** Herb. Bushland, grassland, 1849 m. FOKP 1357 (EA, HIB).

***Laggera brevipes* Oliv. & Hiern.** Herb. Forest clearings and margins, 1789 m. Melly 0278 (EA).

***Laggera elatior* R. E. Fr.** Herb. Moist upland forest, rocky places, 2148 m. SAJIT 006617 (EA, HIB).

***Lactuca glandulifera* Hook. f.** Woody herb. Moist sites along streams, forest margins, in grassland, bushland, cultivated land, 1200–3600 m. Gilbert 6883(EA).

***Linzia gerberiformis* (Oliv. & Hiern) H. Rob.** Herb. Seasonally burned grassland and wooded grassland, 1864–2149 m. Archer 247 (EA), FOKP 1333 (EA, HIB), FOKP 1686 (EA, HIB).

***Linzia ituriensis* (Muschl.) H. Rob.** Perennial herb. Wet forest margins, 2005 m. FOKP 1515 (EA, HIB).

***Lipotriche scandens* (Schumach. & Thonn.) Orchard.** Woody herb. Evergreen forest margins, river, lake and swamp margins, moist grassland, 1857–2250 m. Chandler 421 (EA), SAJIT 006965 (EA, HIB).

***Microglossa pyrifolia* (Lam.) Kuntze.** Shrub. Forest margins, waste shrubland, 1950 m. Ls 503 (EA).

***Mikania chenopodifolia* Willd.** Shrub. Marshy area, 1823 m. Melly 0046 (EA).

***Solanecio angulatus* (Vahl) C. Jeffrey.** Climber. Upland forest, 2026 m. GBK 003/057/2001 (EA), SAJIT 006642 (EA, HIB).

***Solanecio mannii* (Hook. f.) C. Jeffrey.** Shrub or tree. Dry or evergreen forest margins, secondary forest, riverine forest, on rocky slopes in bushland, 1891 m. Melly 0029 (EA).

***Senecio ruwenzoriensis* S. Moore.** Herb. Disturbed montane forests, often as boundary plant, 1892–2334 m. FOKP 1485 (EA, HIB), FOKP 1634, (EA, HIB), Melly 0125 (EA), Melly 0219 (EA).

***Sonchus camporum* (R. E. Fr.) Boulos ex C. Jeffrey.** Perennial herb. Grassland, 1800–2300 m. Dauglish 68 (EA).

***Sphaeranthus suaveolens* (Forsk.) DC.** Herb. Found near freshwater, often in dry streambeds, 1864 m. FOKP 1324 (EA, HIB).

****Tagetes minuta* L.** Shrub. Upland arable land, 1962–2076 m. FOKP 1658 (EA, HIB).

***Taraxacum officinale* Wiggers.** Herb. Riverine, forest edge, 1880–2076 m. Melly 0106 (EA), Melly 0165 (EA).

***Vernonia galamensis* (Cass.) Less.** Shrub. Clearings in woodland and woodland edges, 2184 m. FOKP 1502 (EA, HIB).

***Vernonia urticifolia* A. Rich.** Shrub. Upland forest on edges, 2026–2183 m. FOKP 1503 (EA, HIB), SAJIT 006650 (EA, HIB).

F32. Balsaminaceae

1 Genus, 7 species

***Impatiens burtonii* Hook. f.** Herb. Swampy sites of montane forests, forest edges, 2150 m. Verdcourt 1639.

***Impatiens digitata* Warb.** Herb. Forest edges, 1939 m. Melly 0005 (EA).

***Impatiens hochstetteri* Warb.** Herb. Streamsides in wet forests, 1885–2012 m. FOKP 1450 (EA, HIB), FOKP 1587 (EA, HIB), Melly 0071 (EA), Melly 0227, SAJIT 006946 (EA, HIB).

***Impatiens meruensis* Gilg.** Herb. Highland forest, marshes and streamside, 2051 m. FOKP 1539 (EA, HIB).

***Impatiens niamniamensis* Gilg.** Herb. Upland forest, 1918–2013 m. FOKP 1364 (EA, HIB), FOKP 1464 (EA, HIB), Melly 0109 (EA), SAJIT 006961 (EA, HIB).

***Impatiens pseudoviola* Gilg.** Herb. Wet places in lower highland forests, 1859 m. Melly 0256 (EA).

***Impatiens stuhlmannii* Warb.** Herb. Wet forests, 1821–2027 m. FOKP 1315 (EA, HIB), FOKP 1456 (EA, HIB), Melly 0104 (EA), Melly 0218 (EA), SAJIT 006675 (EA, HIB), SAJIT 006978 (EA, HIB).

F33. Basellaceae

1 Genus, 1 species

***Basella alba* L.** Climber. Hill Side, thickets, hedges, riverine vegetation (margins), cultivations, on swampy ground, 1953 m. Melly 0011 (EA).

F34. Bignoniaceae

2 Genera, 2 species

***Kigelia africana* (Lam.) Benth. subsp. *Africana*.** Tree. Riverine evergreen forest, forest margins, 1736–1826 m. Melly 0259 (EA), Melly 0279 (EA).

***Kigelia africana* subsp. *moosa* (Sprague) Bidgood & Verdc.** Shrub or tree. Riverine evergreen forest, forest margins, 1864 m. FOKP 1328 (EA, HIB).

***Spathodea campanulata* P. Beauv.** Tree. Scattered tree grassland, upland forest, riverine, 2025 m. Melly 0207 (EA).

F35. Boraginaceae

2 Genera, 3 species

***Cynoglossum coeruleum* A. DC.** Perennial herb. Sub montane grassland, forest clearings, along the paths, 2368 m. FOKP 1489 (EA, HIB).

***Cynoglossum lanceolatum* Forssk.** Annual herb. Grassland, riverbanks, riverine forest, roadsides, cultivated ground, hillside, bushland, 1852 m. FOKP 1486 (EA, HIB), Melly 0034 (EA).

***Ehretia cymosa* Thonn.** Tree. Upland moist forest or road patches, 2008–2026 m. Melly 0143 (EA), SAJIT 006668 (EA, HIB).

F36. Brassicaceae

1 Genus, 1 species

***Cardamine africana* L.** Herb. Floor of highland forest and riverine, 1975–2016 m. FOKP 1369, FOKP 1526, Melly 0072, SAJIT 006951 (EA).

F37. Cactaceae

1 Genus, 1 species

***Rhipsalis baccifera* (J. S. Muell.) Stearn.** Epiphyte. Upland dry forest, 1758–1960 m. FOKP 1396 (EA, HIB), FOKP 1470 (EA, HIB), Melly 094 (EA), Melly 0309 (EA).

F38. Campanulaceae

3 Genera, 4 species

***Canarina abyssinica* Engl.** Climber. Wet forest, 1927 m. FOKP 1458 (EA, HIB).

***Canarina eminii* Asch. & Schweinf.** Climber. Wet forest, 2000 m. SAJIT 007011 (EA, HIB).

***Lobelia giberroa* Hemsl.** Shrub. Forest margins, swamps, riverine forest, 1935 m. Melly 0215 (EA).

***Wahlenbergia hookeri* (C.B. Clarke) Tuyn.** Annual herb. Grassland or woodland, often on rocky places or cultivated ground, 800–1950 m. Tallantire 124 (EA).

F39. Cannabaceae

4 Genera, 5 species

***Cannabis sativa* L.** Herb. Upland forest, 0–2100 m. James (EA).
***Celtis africana* Burm. f.** Tree. Riverine forest, dry evergreen forest, 2125 m. FOKP 1630 (EA, HIB).
***Celtis gomphophylla* Baker.** Tree. Forest edge, moist evergreen forest, 1200–1750 m. Melly 0123 (EA).
***Chaetachme aristata* Planch.** Shrub or Small bushy tree. Understorey, margins of uplands rainforests, 1746 m. Melly 0291 (EA).
***Trema orientalis* (L.) Blume.** Shrub or tree. Woodland forest, 2133 m. Melly 0184 (EA).

F40. Capparaceae
2 Genera, 2 species

***Maerua triphylla* A. Rich.** Tree. Upland forest, 2076 m. Melly 0161 (EA).
***Ritchiea albersii* Gilg.** Shrub or tree. Forest margins, forest patches, riverine forest, plantation understorey, 1980–2019 m. FOKP 1548 (EA, HIB), FOKP 1629 (EA, HIB), SAJIT 007020 (EA, HIB).

F41. Caryophyllaceae
1 Genus, 1 species

***Drymaria cordata* (L.) Willd. ex Roem. & Schult.** Herb. Hedges, forest margins, path sides in the wetter forest, 1920–1943 m. FOKP 1316 (EA, HIB), Melly 0084 (EA).

F42. Celastraceae
6 Genera, 7 species

***Gymnosporia arbutifolia* (Hochst. ex A. Rich.) Loes.** Tree. Bushland, riverine or swampy places, bushed grassland, 1989–2125 m. FOKP 1555 (EA, HIB), FOKP 1622 (EA, HIB), SAJIT 007007 (EA).
***Gymnosporia heterophylla* (Eckl. & Zeyh.) Loes.** Tree. In Forest Margin., 1985–2052 m. FOKP 1541 (EA, HIB), FOKP 1556(EA, HIB), Melly 0090 (EA), Melly 0149(EA), SAJIT 007000 (EA, HIB).
***Loeseneriella africana* (Willd.) N. Hallé.** Climbing Shrub. Riverine, also in forest or rocky woodland, 1873–2071 m. FOKP 1349 (EA, HIB), SAJIT 006621 (EA, HIB), SAJIT 006939 (EA, HIB).
***Mystroxylon aethiopicum* (Thunb.) Loes. subsp. *Aethiopicum*.** Tree. Upland forest, 2074–2140 m. FOKP 1637 (EA, HIB), Melly 0152 (EA).
***Simirestis brianii* N. Hallé.** Woody climber. Upland forest, 1936 m. Melly 0216 (EA).
***Salacia cerasifera* Wele. Ex Oliv.** Shrub. Disturbed river valley, 1773–2087 m. Dale 3424(EA), Melly 0290(EA), FOKP 1675(EA, HIB), SAJIT 006998 (EA, HIB).
***Simirestis goetzei* (Loes.) N. Hallé ex R. Wilczek.** Shrub. Woodland, forest thicket, 2019–2361 m. FOKP 1496(EA, HIB), FOKP 1595 (EA, HIB).

F43. Colchicaceae
1 Genus, 1 species

***Gloriosa superba* L.** Herb. Shrubland, bushland, 1836 m. Williams EAH 10576 (EA), Piers 598 (EA), Melly 0051 (EA).

F44. Combretaceae
1 Genus, 2 species

***Combretum paniculatum* Vent.** Vigorous Climber or scrambling shrub. Forest margins, riverine forest, wooded grassland, 1933 m. Melly 0238 (EA).

***Combretum molle* R. Br. ex G. Don.** Tree. Wooded grassland, woodland, rocky hillsides, 2125 m. FOKP 1613 (EA, HIB).

F45. Commelinaceae
4 Genera, 9 species

***Aneilema minutiflorum* Faden.** Herb. Montane and riverine forests, forest edge, 2078 m. Melly 0169 (EA).

***Commelina benghalensis* L.** Herb. Riverine, grassland, bushland, 1947 m. Melly 0070 (EA).

***Commelina africana* L.** Herb. Grassland, 1962 m. FOKP 1655 (EA, HIB), Siemens 101 (EA).

***Commelina aspera* G. Don ex Benth.** Herb. Upland forest, 1920 m. William 611 (EA).

***Commelina latifolia* Hochst. ex A. Rich.** Herb. Weed of cultivation and disturbed habitats, sometimes in bushland and forest edges, 1828 m. Hill 295 (EA).

***Commelina subulata* Roth.** Herb. Common in black cotton soils, 1828 m. Hill 103 (EA).

***Floscopa glomerata* (Willd. ex Schult. & Schult. f.) Hassk.** Herb. Stagnant water pools in forest, 1676–1828 m. Gilbert and Mesfin 6738 (EA), Hill 77A (EA).

***Murdannia semiteres* (Dalzell) Santapau.** Herb. Edges of temporary pools in rocky areas, 1676 m. Hill 34 (EA).

***Murdannia simplex* (Vahl) Brenan.** Herb. Swamps, grassland and rocky places, 1676 m. Hill 102 (EA).

F46. Convolvulaceae
3 Genera, 5 species

***Cuscuta kilimanjari* Oliv.** Climber. Common in upland forest, 2076 m. FOKP 1544 (EA, HIB), Melly 0160 (EA).

***Dichondra repens* J. R. Forst. & G. Forst.** Herb. Weed of irrigated grasslands, lawns and roadsides, 1969 m. FOKP 1435 (EA).

Ipomoea hederifolia **L.** Annual herb. Waste places, thickets, cliffs locally established riverine forests, 0–1650 m. Meibertzhagen in E.A.H. 11364 (EA).

Ipomoea tenuirostris **Choisy.** Climber. Upland forest on the edges, 1827–2018 m. FOKP 1308 (EA), Melly 0206 (EA), Melly 0255 (EA).

Ipomoea wightii **(Wall.) Choisy.** Climber. Upland forest on hill Side, 1942–2071 m. Melly 0009 (EA), SAJIT 006627 (EA, HIB).

F47. Cornaceae

1 Genus, 1 species

Alangium chinense **(Lour.) Harms.** Tree. Wet upland forest or semi-deciduous upland forest, 2023 m. FOKP 1518 (EA, HIB).

F48. Crassulaceae

2 Genus, 3 species

Crassula granvikii **Mildbr.** Herb. Damp open soils, 1864–1927 m. FOKP 1355 (EA, HIB), FOKP 1451 (EA).

Kalanchoe crenata **(Andrews) Haw.** Herb. Upland forest grassland, 1974–2125 m. FOKP 1611 (EA), SAJIT 007005 (EA, HIB).

Kalanchoe prittwitzii **Engl.** Succulent herb. Upland forest thickets, bushland, 2125 m. FOKP 1605 (EA, HIB).

F49. Cucurbitaceae

7 Genera, 12 species

Coccinia barteri **(Hook. f.) Keay.** Climber. Lowland forest margins, 1843 m. SAJIT 006676 (EA, HIB), SAJIT 006976 (EA, HIB).

Coccinia subsessiliflora **Cogn.** Climber. Upland forest twining on tree trunks, 1979 m. Melly 0112 (EA), SAJIT 006676 (EA, HIB), SAJIT 006969 (EA, HIB). New record for Kenya.

Cucumis ficifolius **A. Rich.** Climber. Upland grassland and patchsides, 1936 m. Melly 0092 (EA).

Cucumis oreosyce **H. Schaef.** Climber. Upland grassland edges, 1873–1950 m. FOKP 1353 (EA, HIB), Melly 0233 (EA).

Diplocyclos palmatus **(L.) C. Jeffrey**. Climber perennial. Forest edge of upland forest, 1973 m. Glasgow 46/42 (EA).

Lagenaria abyssinica **(Hook. f.) C. Jeffrey.** Climber. Upland forest, mashy places, 1823–2026 m. FOKP 1653 (EA, HIB), Melly 0041 (EA), Melly 0242 (EA), SAJIT 006641 (EA, HIB), Melly 0214 (EA).

Momordica cissoides **Benth.** Climber. Upland forest, 1743–1872 m. Melly 0295 (EA), SAJIT 006974 (EA, HIB).

***Momordica foetida* Schumach.** Climber. Forest edges, old cultivation and disturbed places in wet regions, 1855–2132 m. SAJIT 006667 (EA, HIB), SAJIT 006970 (EA, HIB), SAJIT 006972 (EA, HIB), Melly 0189, (EA).

***Momordica friesiorum* (Harms) C. Jeffrey.** Climber. Upland forest edges, wet bushlands, 1849 m. FOKP 1342 (EA, HIB).

***Pilogyne minutiflora* (Cogn.) W. J. de Wilde & Duyfjes.** Climber. Hillside, bushland, damp places in grassland, margins of swamps, 1867 m. Melly 0028 (EA).

***Zehneria longiflora* G. W. Hu & Q. F. Wang.** Climber. Twining on trunks and branches of trees and shrubs in upland forest, 1748–1991 m. FOKP 1352 (EA, HIB), Melly 0226 (EA), Melly 0274 (EA), SAJIT 006669 (EA, HIB), SAJIT 006670 (EA, HIB), SAJIT 006672 (EA, HIB), SAJIT 006679 (EA, HIB), SAJIT 006958 (EA, HIB), SAJIT 006959 (EA, HIB), Melly 0093 (EA), Melly 0115 (EA), Melly 0119 (EA), FOKP 1385 (EA, HIB), SAJIT 006981 (EA, HIB). New species.

***Zehneria scabra* Sond.** Perennial Climber. Forest edges, old cultivation, and bushland, 1911–2062 m. FOKP 1427 (EA, HIB), SAJIT 006973 (EA, HIB), FOKP 1527 (EA, HIB), Melly 0135 (EA), Melly 0224(EA), Melly 0231(EA), SAJIT 006665(EA, HIB), SAJIT 006966 (EA), SAJIT 006968 (EA).

F50. Cyperaceae

9 Genera, 26 species

***Carex chlorosaccus* C.B. Clarke.** Herb. Moist forest, damp swamps, 1650 m. Lye and Katende 4961 (EA).

***Carex lycurus* K. Schum.** Herb. Upland river-sides, 1965 m. Siemens 91 (EA).

***Courtoisina assimilis* (Steud.) Maquet.** Herb. Disturbed bare soil in wetlands, 1828 m. Hill 40 (EA).

***Cyperus ajax* C.B. Clarke.** Herb. Highland wet forest, near streams or in clearings, 1965 m. Siemens 57, Siemens 63 (EA).

***Cyperus aterrimus* Hochst. ex Steud.** Herb. Upland grassland, 1965 m. Siemens 46 (EA).

***Cyperus cyperoides* (L.) Kuntze.** Herb. Montane forest, 1676–1927 m. Maluki 1085 (EA), FOKP 1439 (EA, HIB).

***Cyperus dichrostachyus* Hochst. ex A. Rich.** Herb. Highland swamps, 1965 m. Siemens 103, FOKP 1577 (EA, HIB).

***Cyperus fischerianus* Schimp. ex A. Rich.** Herb. Moist upland forest, 1965 m. Bogdan 4260 (EA), Siemens 104 (EA).

***Cyperus latifolius* Poir.** Herb. In Forest Margin, wetland, 1975–1988 m. FOKP 1551 (EA, HIB), SAJIT 007001 (EA, HIB), SAJIT 007004 (EA, HIB).

***Cyperus marquisensis* F.Br.** Herb. Wet disturbed places, 1700 m. Hohl 102 (EA).

***Cyperus platycaulis* Baker.** Herb. Wet areas, 1965 m. Siemens 45 (EA).

***Cyperus rigidifolius* Steud.** Herb. Upland grazing fields, 1900–1965 m. FOKP 1582 (EA, HIB), Siemens 64 (EA), Hohl 94 (EA).

***Cyperus schimperianus* Steud.** Perennial Herb. Riverine, 1770 m. Melly 0315 (EA).

***Fimbristylis dichotoma* (L.) Vahl.** Herb. Riverine, 1700–1987 m. Hohl101 (EA), FOKP 1581 (EA, HIB).

***Fimbristylis subaphylla* Boeckeler.** Herb. Upland forest, 1700 m. Agnew and Musumba 8613 (EA).

***Kyllinga bulbosa* P. Beauv.** Herb. Grassland damp sites, a weed in lawns, roadsides, 1975–2032 m. FOKP 1549 (EA, HIB), Hooper and Townsend 1528, SAJIT 007002 (EA, HIB), Hill 42 (EA).

***Kyllinga eximia* C.B. Clarke.** Herb. Shallow sandy soils in bushland, 2125 m. FOKP 1610 (EA, HIB).

***Kyllinga odorata* Vahl.** Herb. Riverine, 2001 m. FOKP 1420 (EA, HIB).

***Kyllinga pulchella* Kunth.** Herb. Woodland edges, 1828 m. Siemens 65 (EA).

***Lipocarpha chinensis* (Osbeck) J. Kern.** Herb. Permanent swamps and wet places, 1828 m. Hill 288 (EA).

***Mariscus dubius* (Rottb.) Kük. ex C. E. C. Fisch. subsp. *Dubius*.** Herb. Shallow soil seepage, 1700 m. Hohl 94 (EA).

***Mariscus hemisphaericus* (Boeckeler) C.B. Clarke.** Herb. Moist grassland 2052 m. FOKP 1542 (EA).

***Mariscus longibracteatus* Cherm.** Herb. Marshy places, 1987 m. FOKP 1583 (EA, HIB), Siemens 62 (EA).

***Mariscus tomaiophyllus* (K. Schum.) C.B. Clarke.** Perennial herb. Montane swamps, 1800–2900 m. Siemens 50 (EA).

***Pycreus elegantulus* (Steud.) C.B. Clarke.** Herb. Disturbed upland marshes, 1986 m. FOKP 1579 (EA, HIB).

***Pycreus flavescens* (L.) P. Beauv. ex Rchb.** Herb. Soggy open places in the rainy season, often on black cotton soils, 2038 m. SAJIT 007023 (EA, HIB).

***Scleria bulbifera* Hochst. ex A. Rich.** Herb. Seasonally wet grassland, 2125 m. Dyer 1180 (EA).

F51. Dichapetalaceae

1 Genus, 1 species

***Dichapetalum madagascariense* Poir.** Liana, shrub or small tree. Regenerating forest, moist upland forest, 1967 m. FOKP 1668 (EA, HIB).

F52. Dioscoreaceae

1 Genus, 4 species

***Dioscorea asteriscus* Burhill.** Climber. Upland forest, 1866 m. SAJIT 006980 (EA, HIB).

***Dioscorea praehensilis* Benth.** Climber. Rainforest, riverine, 1700–1782 m. Bally 13687 (EA), Melly 0297 (EA, HIB).

***Dioscorea schimperiana* Hochst. ex Kunth.** Climber. Wooded grassland, 2118–2148 m. Melly 0191 (EA), Williams 577 (EA), SAJIT 006619 (EA, HIB).

***Dioscorea quartiniana* A. Rich.** Climber. Woody grassland and bushland, 1923 m. Melly 0087 (EA).

F53. Ebenaceae

1 Genus, 1 species

***Diospyros abyssinica* (Hiern) F. White.** Tree. Riverine forests, 1930 m. Melly 0089 (EA).

F54. Euphorbiaceae

10 Genera, 14 species

***Acalypha villicaulis* Hochst. ex A. Rich.** Herb or weak shrub. Hill Side, Highland forest, warm areas, 1950 m. Melly 0013 (EA).

***Acalypha volkensii* Pax.** Shrub. Upland grassland, 1983 m. FOKP 1546 (EA, HIB).

***Alchornea hirtella* Benth.** Shrub or tree. Moist forests, 1974 m. FOKP 1389 (EA, HIB).

***Alchornea laxiflora* (Benth.) Pax & K. Hoffm.** Shrub or tree. Moist or dry forests, 1858 m. SAJIT 006975 (EA).

***Croton macrostachyus* Hochst. ex Delile.** Tree. Forest margins, 1945–2108 m. FOKP 1624 (EA, HIB), Melly 0008 (EA).

***Erythrococca trichogyne* (Műll. Arg.) Prain.** Shrub. Moist forests and riverine, 1849–1967 m. FOKP 1344 (EA, HIB), Melly 0062 (EA), Melly 0234 (EA), SAJIT 006992 (EA, HIB).

***Erythrococca bongensis* Pax.** Tree. Dry forest, riverine bushland, woodland, shrubby grassland, Wooded bushland, or thicket, 1892–1910 m. SAJIT 006991 (EA, HIB), SAJIT 006393 (EA, HIB).

***Erythrococca fischeri* Pax.** Shrub. Grassland, woodland, 1973–2086 m. Melly 0064 (EA), Melly 0171 (EA), SAJIT 006626 (EA, HIB).

***Macaranga capensis* var. *kilimandscharica* (Pax) Friis & M. G. Gilbert.** Tree. Moist upland forests, often in forest edges, 1970 m. Melly 0066 (EA).

***Neoboutonia macrocalyx* Pax.** Tree. Upland forests, mostly on edges and in clearings, 1934–2134 m. Melly 0091 (EA), Makin 16706, Melly 0195 (EA).

***Ricinus communis* L.** Woody perennial herb. Bushland, Path sides, 1931 m. Melly 0085 (EA).

***Shirakiopsis elliptica* (Hochst.) Esser.** Tree. Riverine forests, moist and dry forest mostly near water, 150–2148 m. Brunt1328 (EA), SAJIT 006612 (EA, HIB).

***Tragia brevipes* Pax.** Herb. Dry upland forest, 1854–1967 m. FOKP 1667 (EA, HIB), Melly 0035 (EA).

***Tragiella natalensis* (Sond.) Pax & K. Hoffm.** Twining or scrambling perennial herb. Upland forest on roadsides, Forest margins, 1961–2087 m. FOKP 1663 (EA, HIB), FOKP 1673 (EA, HIB), SAJIT 007033 (EA, HIB).

F55. Fabaceae

21 Genera, 31 species

Acacia lahai **Steud. & Hochst. ex Benth.** Tree. Forms dense woodland where upland forest has disappeared, or invading grassland, 2023 m. FOKP 1589 (EA, HIB).

Acacia pentagona **(Schum. & Thonn.) Hook. f.** Robust liana. In evergreen forest, 1707 m. Melly 0287 (EA).

Albizia amara **(Roxb.) B. Boivin.** Tree. Bushland, wooded grassland, 1957 m. Melly 0004 (EA).

Alysicarpus glumaceus **(Vahl) DC.** Herb. Common in seasonally flooded grassland, especially short grass on shallow soils, 2149 m. FOKP 1513 (EA, HIB).

Amphicarpaea africana **(Hook. f.) Harms.** Climber. Upland forest edges, 2071 m. SAJIT 006624 (EA, HIB).

*****Caesalpinia decapetala*** **(Roth) Alston.** Tree. Forest edge, 1969 m. Melly 0003 (EA).

Calpurnia aurea **(Aiton) Benth.** Shrub. Moist forest margins and riverine forest, 1995–2114 m. FOKP 1564 (EA, HIB), FOKP 1623 (EA, HIB), SAJIT 006652 (EA, HIB).

Chamaecrista kirkii **(Oliv.) Standl.** Herb. Grassland, marshy places, forest margins and clearings, 2125 m. FOKP 1617 (EA, HIB).

Chamaecrista mimosoides **(L.) Greene.** Herb. Common in disturbed places and open habitats on shallow soils, 2133 m. Melly 0185 (EA).

Crotalaria agatiflora **Schweinf.** Perennial herb or shrub. Bushed grassland, roadsides, forest margins, waste places, 1888 m. SAJIT 006989 (EA, HIB).

Crotalaria axillaris **Aiton.** Shrub. Bushland, 1987–2052 m. FOKP 1537 (EA, HIB), FOKP 1547 (EA, HIB).

Crotalaria mauensis **Baker f.** Shrub. Under forest, 2073 m. Melly 0172 (EA).

Dalbergia lactea **Vatke.** Shrub. Riverine, 1856–2026 m. Melly 0232 (EA), FOKP 1312 (EA, HIB), SAJIT 006985 (EA, HIB), Melly 0126, (EA).

Desmodium adscendens **(Sw.) DC.** Annual, perennial herb. Shaded forest clearings or margins, old cultivated fields, grassland of stream banks, 2135 m. FOKP 1513 (EA, HIB), Melly 0178 (EA).

Desmodium repandum **(Vahl) DC.** Herb. Upland forest, riverine by path sides, 1938 m. Melly 0235 (EA).

Dumasia villosa **DC.** Climber. Wet and evergreen forest, thickets, 1974 m. FOKP 1390 (EA, HIB).

Eriosema buchananii **Baker f.** Shrubby herb. Upland forest grassland, 1821–2148 m. Melly 0050 (EA), SAJIT 006615(EA, HIB).

Eriosema psoraloides **(Lam.) G. Don.** Perennial herb or subshrub. Wooded grassland, shrub, bushland, forest margins, 1861 m. Melly 0190 (EA), Melly 0254 (EA).

Haydonia triphylla **R. Wilczek.** Herb. Grassland, 1500–2100 m. Whyte.

Indigofera homblei **Baker f. & Martin.** Shrub. Upland forest, 2134 m. Melly 0187 (EA).

Lablab purpureus **(L.) Sweet.** Climbing herb. Riverine forests, marshy area, 1818 m. Melly 0038 (EA).

Neonotonia wightii **(Wight & Arn.) J. A. Lackey.** Climber. Forest edges, disturbed ground, 2071 m. SAJIT 006622 (EA, HIB).

****Senna didymobotrya* (Fresen.) H. S. Irwin & Barneby.** Shrub. Bushland, 1939 m. Melly 0095 (EA).

****Senna obtusifolia* (L.) H. S. Irwin & Barneby.** Shrub. Riverine, hillside, shrubland, 1896 m. Melly 0026 (EA).

****Senna septemtrionalis* (Viv.) H. S. Irwin & Barneby.** Shrub. Upland forest, riverine, grassland, waste places, 1992–2076 m. FOKP 1565 (EA, HIB), Melly 0159 (EA).

***Sesbania sesban* (L.) Merr.** Soft wooded tree. Riverine, occur in dense stands, 1877 m. Melly 0249 (EA).

***Trifolium burchellianum* Ser.** Herb. Moist upland grassland, forest, 1929 m. FOKP 1472 (EA, HIB).

***Trifolium usambarense* Taub.** Annual or perennial herb. Marshy places, 1800 m. Melly 0265 (EA).

***Vigna luteola* (Jacq.) Benth.** Herb. Swampy grassland and forest margins, 1920 m. FOKP 1672 (EA, HIB).

***Vigna parkeri* Baker.** Perennial herb. Grassland, thicket, forest margins, weed in cultivation, 1785–1927 m. FOKP 1452 (EA, HIB), Melly 0313 (EA).

***Zornia setosa* Baker f.** Herb. Grassland with impeded drainage, 2014–2018 m. FOKP 1645 (EA, HIB), FOKP 1646 (EA, HIB), Melly 0213 (EA).

F56. Gentianaceae
1 Genus, 1 species

***Anthocleista grandiflora* Gilg.** Tree. Riverine, swampy places in forests, 1883 m. SAJIT 006949 (EA, HIB).

F57. Hamamelidaceae
1 Genus, 1 species

***Trichocladus ellipticus* Eckl. & Zeyh.** Shrub or tree. Dry or moist forest, 1764 m. Melly 0310 (EA).

F58. Hydrocharitaceae
3 Genera, 3 species

***Egeria densa* Planch.** Aquatic free-flowing herb. Water pools, 1828 m. Hill 690 (EA).

***Ottelia ovalifolia* Rich.** Aquatic perennial with submerged or floating leaves. Locally common in pools of water, 1864 m. FOKP 1329 (EA).

***Vallisneria spiralis* L.** Submerged herb. Recorded in the Nandi hills on water pools, 2025 m. Odero 1E (EA).

F59. Hypericaceae
2 Genera, 2 species

***Hypericum revolutum* Vahl.** Shrub. Grows along streams in upland forest thickets, dry bushland, 1760 m. Melly 0308 (EA).

***Harungana madagascariensis* Lam. Ex Poir.** Tree. Moist forests margins, 1757 m. Melly 0311 (EA).

F60. Hypoxidaceae

1 Genus, 3 species

***Hypoxis angustifolia* Lam.** Herb. Grassland in upland forest, 1730–2149 m. FOKP 1559 (EA, HIB), FOKP 1689 (EA, HIB), Davide 7121 (EA).

***Hypoxis obtusa* Burch. ex Ker Gawl.** Herb. Common in burnt grassland and shallow soils, 2005 m. Hill 91 (EA).

***Hypoxis villosa* L. f.** Herb. Burnt grassland on shallow or rocky soils, 1962 m. FOKP 1659 (EA, HIB).

F61. Icacinaceae

1 Genus, 1 species

***Apodytes dimidiata* E. Mey. ex Arn.** Shrub or tree. Upland rain forest, and forest patches, 1751–2000 m. FOKP 1572 (EA, HIB), Melly 0281 (EA).

F62. Iridaceae

2 Genera, 2 species

***Aristea alata* Baker.** Rhizomatous perennial herb. Forest margins and grass glades, 2195 m. Mainwring 10559 (EA).

***Freesia laxa* (Thunb.) Goldblatt & J. C. Manning.** Herb. Rocky grassland, 1828 m. Hill 2 (EA).

F63. Lamiaceae

14 Genera, 28 species

***Achyrospermum parviflorum* S. Moore.** Herb. Undergrowth of rain-forest, swamp forest riverine forest, 1050–1700 m. Tweedie 4150 (EA).

Clerodendrum formicarum Gűrke. Supported shrub. Upland forest, 1872–1952 m. Melly 0056 (EA), Melly 0252 (EA).

***Clerodendrum johnstonii* Oliv.** Shrub. Upland forest and thicket, or disturbed scrubland, marshy area, 1823–2148 m. Melly 0047 (EA), SAJIT 006601 (EA, HIB).

Clerodendrum melanocrater Gürke. Climber. Upland forest, 1973 m. SAJIT 006671 (EA, HIB).

***Clerodendrum rotundifolium* Oliv.** Shrub. Wooded grassland, riverine woodland, 1946 m. Melly 0059 (EA).

***Clinopodium abyssinicum* (Hochst. ex Benth.) Kuntze.** Herb. Woodland, 1864 m. FOKP 1325 (EA, HIB).

***Fuerstia africana* T.C.E. Fr.** Herb. Grassland and understorey of upland forest, 2023–2143 m. FOKP 1590 (EA, HIB), Melly 0163 (EA)

***Isodon ramosissimus* (Hook. f.) Codd.** Herb. Forest undergrowth and margins upland grasslands, descending altitudes along rivers, 750–2100 m. Tweedie 4153 (EA).

***Leonotis martinicensis* (Jacq.) J. C. Manning & Goldblatt.** Herb. Open ground, disturbed places especially in farmland, 2058 m. Melly 0156 (EA).

***Leonotis ocymifolia* (Burm. f.) Iwarsson.** Shrub. Upland forest, 2121 m. Melly 0188 (EA).

***Leucas deflexa* Hook. f.** Herb. Upland grassland, 1967 m. FOKP 1666 (EA, HIB).

***Ocimum gratissimum* L.** Perennial herb or subshrub. Disturbed bushland, Hillside, shrubland, 1905 m. Melly 0022 (EA).

***Ocimum lamiifolium* Hochst. ex Benth.** Shrub. Upland forest, 1930–2258 m. FOKP 1479 (EA, HIB), SAJIT 006999 (EA, HIB).

***Ocimum obovatum* E. Mey. ex Benth.** Herb or shrub. Upland grassland, on poor drainage, 2149 m. FOKP 1682 (EA, HIB).

***Orthosiphon rubicundus* (D. Don) Benth.** Herb. Common in wooded grassland, 2036 m. FOKP 1507 (EA, HIB).

***Orthosiphon schimperi* Benth.** Herb. Wooded grassland, 1927 m. FOKP 1460 (EA, HIB).

***Platostoma africanum* P. Beauv.** Perennial herb. Damp places in grassland, roadside, by streams, forest edges, shrubland, 1857–1920 m. FOKP 1310 (EA, HIB), Melly 0023 (EA).

***Platostoma denticulatum* Robyns.** Herb. Riverside, wetland often in partial shade at forest edges, roadside grassland, 1883 m. SAJIT 006948 (EA, HIB).

***Plectranthus alpinus* (Vatke) Ryding.** Shrub. Shady forest, 1963–1991 m. FOKP 1413, Melly 0236 (EA).

***Plectranthus barbatus* Andrews.** Shrub. Bushland, rocky grassland, 1823 m. Melly 0044 (EA).

***Plectranthus bojeri* (Benth.) Hedge.** Herb. Hillside, shrubland, on shallow soils, 1804 m. Melly 0018 (EA).

Plectranthus kamerunensis Gürke. Shrub. Upland forest, 2010 m. FOKP 1406 (EA, HIB).

***Plectranthus mollis* (Aiton) Spreng.** Shrub. Upland forest, 1904 m. FOKP 1367 (EA, HIB), Melly 0103 (EA).

***Plectranthus punctatus* (L. f.) L'Hér.** Herb. Disturbed upland forests, 2001 m. FOKP 1422 (EA, HIB).

Plectranthus sylvestris Gürke. Herb or shrub. Disturbed places of upland forest, plantation of exotics, 1943 m. SAJIT 007034 (EA, HIB).

Pycnostachys niamniamensis Gürke. Annual herb. Forest undergrowth and margins upland grasslands, descending altitudes along rivers, 750–2100 m. Duke 3411 (EA).

***Rotheca myricoides* (Hochst.) Steane & Mabb.** Shrub. Upland dry forest, grazed bushland, grassland, 1861–2134 m. FOKP 1641 (EA, HIB), Melly 0036 (EA), Melly 0053 (EA), Melly 0201 (EA).

***Tetradenia riparia* (Hochst.) Codd.** Shrub. On the rocky slopes, 2148 m. SAJIT 006613 (EA, HIB).

F64. Linderniaceae

1 Genus, 3 species

***Craterostigma newtonii* (Engl.) Eb. Fisch., Schäferh. & al.** Herb. Local on shallow soils, 2120–2125 m. FOKP 1604 (EA, HIB), Melly 0203 (EA).

***Craterostigma nummulariifolium* (D. Don) Eb. Fisch., Schäferh. & Kai Müll.** Herb. Weed of cultivation, streamside in both open country and wet, mossy, evergreen forests and in thickets on boulder-strewn hillsides, 1942 m. Rodgers 714 (EA), Melly 0082 (EA).

***Craterostigma pumilum* Hochst.** Herb. Over rocks, in montane forest, 2149 m. FOKP 1685 (EA, HIB).

F65. Loranthaceae

4 Genera, 6 species

***Agelanthus pennatulus* (Sprague) Polhill & Wiens.** Epiphyte. In Forest Margin, 1988 m. SAJIT 007009 (EA, HIB). Vulnerable.

***Agelanthus platyphyllus* (Hochst. ex A. Rich.) Balle.** Shrub. Deciduous woodland and woodland grassland, almost always on Combretum or Terminalia, 1200–1600 m. Davidse 7125 (EA).

***Agelanthus zizyphifolius* (Engl.) Polhill & Wiens.** Epiphytic Shrub. Under forest, 2026 m. SAJIT 006653 (EA, HIB).

***Englerina woodfordioides* (Schweinf.) Balle.** Shrub. Upland forest, 1998–2148 m. FOKP 1311 (EA, HIB), FOKP 1594 (EA, HIB), Melly 0130 (EA), SAJIT 006610 (EA, HIB), SAJIT 006657 (EA, HIB), SAJIT 006666, (EA, HIB).

***Phragmanthera usuiensis* (Oliv.) M. G. Gilbert.** Shrub. Upland forest, 2133 m. FOKP 1481 (EA, HIB), Melly 0186 (EA).

***Tapinanthus constrictiflorus* (Engl.) Danser.** Epiphyte. Evergreen forests, on various hosts including plantation crops, 2134–2300 m. Archer 237 (EA), Melly 0196 (EA).

F66. Lythraceae

1 Genus, 1 species

***Rotala tenella* (Guill. & Perr.) Hiern.** Herb. Grassland, roadside, 2002–2026 m. Melly 0137 (EA), SAJIT 006640 (EA, HIB).

F67. Malvaceae

8 Genera, 14 species

***Abutilon longicuspe* Hochst. ex A. Rich.** Shrub. Upland forest, forest margins, scrubland, 2026 m. SAJIT 006649 (EA, HIB).

***Dombeya burgessiae* Gerrard ex Harv.** Shrub or tree. Semi-evergreen bushland on rocky sites, riverine, wooded grassland, 2058 m. FOKP 1600 (EA, HIB).

***Dombeya torrida* (J. F. Gmel.) B. Bamps.** Tree. Upland forest, 1993 m. Melly 0139 (EA).

***Hibiscus calyphyllus* Cav.** Shrub. Rainforest, riverine forest, thickets, grassland, 2000 m. Melly 0148 (EA).

***Hibiscus macranthus* Hochst. ex A. Rich.** Small shrub. Common in forest edges and grassland in cleared forest, 2019 m. FOKP 1596 (EA, HIB).

***Kosteletzkya adoensis* (Hochst. Ex A. Rich) Mast.** A perennial herb or Shrub. Forest edges and cleared forests, 1769 m. Melly 0271 (EA).

***Malvastrum coromandelianum* (L.) Garcke.** Woody annual or perennial. Wasteland, bushland edges and grassland, 2022 m. Melly 0205 (EA).

***Pavonia urens* Cav.** Shrub. Road patches in upland forest, 1758–2026 m. FOKP 1652 (EA, HIB), Melly 0142 (EA), Melly 0263 (EA), SAJIT 006638, (EA, HIB).

***Pavonia procumbens* (Wight) Walp.** Woody herb. Dry woodland and rocks, 2014 m. FOKP 1650 (EA, HIB).

***Sida acuta* Burn. f.** Herb. Disturbed places on grassland forest, 1993 m. Melly 0118 (EA).

***Sida rhombifolia* L.** Herb. Hillside, grassland, bushland, 1889 m. Melly 0030 (EA).

***Triumfetta brachyceras* K. Schum.** Woody herb or shrub. Forest edges and along roadsides, 1751–1920 m. FOKP 1670 (EA, HIB), Melly 0272 (EA).

***Triumfetta rhomboidea* Jacq.** Shrub. Weed of cultivation, hillside, shrubland, 1890 m. Melly 0020 (EA).

***Triumfetta tomentosa* Bojer.** Shrub. Forest clearings, old fields, often secondary vegetation, 2009 m. Melly 0146 (EA).

F68. Melastomataceae

3 Genera, 3 species

***Dissotis speciosa* Taub.** Woody herb or shrub. Marshy places, valley grassland, 1784 m. Melly 0301 (EA).

***Dupineta brazza* (Cogn.) Veranso-Libalah & G. Kadereit.** Herb. Forest margins, valley and upland grassland and deciduous bushland, 900–1800 m. Williams 571 (EA).

***Tristemma mauritianum* J. F. Gmel.** Shrub or herb. Swampy places, 1800 m. Melly 0302 (EA).

F69. Meliaceae

3 Genera, 3 species

***Lepidotrichilia volkensii* (Gürke) Leroy.** Tree. Forest margins, 1929–1981 m. FOKP 1386 (EA, HIB), Melly 0098 (EA).

***Trichilia emetica* Vahl.** Tree. Riverine, riverine forest and woodland, lake-shore thicket, 1945 m. SAJIT 007035 (EA, HIB).

Turraea holstii Gürke. Tree. Upland forest, 1915–2026 m. FOKP 1335 (EA, HIB), SAJIT 006647 (EA, HIB), SAJIT 006938 (EA, HIB).

F70. Melianthaceae

1 Genus, 1 species

Bersama abyssinica **Fresen.** Tree. Upland forest, 1805–2392 m. FOKP 1474 (EA, HIB), Melly 0081 (EA), Melly 0237 (EA), Melly 0276 (EA), SAJIT 006602 (EA, HIB), SAJIT 007012 (EA, HIB).

F71. Menispermaceae

3 Genera, 6 species

Cissampelos friesiorum **Diels.** Climber. Upland forest on edges, 2012 m. SAJIT 007015 (EA, HIB).
Cissampelos mucronata **A. Rich.** Climber. Riverine, 2148 m. SAJIT 006599 (EA, HIB).
Cissampelos pareira **L.** Climber. Upland forest, woodland, 1934–2023 m. FOKP 1591 (EA, HIB), Melly 0077 (EA).
Stephania abyssinica **(Quart. -Dill. & A. Rich.) Walp.** Climber. Upland forest, 2026 m. SAJIT 006654 (EA, HIB), SAJIT 006659 (EA, HIB).
Stephania cyanantha **Welw. ex Hiern.** Climber. Hill Side of upland forest, 1739–2026 m. FOKP 1455 (EA, HIB), FOKP 1571 (EA, HIB), Melly 0025 (HIB), Melly 0296 (HIB), SAJIT 006651 (EA, HIB).
Tiliacora funifera **(Miers) Oliv.** Woody Liana. Rainforest, riverine forest, moist shady places in woodland, 1744–1973 m. Melly 0294 (EA), SAJIT 006673 (EA, HIB).

F72. Monimiaceae

1 Genus, 1 species

Xymalos monospora **(Harv.) Baill.** Tree. Moist upland forest, 1849–2005 m. FOKP 1356 (EA, HIB), FOKP 1512 (EA, HIB).

F73. Moraceae

4 Genera, 11 species

Dorstenia barnimiana **Schweinf.** Herb. Wet upland forest, 2015 m. FOKP 1570 (EA, HIB).
Ficus asperifolia **Miq.** Shrub. Forest margins and thickets, 1887 m. Melly 0245 (EA).
Ficus cyathistipula **Warb.** Tree. Rain-forest and other wetter evergreen forest, 700–1800 m. Green 12 (EA).
Ficus exasperata **Vahl.** Tree. Wet forests on the margins, 1–1850 m. Lucas 146 (EA).
Ficus lutea **Vahl.** Tree. Rain-forest and other wetter evergreen forest, riverine and ground-water forests sometimes on rocks, 1931 m. FOKP 1441 (EA, HIB).

***Ficus ottoniifolia* (Miq.) Miq.** Tree. Upland forest on the margins, woodland forest, riverine, 1757–2070 m. FOKP 1678 (EA, HIB), Melly 0063 (EA), Melly 0300 (EA), SAJIT 006971 (EA, HIB), SAJIT 006990 (EA, HIB).

***Ficus sur* Forssk.** Tree. Riverine forest, bushland, groundwater forest, 1–2100 m. Dale 3405.

***Ficus sycomorus* L.** Tree. Forest, woodland and wooded grassland, sometimes along rivers and lakes or amongst rocks, planted for ornament and back-cloth, 1772–2076 m. Williams 578 (EA), Melly 0168 (EA), Melly 0267 (EA).

***Ficus thonningii* Blume.** Tree. Rain-forest and other wetter evergreen forest, riverine and groundwater forests, 1800 m. Wye 1929 (EA).

***Morus mesozygia* Stapf.** Tree. Moist forest, 1200–1650 m. Wormald 25 (EA).

***Trilepisium madagascariense* DC.** Tree. Rain-forest and other wetter evergreen forest, riverine and groundwater forests, 1800 m. Wye 1843(EA).

F74. Musaceae

1 Genus, 1 species

***Ensete ventricosum* (Welw.) Cheesman.** Giant herb. Upland forest, 1856 m. Melly 0258 (EA).

F75. Myrtaceae

3 Genera, 3 species

****Eucalyptus saligna* Sm.** Tree. Common plantation timber, 1952 m. Melly 0240 (EA).

***Psidium guajava* L.** Tree. Upland forest, bushland, 1929 m. Melly 0086 (EA).

***Syzygium guineense* (Willd.) DC.** Tree. Wooded grassland, riverine, 1746–2071 m. FOKP 1628 (EA, HIB), Melly 0173 (EA), Melly 0282 (EA).

F76. Ochnaceae

1 Genus, 2 species

***Ochna holstii* Engl.** Tree. In Forest, dominant trees, very big, 1985–2052 m. FOKP 1531 (EA, HIB), FOKP 1597 (EA, HIB), SAJIT 007019 (EA, HIB).

***Ochna insculpta* Sleumer.** Tree. Upland forest, woodland, 1991–2051 m. FOKP 1415 (EA, HIB), FOKP 1543 (EA, HIB), FOKP 1568, (EA, HIB).

F77. Oleaceae

4 Genera, 6 Species

***Chionanthus mildbraedii* (Gilg & G. Schellenb.) Stearn.** Tree. Wet upland Forest, 1831 m. Melly 0262 (EA).

***Jasminum abyssinicum* Hochst. ex DC.** Shrub. Upland evergreen bushland, 1791–1879 m. Melly 0266 (EA), SAJIT 006953 (EA, HIB).

***Jasminum grandiflorum* subsp. *floribundum* (R. Br. ex Fresen.) P. S. Green.** Shrub or scrambler. Upland evergreen bushland, 2100 m. Hill 312 (EA).

***Olea capensis* L.** Tree. Wet and dry evergreen mixed forest, 1150–2550 m. Battiscombe 135 (EA).

***Olea welwitschii* (Knobl.) Gilg & Schellenb.** Tree. Lowland rain to upland dry evergreen forest, 750–1950 m. Battiscombe 660 (EA).

***Schrebera alata* (Hochst.) Welw.** Tree. Dry forest edges, evergreen bushland, 2143 m. Melly 0183 (EA).

F78. Onagraceae

1 Genus, 2 species

***Ludwigia abyssinica* A. Rich.** Succulent herb. Swampy places, 1798 m. Melly 0314 (EA).

***Ludwigia adscendens* subsp. *diffusa* (Forssk.) P. H. Raven.** Herb. Marshy area, riverine, 1823 m. Melly 0042 (EA).

F79. Ophioglossaceae

1 Genus, 1 species

***Ophioglossum reticulatum* L.** Herb. In Forest margins and damp pockets of soils on the rocky outcrops, 2003 m. SAJIT 007010 (EA, HIB).

F80. Orobanchaceae

1 Genus, 1 species

***Orobanche minor* Sm.** Herb. Upland forest, 1991 m. FOKP 1414 (EA, HIB).

F81. Orchidaceae

17 Genera, 36 species

***Aerangis ugandensis* Summerh.** Herb. In moist forest, near rivers on large tree trunks and often with its roots in a deep growth of moss, 1500–2000 m. William and Piers 601 (EA).

***Angraecum erectum* Summerh.** Epiphyte. Dry forest, 1975 m. FOKP 1360 (EA, HIB).

***Angraecum humile* Summerh.** Dwarf epiphytic herb. Upper branches of forest trees, 1785 m. Melly 0268 (EA).

***Bolusiella maudiae* (Bolus) Schltr.** Epiphyte. Humid forest, 2026 m. FOKP 1680 (EA, HIB) Tweedie 230 (EA), Williams and Piers 615 (EA).

***Bulbophyllum cochleatum* Lindl.** Epiphyte. Shady forest, 2138 m. FOKP 1680 (EA, HIB).

***Bulbophyllum cochleatum* var. *bequaertii* (De Wild.) J. J. Verm.** Epiphytic Herb. Epiphytic in rain forest, 900–2000 m. Tweedie 233 (EA).

***Bulbophyllum bidenticulatum* subsp. *joyceae* J. J. Verm.** Epiphyte. Upland forest, 1914 m. Melly 0111 (EA).

Bulbophyllum encephalodes **Summerh.** Epiphyte. Upland forest, 1991 m. Melly 0113 (EA).

Bulbophyllum josephi **(Kuntze) Summerh.** Epiphyte. Upland forest, 1914 m. Melly 0110 (EA).

Bulbophyllum intertextum **Lindl.** Epiphyte. Warm forests, 1700–2019 m. FOKP 1632 (EA, HIB).

Cribbia brachyceras **(Summerh.) Senghas.** Epiphyte. On mossy trunks of trees and rocks in forests, 1500–2200 m. Tweedie 287 (EA).

Cyrtorchis arcuata **(Lindl.) Schltr.** Epiphyte. On trees and rocks in bush, woodland and forest, 0–2000 m. FOKP 1580 (EA, HIB), William and Piers 609 (EA).

Diaphananthe sarcophylla **(Schltr. ex Prain) P. J. Cribb & Carlsward.** Herb. Dry upland forest on trees, 1964 m. FOKP 1575 (EA, HIB).

Disperis anthoceros **Rchb.f.** Herb. Under forest on ground litter in evergreen forest, 2082 m. Melly 0153 (EA).

Disperis dicerochila **Summerh.** Herb. Upland forest, leaf litter, mossy branches and on rocks in upland rain forest, 1886 m. Melly 0108 (EA).

Epipogium roseum **(D. Don) Lindl.** Herb. Upland forest on leaf mould in wet forests, 2030–2033 m. FOKP 1477 (EA, HIB), FOKP 1517 (EA, HIB), FOKP 1625 (EA, HIB), FOKP 1649 (EA, HIB), SAJIT 007021 (EA, HIB).

Eulophia galeoloides **Kraenzl.** Herb. Upland forest on trees, 2023–2055 m. FOKP 1593 (EA, HIB), SAJIT 007029 (EA, HIB).

Eulophia horsfallii **(Bateman) Summerh.** Herb. Robust Orchid of swamps and river edges, 1925 m. FOKP 1465 (EA, HIB).

Eulophia latilabris **Summerh.** Herb. Grassland and swampy places, 1812 m. Melly 0264 (EA).

Eulophia stachyodes **Rchb. f.** Herb. Grassland, bushland and woodland, 950–2100 m. Rodgers 719 (EA).

Eulophia streptopetala **Lindl.** Herb terrestrial. In grassland, bushland and woodland, 950–2100 m. SAJIT 006660 (EA, HIB).

Habenaria chirensis **Rchb. f.** Herb. Damp grassland, swamps, wet places amongst rocks, 2026 m. SAJIT 006655 (EA, HIB).

Kylicanthe rohrii **(Rchb. f.) Descourvières & Farminhão.** Epiphyte. Dry upland forest, 2070 m. FOKP 1679 (EA, HIB).

Microcoelia globulosa **(Ridl.) L. Jonss.** Epiphytic herb. Riverine forests, 1740–1966 m. FOKP 1660 (EA, HIB), Melly 0285 (EA).

Nervilia bicarinata **(Blume) Schltr.** Herb. Upland forest, 1975 m. FOKP 1392 (EA, HIB).

Nervilia kotschyi **(Rchb. f.) Schltr.** Herb. Short grassland and amongst bushes and shrubs, 1864–2020 m. FOKP 1337 (EA, HIB) FOKP 1626 (EA, HIB), SAJIT 007024 (EA, HIB).

Nervilia lilacea **Jum. & H. Perrier.** Herb. Rain forest floor margins, 2010–2052 m. FOKP 1530 (EA, HIB), FOKP 1567 (EA, HIB). New record for Kenya.

Polystachya adansoniae **Rchb. f.** Epiphytic Herb. Dry forest, 1961–1976 m. FOKP 1400 (EA, HIB), Melly 0221 (EA).

Polystachya bennettiana **Rchb. f.** Epiphyte. In dry forest, on big trees, 2034–2125 m. FOKP 1620, SAJIT 007028 (EA, HIB).

Polystachya cultriformis **(Thouars) Lindl. ex Spreng.** Epiphyte. Riverine, 1985–2125 m. FOKP 1444 (EA, HIB), FOKP 1621 (EA, HIB), SAJIT 007017, (EA, HIB).

Polystachya fusiformis **(Thouars) Lindl.** Epiphytic herb. Upland forest, 2062 m. FOKP 1528 (EA, HIB).

Polystachya golungensis **Rchb. f.** Epiphytic herb. Light shade on trees or rocks, 2052 m. FOKP 1532 (EA, HIB).

Polystachya tenuissima **Kraenzl.** Epiphyte. Upland forest, 1927–2092 m. FOKP 1447 (EA, HIB), FOKP 1633 (EA, HIB), SAJIT 007025 (EA, HIB).

Polystachya simplex **Rendle.** Epiphyte. Dry highland forest, 2125 m. FOKP 1501 (EA, HIB), SAJIT 006656 (EA, HIB).

Polystachya spathella **Kraenzl.** Epiphyte. Highland forest, 2040 m. SAJIT 007027 (EA, HIB).

Rhipidoglossum rutilum **(Rchb. f.) Schltr.** Epiphyte. Evergreen forest, 1930–1939 m. FOKP 1448 (EA, HIB), Melly 0088 (EA), Melly 0222 (EA

Satyrium crassicaule **Rendle.** Herb. Wetland, swamps, 1851–1964 m. FOKP 1446 (EA, HIB), SAJIT 006986 (EA, HIB), SAJIT 007038 (EA, HIB).

F82. Oxalidaceae

1 Genus, 2 species

Oxalis corniculata **L.** Herb. Grassland, Disturbed ground, 2076 m. Melly 0167 (EA).

Oxalis obliquifolia **Steud. ex A. Rich.** Herb. Grassland, shallow soils, 830–3300 m. Tulin 81 (EA).

F83. Passifloraceae

2 Genera, 4 species

Adenia bequaertii **Robyns & Lawalrée.** Climber. Forest edge, 1996 m. Melly 0136 (EA).

Adenia cissampeloides **(Planch. ex Hook.) Harms.** Climber. Dry or moist forest on margins, 1849–2148 m. Melly 0170 (EA), FOKP 1345 (EA, HIB), Melly 0225 (EA), SAJIT 006600 (EA, HIB), SAJIT 006931 (EA, HIB), SAJIT 006933 (EA, HIB).

Adenia lobata **subsp.** ***rumicifolia*** **(Engl. & Harms) Lye.** Woody Climber. Moist evergreen (riverine) forest, 1757–1989 m. Melly 0292 (EA), Gillet 16701 (EA), SAJIT 007006 (EA, HIB).

****Passiflora edulis*** **Sims.** Climber. Cultivated, forest edges and disturbed places, 1719 m. Melly 0273 (EA).

F84. Penaeaceae

1 Genus, 1 species

***Olinia rochetiana* A. Juss.** Shrub or tree. Drier upland forest, found also in forest remnants such as fire-induced thickets, 2071 m. SAJIT 006631 (EA, HIB).

F85. Peraceae
1 Genus,1 species

***Clutia abyssinica* Jaub. & Spach.** Shrub. Secondary bushland, 2005–2326 m. FOKP 1483 (EA, HIB), FOKP 1602 (EA, HIB), Melly 0128 (EA).

F86. Phyllanthaceae
2 Genus, 6 species

***Bridelia micrantha* (Hochst.) Baill.** Shrub or tree. Usually riverine or in forest margins, Less often in bushed or wooded grassland, 1751 m. Melly 0288 (EA).
***Phyllanthus boehmii* Pax.** Herb. Grassland, 1987 m. FOKP 1584 (EA, HIB).
***Phyllanthus fischeri* Pax.** Shrub. Woodland, Forest edge and clearings, river line bushes, 1450–2700 m. FOKP 1561 (EA, HIB).
***Phyllanthus maderaspatensis* L.** Sub Shrub. Grassland in dry upland forest, 2076 m. Melly 0162 (EA).
***Phyllanthus nummulariifolius* Poir.** Shrub. Dry scattered tree grassland, 2125 m. FOKP 1615 (EA, HIB).
***Phyllanthus ovalifolius* Forssk.** Shrub or tree. Upland forest, bushland, 1745 m. Melly 0283 (EA).

F87. Phytolaccaceae
1 Genus, 2 species

***Phytolacca dodecandra* L'Hér.** Climbing Shrub. Bushland and cleared forest, 1960 m. Melly 0228 (EA).
****Phytolacca octandra* L.** Shrub. Moist forest margin, 2151 m. Melly 0193 (EA).

F88. Piperaceae
2 Genera, 5 species

***Peperomia abyssinica* Miq.** Succulent perennial herb. Wet upland forest, 1973 m. Melly 0316 (EA).
***Peperomia fernandopoiana* C. DC.** Herb. Highland forest on trees, 1872–1973 m. SAJIT 006954 (EA, HIB).
***Peperomia retusa* (L. f.) A. Dietr.** Epiphytic herb. Upland forest, 1889–2026 m. Melly 0068 (EA), SAJIT 006648 (EA, HIB), SAJIT 006960 (EA, HIB).
***Peperomia tetraphylla* (G. Forst.) Hook. & Arn.** Epiphytic creeping herb. Wet upland forests, occasionally in dry savannah edges. Forms mats on horizontal branches, 1936–2016 m. FOKP 1525 (EA, HIB), Melly 0223 (EA).

Piper capense **L. f.** Shrubby herb or climber. Wet highland forest, valley, 1969 m. Melly 0017 (EA).

F89. Pittosporaceae
1 Genus, 1 species

Pittosporum viridiflorum **Sims.** Tree or shrub. Evergreen riverine, wooded grassland, 2120–2148 m. FOKP 1619 (EA, HIB), Melly 0204 (EA), SAJIT 006618 (EA, HIB).

F90. Plantaginaceae
1 Genus, 2 species

Veronica abyssinica **Fresen.** Herb. Upland grassland, 1990 m. FOKP 1578 (EA, HIB).
Veronica javanica **Blume.** Herb. Disturbed upland grassland, sometimes weed of garden or crops, 2186 m. FOKP 1497 (EA, HIB).

F91. Poaceae
19 Genera, 30 species

Adenochloa hymeniochila **(Nees) Zuloaga.** Herb. Swampy places, 1965 m. Siemens 97 (EA).
Andropogon schirensis **Hochst.** Herb. Grassland, 1785 m. Dale 24 (EA).
Brachiaria umbratilis **Napper.** Herb. Upland forest margins, 1676 m. Maluki 1092 (EA).
Cenchrus clandestinus **(Hochst. ex Chiov.) Morrone.** Herb. Grassland, 1965 m. Siemens 76 (EA).
Cenchrus macrourus **(Trin.) Morrone.** Herb. Stream banks, 1765 m. Melly 0303 (EA).
Cenchrus unisetus **(Nees) Morrone.** Herb. Upland grassland, 1676 m. Maluki 1077 (EA).
Chloris pycnothrix **Trin.** Herb. Very common on trampled weedy path sides, 0–2300 m. Siemens 77 (EA).
Cynodon dactylon **(L.) Pers.** Herb. Disturbed short grassland, 0–2000 m. Siemens 72 (EA).
Digitaria abyssinica **(Hochst. ex A. Rich.) Stapf.** Herb. Frequent weed along the road and disturbed damp grassland, 0–3000 m. Hohl 93 (EA).
Digitaria ternata **(A. Rich.) Stapf.** Herb. In Forest Margin, wetland, 1975 m. SAJIT 007003 (EA, HIB).
Digitaria velutina **(Forssk.) P. Beauv.** Herb. Very common in disturbed sites, 0–2300 m. Siemens 99 (EA).
Eragrostis atrovirens **(Desf.) Trin. ex Steud.** Herb. Uncommon in wet grassland, 1667 m. Maluki 1070 (EA).
Eragrostis exasperata **Peter.** Herb. Seasonally wet and shallow soils, 300–2000 m. Hohl 89 (EA).

***Eragrostis paniciformis* (A. Braun) Steud.** Herb. Common after rains in upland grassland in openings, 300–3000 m. Dale 1(EA).

***Eragrostis patula* (Kunth) Steud.** Herb. Common weed of dry bushland, 0–2800 m. Conell G643(EA), Hohl 103(EA).

***Eragrostis racemosa* (Thunb.) Steud.** Herb. Common in most dry upland grassland, drainage line, 1300–2600 m. Williams 613 (EA).

***Exotheca abyssinica* (Hochst. ex A. Rich.) Andersson.** Herb. Upland grassland, 1676–1826 m. Maluki 1069 (EA), Conell G640 (EA).

***Hyparrhenia cymbaria* (L.) Stapf.** Herb. Upland forest, 1828 m. Hill 82 (EA).

***Hyparrhenia filipendula* (Hochst.) Stapf.** Herb. Disturbed tall grassland, 1872 m. Dyer 1154 (EA).

***Hyperthelia dissoluta* (Nees ex Steud.) Clayton.** Herb. Upland grassland, 2133 m. Conell G642 (EA).

***Leersia hexandra* Sw.** Perennial grass. Moist, marshy areas, 1698 m. Melly 0286 (EA), Siemens 98 (EA).

***Loudetia kagerensis* (K. Schum.) C. E. Hubb. ex Hutch.** Herb. Stony soils, 1962 m. FOKP 1657 (EA, HIB), Conell G645(EA).

***Oplismenus hirtellus* (L.) P. Beauv.** Herb. Forest shade, 1965 m. Siemens 109 (EA).

***Panicum subalbidum* Kunth.** Herb. Riverine, 1965 m. Siemens 88A (EA).

***Pseudechinolaena polystachya* (Kunth) Stapf.** Herb. Seasonal swamps and along the rivers, 2011 m. FOKP 1405 (EA, HIB).

***Rhytachne rottboellioides* Desv.** Herb. In swamps and seasonally wet grassland, 1–2100 m. Brunt 1358 (EA).

***Setaria sphacelata* (Schumach.) Stapf & C. E. Hubb. ex M. B. Moos.** Herb. Upland grassland, stony hillside, 1965–3300 m. FOKP 1656 (EA, HIB), Malaki 1068 (EA), Guy 2928 (EA).

***Urochloa brizantha* (A. Rich.) R. D. Webster.** Herb. Upland grassland, 1676–1700 m. Maluki 1090 (EA), Hohl 90 (EA).

***Urochloa jubata* (Fig. & De Not.) Sosef.** Herb. Damp upland pasture, 1676 m. Maluki 1084 (EA).

***Urochloa semiundulata* (Hochst. ex A. Rich.) Ashalantha & V. J. Nair.** Herb. Disturbed bushland and grassland, 1750 m. Dale 19 (EA).

F92. Polygonaceae

2 Genera, 6 species

***Persicaria decipiens* (R. Br.) K. L. Wilson.** Herb. Waterside grassland, 1993 m. Melly 0140 (EA).

***Persicaria lapathifolia* (L.) Delarbre.** Herb. Marshy area, 1823 m. Melly 0048 (EA).

***Persicaria nepalensis* (Meisn.) H. Gross.** Shrub. Wet forest, 2007 m. FOKP 1423 (EA, HIB).

***Persicaria senegalensis* (Meisn.) Soják.** Herb. Common in water sites and marshes, 1927 m. FOKP 1459 (EA, HIB).

***Persicaria setosula* (A. Rich.) K. L. Wilson.** Herb. Upland forest on marshy places, 1925–1982 m. FOKP 1466 (EA, HIB), FOKP 1550 (EA, HIB), SAJIT 007039 (EA, HIB).

***Polygonum afromontanum* Greenway.** Herb. Roadside, 1942 m. Melly 0083 (EA).

F93. Polygalaceae

2 Genera, 3 species

***Polygala sparsiflora* Oliv.** Herb. Brachystegia woodland, bushland and grassland, sometimes in marshes and seepage areas, 1000–2200 m. Dale 3182 (EA).

***Polygala sphenoptera* Fresen.** Herb. Upland grassland, disturbed soil, 1987–2140 m. FOKP 1640 (EA, HIB), SAJIT 007008 (EA, HIB).

***Securidaca welwitschii* Oliver.** Scandent shrub or liana. Upland Evergreen Forest, 1774–1947 m. FOKP 1343 (EA, HIB), Gillett 16730 (EA), Melly 0289 (EA), SAJIT 006955 (EA, HIB), SAJIT 006984 (EA, HIB).

F94. Primulaceae

2 Genera, 2 species

***Embelia schimperi* Vatke.** Shrub or small tree. Upland forest, 1740–2026 m. FOKP 1558 (EA, HIB), Melly 0212 (EA), Melly 0284 (EA), SAJIT 006633 (EA, HIB), SAJIT 006950, (EA, HIB).

***Maesa lanceolata* Forssk.** Tree. Widespread secondary forest, forest margin, 1950–1997 m. Melly 0014 (EA), Melly 0145 (EA).

F95. Proteacae

1 Genus, 1 Species

***Protea madiensis* Oliv.** Shrub. Wooded grassland, 2149 m. FOKP 1683 (EA, HIB).

F96. Putranjivaceae

1 Genus, 1 species

***Drypetes gerrardii* Hutch.** Shrub. Roadside, 2000 m. Melly 0131 (EA).

F97. Ranunculaceae

3 Genera, 3 species

***Clematis brachiata* Thunb.** Climber. Rocky place, wooded grassland, 2148 m. SAJIT 006614 (EA, HIB).

***Ranunculus multifidus* Forssk**. Perennial herb. Marshy area, 1823 m. Melly 0049 (EA).

***Thalictrum rhynchocarpum* Quart. -Dill. & A. Rich. ex A. Rich.** Herb. Upland forest, 1946 m. Melly 0061 (EA).

F98. Rhamnaceae
3 Genera, 3 species

***Gouania longispicata* Engl.** Liana or sprawling shrub. Riverine forest, upland forest (margins, clearings), 1973 m. SAJIT 006677 (EA, HIB).
***Helinus mystacinus* (Aiton) E. Mey. ex Steud.** Shrub. Upland forest, 2125 m. FOKP 1603 (EA, HIB).
***Scutia myrtina* (Burm. f.) Kurz.** Shrub. Moist, dry forest, riverine, 1947 m. Melly 0067 (EA).

F99. Rhizophoraceae
1 Genus, 2 species

***Cassipourea malosana* (Baker) Alston.** Tree. Bushland, understorey of moist forest, 1920 m. FOKP 1317 (EA, HIB).
***Cassipourea ruwensorensis* (Engl.) Alston.** Tree. Evergreen forest, 1952 m. Melly 0079 (EA).

F100. Rosaceae
3 Genera, 5 species

***Alchemilla kiwuensis* Engl.** Herb. Highland grassland or as a weed, 1981 m. FOKP 1552 (EA, HIB), Fries 613 (EA).
***Prunus africana* (Hook. f.) Kalkman.** Tree. Forest edge and grazing land, 1970 m. Moon 765(EA). Vulnerable.
***Rubus apetalus* Poir.** Shrub. Upland bushland, 1974 m. Melly 0120 (EA).
***Rubus pinnatus* Wild.** Shrub. Upland rain forest, 1823–2135 m. Melly 0040 (EA), Melly 0176 (EA).
***Rubus steudneri* Schweinf.** Shrub. Upland forest, roadside, 1993 m. Melly 0141 (EA).

F101. Rubiaceae
18 Genera, 23 species

***Canthium bugoyense* (K. Krause) Lantz.** Shrub. Upland forest on the margins, 1925–1951 m. Melly 0058 (EA), SAJIT 006930 (EA, HIB).
***Canthium oligocarpum* Hiern.** Shrub or tree. Moist forest, 2000 m. FOKP 1482 (EA, HIB).
***Coffea eugenioides* S. Moore.** Shrub. Dry bushland, 1955–2087 m. FOKP 1674 (EA, HIB), Gillett 16698 (EA), SAJIT 007036 (EA, HIB).
***Galium aparinoides* Forssk.** Climber. Upland forest edges, 2016 m. FOKP 1523 (EA, HIB).
***Gardenia volkensii* K. Schum.** Shrub. Riverine woodland, wooded grassland, 1–1750 m. Rindsay 1958 (EA).

***Heinsenia diervilleoides* K. Schum.** Tree. Upland forest, evergreen, rainforest, moist evergreen forest, 1815–1973 m. FOKP 1336 (EA, HIB), Melly 0248 (EA), SAJIT 006674 (EA, HIB), Tweedie 41631 (EA), SAJIT 006977 (EA, HIB).

***Hymenodictyon floribundum* (Hochst. & Steud.) B. L. Rob.** Tree. Upland Forest, 2143–2148 m. Dale 3177 (EA), Melly 0182 (EA), SAJIT 006608(EA, HIB).

***Keetia gueinzii* (Sond.) Bridson.** Climber. Moist forest, bushland, 2134–2148 m. Melly 0200 (EA), SAJIT 006603 (EA, HIB).

***Mussaenda arcuata* Lam. ex Poir.** Shrub, scandent shrub or climber. Grassland, bushland, open or closed forest, evergreen rainforest, 700–1830 m. Makin 307 (EA).

***Oldenlandia corymbosa* L.** Herb. Dry areas in upland forest, 2023 m. FOKP 1592 (EA, HIB).

***Oldenlandia herbacea* (L.) Roxb.** Herb. On rocky places, grassland, bushland, thickets, 0–2160 m. SAJIT 006607 (EA, HIB).

***Oxyanthus speciosus* DC.** Tree. Forest riverine, 1809–1873 m. FOKP 1354 (EA, HIB), Melly 0250 (EA), Melly 0306 (EA).

***Pavetta abyssinica* Fresen.** Tree. Shrubland, riverine and secondary bushland, 1836–1864 m. FOKP 1334 (EA, HIB), Melly 0052 (EA), SAJIT 006964 (EA, HIB).

***Pavetta crassipes* K. Schum.** Shrub. Wooded grassland, 2016–2071 m. Melly 0211 (EA), SAJIT 006628 (EA, HIB).

***Pentas longiflora* Oliv.** Shrubby Herb. Grassland, bushland, scrub, thicket and forest edges, sometimes in damp places usually on volcanic soils, 2148–2450 m. Puruglose 3628 (EA), SAJIT 006606 (EA, HIB).

***Psychotria capensis* var. *puberula* (E.M.A. Petit) Verdc.** Tree. Swampy places, riverine, 1763–2026 m. FOKP 1588 (EA, HIB), Melly 0217 (EA), Melly 0304 (EA), SAJIT 006632 (EA, HIB).

***Rutidea orientalis* Bridson.** Shrub. Woodland, 1864–2026 m. FOKP 1331(EA, HIB), Melly 0080 (EA), SAJIT 006634 (EA, HIB).

***Rytigynia acuminatissima* (K. Schum.) Robyns.** Shrub. Drier forest margins, 1957–1992 m. FOKP 1382 (EA, HIB), FOKP 1566 (EA, HIB).

***Spermacoce princeae* (K. Schum.) Verdc.** Herb. Wet forests and on the forest edges, 1823–2076 m. Melly 0045 (EA), Melly 0166 (EA).

***Tarenna pavettoides* (Harv.) Sim.** Small tree or shrub. Upland forest, riverine forest or secondary bushland near forest, 0–1920 m. Girbert and Tadessa 6699 (EA), Melly 0151 (EA).

***Vangueria apiculata* K. Schum.** Tree. Thickets, riverine, wooded grassland, bushland, 1913–2000 m. Melly 0100 (EA), Melly 0121 (EA).

***Vangueria madagascariensis* J. F. Gmel.** Tree. Riverine, wooded grassland, bushland, 1861 m. SAJIT 006996 (EA, HIB).

***Vangueria volkensii* K. Schum.** Tree. Riverine, bushland, 1920–2260 m. FOKP 1309 (EA, HIB), FOKP 1480 (EA, HIB), Melly 0177 (EA).

F102. Rutaceae

4 Genera, 4 species

***Clausena anisata* (Willd.) Hook. f. ex Benth.** Shrub. Forest, secondary bushland, 1799 m. Melly 0275 (EA).

***Fagaropsis hildebrandtii* (Engl.) Milne-Redh.** Shrub or tree. Rocky evergreen bush or woodland or dry forest, 2046 m. FOKP 1599 (EA, HIB).

***Toddalia asiatica* (L.) Lam.** Liana. Forest margin, grassland thickets, 1998 m. Melly 0144 (EA).

***Zanthoxylum gilletii* (De Wild.) P. G. Waterman.** Tree. Rain forest, 900–2400 m. Board 5 (EA).

F103. Salicaceae

5 Genera, 8 species

***Casearia battiscombei* R. E. Fr.** Tree. Upland moist forest, 2278 m. FOKP 1478 (EA, HIB).

***Casearia gladiiformis* Mast.** Shrub or tree. Usually riverine or in forest margins. Less often in bushed or wooded grassland, 2078 m. Melly 0175 (EA).

***Dovyalis abyssinica* (A. Rich.) Warb.** Tree. Upland moist forest, 1928 m. FOKP 1469 (EA, HIB).

***Dovyalis macrocalyx* (Oliv.) Warb.** Shrub. Upland forest, grassland, 1867–2052 m. FOKP 1372 (EA, HIB), FOKP 1395 (EA, HIB), FOKP 1534 (EA, HIB), SAJIT 006637 (EA, HIB), SAJIT 006937 (EA, HIB).

***Flacourtia indica* (Burm. f.) Merr.** Tree or Shrub. Drier forest edges, wooded grassland or woodland, clump bushland, 2020–2138 m. FOKP 1573 (EA, HIB), Melly 0198 (EA).

***Oncoba routledgei* Sprague.** Tree or Shrub. Moist upland forest often riverine, 1859–1884 m. SAJIT 006952 (EA, HIB), SAJIT 006963 (EA, HIB).

***Oncoba spinosa* Forssk.** Tree or Shrub. Riverine forest or bushland, 1934 m. Melly 0076 (EA).

***Trimeria grandifolia* (Hochst.) Warb.** Tree. Bushland, 2013–2078 m. FOKP 1535 (EA, HIB), FOKP 1557 (EA, HIB), Melly 0174 (EA), SAJIT 006625 (EA, HIB).

F104. Santalaceae

1 Genus, 1 species

***Viscum schimperi* Engl.** Herb. Dry evergreen forest and associated bushland, 2179 m. FOKP 1500 (EA, HIB).

F105. Sapindaceae

3 Genera, 5 species

***Allophylus africanus* P. Beauv.** Shrub or tree. Riverine of grassland, termite mounds, wooded and semi-open grasslands, thickets and scrub, 30–2400 m. Battiscombe 289 (EA).

***Allophylus ferrugineus* Taub.** Tree or Shrub. Moist or dry forest, riverine, 1828 m. Siemens 6457 (EA).

***Allophylus rubifolius* (Hochst. ex A. Rich.) Engl.** Tree or Shrub. Dry bushland, woodland, moist forest, 1952–1968 m. Melly 0016 (EA), Melly 0078 (EA).

***Allophylus rubifolius* var. *alnifolius* (Baker) Friis & Vollesen.** Shrub. Dry forest, 1869 m. Melly 0251 (EA).

***Deinbollia kilimandscharica* Taub.** Tree. Upland forest, 1828–1973 m. Melly 0065 (EA), Melly 0257 (EA), Tweedie 4158 (EA).

***Paullinia pinnata* L.** Shrubby Climber. Forest margins, gallery forest, moist thickets and scrub, 0–1600 m. Gillett 16699 (EA).

F106. Sapotaceae

1 Genus, 1 species

***Synsepalum cerasiferum* (Welw.) T. D. Penn.** Tree. Lowland rain-forest, groundwater forest and riverine forest, 300–1500 m. Shantz 125 (EA).

F107. Schrophulariaceae

1 Genera, 1 species

***Buddleja polystachya* Fresen.** Tree. Upland forest, Bushland, 1913 m. Melly 0241 (EA).

F108. Smilacaceae

1 Genus, 2 species

***Smilax anceps* Wild.** Climber. Wet forest, 2026–2134 m. Melly 0199 (EA), SAJIT 006658 (EA, HIB).

***Smilax aspera* L.** Climber. Evergreen upland forest, 1920 m. FOKP 1314 (EA, HIB).

F109. Solanaceae

4 Genera, 11 species

****Cestrum aurantiacum* Lindl.** Shrub. Upland forest, cultivated and disturbed ground, 2074–2183 m. FOKP 1499 (EA, HIB), Melly 0150 (EA).

***Discopodium penninervium* Hochst.** Shrub. Upland forest, 2071 m. SAJIT 006620 (EA, HIB).

****Physalis peruviana* L.** Herb. Cultivated fields, 1873 m. FOKP 1350 (EA, HIB).

***Solanum aculeastrum* Dunal.** Shrub. Forest margin, 1823–2026 m. Melly 0124 (EA), SAJIT 006661 (EA, HIB).

***Solanum americanum* Mill.** Shrub. Cultivated areas, 1823–2086 m. Melly 0043 (EA), Melly 0158 (EA).

***Solanum anguivi* Lam.** Shrub. Hill Side of upland forest, cultivated areas, 1863–2026 m. FOKP 1373 (EA, HIB), Melly 010 (EA), Melly 0253 (EA), Melly 0099 (EA), SAJIT 006643 (EA, HIB), SAJIT 006646 (EA, HIB).

***Solanum incanum* L.** Shrub. Waste places, secondary vegetation, a weed in grassland, 2076 m. Melly 0164 (EA).

***Solanum mauense* Bitter.** Shrub. Secondary forest, 1815 m. Melly 0019 (EA).

****Solanum mauritianum* Scop.** Shrub. Hillside/bushland, cultivation, 1846–2026 m. Melly 0033 (EA), SAJIT 006635 (EA, HIB).

***Solanum sessiliflorum* M. F. Dun.** Shrub. Cultivation or disturbed places, 2052 m. FOKP 1536 (EA, HIB).

***Solanum terminale* Forssk.** Shrub or Liana. Forest margins, riverine, evergreen bushlands woodland, 1927–1960 m. FOKP 1457 (EA, HIB), Melly 0012, Melly 0154 (EA), Melly 0229 (EA).

F110. Stilbaceae

1 Genus, 1 species

***Nuxia congesta* R. Br. ex Fresen.** Tree. Upland forest, grassland, 2148 m. SAJIT 006616 (EA, HIB).

F111. Strombosiaceae

1 Genera, 1 Species

***Strombosia scheffleri* Engl.** Tree. Dominant in moist forest, 1849 m. FOKP 1346 (EA, HIB).

F112. Urticaceae

8 Genera, 8 species

***Didymodoxa caffra* (Thunb.) Friis & Wilmot-Dear.** Herb. Disturbed places in upland forest, in shade amongst rocks, 2383 m. FOKP 1475 (EA, HIB).

***Droguetia debilis* Rendle.** Herb. Marshy areas, upland forest, 1968–2026 m. Melly 0074 (EA), SAJIT 006645 (EA, HIB).

***Elatostema monticola* Hook. f.** Herb. Riverine, wet places, 1975 m. Melly 0073 (EA).

***Laportea alatipes* Hook. f.** Herb. Disturbed places in wet upland forest, 1851–2005 m. FOKP 1418 (EA, HIB), SAJIT 006982 (EA, HIB).

***Pilea rivularis* Wedd.** Herb. Upland forest, streams, and paths, 2007 m. FOKP 1425 (EA, HIB).

***Pouzolzia parasitica* (Forssk.) Schweinf.** Herb. Upland forest, 2014 m. FOKP 1651 (EA, HIB).

***Urera hypselodendron* (Hochst. ex A. Rich.) Wedd.** Climber-woody. Moist upland forest, 2022–2071 m. SAJIT 006623 (EA, HIB), SAJIT 007013 (EA, HIB).

***Urtica massaica* Mildbr.** Herb. Upland forest, 1969–2083 m. FOKP 1436 (EA, HIB), Melly 0208 (EA).

F113. Verbenaceae

1 Genera, 2 species

*_**Lantana camara**_ **L.** Shrub. Hillside, shrubland, 1802 m. Melly 0024 (EA).
*_**Lantana trifolia**_ **L.** Shrub. Marshy area, bushland, 1823 m. Melly 0039 (EA).

F114. Violaceae

2 Genera, 2 species

Afrohybanthus enneaspermus **(L.) Flicker.** Herb. Forest edge, disturbed dry bushland, 1992 m. Melly 0133 (EA).

Rinorea brachypetala **(Turcz.) O. Ktze.** Shrub or small tree. Evergreen forests, along rivers, 850–1900 m. Gillett 16730 (EA).

F115. Vitaceae

4 Genera, 9 species

Cayratia gracilis **(Guill and Perr.) Suess.** Climber. Forest edges of riverine forest, lowland forest, 1946 m. Melly 0054 (EA).

Cissus humbertii **Robyns & Lawalrée.** Climber. Bushland, forest edges, 1700–1925 m. Melly 0096 (EA). Vulnerable.

Cissus oliveri **(Engl.) Gilg.** Climber. Upland forest, 1960 m. FOKP 1383 (EA, HIB).

Cyphostemma bambuseti **(Gilg & M. Brandt) Desc. ex Wild & R. B. Drumm.** Climber. Forest edge of dry upland forest, 1882–1968 m. Melly 0015 (EA), Melly 0230 (EA), Melly 0243 (EA), SAJIT 006945 (EA, HIB).

Cyphostemma cyphopetalum **(Fresen.) Desc. ex Wild & R. B. Drumm.** Climber. Roadside, evergreen upland forest, 2001 m. Melly 0129 (EA).

Cyphostemma kilimandscharicum **(Gilg) Desc. ex Wild & R. B. Drumm.** Climber. Upland rainforest, 1826–2052 m. FOKP 1529 (EA, HIB), Melly 0261 (EA), SAJIT 006994 (EA, HIB).

Cyphostemma ukerewense **(Gilg) Desc.** Climber. In Forest, on tree, 1890–1916 m. SAJIT 006936 (EA, HIB), SAJIT 006944 (EA, HIB).

Rhoicissus revoilii **Planch.** Climber. Disturbed bushland and woodland, 2143 m. Melly 0181 (EA).

Rhoicissus tridentata **(L. f.) Wild & R. B. Drumm.** Shrub. Upland wooded grassland and forest thickets, 1992–2125 m. Melly 0138 (EA), FOKP 1612 (EA, HIB).

F116. Xyridaceae

1 Genus, 1 species

Xyris straminea **L. A. Nilsson.** Herb. Edges of pools in dry places, 2050 m. Gilbert and Mesfin 6737 (EA).

F117. Zingiberaceae

1 Genus, 2 species

***Aframomum angustifolium* (Sonn.) K. Schum.** Herb. Riverine forest, 1912 m. SAJIT 006995 (EA, HIB).

***Aframomum zambesiacum* (Baker) K. Schum.** Herb. Along path sides in wet forest, 1903 m. SAJIT 006957 (EA, HIB).

F118. Zygophyllaceae

1 Genus, 1 species

***Tribulus terrestris* L.** Herb. Forest edge, 2035 m. Melly 0209 (EA).

Discussion

The present checklist provides a comprehensive inventory of the vascular plants found in North and South Nandi forests. Our list almost doubles the previous floristic account by Girma et al. (2015) where 321 plant species in 92 families and 243 genera were recorded.

Most of the species in our checklist are present in the adjacent Kakamega rainforest (Fischer et al. 2010). This could be because in the early 20th century, Kakamega, North and South Nandi forests were once joined, forming a u-shaped forest block (Kigomo 1987; Mitchell et al. 2006; Lung and Schaab 2010). That forest block is currently divided into three different areas, namely Kakamega, North Nandi and South Nandi forests. Nandi forests play an essential role in the endeavour of conserving the Kakamega forest and they are environmentally significant as they protect the catchment of Nandi escarpment and the Lake Victoria basin.

South Nandi and North Nandi forests contain highland elements in its fauna and flora and are thus unique (Girma et al. 2015). Moreover, together with Kakamega forest, the North Nandi forest and South Nandi forest form part of the western rainforest region and the easternmost fragment of the Guinea-Congolian phytogeographical region (Mbuvi et al. 2015). The high number of threatened species in these forests indicates their importance as a global biodiversity resource (MEWNR 2015).

These forests are surrounded by many people who depend on them entirely or partially for their ecosystem services like timber, firewood, pasture, charcoal, medicinal plants for people and livestock and building materials, amongst many other functions (Fashing and Mwangi 2004; Akwee et al. 2010; Maua et al. 2018b).

Currently, this region is amongst the most densely populated rural areas in Kenya (Mitchell et al. 2006). The demand pressure on the limited resources of North and South Nandi forests is high (Kogo et al. 2019). Therefore, efforts to manage and conserve the forest's resources in a sustainable way will be crucial to the survival of this vulnerable ecosystem (Bennun and Njoroge 1999; Matiru 2002).

Conclusion

The description of one new species and two new records for Kenya from Nandi forests, together with this comprehensive checklist, is a clear indication that opportunities for scientific studies are abundant in North Nandi and South Nandi Forests and are of crucial importance to the conservation of these unique ecosystems. Other than this checklist, very little is known about the specifics of the community or ecosystem ecology of North and South Nandi Forests. Hence, more studies should be done in this area to fill the existing knowledge gaps.

Acknowledgments

We would like to thank the National Museums of Kenya and the East Africa Herbarium (EA) for the provision of herbarium specimens for data extraction, as well as preservation of our collected voucher specimens. Much gratitude goes to the National Commission of Science, Technology and Innovation NACOSTI (NACOSTI/P/19/20003/28091), Kenya Forest Service (KFS) and Kenya Wildlife Service (KWS) for granting research permits and providing security during floristic surveys. We are also grateful to the team of researchers from the EA and SAJOREC who took part in the field collections, as well as KWS rangers and forest guides who provided security in the course of our work. Special thanks to Mrs. Deborah Boro for linguistic editing for our manuscript. This study was supported by grants from the National Natural Science Foundation of China (31970211) and the Sino-Africa Joint Research Center, CAS (SAJC201614).

References

Agnew ADQ (2013) Upland Kenya wild flowers and ferns, third edition. Nature Kenya Publications, Nairobi.

Agnew ADQ, Agnew S (1994) Upland Kenya wild flowers, second edition. East Africa Natural History Society, Nairobi.

Akwee P, Palapala V, Gweyi-Onyango J (2010) A comparative study of plant species composition of grasslands in Saiwa Swamp National Park and Kakamega Forest, Kenya. Journal of Biodiversity 2(2): 77–83. https://doi.org/10.1080/09766901.2010.11884719

Althof AJ (2005) Human impact on flora and vegetation of Kakamega Forest, Kenya-Structure, distribution, and disturbance of plant communities in an East African rainforest. PhD thesis, University of Koblenz, Germany.

Armstrong AH (2016) Tropical Rainforest Ecosystems. International Encyclopedia of Geography: People, the Earth, Environment and Technology, 1–16. https://doi.org/10.1002/9781118786352.wbieg0644

Beentje H, Adamson J, Bhanderi D (1994) Kenya trees, shrubs, and lianas. National Museums of Kenya, Nairobi, Kenya.

Bennun LA, Njoroge P (1999) Important bird areas in Kenya: Nature Kenya, East Africa Natural History Society, Nairobi, Kenya. https://doi.org/10.5962/bhl.title.87589

Chase MW, Christenhusz M, Fay M, Byng J, Judd WS, Soltis D, Soltis PS, Stevens PF (2016) An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. Botanical Journal of the Linnean Society 181(1): 1–20. https://doi.org/10.1111/boj.12385

Christenhusz MJ, Reveal JL, Farjon A, Gardner MF, Mill RR, Chase MW (2011) A new classification and linear sequence of extant gymnosperms. Phytotaxa 19(1): 55–70. https://doi.org/10.11646/phytotaxa.19.1.3

Diamond AW, Fayad VC (1979) Preliminary comparisons between the avifaunas of the North Nandi and Kakamega Forests. Scopus, Nairobi 3(4): 93–100.

Ehrich D, Gaudeul M, Assefa A, Koch MA, Mummenhoff K, Nemomissa S, Brochmann C (2007) Genetic consequences of Pleistocene range shifts: Contrast between the Arctic, the Alps and the East African mountains. Molecular Ecology 16(12): 2542–2559. https://doi.org/10.1111/j.1365-294X.2007.03299.x

Fashing PJ, Mwangi GJ (2004) Spatial variability in the vegetation structure and composition of an East African rain forest. African Journal of Ecology 42(3): 189–197. https://doi.org/10.1111/j.1365-2028.2004.00512.x

Filgueiras TS, Brochado AL, Nogueira PE, Gualla GF (1994) Caminhamento-Um método expedito para levantamentos florísticos e qualitativos. Caderno Geociências IBGE 12: 39–43.

Fischer E, Rembold K, Althof A, Obholzer J, Malombe I, Mwachala G, Theisen I (2010) Annotated checklist of the vascular plants of Kakamega Forest, Western Province, Kenya. Journal of East African Natural History 99(2): 129–226. https://doi.org/10.2982/028.099.0205

FTEA (1952–2012) Flora of Tropical East Africa. Royal Botanic Gardens, Kew, London.

Girma A, Fischer E, Dumbo B (2015) Vascular Plant Diversity and Community Structure of Nandi Forests, Western Kenya. Journal of East African Natural History 103(2): 125–152. https://doi.org/10.2982/028.103.0202

Hall JB, Swaine MD (1981) Distribution and ecology of vascular plants in a tropical rain forest – Forest vegetation in Ghana. Springer Netherlands, Netherlands, 383 pp. https://doi.org/10.1007/978-94-009-8650-3

IUCN (2019) IUCN Red List Categories and Criteria. Version 2019–1 https://www.iucnredlist.org/ [downloaded on 25.02.2020]

KIFCON [Kenya Indigenous Forest Conservation Programme] (1994a) Forest Inventory Report No. 11 South Nandi and Ururu.

KIFCON [Kenya Indigenous Forest Conservation Programme] (1994b) Forest Inventory Report No. 10 North Nandi, Kaptaroi and Taressia.

Kigomo BN (1987) Some observations on regeneration trials in the Kakamega and South Nandi natural forests, Kenya. East African Agricultural and Forestry Journal 52(3): 184–195. https://doi.org/10.1080/00128325.1987.11663515

Kogo BK, Kumar L, Koech R (2019) Forest cover dynamics and underlying driving forces affecting ecosystem services in western Kenya. Remote Sensing Applications: Society and Environment 14: 75–83. https://doi.org/10.1016/j.rsase.2019.02.007

Koros H, Malombe I, Mwendwa K, Jeruto P, Agevi H, Konje M (2016) Indigenous Knowledge, Uses and Conservation of Prunus africana (Hook. F.) Kalkman in Nandi Forests. Journal of Natural Sciences Research 6: 2224–3186.
Lewis SL (2006) Tropical forests and the changing earth system. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences 361(1465): 195–210. https://doi.org/10.1098/rstb.2005.1711
Lung T, Schaab G (2010) A comparative assessment of land cover dynamics of three protected forest areas in tropical eastern Africa. Environmental Monitoring and Assessment 161(1): 531–548. https://doi.org/10.1007/s10661-009-0766-3
Matiru V (2002) Forest Landscape Restoration. Kenya Country Report. Analysis of Existing Initiatives and policy and Legal Framework in Kenya. IUCN and WWF.
Maua JO, Tsingalia MH, Cheboiwo J (2018a) Species diversity and utilization of Non-Timber Forest Products (NTFPs) by households adjacent to South Nandi Forest, Kenya. Journal of Natural Sciences Research 8(20).
Maua JO, Tsingalia MH, Cheboiwo J (2018b) Socioeconomic factors influencing dependence of households on non-timber forest products in South Nandi Forest. Kenya Journal of Economics and Sustainable Development 9(14).
Mbuvi M, Musyoki J, Ayiemba W, Gichuki J (2015) Determining the potential for introducing and sustaining participatory forest management: A case study of South Nandi Forest of Western Kenya. International Journal of Biodeversity and Conservation 7(3): 190–201. https://doi.org/10.5897/IJBC2014.0786
McFarland BJ (2018) The Context of tropical rainforest deforestation and degradation. In Conservation of Tropical Rainforests. Palgrave Macmillan, Cham, 7–58. https://doi.org/10.1007/978-3-319-63236-0_2
Melly DK, Wei N, Kathambi V, Rono PC, Kipkoech S, Watuma BM, Kamau P, Gituru RW, Hu GW (2019) *Coccinia subsessiliflora*, a new record for Kenya and notes on its phylogenetic position. Phytotaxa 424(2): 106–14. https://doi.org/10.11646/phytotaxa.424.2.4
MEWNR (2015) Kenyas Biodiversity Atlas. Ministry of Environment, Natural Resources and Regional Development Authorities, Nairobi, Kenya.
Mitchell N, Lung T, Schaab G (2006) Tracing significant losses and limited gains in forest cover for the Kakamega-Nandi complex in western Kenya across 90 years by use of satellite imagery, aerial photography, and maps. Paper presented at the Proceedings of the ISPRS (TC7) Mid-Term Symposium "Remote Sensing: From Pixels to Processes, 8–11.
Musila W, Kirika P, Kimme J, Chesire C, Malombe I (2011) Plant species composition and diversity in South/North Nandi and Cherangani Hills forests. In: Musila W, Malombe I, Mwachala G (Eds) Strengthening the Protected Area Network within the Eastern Montane Forest Hotspot of Kenya: A rapid biodiversity survey of Nandi Hills and Cherangani Hills Forests. Nature Kenya, 12–22.
Mutoko MC, Hein L, Shisanya CA (2015) Tropical forest conservation versus conversion trade-offs: Insights from analysis of ecosystem services provided by Kakamega rainforest in Kenya. Ecosystem Services 14: 1–11. https://doi.org/10.1016/j.ecoser.2015.03.003
Mwavu EN, Witkowski ETF (2009) Population structure and regeneration of multiple-use tree species in a semi-deciduous African tropical rainforest: implications for primate conservation. Forest Ecology and Management 258(5): 840–849. https://doi.org/10.1016/j.foreco.2009.03.019

Njunge J, Mugo J (2011) Composition and Succession of the Woody Flora of South Nandi Forest, Kenya. Research Journal of Botany 6(3): 112. https://doi.org/10.3923/rjb.2011.112.121

Pariona A (2018) How Much of The Surface of The Earth Is Covered By Rainforests? WorldAtlas. https://www.worldatlas.com/articles/how-much-of-the-surface-of-the-earth-is-covered-by-rainforests.html [accessed on 18.05.2020]

Pascaline J, Charles M, Lukhoba C, George O (2011) Phytochemical constituents of some medicinal plants used by the Nandis of South Nandi district, Kenya. Journal of Animal & Plant Sciences 9(3): 1201–1210.

Peltorinne P (2004) The forest types of Kenya. Taita Hills and Kenya. In: Pellikka P, Ylhaisi J, Clark B (Eds) Taita Hills and Kenya, 2004 – seminar, reports and journal of a field excursion to Kenya. Expedition reports of the Department of Geography, University of Helsinki 40, 8–13. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.494.8558&rep=rep1&type=pdf

PPG I (2016) A community-derived classification for extant lycophytes and ferns. Journal of Systematics and Evolution 54(6): 563–603. https://doi.org/10.1111/jse.12229

Russo SE, Kitajima K (2016) The ecophysiology of leaf lifespan in tropical forests: adaptive and plastic responses to environmental heterogeneity. In: Goldstein G, Santiago L. (Eds) Tropical Tree Physiology. Tree Physiology, vol 6. Springer, Cham. https://doi.org/10.1007/978-3-319-27422-5_17

Schifter H, Cunningham-van Someren G, van Someren GC (1998) The Avifauna of the North Nandi Forest, Kenya. Annalen des Naturhistorischen Museums in Wien, Serie B für Botanik und Zoologie: 425–479.

Tanui JG (2015) The Extent of Spatial Temporal Variations in Land Use and its Implications on Forest Ecosystems: A Case of Nandi Hills Forests Kenya. Space 5(8): 129–139.

Thiers B (2016) Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/

Tian J, Kathambi V, Kamau P, Mwachala G, Malombe I, Hu GW (2019) The first report of *Nervilia lilacea* Jum. & H. Perrier (Orchidaceae, Epidendroideae) from Kenya and the Northern Hemisphere. PhytoKeys 11. https://doi.org/10.3897/phytokeys.135.46629

Vuyiya E, Konje M, Tsingalia H, Obiet L, Kigen C, Wamalwa S, Nyongesa H (2014) The impacts of human activities on tree species richness and diversity in Kakamega Forest, Western Kenya. International Journal of Biodeversity and Conservation 6(6): 428–435. https://doi.org/10.5897/IJBC2014.0711

Wass P (1995) Kenya's indigenous forests: IUCN, Gland, Switzerland, and Cambridge, UK in collaboration with ODA.

Wei N, Miyawa DO, David MK, Ngumbau VM, Zhong ZX, Mwachala G, Hu GW, Wang QF (2017) *Zehneria longiflora* (Cucurbitaceae), a new species from Kenya. Phytotaxa 324(1): 89–94. https://doi.org/10.11646/phytotaxa.324.1.7

Zhou YD, Liu B, Mbuni Y, Yan X, Mwachala G, Hu G, Wang QF (2017) Vascular flora of Kenya, based on the flora of tropical East Africa. PhytoKeys 90: 113–126.

PhytoKeys 155: 141–153 (2020)
doi: 10.3897/phytokeys.155.51469
http://phytokeys.pensoft.net

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Lectotypification of the name *Stereodon nemoralis* Mitt. (Plagiotheciaceae), a basionym of *Plagiothecium nemorale* (Mitt.) A. Jaeger

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Academic editor: Matt von Konrat | Received 25 February 2020 | Accepted 19 June 2020 | Published 7 August 2020

Citation: Wolski GJ, Faltyn-Parzymska A, Proćków J (2020) Lectotypification of the name *Stereodon nemoralis* Mitt. (Plagiotheciaceae), a basionym of *Plagiothecium nemorale* (Mitt.) A. Jaeger. PhytoKeys 155: 141–153. https://doi.org/10.3897/phytokeys.155.51469

Abstract

In 1859, William Mitten described *Stereodon nemoralis* (≡ *Plagiothecium nemorale*) based on the gathering of Sir J.D. Hooker from India. However, the protologue did not indicate any specific specimen or illustration. For the past 50 years, the original material (NY 913349) deposited at the NY Herbarium has been considered as the holotype. However, this assumption has since been found to be incorrect, because in the Herbarium of The Natural History Museum exists other original material of this species (BM 1030713), collected by Hooker. In addition, the specimen from NY Herbarium is in poor condition and its most important diagnostic characters are not visible. In contrast, the material from BM Herbarium is in very good condition, and therefore it is herein designated as the lectotype. Also, the paper describes the resolution of this type, a process complicated by changes that had occurred in the provisions of subsequent botanical *Codes*.

Keywords

Codes of Botanical Nomenclature, Hooker collection, India, Mitten collection, nomenclatural types, *Plagiothecium*, *Stereodon*, typification

Introduction

During his travels around India (between 1847–1851), staying from 20 to 24 May 1848 on Mount Tonglo (alt. 3036 m) in the Singalila Range in the Eastern Himalayas of Sikkim Sir Joseph Dalton Hooker collected many specimens of mosses (Hooker 1854). Collections gathered by him were subsequently examined by W. Mitten and W. Wilson, who, based on their findings, published jointly an incomplete provisional list of moss taxa from this expedition (Mitten and Wilson 1857). In 1859 Mitten also used this collection for the publication of his famous *Musci Indiae Orientalis* in which he described many new species, including *Stereodon nemoralis* (Mitten 1859).

The first set of specimens is preserved in the Hooker's Herbarium which was acquired in 1867 by Kew Gardens (K), but after World War II the bryophyte collection in K, thanks to a decision of the British government, was transferred to the British Museum (BM). Mitten retained many duplicates in his private herbarium which after his death in 1903 was bought by the New York Botanical Garden (NY).

Stereodon nemoralis was incorporated into the genus *Plagiothecium* by Augusto Jaeger in 1878, and its name changed to *Plagiothecium nemorale* (Mitt.) A. Jaeger (Jaeger 1878). Since then, many new taxa have been described within the genus; however, the number of potential species is still unclear (Wolski 2018). In the most recent revision of the genus, Wynns (2015) recognised 67 taxa, with a further 46 awaiting detailed research to determine their taxonomic status. Therefore, it can be expected that the number of species belonging to this genus will change in the near future, especially taking into account the increasing interest in research of the genus, as well as the more widespread use of molecular methods. These observations have been confirmed by recent research (Wynns 2015; Wynns and Schröck 2018; Ignatova and al. 2019; Wolski and Nowicka-Krawczyk 2020).

Plagiothecium nemorale has long been a neglected species, until it was resurrected from obsolescence by Iwatsuki (1970), when he found that it was the oldest available name for *P. sylvaticum* which proved to be conspecific with *P. denticulatum* (Hedw.) Schimp. and *P. neglectum* Mönk. Iwatsuki (1970) also proposed the specimen collected by J.D. Hooker, and currently deposited at the NY Herbarium (NY 913349), to accept to be the holotype of the name *P. nemorale*. In this revision of the genus, as in others, no other indicated type specimens or original material appear with the name *P. nemorale*.

Materials and methods

After Mitten's death in 1906, his entire herbarium was purchased by the NY Herbarium, and that is where most of the types of the species described by Mitten can currently be found. In addition, according to Thiers (1983), and information obtained from the curators of the **FH**, **G**, **MICH**, and **NY** herbaria during the conducted research, the types of the species from the *Plagiothecium* genus given by Mitten are deposited only in the **NY** Herbarium. In contrast, the **FH**, **G** and **MICH** collections only include selected duplicate specimens (but not types) from his collection.

A number of other herbaria from around the world were also searched, as well as various virtual databases with a global reach, such as JSTOR Global Plants, GBIF, Tropicos, INCT – the Virtual Herbarium of Flora and Fungi, the Chinese Virtual Herbarium and the Consortium of North American Bryophyte Herbaria (CNABH). A list of all checked herbaria is available on request directly from the first author.

Results

In 2016 and 2018, during the taxonomic revision of *Plagiothecium nemorale sensu lato*, its type specimens were examined. It was found that the NY Herbarium included two specimens with separate numbers on one herbarium sheet (Fig. 1). However, one of them (NY 913350) was not, in fact, a plant specimen, but a photograph of specimen NY 913349 (Fig. 2) with the note “Type. Photo by Z. Iwatsuki” (Fig. 1). Hence, NY 913350 is a photograph of plant specimen NY 913349 located on the same herbarium sheet but marked with a different number (Fig. 3).

The information given on the herbarium sheet, comprising the name of the collector, the description of the location, and even the substratum on which the specimen grew, i.e. the fern visible in the picture, is the same as in the protologue (Mitten 1859). Based on this similarity, and it being the only original known specimen, it has been recognised as a holotype by various researchers, including Iwatsuki (1970) and Thiers (1992).

The herbarium sheet also included a label with the inscription: “Syntype of: *Stereodon nemoralis* Mitt. J. Linn. Soc. Bot. Supp. 1: 104. 1859 ≡ *Plagiothecium sylvaticum* (Brid.) B.S.G. cf. Card.”. It was not possible to determine when the label had been stuck to the herbarium sheet: it could have been a few years or several decades previously. Nevertheless, it was reported to have been placed there by the NY Herbarium staff by mistake (Herbarium staff, pers. comm.). However, this appeared to be a mistake only until July 2011, when the *Vienna Code* ceased to apply (McNeill et al. 2006). From this time, when the *Melbourne Code* came into force (McNeill et al. 2012), and Recommendation 9A.4 originally introduced by the *Vienna Code*, i.e. “When a single gathering is cited in the protologue, but a particular institution housing it is not designated, it should be assumed that the specimen housed in the institution where the author is known to have worked is the holotype, unless there is evidence that further material of the same gathering was used” (McNeill et al. 2006), was removed, the “syntype” label became correct; however, this can be stated as a fact now, especially since it is now known that another specimen of the original material was deposited at BM. In some databases, such as the NY Herbarium and JSTOR Global Plants, the status of the type had not been changed to “syntype” by the time of writing, because the label was still thought to have been attached by mistake.

After careful analysis of the material, it can be said that the available material at NY (NY 913349) differs significantly from that which was photographed and published by Iwatsuki in 1970. It is easy to assess the changes in the amount of available material (Figs 2, 3). Our research confirms that the material from NY is preserved in very poor

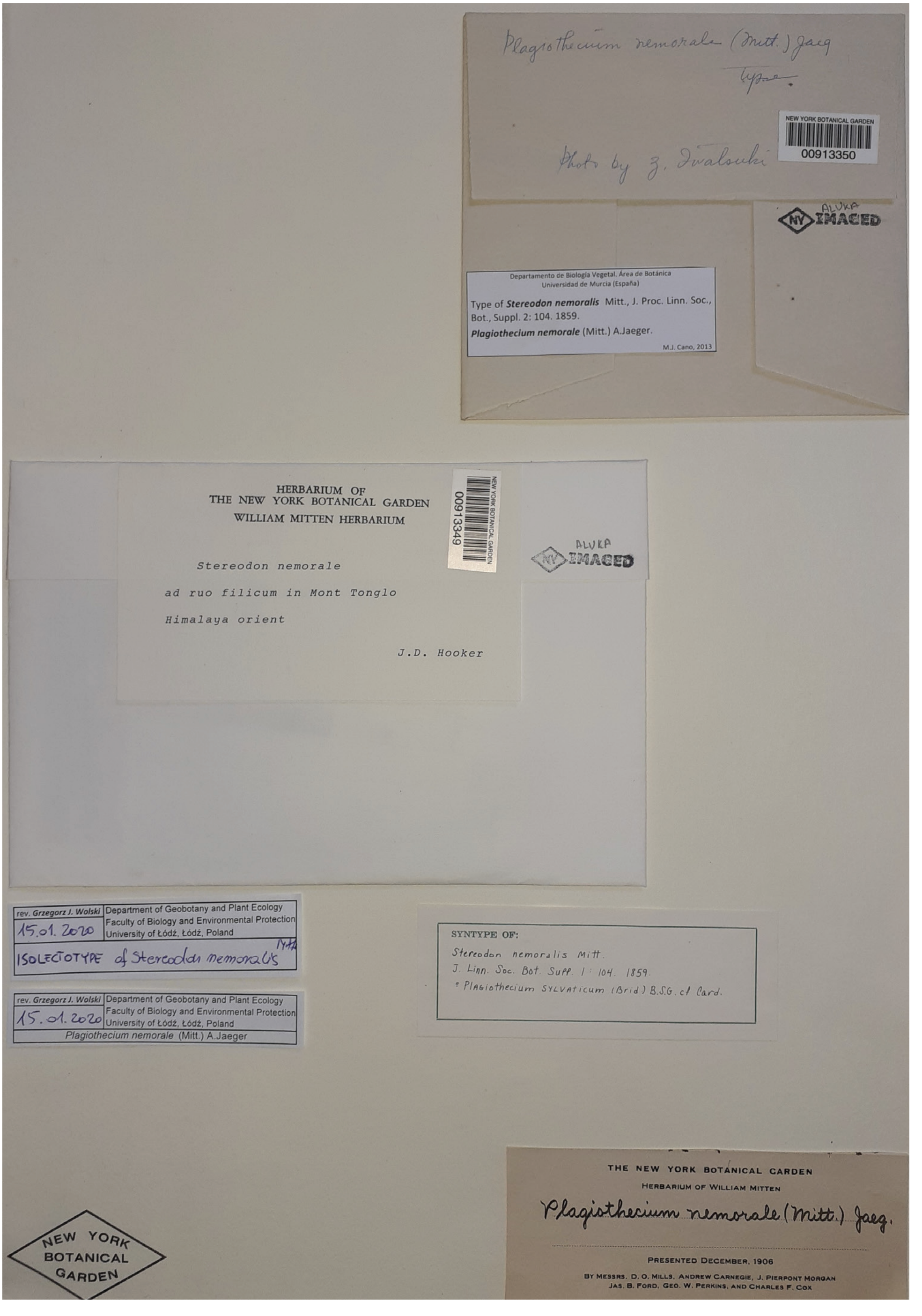

Figure 1. Herbarium sheet of *Stereodon nemoralis* Mitt. deposited in the New York Botanical Garden Herbarium (NY 913349 and NY 913350).

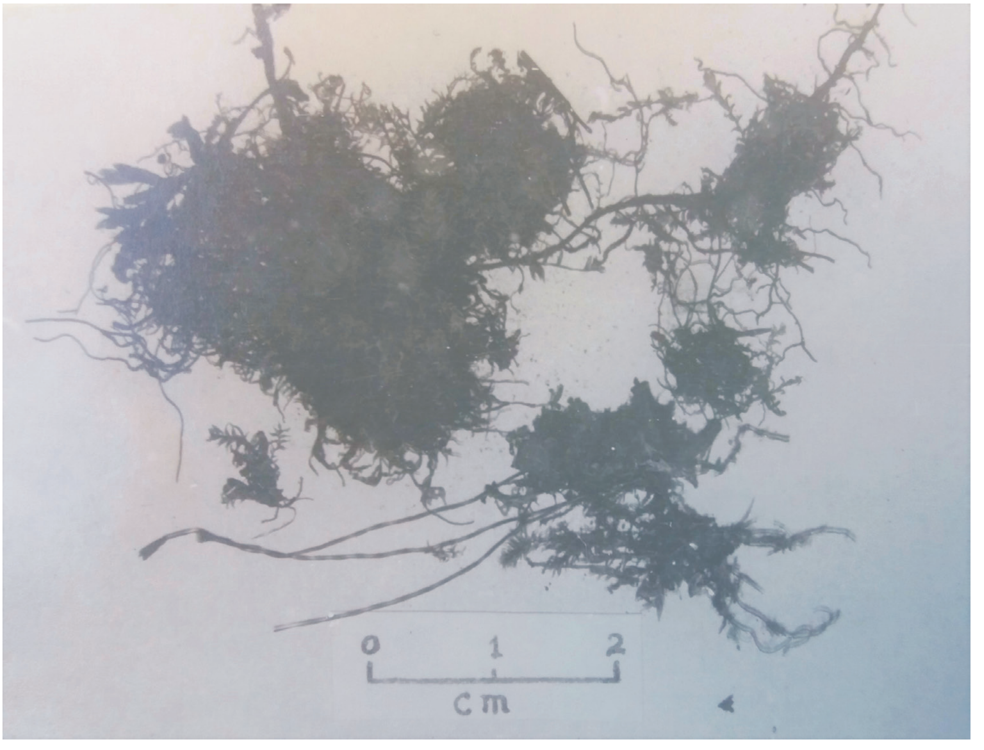

Figure 2. Photograph of the specimen NY 913349 taken by Iwatsuki (stored as NY 913350).

condition, and not as much turf is as visible as earlier (Figs 2, 3). The most important diagnostic characters of the species are not visible. In the case of *P. nemorale*, as well as the whole *Plagiothecium* genus, the most important taxonomic features are associated with stem leaves, i.e. their shape, symmetry and length, and with the shape, length and width of the middle part of the cells of these leaves. The examined specimen (NY 913349) does not have any whole stem leaves or leafy stems, and the available leaves are half or a third of normal size, suggesting that they originate from the top of the stem or from branches. Such leaves are not considered in the case of revision of the genus *Plagiothecium*. In addition, the leaves are considerably damaged: two of the best-preserved top stem or branch leaves are presented in Fig. 4. In its current state, the material indicates that the specimen belongs to the *Plagiothecium* genus, but there is no absolute certainty that it really belongs to *P. nemorale*. It should also be noted that the examined specimen (NY 913349) is not homogeneous: the fragments of the remains of the *Plagiothecium* specimen are accompanied by those of a young fern in the turf, which Mitten (1859) mentions in the diagnosis, as well as stems of other mosses (*Fissidens* sp.) (Fig. 3).

As a part of the taxonomic revision of *P. nemorale*, efforts were made to find the entire original material and the species names now considered to be synonyms of this species. In the case of *S. nemoralis*, this also concerned specimens collected by Hooker from India or other materials from Mitten's collections. A global search of herbaria

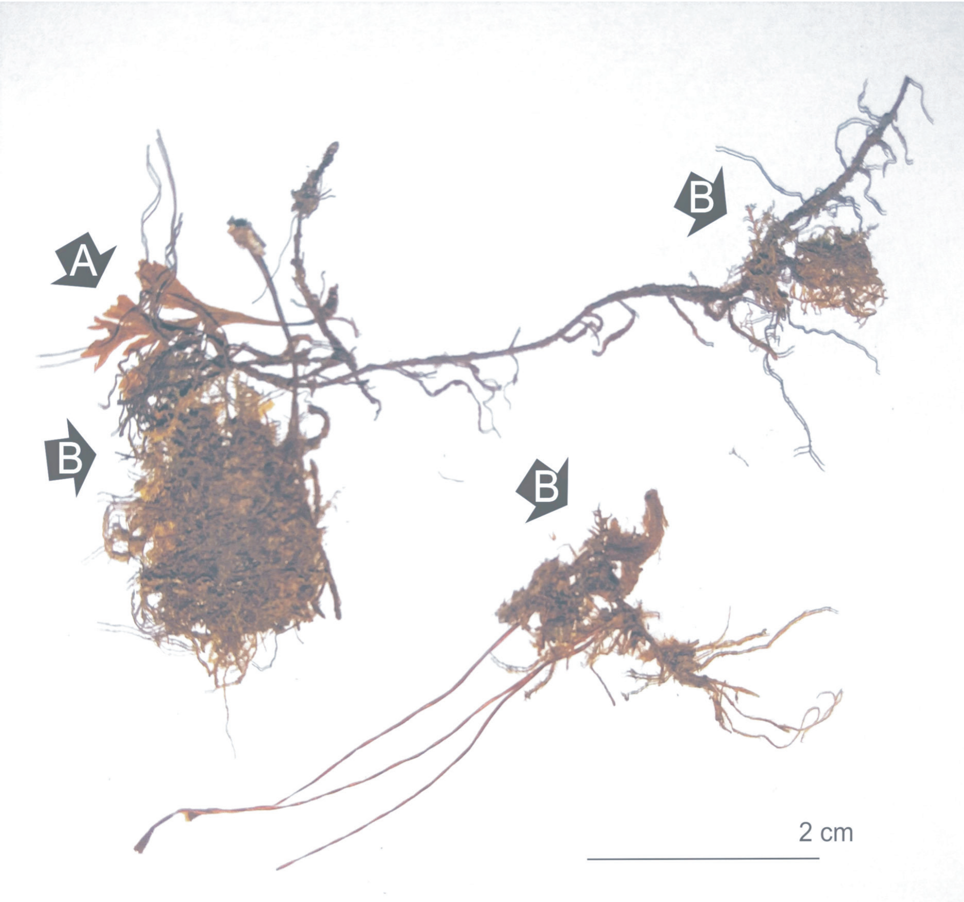

Figure 3. Remains of the holotype of the *Stereodon nemoralis* Mitt. (NY 913349) **A** young fern **B** stems of *Fissidens* sp. moos.

revealed the existence of specimen BM 1030713, labelled as an isotype of *S. nemoralis* (Fig. 5), with a herbarium sheet bearing the stamp "Herbarium Hookerianum 1867". We believe, however, that the date on this seal indicates the date of inclusion in Hooker's herbarium at Kew (currently in BM), not the date of collection of the specimen.

This conclusion is supported by the following passage from Page 4 of Mitten's book (1859): "The materials from the present enumeration have been derived from the collections (…), but more especially from those made by (…) Dr J.D. Hooker in the Sikkim-Himalaya and East Nepal (…). (…), the entire extensive collections of (…) Dr J.D. Hooker were entrusted to the author for segregation and distribution."

In addition, Article 9.1 of the *Shenzhen Code* (Turland et al. 2018) states that "A holotype of a name of a species or infraspecific taxon is the one specimen or illustration (…) either (a) indicated by the author(s) as the nomenclatural type or (b) used by the author(s) when no type was indicated". It would therefore appear that no holotype of

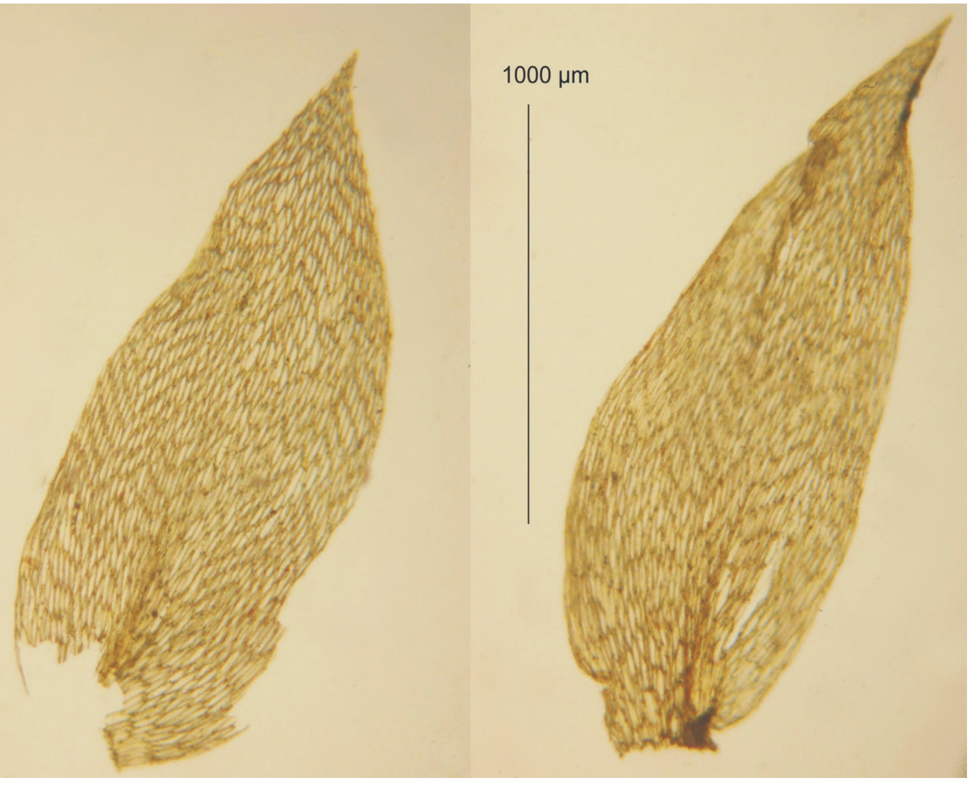

Figure 4. The best remains of top stem or branch leaves of *Stereodon nemoralis* Mitt. (NY 913349), loosely left in the envelope.

S. nemoralis Mitt. exists, and that all the specimens, including that stored at the NY Herbarium (NY 913349), represent only a part of the material that was available to Mitten when he described the new species in 1859. According to Art. 9.6 (last sentence: “Reference to an entire gathering, or a part thereof, is considered citation of the included specimens”), these are syntypes.

Although the protologue by Mitten did not indicate the specimen or the illustration as a type according to Article 9.1 (a) of the *Shenzhen Code* (Turland et al. 2018), and merely cited a gathering by Hooker, the specimen from the NY Herbarium has nevertheless been considered a holotype for the past 50 years. For this consideration to be valid, the holotype would have to be the one specimen used by Mitten, according to Article 9.1 (b) of the *Shenzhen Code* (Turland et al. 2018); however, it is unclear whether the protologue only referred to the specimen now stored in the NY Herbarium, as this was not confirmed at the time of publication. The matter is further complicated by the existence of a duplicate specimen in the BM herbarium, as also not noted by Mitten (1859).

This specimen in NY has been considered as a holotype by a number of researchers (see: Iwatsuki 1970; Thiers 1992), and this information is still being reproduced in

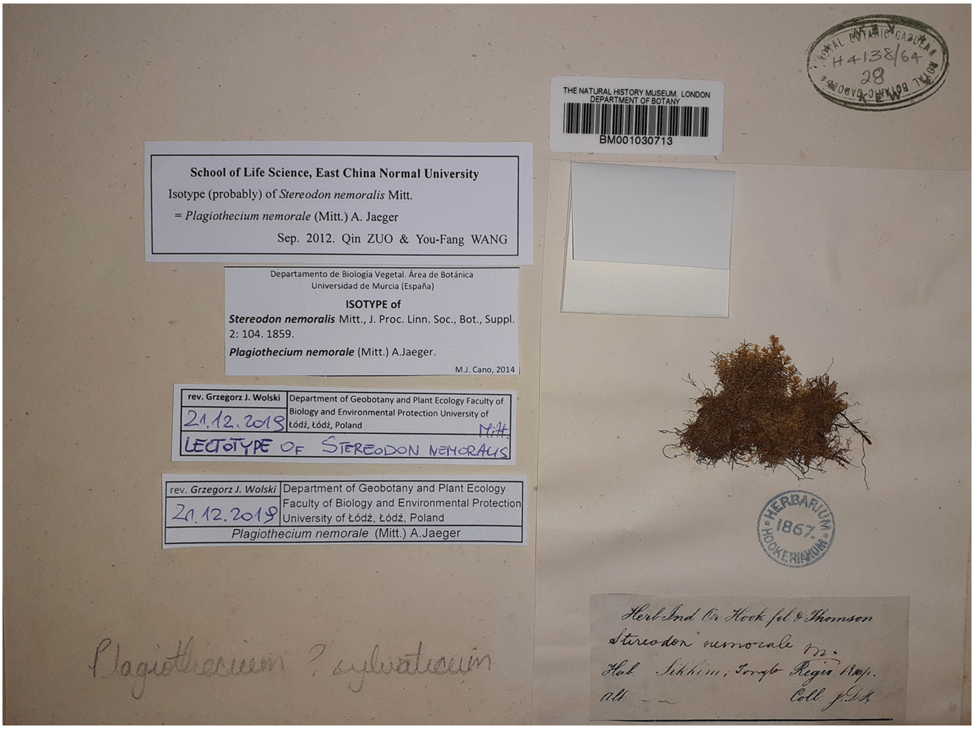

Figure 5. A specimen of *S. nemoralis* Mitt. from the BM Herbarium (BM 1030713).

sources such as the NY Herbarium and JSTOR Global Plants (accessed on October 6, 2019). A detailed analysis was performed of the *Edinburgh Code* (Lanjouw et al. 1966) which was in force during Iwatsuki's work, despite his paper being published only in 1970, and of the *Seattle Code*, which was in force in 1970 but was not yet published in print (Stafleu et al. 1972); the analysis highlighted three significant points: Article 7 Note 3 "If no holotype was indicated by the author who described a taxon, (...) a lectotype (…) for it may be designated", Appendix III Point 1: "The choice made by the original author, if definitely expressed at the time of the original publication of the name of the taxon, is final. If he included only one element, that one must always be accepted as the holotype (…)", and Appendix III Point 3: "A lectotype may be chosen only when an author failed to designate a holotype (...)". Therefore, with this in mind, the specimen from NY (NY 913349) should be regarded as a lectotype rather than a holotype. However, in his revision for *S. nemoralis*, Iwatsuki (1970) cites only one specimen from the NY Herbarium, i.e. NY 913349, and recognises it as a holotype: this confirms that Iwatsuki was (probably) not aware of the existence of the additional original material of *S. nemorale* from the Mitten herbarium collected by J.D. Hooker in India, which was stored at the BM herbarium, or, perhaps, that it was rather a result of a "semi-mechanical" approach to the problem of typification of moss names.

Specimen NY 913349 cannot be recognised as a holotype based on Rec. 9A.4 of the *Vienna Code* posted above (McNeill et al. 2006), nor the *Tokyo Code* (Greuter et al. 1994), because it was not included in the *Edinburgh Code* (Lanjouw et al. 1966) or the *Seattle Code* (Stafleu et al. 1972) and could not be known to Iwatsuki in 1970; however, it could have been used at that time due to the author's intuition and general knowledge of the matter. However, after being found to be in conflict with other provisions, Rec. 9A.4 was later removed from the *Melbourne Code* (McNeill et al. 2012).

In the protologue of *S. nemoralis*, not only did Mitten not refer to any single specimen, but also he explicitly stated that he was in possession of all materials acquired by J.D. Hooker and was responsible for their "segregation and distribution" (Mitten 1859). Considering this fact, and also Article 9.6 of the *Shenzhen Code* (Turland et al. 2018) stating that "A syntype is any specimen cited in the protologue when there is no holotype, or any one of two or more specimens simultaneously designated in the protologue as types" as well as Article 40.2 (Note 1) stating that "When the type is indicated by reference to an entire gathering, or a part thereof, that consists of more than one specimen, those specimens are syntypes", it is obvious that both the specimens from the NY Herbarium (NY 913349), and the BM Herbarium (BM 1030713) are syntypes.

Due to the bad condition of the specimen from the NY Herbarium (NY 913349) and on the basis of the following five Articles of the *Shenzhen Code* (Turland et al. 2018), we propose that the specimen from the BM Herbarium (BM 1030713) be designated a lectotype of *S. nemoralis* Mitt.: Article 9.3, stating that: "A lectotype is one specimen or illustration designated from the original material (…) as the nomenclatural type, in conformity with Art. 9.11 and 9.12, if the name was published without a holotype, or if the holotype is lost or destroyed, or if a type is found to belong to more than one taxon"; Article 9.11 stating that: "If the name of a species or infraspecific taxon was published without a holotype (…), or when the holotype or previously designated lectotype has been lost or destroyed, or when the material designated as type is found to belong to more than one taxon, a lectotype or, if permissible (…), a neotype as a substitute for it may be designated"; Article 9.12: "In lectotype designation, an isotype must be chosen if such exists, or otherwise a syntype or isosyntype if such exists. If no isotype, syntype or isosyntype is extant, the lectotype must be chosen from among the paratypes if such exist. If none of the above specimens exists, the lectotype must be chosen from among the uncited specimens and cited and uncited illustrations that comprise the remaining original material, if such exist"; Article 7.10: "For purposes of priority (…), designation of a type is achieved only by effective publication (…)" and Article 7.11: "For the purposes of priority (…), designation of a type is achieved only if the type is definitely accepted as such by the typifying author, if the type element is clearly indicated by direct citation including the term 'type' (typus) or an equivalent, and, on or after 1 January 2001, if the typification statement includes the phrase 'designated here' (hic designatus) or an equivalent".

Description of the lectotype

The specimen from the BM Herbarium (BM 1030713) is a medium-sized plant, light green to yellowish, without metallic luster. Stems to 2 cm long, complanate-foliate, in cross-section rounded, with a diameter of 300–350 μm, central strand developed, epidermal cells 8–15 × 15–25 μm, parenchyma thin-walled, 20–50 × 11–35 μm; leaves gently concave, symmetrical, ovate, in dry condition shrunken, those from the middle of the stem 2.2–2.4 mm long, and the width measured at the widest point 1.0–1.3 mm; the apex straight, denticulate, acute, apiculate; two costae, extending almost to ½ leaf length, reaching 0.50–0.60 mm; hexagonal and narrowly-hexagonal cells in regular transverse rows, areolation very lax; cells reach 55–96 × 15–18 μm at the apex, 75–97 × 16–20 μm at mid-leaf, and 74–125 × 14–20 μm at the lower part of the leaf; decurrencies of 3 rows of rectangular cells, 25–35 × 20–30 μm (Fig. 6).

Throughout its range in Eurasia (Wolski 2017; Wolski and Nowicka-Krawczyk 2020) and North America (Wolski 2020), *P. nemorale* is characterised by: symmetrical leaves, a denticulate leaf apex, and decurrencies of two or three rows with mainly rectangular cells. Middle leaf cells are hexagonal to narrowly hexagonal, but their length does not exceed 100 μm. Thus, all the features of the described lectotype (BM 1030713) are within the range of variability for *P. nemorale* reported from the northern hemisphere (Wolski 2017, 2020; Wolski and Nowicka-Krawczyk 2020).

These features also distinguish very well *P. nemorale* from other similar or closely related species. For example, resurrected recently *P. longisetum* Lindb. is characterised by: asymmetrical leaves, a not denticulate leaf apex, and extended hexagonal leaf cells whose length is in the range from 100 to 150 μm (Wolski and Nowicka-Krawczyk 2020); *P. angusticellum* G. J. Wolski & P. Nowicka-Krawczyk is also

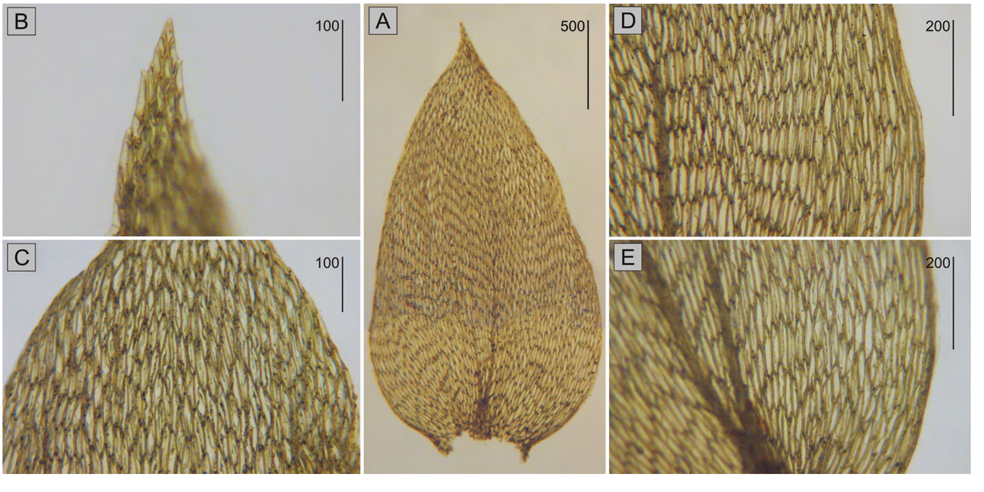

Figure 6. Lectotype of *S. nemoralis* Mitt. from the BM Herbarium (BM 1030713) **A** leaf shape **B** the serrated leaf apex **C–E** the shape and dimensions of cells from individual leaf zones: **C** from the upper part **D** from the middle part **E** from the lower part of the leaf. Scale bars: in μm.

distinguished from the species mentioned above by: an asymmetrical, but slightly curved and not denticulate apex, and narrowly elongate-hexagonal (113–143 × 15–19 μm), gently asymmetrical middle leaf cells (Wolski and Nowicka-Krawczyk 2020). *P. denticulatum* is distinguished from *P. nemorale* not only by leaf symmetry but mainly by decurrent angular cells rounded to rounded rectangular, inflated, forming very distinct auricles.

Formal typification may be summarised thus:

Stereodon nemoralis Mitt., Journ. Linn. Soc. Bot. Suppl. 1: 104 (1859) ≡ *Plagiothecium nemorale* (Mitt.) A. Jaeger, Ber. S. Gall. Naturw. Ges. 1876–1877: 451 (1878) ≡ *P. silvaticum* var. *nemorale* (Mitt.) Paris, Index Bryol.: 967 (1898). **Type citation**: *Hab*. In Himalayae orient. reg. temp., Sikkim, in monte Tonglo (ad radicem filicis cujusdam), *J. D. Hooker* ! **Lectotype** (*designated here*): "Herb. Ind Or Hook. Fil. & Thomson *Stereodon nemorale* m. Hab. Sikkim, Tonglo Regio temp. Alt. – J. D. H." – BM 1030713!: **isolectotype**: NY 913349!

Acknowledgments

We are grateful to Professor John McNeill from Royal Botanic Garden Edinburgh, Scotland and to Professor Nicholas Turland from Botanischer Garten und Botanisches Museum Berlin, Freie Universität Berlin, Germany for their priceless comments and remarks which contributed to this article. In addition, we are grateful to the curators of the BM Herbarium, to Professor Leonard T. Ellis from the Natural History Museum, U.K. and to Laura Briscoe, MSc, Collections Manager of the Cryptogamic Herbarium NY (New York Botanical Garden, USA) for the loan of type specimens. Furthermore, we are grateful to Professor William R. Buck and Laura Briscoe MSc (NY), for all consultations on the *S. nemoralis* type, and also, we would like to thank very much three reviewers of the manuscript for their helpful comments, suggestions and text corrections.

References

Greuter W, Barrie FR, Burdet HM, Chaloner WG, Demoulin V, Hawkswort DL, Jürgensen PM, Nicolson DH, Silva PC, Trehane P, McNeill J (1994) International Code of Botanical Nomenclature (Tokyo Code) adopted by the Fifteenth International Botanical Congress, Yokohama, August-September 1993. Regnum Vegetabile 131. Königstein: Koeltz Scientific Books. https://archive.bgbm.org/iapt/nomenclature/code/tokyo-e/Contents.htm

Hooker JD (1854) Himalayan Journals; or Notes of a Naturalist in Bengal, the Sikkim and Nepal Himalayas, the Khasia Mountains & c. Vol. 1. London, John Murray, Albemarle Street, 1–408. https://doi.org/10.5962/bhl.title.60447

Ignatova EA, Fedorova AV, Kuznetsova OI, Ignatov MS (2019) Taxonomy of the *Plagiothecium laetum* complex (Plagiotheciaceae, Bryophyta) in Russia. Arctoa 28(1): 28–45. https://doi.org/10.15298/arctoa.28.05

Iwatsuki Z (1970) A revision of *Plagiothecium* and its related genera from Japan and her adjacent areas. The Journal of the Hattori Botanical Laboratory 33: 331–380.

Jaeger A (1878) Genera et species muscorum systematyce disposita seu Adumbratio flotae muscorum totius orbis tetrarum. In: Wartman N (Ed.) Bericht über die Thätigkeit der St. Gallischen Naturwissenschaftlichen Gesellschaft während des Vereinsjahres 1876–77. Zollikofer'sche Buchdruckerei, St. Gallen, 211–454.

Lanjouw J, Mamay SH, McVaugh R, Robyns W, Rollins RC, Ross R, Rosseau J, Schulze GM, Smith AC, de Vilmorin R, Stafleu FA (1966) International Code of Nomenclature adopted by the Tenth International Botanical Congress, Edinburgh, August 1964. Regnum Vegetabile 46. International Bureau for Plant Taxonomy and Nomenclature, Utrecht.

McNeill J, Barrie FR, Burdet HM, Demoulin V, Hawksworth DL, Marhold K, Nicolson DH, Prado J, Silva PC, Skog JE, Wiersema JH, Turland NJ (2006) International Code of Botanical Nomenclature (Vienna Code): Adopted by the Seventeenth International Botanical Congress Vienna, Austria, July 2005. Regnum Vegetabile 146. A.R.G. Gantner Verlag KG, Ruggell. https://doi.org/10.1007/BF02811129

McNeill J, Barrie FR, Buck WR, Demoulin V, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Marhold K, Prado J, Prud'homme van Reine WF, Smith GF, Wiersema JH, Turland NJ (Eds) (2012) International Code of Nomenclature for algae, fungi, and plants (Melbourne Code): Adopted by the Eighteenth International Botanical Congress Melbourne, Australia, July 2011. Regnum Vegetabile 154. Koeltz Scientific Books, Königstein.

Mitten W (1859) Musci Indiae Orientalis; an Enumeration of the Mosses of the East Indies. Journal of the Proceedings of the Linnean Society, Supplement to Botany: 1–174. https://doi.org/10.1111/j.1095-8339.1859.tb02466.x

Mitten W, Wilson W (1857) Enumeration of the Mosses collected in India by Dr. J. D. Hooker, F.R.S., and Dr. Thomas Thomson, F.R.S., with their habitats, elevations, and the numbers under which they have been distributed. Hooker's Journal of Botany Kew Garden Miscellany 9: 289–300, 321–333, 363–370.

Stafleu FA, Bonner CEB, McVaugh R, Meikle RD, Rollins RC, Ross R, Schopf JM, Schulze GM, de Vilmorin R, Voss EG (Eds) (1972) International Code of Nomenclature adopted by the Eleventh International Botanical Congress, Seattle, August 1969. Regnum Vegetabile 82. A. Oosthoek's Uitg., Utrecht.

Thiers BM (1983) Index to the genera and species of Hepaticae described by William Mitten. Brittonia 35(3): 271–300. https://doi.org/10.2307/2806026

Thiers BM (1992) Indices to the species of mosses and lichens described by William Mitten. Memoirs of the New York Botanical Garden 68: 1–113.

Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Kusber W-H, Li D-Z, Marhold K, May TW, McNeill J, Monro AM, Prado J, Price MJ, Smith GF (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Regnum Vegetabile 159. Koeltz Botanical Books, Glashütten. https://doi.org/10.12705/Code.2018

Wolski GJ (2017) Morphological and anatomical variability of *Plagiothecium nemorale* in Central Poland. Herzogia 30(1): 36–50. https://doi.org/10.13158/heia.30.1.2017.36

Wolski GJ (2018) Are *Plagiothecium cavifolium*, *P. nemorale* and *P. succulentum* indeed variable species? Pakistan Journal of Botany 50(4): 1579–1589.

Wolski GJ (2020) Reassessing the taxonomic diversity of *Plagiothecium* section *Orthophyllum* in the North American bryoflora. Brittonia in print.

Wolski GJ, Nowicka-Krawczyk P (2020) Resurrection of the *Plagiothecium longisetum* Lindb. and proposal of the new species – *P. angusticellum*. PLoS One 15(3): e0230237. https://doi.org/10.1371/journal.pone.0230237

Wynns JT (2015) Molecular phylogeny and systematic revision of the pleurocarpous moss genus *Plagiothecium*. PhD Thesis, University of Copenhagen, Denmark.

Wynns JT, Schröck C (2018) Range extensions for the rare moss *Plagiothecium handelii*, and its transfer to the resurrected genus *Ortholimnobium*. Lindbergia 41(1). https://doi.org/10.25227/linbg.01087