

Studies on the moss flora of the Bío-Bío Region of Chile: Part 3

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Abstract

This is the final report on the moss flora of the Bío-Bío Region (Región VIII) in south-central Chile where collections were made in 2001–2003. Reported in this paper are one species new to South America, four species new to Chile and 16 species new to the Region. With these new additions the total number of taxa in the Bío-Bío Region is 343, corresponding to 331 species and 12 infraspecific taxa. A complete checklist of the mosses for all the provinces in the Region is presented.

Keywords

Bryophyta, floristics, Bío-Bío Region, checklist, South America

Introduction

This is the final paper on the moss flora of the Bío-Bío Region of Chile, reporting the identifications for the specimens collected by R.R. Ireland and Gilda Bellolio in 2001–2003. Two earlier papers by Ireland et al. (2006, 2010) reported many mosses new for the Region, as well as for all of Chile. In the present paper are reports for one

species new for South America, four new for Chile and 16 new for the Bío-Bío Region. All collection numbers are those of the two authors and the identifications were made by R.R. Ireland and Juan Larraín, with the exception of some problematic specimens that were identified by various other bryologists.

The original checklist of the mosses by He (1998) reported 190 taxa for the Region which was later updated by Müller (2009a, b) who reported 315 taxa. This number was subsequently increased to 323 taxa by Ireland et al. (2010). The total number of taxa now known for the Bío-Bío Region is 343, which is the current number reported in the present paper.

Since the publication of the first paper of this series on the Bío-Bío moss flora (Ireland et al. 2006), the administrative division of Chile has slightly changed, modifying the map given in the latter reference. In October 2007, two new regions were created after the breakup of the former I and X Regions: Region XV (Arica y Parinacota) became the northernmost region after splitting of the former I Region, whereas Region XIV (Los Ríos) was created to separate the administration of Valdivian area from the rest of the former Los Lagos Region (X Region, see Fig. 1).

Methods

Phytogeographic information, climate and geomorphology for the four provinces (Arauco, Bío-Bío, Concepción, Ñuble) in the Region are all reported in the first paper of this project by Ireland et al. (2006). Voucher specimens of most of the collections are at CONC, MO and US, with many at NY. All numbers listed below correspond to specimens collected by Robert R. Ireland and G. Bellolio, unless otherwise indicated.

For the taxonomy we follow Müller (2009a), with the exception of the genus *Bryum* for which we followed the segregates outlined in Spence (2014). Segregates of *Racomitrium* are not recognized as suggested by Larraín et al. (2013). Synonyms are indicated for taxa treated under a different name in Müller (2009a) or on the Internet at www.tropicos.org.

For the biogeographical analysis, we grouped the taxa into seven groups: “Endemic” meaning taxa distributed in Chile, adjacent Argentina, sometimes extending into the Falkland Islands, South Georgia or the Juan Fernández Islands; “Wide Distribution” meaning taxa distributed in several continents or without a clear geographical pattern; “Southern Hemisphere” refers to widely distributed subantarctic species sometimes reaching tropical areas in the Andes or in South East Asia; “Bipolar” meaning taxa distributed in the temperate areas of both hemispheres; “Neotropical” meaning taxa widely distributed in Latin America and the Caribbean, including some species restricted to South America; “Gondwanic” referring to taxa distributed in southern South America and New Zealand and Australia; and “Neotropical + African” meaning taxa distributed both in the tropical and/or subtropical areas of both Latin America and Africa.

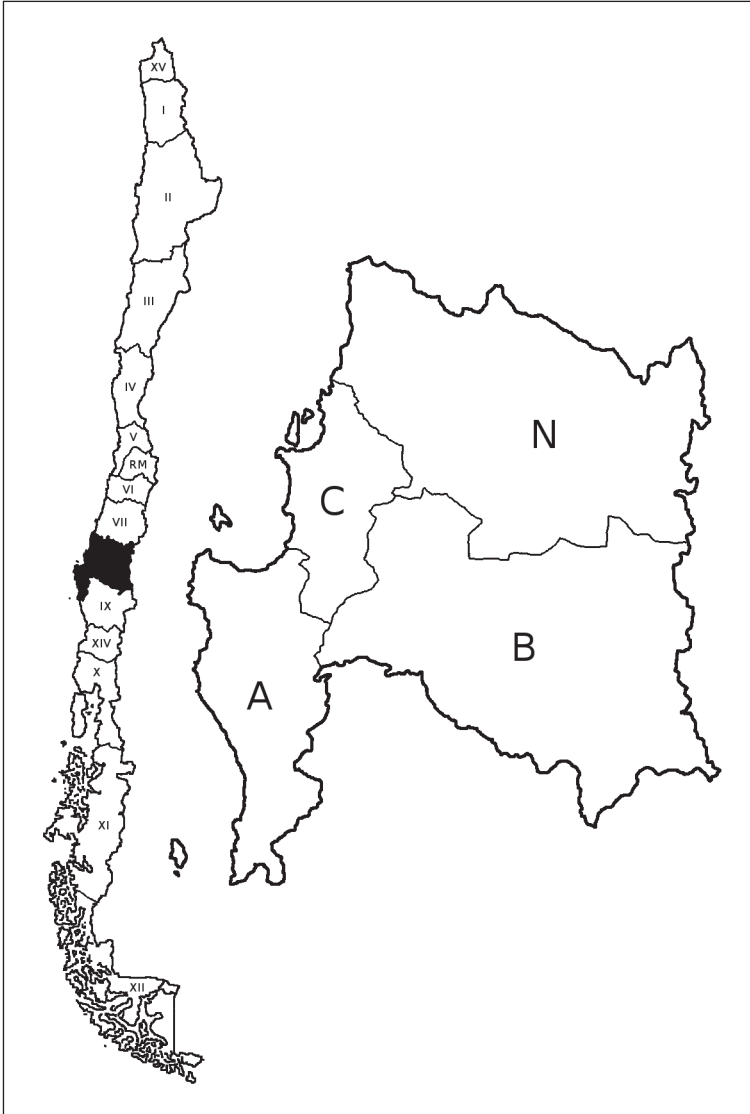


Figure 1. Left. Map of Chile showing in black the location of Bío-Bío Region (VIII) and the rest of Chilean Regions in Roman numerals (RM=Metropolitan Region). **Right.** Detail of Bío-Bío Region map showing the four provinces (A=Arauco, B=Bío-Bío, C=Concepción, N=Ñuble).

Results

Moss new to South America and Chile

Sematophyllum harpidioides (Renauld & Cardot) F.D.Bowers – Arauco Prov., Sta. Aurora farm (Mininco), 38°01'S, 73°16'W. alt. ca. 486 m, 33513 (Det. B.H. Allen 2014); road from Curanilahue to Trongol, 19 km SE of Curanilahue, 37°34'S, 73°12'W, alt.

ca. 990 m, 33095, 33109; Mocha Island, trail in National Park, 38°20'S, 75°53'W, alt. ca. 15–350 m, 33124; Lincuyin, W of Lanalhue Lake, 37°57'S, 73°19'W, alt. ca. 250 m, 33464, 33465; Hwy. P-80-R, 13 km E of Antiquina, 38°03'S, 73°16'W, alt. 531 m, 33552; 4 km W of Mahuique, 38°10'S, 73°14'W, alt. ca. 590 m, 33596; road from Contulmo to Purén, 2 km S of Contulmo, 38°03'S, 73°13'W, alt. ca. 410 m, 33640, 33648.

Known only from Central America (Costa Rica and Honduras) according to B.H. Allen (MO) and specimens cited in Tropicos.

Mosses new to Chile

Bryum insolitum Cardot – Ñuble Prov., road to garbage dump, 6 km E of Quirihue, 36°17'S, 72°28'W, alt. ca. 570 m, 32347a (det. by J.R. Spence 2016).

Known only from Mexico and Bolivia (Ochi 1980).

Ptychostomum bimum (Schreber) J.R.Spence – Concepción Prov., waterfalls at toll booth near Sta. Juana, 1 km S of Curali, 37°15'S, 72°57'W, alt. ca. 135 m, 33934 (det. J.R. Spence 2014).

A widely distributed taxon (Spence 2014) that has been often lumped together with *P. creberrimum* or with *P. pseudotriquetrum* (Hedw.) G.Gaertn., B.Mey. & Scherb. (Zolotov 2000). Not previously reported for Chile.

Ptychostomum creberrimum (Taylor) J.R.Spence & H.P.Ramsey – Bío-Bío Prov., Jaujau Farm (Mininco), 38°02'S, 71°57'W, alt. ca. 760 m, 35465 (det. J.R. Spence 2014).

A widely distributed taxon (Spence 2014) not previously reported for Chile.

Ptychostomum inclinatum (Sw. ex Brid.) J.R.Spence – Ñuble Prov., Termas de Chillán & environs, 36°55'S, 71°42'W, alt. ca. 1660 m, 30585, 30617 (both det. by J.R. Spence 2014).

A widely distributed taxon (Spence 2014) not previously reported for Chile.

Mosses new to Bío-Bío Region of Chile

Barbula costesii Thér. – Ñuble Prov., road from Quirihue to Cobquecura, 36°13'S, 72°36'W, alt. ca. 360 m, 32300; road to Trapiche, 6 km NW of San Carlos, 36°21'S, 71°58'W, alt. ca. 290 m, 34772 (mixed with *Didymodon fuscus* (Müll.Hal.) J.A.Jiménez & Cano; both specimens det. by J.A. Jiménez 2010).

Reported from Regions V and XII (Müller 2009a).

Bryoerythrophyllum berthoanus (Thér.) J.A.Jiménez – Ñuble Prov., Río Diguillín, Los Maños, ca. 10 km SE of Recinto, 36°53'S, 71°38'W, alt. ca. 500 m, 30759 (mixed with *Didymodon fuscus* (Müll.Hal.) J.A.Jiménez & Cano; det. by J.A. Jiménez 2010).

Reported from Regions V, RM & VII (Müller 2009a). This record represents a southern extension of the distribution of this taxon.

Bryoerythrophyllum campylocarpum (Müll.Hal.) H.A.Crum – Concepción Prov., Nonguén Valley, CORFO farm, 36°53'S, 72°59'W, alt. ca. 102 m, 31326 (det. by J.A. Jiménez 2010).

Reported for Region IX & Juan Fernández Is. (Müller 2009a). This record represents a northern extension of the continental Chile distribution of this taxon.

Bryum longidens Thér. – Arauco Prov., Llanahue Lake, 6 km S of Hwy. P-70, 37°55'S, 73°20'W, alt. ca. 33 m, 33447; Hullinco Falls, 37°45'S, 73°22'W, alt. ca. 130 m, 33662. Bío-Bío Prov., road from Tumeco to Florida, 2 km N from Hwy. 0–50, 36°57'S, 72°40'W, alt. ca. 190 m, 32053. Concepción Prov., road from Santa Juana to La Laja, 19 km SE of Santa Juana, 37°16'S, 72°47'W, alt. ca. 135 m, 32879; Ñuble Prov., road to garbage dump, 12 km E of Quirihue, 36°17'S, 72°25'W, alt. ca. 350 m, 32352 (all det. by J.R. Spence 2014–2016).

Previously known only from the type from Valparaíso Region (V). The name appeared after its synonymization under *B. pseudocapillare* Besch. made by Ochi (1980). This record represents a southern extension of the distribution of this taxon.

Bryum pauperculum E.B.Bartram – Bío-Bío Prov., National Park Lake Laja, Los Barros Military Base, 37°27'S, 71°19'W, alt. ca. 1500 m, 34115. Ñuble Prov., Shangri-La, old German refuge, 36°52'S, 71°31'W, alt. ca. 1350 m, 34462 (both det. by J.R. Spence 2014).

Previously known only from the type from Tierra del Fuego (Region XII). The name appeared after its synonymization under *B. pallens* Sw. made by Ochi (1982). These records represent a northern extension of the distribution of this taxon.

Bryum puconense Herzog & Thér. – Arauco Prov., Mocha Island, 38°21'S, 73°56'W, alt. ca. 25 m, 33182. Bío-Bío Prov., Saltillo del Itata, small falls on Itata River, 37°04'S, 72°09'W, alt. ca. 210 m, 34940 (both det. by J.R. Spence 2014).

Reported for Regions IX (Ochi 1982), and XI (Larraín 2016).

Bryum zeballosicum Cardot & Broth. – Concepción Prov., road from Santa Juana to La Laja, 1 km E of Santa Juana, 37°10'S, 72°55'W, alt. ca. 50 m, 32852 (det. by J.R. Spence 2016).

Reported for Metropolitan Region (Müller 2009a). This record represents a southern extension of the distribution of this taxon.

Calliargonella cuspidata (Hedw.) Loeske – Arauco Prov., Road from Curanilahue to Trongol, 19 km SE of Curanilahue, 37°34'S, 73°12'W, alt. 990 m, 33096. Bío-Bío Prov., 37.7 km S of El Barco Lake, 38°02'S, 71°21'W, alt. ca. 950 m, 34249. Concepción Prov., Universidad de Concepción campus, behind Facultad de Ciencias Naturales y Oceanográficas building, 36°49'S, 73°02'W, alt. ca. 30 m, Larraín 32760 (det. by J. Larraín 2010).

Reported for Regions IX, X and XIV (Müller 2009a). This record represents a northern extension of the distribution of this taxon in Chile.

Campylopus acuminatus Mitt. – Arauco Prov., Road from Curanilahue to Trongol, 19 km SE of Curanilahue, 37°34'S, 73°12'W, alt. 990 m, 33092.

Reported for Regions IX – XII & XIV (Müller 2009a).

Dendrocryphaea gorveana (Mont.) Paris & Schimp. – Concepción Prov., Reserva Nacional Nonguén, by trail next to Nonguén river, 36°53'S, 72°59'W, alt. ca. 300 m, Larraín 32750 (det. by J. Larraín 2016).

Reported for Regions VII, and XIV-XI (Müller 2009a).

Poblia wilsonii (Mitt.) Ochyra – Concepción Prov., Patahual, 37°00'S, 72°59'W, alt. ca. 56.8 m, 30408; Lonco & Villuco, 36°52'S, 73°00'W, alt. ca. 15 m, 31025; Quebrada Honda, 36°41'S, 72°58'W, alt. ca. 104 m, 31689 (det. J. Larraín 2008); road to Las Pataguas, 3 km N from Hwy. 148, 36°49'S, 72°53'W, alt. ca. 222 m, 31761, 31764; road from Hualqui to Quilacoya, 5 km S of Hualqui, 37°01'S, 72°58'W, alt. ca. 107 m, 32081; road from Dichato to Burca, 3 km N of Dichato, 36°31'S, 72°54'W, alt. ca. 89 m, 32219. Ñuble Prov., road from La Achira to Trehuaco, 36°15'S, 72°45'W, alt. ca. 410 m, 32519; Colmuvao, 36°18'S, 72°49'W, alt. 19 m, 32778.

Reported for Regions II–VI, RM, & XII (Müller 2009a).

Rosulabryum campylothecium (Taylor) J.R. Spence – Concepción Prov., Caleta Chome, Punta Hualpén, 36°46'S, 73°12'W, alt. ca. 36 m, 31983. Ñuble Prov., Cayumanque hill, 36°42'S, 72°31'W, alt. ca. 483 to 792 m, 31550 (both det. by J.R. Spence 2014).

Reported for Regions IV, V & IX (as *Bryum campylothecium* Taylor by Müller 2009a).

Rosulabryum torquescens (Bruch & Schimp.) J.R. Spence – Concepción Prov., Park “Jorge Alessandri” (Compañía Manufacturera de Papeles y Cartones), 36°56'S, 73°09'W, alt. ca. 200–490 m, 32819 (det. by J.R. Spence 2014).

Reported for Regions VII & X (as *Bryum torquescens* Bruch ex DeNot by Müller 2009a).

Rosulabryum viridescens (Welw. & Duby) Ochyra – Ñuble Prov., Las Trancas, 36°54'S, 71°30'W, alt. ca. 1300 m, 35912 (det. by J.R. Spence 2014).

Reported for Region IV & South Chile (as *Bryum viridescens* Welw. & Duby by Müller 2009a).

Syntrichia costesii (Thér.) R.H. Zander – Ñuble Prov., Los Cipreses Farm, 36°56'S, 71°33'W, alt. ca. 1010 m, 35838, 35842; Las Trancas, 36°54'S, 71°30'W, alt. ca. 1300 m, 35893.

Reported from Regions V, VII, IX – XII (Müller 2009a, Larraín 2016).

Syntrichia socialis (Dusén) R.H. Zander – Bío-Bío Prov., Las Perlas Lake, 15 km NW of Cabrero, 36°57'S, 72°26'W, alt. ca. 300 m, 35954 (det. by R.H. Zander – reported in Tropicos).

Reported from Regions X & XII (Müller 2009a). This record represents a northern extension of the distribution of this taxon.

Checklist of the mosses of the Bío-Bío Region of Chile

+++ New to South America; ++ New to Chile; + New to Bío-Bío Region (Región VIII);
 * Excluded from Chile; ** Excluded from Bío-Bío Region. (Provinces of the Bío-Bío Region represented by the following letters: A=Arauco; B=Bío-Bío; C=Concepción; N=Ñuble). All new provincial records since Ireland et al. (2010) paper, list the province in bold print indicating the corresponding voucher(s) in parenthesis.

Acaulon uleanum Müll.Hal. – C

Achrophyllum anomalum (Schwägr.) H.Rob. – B

Achrophyllum magellanicum (Besch.) Matteri – A, B, C, N

var. *oligodontum* (Matteri) Matteri – B, C

Acrocladium auriculatum (Mont.) Mitt. – A, B, N

Amblystegium serpens (Hedw.) Schimp. – C, N

Amphidium tortuosum (Hornsch.) Cufod. – A, B, C, N

Ancistrodes genuflexa (Müll.Hal.) Crosby – A, B, C, N

Andreaea acutifolia Hook.f. & Wilson – B

Andreaea alpina Hedw. – N

Andreaea rupestris Hedw. – A, B, N

Andreaea subulata Harv. – B, N

Anomobryum julaceum (Schrader ex G.Gaertn., B.Mey. & Scherb.) Schimp. – A, B, C, N

Aongstroemia gayana (Mont.) Müll.Hal. – B, C, N

Arbusculohypopterygium arbuscula (Brid.) M.Stech, T.Pfeiff. & W.Frey – A, B

Atractylolcarpus patagonicus Herzog & Thér. – **B (35459)**, C

Barbula convoluta Hedw. – C

+*Barbula costesii* Thér. – **N (32300, 34772)**

Bartramia bellolioella B.H.Allen & Ireland – A, N

Bartramia ithyphylla subsp. *patens* (Brid.) Fransén – N

Bartramia ithyphylloides Schimp. ex Müll.Hal. – A, B, C, N

Bartramia mossmaniana Müll.Hal. – A, B, N

**Bartramia potosica* Mont. – N (misidentified specimens that are all *B. ithyphylla* subsp. *patens* –see Ireland et al. 2010, p. 43).

Bartramia stricta Brid. – A, B, C, N

Blindia magellanica Schimp. – A, B, C, N

Brachymenium acuminatum Harv. – A, B, C, N

Brachymenium exile (Dozy & Molk.) Bosch & Sande Lac. – C

Brachymenium gilliesii (Hook.) A.Jaeger – B, N (Syn. *Bryum gilliesii* Hook.)

Brachymenium meyenianum (Hampe) A.Jaeger – N

Brachymenium robertii Broth. – C

Brachytheciastrum microcollinum (E.B.Bartram) Ignatov & Huttunen – N

Brachytheciastrum paradoxum (Hook.f. & Wilson) Ignatov & Huttunen – A, B, N

Brachythecium albicans (Hedw.) Schimp. – N

- Brachythecium conostomum* (Taylor) A.Jaeger – A, B, N
Brachythecium rutabulum (Hedw.) Schimp. – A, B, N
Brachythecium subpilosum (Hook.f. & Wilson) A.Jaeger – A, B, C, N
Brachythecium subplicatum (Hampe) A.Jaeger – A, B, C, N
Breutelia dumosa Mitt. – B, C
Breutelia integrifolia (Taylor) A.Jaeger – B, N
Breutelia subplicata Broth. – A, B, C, N
Breutelia tomentosa (Sw. ex Brid.) A.Jaeger – C
+ *Bryoerthrophyllum berthoanus* (Thér.) J.A.Jiménez – N (30759) Mixed with
Didymodon fuscus and filed in herbarium collections under this species.
+ *Bryoerthrophyllum campylocarpum* (Müll.Hal.) H.A.Crum – C (31326)
Bryum argenteum Hedw. – A, B, C, N
Bryum densifolium Brid. – N
Bryum elegantulum Lorentz – C
++ *Bryum insolitum* Cardot – N (32347a)
+ *Bryum longidens* Thér. – A (33447, 33662), B (32053, 34815, 35759), C (32879),
N (32352)
Bryum mucronatum Mitt. – N
Bryum nivale Müll.Hal. – B
Bryum orbiculatifolium Cardot & Broth. – B
+ *Bryum pauperculum* E.B.Bartram – B (34115), N (34462)
Bryum platyphyllum (Schwägr.) Müll.Hal. – A (33251), B
+ *Bryum puconense* Herzog & Thér. – A (33182), B (34940)
Bryum revolutum Müll.Hal. – C
Bryum subgracillimum Thér. – C
+ *Bryum zeballosicum* Cardot & Broth. – C (32852)
+ *Calliergonella cuspidata* (Hedw.) Loeske – A (33096), B (34249), C (32760 Coll.
Larraín)
Calyptopogon mnioides (Schwägr.) Broth. – A, B, C, N
Camptodontium cryptodon (Mont.) Reimers – A, B, N
Campylopodium medium (Duby) Giese & J.-P.Frahm – A
+ *Campylopus acuminatus* Mitt. – A (33092)
Campylopus aureonitens subsp. *recurvifolius* (Dusén) J.-P.Frahm – B, C
Campylopus clavatus (R.Br.) Wilson – A, C
Campylopus fragilis (Brid.) Bruch & Schimp. – A
Campylopus incrassatus Müll.Hal. – A, B, C, N
Campylopus introflexus (Hedw.) Brid. – A, B, C, N
Campylopus laxoventralis Herzog ex J.-P.Frahm – C
Campylopus modestus Cardot – C, N
Campylopus pilifer Brid. – A, B, C, N (30573, 30753, 30832, 32334, 32581,
34445, 34684, 35828, 36117, 36143)
Campylopus purpureocaulis Dusén – C
Campylopus pyriformis (Schultz) Brid. – A (32954, 33204, 36255), C, N (32387)

- Campylopus vesticaulis* Mitt. – A, C, N
- Campylostelium saxicola* (F. Weber & D. Mohr) Bruch & Schimp. – A, C, N
- Catagoniopsis berteriana* (Mont.) Broth. – A, B, C, N
- Catagonium nitens* (Brid.) Cardot – A, B, C, N
var. *myurum* (Cardot & Thér.) S.H. Lin – N
- Catagonium nitidum* (Hook. f. & Wilson) Broth. – N
- Ceratodon purpureus* (Hedw.) Brid. – A, B, C, N
subsp. *convolutus* (Reichardt) Burley – A, B, C, N
subsp. *stenocarpus* (Bruch & Schimp.) Dixon – A, B, C, N
- Chileobryon callicostelloides* (Broth. ex Thér.) Enroth – A, B, C, N
- Chorisodontium aciphyllum* (Hook. f. & Wilson) Broth. – N
- Chrysoblastella chilensis* (Mont.) Reimers – A, B, C, N
- Cratoneuron filicinum* (Hedw.) Spruce – B, N, A
- Cratoneuropsis relaxa* subsp. *minor* (Wilson & Hook. f.) Ochyra – A, B, C, N
- Cryphaea consimilis* Mont. – A, B, C, N
- Cryphaeophilum molle* (Dusén) M. Fleisch. – A, B, C, N
- Cryptopapillaria penicillata* (Dozy & Molk.) M. Menzel – A, C
- **Daltonia gracilis* Mitt. – A, B, N (considered a synonym of *D. marginata* Griff. by P. Majestyk 2011).
- Daltonia marginata* Griff. – A (33520) (det. Majestyk (2011) from MO specimen cited in publication).
- ***Daltonia ovalis* Taylor – A, B (reported by He (1998) as *D. trachydonta* Mitt. but unable to confirm specimens which were not cited).
- Daltonia splachnoides* (Sm.) Hook. & Taylor – A (33611) (det. Majestyk (2011) from MO specimen cited in publication).
- **Daltonia trachydonta* Mitt. – A, B (considered a synonym of *D. ovalis* Taylor by Majestyk 2011).
- Dendrocryphaea cuspidata* (Sull.) Broth. – A, B, C, N
- +*Dendrocryphaea gorveana* (Mont.) Paris & Schimp. – C (32750 Coll. Larraín)
- Dendrocryphaea lechleri* (M. Fleisch.) Paris & Schimp. ex Thér. – A, C
- Dendroligotrichum dendroides* (Brid. ex Hedw.) Broth. – A, B
- Dicranella campylophylla* (Taylor) A. Jaeger – A, B, N
- **Dicranella harrisii* (Müll. Hal.) Broth. – C (excluded from Chile—see Ireland et al. 2010, p. 44).
- Dicranella hookeri* (Müll. Hal.) Cardot – A (33219), B, C, N (31068a, 36218)
- Dicranella vaginata* (Hook.) Cardot – A, B (Syn. *Anisothecium vaginatum* (Hook.) Mitt.).
- Dicranoloma billardiarei* (Brid.) Paris – A, C
- Dicranoloma chilense* (De Not.) Ochyra & Matteri – A, B
- Dicranoloma dusenii* (Broth.) Broth. – A
- Dicranoloma perremotifolium* (Dusén) Broth. – A, B
var. *fragile* (Dusén) Thér. – A
- Didymodon australasiae* (Hook. & Grev.) R.H. Zander – A (33179, C, N (32536, 34720)

- Didymodon deciduus* R.H.Zander – B
Didymodon fuscus (Müll.Hal.) J.A.Jiménez & Cano – A (33156, 33159, 33673),
 B, C, N
Didymodon rigidulus Hedw. – A, B, N
Didymodon vinealis (Brid.) R.H.Zander – B, C
Diphyscium pilmaiquen (Crosby) Magombo – A
Distichophyllum krausei (Lorentz) Mitt. – N
Ditrichum conicum (Mont.) Mitt. – A (33114), B, N (31556)
Ditrichum cylindricarpum (Müll.Hal.) F.Muell. – A, B, N
Ditrichum difficile (Duby) M.Fleisch. – A, B, C, N
Ditrichum hallei Cardot & Broth. – N
Ditrichum hookeri (Müll.Hal.) Hampe – A, B, N
Drepanocladus aduncus (Hedw.) Warnst. – B
Drepanocladus polygamus (Schimp.) Hedenäs – C, N (Syn. *Campylium polygamum*
 (Schimp.) C.E.O.Jensen).
Drummondia obtusifolia Müll.Hal. – B, N
Dryptodon austrofunalis (Müll.Hal.) Ochyra & Żarnowiec – A, B, C, N (Syn. *Grimmia austrofunalis* Müll.Hal.).
Dryptodon navicularis (Herzog) Ochyra & Żarnowiec – B (Syn. *Grimmia navicularis*
 Herzog).
Dryptodon trichophyllus (Grev.) Brid. – A, B, C, N (Syn. *Grimmia trichophylla*
 Grev.).
Encalypta ciliata Hedw. – B
Entosthodon apophysatus (Taylor) Mitt. – B, C
Entosthodon laevis (Mitt.) Fife – C
Entosthodon obtusifolius Hook.f. – A, C, N (32721, 34919)
Eriodon conostomus Mont. – A, B
Eucamptodon perichaetialis (Mont.) Mont. – A, B, C, N
Eucladium verticillatum (Brid.) Bruch & Schimp. – N
Eurhynchiella acanthophylla (Mont.) M.Fleisch. – A, B, C, N
Eurhynchium corralense (Lorentz) A.Jaeger – A, B, C, N
Eurhynchium fuegianum Cardot – N
Eustichia longirostris (Brid.) Brid. – A, B, C, N
Fabronia ciliaris (Brid.) Brid. – B, C, N
 var. *wrightii* (Sull.) W.R.Buck – B
Fabronia jamesonii Taylor – A, B, C, N
Fissidens asplenoides Hedw. – A, B, C, N
Fissidens bryoides var. *pusillus* (Wilson) Pursell – A, B (34818, 34857, 34944), C,
 N (30614, 30647)
 var. *viridulus* (Sw.) Broth. – A, B (34814, 34884, 34954, 34983, 35053, 35072,
 35229, 35522, 35697, 35704, 35742, 35769) C, N (34600, 35798, 35799,
 35969)
Fissidens crispus Mont. – A, B, C, N (32301)

- Fissidens curvatus* Hornsch. – A, B, C, N
Fissidens maschalanthus Mont. – A
Fissidens oblongifolius Hook.f. & Wilson – A, B, C, N
Fissidens rigidulus Hook.f. & Wilson – A, B, C, N
Fissidens scalaris Mitt. – B, C
Fissidens serratus Müll.Hal. – C
 var. *leptochaete* (Dusén) Brugg.-Nann. & Pursell – B, C
Fissidens taxifolius Hedw. – C
Funaria chilensis (Thér.) Thér. – C, N
**Funaria commixta* Thér. – C (identification of this species by Ireland & Bellolio 31631 was reidentified as *F. costesii* Thér. according to Cuvertino et. al. 2012).
Funaria costesii Thér. – C
Funaria hygrometrica Hedw. – A, B, C, N
Gemmabryum dichotomum (Hedw.) J.R.Spence & H.R.Ramsay – C (Syn. *Bryum dichotomum* Hedw.).
Gemmabryum valparaisense (Thér.) J.R.Spence – C (Syn. *Bryum valparaisense* Thér.).
Glyphothecium gracile (Hampe) Broth. – A, B, C, N
Grimmia laevigata (Brid.) Brid. – B, N
Grimmia reflexidens Müll.Hal. – B, N
**Gymnostomum aeruginosum* Sm. – B, C, N (excluded from South America by Cano & Jiménez 2013).
Gymnostomum calcareum Nees & Hornsch. – A (33193), B, C, N
**Gymnostomum tenerrimum* (Müll.Hal.) Wijk & Margad. – C, N (considered a synonym of *G. calcareum* by Cano and Jiménez 2013).
Haplohymenium longinerve (Broth.) Broth. – B
Hebantia rigida (Lorentz) G.L.Merr. – A, C, N
Hedwigidium integrifolium (P.Beauv.) Dixon – B, N
Hennediella arenae (Besch.) R.H.Zander – A (31261, 33555, 33651, 33670), C, N
 (Syn. *Tortula polycarpa* Dusén).
Hennediella kunzeana (Müll.Hal.) R.H.Zander – A, B, C, N
Holodontium strictum (Hook.f. & Wilson) Ochyra – N
Hymenodontopsis mnioides (Hook.) N.E.Bell, A.E.Newton & D.Quandt – A, B, C, N
 (Syn. *Pyrrhobryum mnioides* (Hook.) Manuel).
Hypnodendron microstictum Mitt. ex A.Jaeger & Sauerb. – A, B, C, N
Hypnum cupressiforme Hedw. – A, B, C, N
 var. *filiforme* Brid. – A, B, N
Hypopterygium didictyon Müll.Hal. – B, C
Imbribryum clavatum (Schimp.) J.R.Spence & H.P.Ramsay – B (35236), C, N
 (34743) (Syn. *Bryum clavatum* (Schimp.) Müll.Hal.).
Imbribryum laevigatum (Hook.f. & Wilson) J.R.Spence & H.P.Ramsay – A, B (Syn. *Bryum laevigatum* Hook.f. & Wilson).
Isopterygiopsis pulchella (Hedw.) Z.Iwats. – B
Juratzkaea seminervis (Kunze ex Schwägr.) Lorentz – A, B, C, N

- Kindbergia praelonga* (Hedw.) Ochyra – A, B, C
Leptobryum pyriforme (Hedw.) Wilson – N
Leptodictyum riparium (Hedw.) Warnst. – B, N
Leptodon smithii (Hedw.) F. Weber & D. Mohr – A, B, C, N
Leptodontium proliferum Herzog – A
Leptostomum menziesii R.Br. – A, B, N
Leptostomum splachnoideum Hook. & Arn. – A, C, N
Leptotheca gaudichaudii Schwägr. – A, B, C, N
Lepyrodon hexastichus (Mont.) Wijk & Margad. – A, B, C, N
Lepyrodon lagurus (Hook.) Mitt. – A, B, N
Lepyrodon parvulus Mitt. – A, B, C, N
Lepyrodon patagonicus (Cardot & Broth.) B.H. Allen – A, B, C
Lepyrodon tomentosus (Hook.) Mitt. – A, N
Looseria orbiculata (Thér.) D. Quandt, Huttunen, Tangney & M. Stech – A, B, C, N
 (Syn. *Lembophyllum orbiculatum* (Thér.) Tangney).
Lopidium concinnum (Hook.) Wilson – A, B
Macrocoma sullivantii (Müll. Hal.) Grout – A, B, C, N
Macromitrium crassiusculum Lorentz – A, B, C, N (34703)
Macromitrium krausei Lorentz – N
Macromitrium microcarpum Müll. Hal. – A, C, N
Microcampylopus leucogaster (Müll. Hal.) B.H. Allen – A, C, N
Neckera chilensis Schimp. ex Mont. – A, B, C, N
Neckera scabridens Müll. Hal. – A, B, C, N
Notoligotrichum minimum (Cardot) G.L. Sm. – B
Oedipodium griffithianum (Dicks.) Schwägr. – B
Oligotrichum canaliculatum (Hook. & Arn.) Mitt. – A, B, C, N
Orthodontium gracile (Wilson) Schwägr. ex B.S.G. – B, C, N
 **Orthodontium pellucens* (Hook.) B.S.G. – A, B, C, N (reported by Ireland et al. 2006 from all 4 provinces but all collections are *Eucamptodon perichaetialis*, which were misidentified).
 **Orthotrichum aequaetoreum* Mitt. – N (reported by Ireland et al. 2006, but misidentified specimen 30686 is *O. freyanum* and misreported specimen 30687 is *O. latimarginatum*).
Orthotrichum anaglyptodon Cardot & Broth. – B, N
Orthotrichum araucarieti Müll. Hal. – B, N
Orthotrichum assimile Müll. Hal. – A, B, C, N
Orthotrichum brotheri Dusén ex Lewinsky – A, B, C, N
Orthotrichum densum Lewinsky – N
Orthotrichum elegantulum Schimp. ex Mitt. – B, C (32891), N
Orthotrichum freyanum Goffinet, W.R. Buck & M.A. Wall – B, N (30686)
Orthotrichum hortense Bosw. – B
Orthotrichum incanum Müll. Hal. – B, C, N
Orthotrichum latimarginatum Lewinsky – N

- Orthotrichum laxifolium* Wilson – N
Orthotrichum ludificans Lewinsky – B
Orthotrichum cf. *pariatum* Mitt. – B, N
Orthotrichum perexiguum Dusén ex Lewinsky – B
Orthotrichum rupestre Schleich. ex Schwägr. – B, N
Orthotrichum tristriatum Lewinsky – A, B, C, N
Orthotrichum truncatum Lewinsky & Deguchi – A, B, C
Papillaria flexicaulis (Wilson) A.Jaeger – B, C (Syn. *Meteorium flexicaule* Wilson).
Philonotis elongata (Dism.) H.A.Crum & Steere – C
Philonotis esquelensis Matteri – C (reported by Jimenez et al. 2014)
Philonotis krausei (Müll.Hal.) Broth. – A, B, C, N
Philonotis nigroflava Müll.Hal. – A, B, N
Philonotis scabrifolia (Hook.f. & Wilson) Braithw. – A, B, C, N
Philonotis vagans (Hook. & Wilson) Mitt. – A, B, N
Physcomitrium badium Broth. – C
Physcomitrium lorentzii Müll.Hal. – A
Plagiothecium denticulatum (Hedw.) Schimp. – N
Plagiothecium orthocarpum Mitt. – C
Plagiothecium ovalifolium Cardot – B
Platyneuron praealtum (Mitt.) Ochyra & Bedn.-Ochyra – A, B, N
**Pleuridium andinum* Herzog – C, N (excluded from Chile—see Ireland et al. 2010, p. 44, both collections, 31527 & 31965, are *P. subnervosum*).
Pleuridium robinsonii (Mont.) Mitt. – A, B, C, N
Pleuridium subnervosum (Müll.Hal.) A.Jaeger ex Paris – C, N (Syn. *Pleuridium macrothecium* Dusén).
Pogonatum perichaetiale subsp. *oligodus* (Kunze ex Müll.Hal.) Hyvönen – B, C, N
(Syn. *P. oligodus* (Kunze ex Müll.Hal.) Mitt.).
Pohlia chilensis (Mont.) A.J.Shaw – A, B, C, N
Pohlia cruda (Hedw.) Lindb. – A, B, C, N
Pohlia nutans (Hedw.) Lindb. – A, N
Pohlia wahlenbergii (F.Weber & D.Mohr) A.L.Andrews – A, B, C, N
+ *Pohlia wilsonii* (Mitt.) Ochyra – C (30408, 31025, 31689, 31761, 32081, 32219),
N (32519, 32778)
Polytrichastrum alpinum (Hedw.) G.L.Sm. – N
Polytrichum juniperinum Hedw. – A, B, C, N
Polytrichum piliferum Scherb. ex Hedw. – A, B, N
Polytrichum strictum Menzies ex Brid. – N
Porothamnium arbusculans (Müll.Hal.) M.Fleisch. – A, B, C, N
Porothamnium leucocaulon (Müll.Hal.) M.Fleisch. – N
Porothamnium panduraefolium (Müll.Hal.) M.Fleisch. – A, C, N
Porothamnium valdiviae (Müll.Hal.) M.Fleisch. – B, C (31959), N
Porotrichum chilense Thér. – B, N
Porotrichum korthalsianum (Dozy & Molk.) Mitt. – A, B, C

- Porotrichum lancifrons* (Hampe) Mitt. – A, B, C, N
Pseudocrossidium crinitum (Schultz) R.H.Zander – B, C, N
Pseudocrossidium santiagensis (Broth.) M.J.Cano – C
Pseudotaxiphyllum elegans (Brid.) Z.Iwats. – A
Ptychomitrium deltorii (Thér.) Broth. – C
Ptychomitrium sellowianum (Müll.Hal.) A.Jaeger – A, C, N
Ptychomnion cygnisetum (Müll.Hal.) Kindb. – A
++*Ptychostomum bimum* (Schreber) J.R.Spence – C (33934)
++*Ptychostomum creberrimum* (Taylor) J.R.Spence & H.P.Ramsey – B (35465)
++*Ptychostomum inclinatum* (Sw. ex Brid.) J.R.Spence – N (30585, 30617)
Ptychostomum orthothecium (Cardot & Broth.) Holyoak & N.Pederson – C (Syn. *Bryum orthothecium* Cardot & Broth.).
Ptychostomum turbinatum (Hedw.) J.R.Spence – N (Syn. *Bryum turbinatum* (Hedw.) Turner).
**Racomitrium crispipilum* (Taylor) A.Jaeger – A, B, N (excluded from Chile flora—see Larraín 2012).
**Racomitrium crispulum* (Hook.f. & Wilson) Wilson – N (excluded from Chile flora—see Ireland et al. 2010, p. 43).
Racomitrium didymum (Mont.) Lorentz – A, B, N (Syn. *Bucklandiella didyma* (Mont.) Bedn.-Ochyra & Ochyra).
Racomitrium geronticum Müll.Hal. – A, B, C, N (Syn. *R. lanuginosum* subsp. *geronticum* (Müll.Hal.) Vitt & C.Marsh; Syn. *R. patagonicum* Bedn.-Ochyra & Ochyra).
**Racomitrium lanuginosum* (Hedw.) Brid. – B (excluded from Chile flora—see Larraín 2012).
Racomitrium lamprocarpum (Müll.Hal.) A.Jaeger – A, B, N (Syn. *Bucklandiella lamprocarpa* (Müll.Hal.) Bedn.-Ochyra & Ochyra).
Racomitrium orthotrichaceum (Müll.Hal.) Paris – N (Syn. *Bucklandiella orthotrichacea* (Müll.Hal.) Bedn.-Ochyra & Ochyra).
Racomitrium rupestre (Hook.f. & Wilson) Hook.f. & Wilson – B, N (Syn. *Bucklandiella rupestris* (Hook.f. & Wilson) Bedn.-Ochyra & Ochyra).
Racomitrium subcrispipilum Müll.Hal. – B, N (Syn. *Racomitrium striatipilum* Cardot).
Racopilum cuspidigerum (Schwägr.) Ångström – A, C
Renauidia chilensis Thér. – C
Rhabdoweisia crispata (Dicks.) Lindb. – C
Rhabdoweisia fugax (Hedw.) Bruch & Schimp. – A, C
Rhaphidorrhynchium amoenum (Hedw.) M.Fleisch. – A, C
Rhaphidorrhynchium leptophyllum (Mitt.) Broth. – C
Rhaphidorrhynchium callidum (Mont.) Broth. – A, B, C, N
Rhaphidorrhynchium scorpiurus (Mont.) Broth. – A (Syn. *Sematophyllum scorpiurus* (Mont.) Mitt.).
Rhynchostegium complanum (Mitt.) A.Jaeger – C
Rigodium adpressum Zomlefer – A, B, C, N

- Rigodium brachypodium* (Müll.Hal.) Paris – A, B, C, N
Rigodium implexum Kunze ex Schwägr. – A, C, N
Rigodium pseudothuidium Dusén – C, N
Rigodium tamarix Müll.Hal. – A, B, C, N
Rigodium toxarion (Schwägr.) A.Jaeger – A, B, C, N
Rosulabryum billardieri (Schwägr.) J.R.Spence – A, B, C, N (Syn. *Bryum billardieri* Schwägr.).
+*Rosulabryum campylothecium* (Taylor) J.R.Spence – **C (31983)**, **N (31550)** (Syn. *Bryum campylothecium* Taylor).
Rosulabryum capillare (Hedw.) J.R.Spence – **B (34950)**, C (Syn. *Bryum capillare* Hedw.).
+*Rosulabryum torquescens* (Bruch & Schimp.) J.R.Spence – **C (32819)** (Syn. *Bryum torquescens* Bruch & Schimp.).
+*Rosulabryum viridescens* (Welw. & Duby) Ochyra – **N (35912)** (Syn. *Bryum viridescens* Welw. & Duby)
Sanionia symmetrica (Renauld & Cardot) Wheldon – N
Sanionia uncinata (Hedw.) Loeske – B, N
Schimperobryum splendidissimum (Mont.) Margad. – A, B, C, N
var. *perdentatum* Matteri – C
Schistidium apocarpum (Hedw.) Bruch & Schimp. – B, C, N
Schistidium rivulare (Brid.) Podp. – B, C, N
Schistidium falcatum (Hook.f. & Wilson) B.Bremer – B, N
Schistidium scabripes (E.B.Bartram) Deguchi – N
Schizymenium multiflorum (E.B.Bartram) A.J.Shaw – N
Sciuro-hypnum plumosum (Hedw.) Ignatov & Huttunen – N
Scouleria patagonica (Mitt.) A.Jaeger – B, N
+++*Sematophyllum harpidioides* (Renauld & Cardot) F.D.Bowers – **A (33095, 33109, 33464, 33465, 33513, 33552, 33596, 33640, 33648)**
Sphagnum fimbriatum Wilson – A, N (as *S. flexuosum* Dozy & Molk.—see Ireland et al. 2010, p. 43).
**Sphagnum flexuosum* Dozy & Molk. – N (excluded from Chile— see *S. fimbriatum* above).
Sphagnum magellanicum Brid. – A
Sphagnum recurvum var. *brevifolium* (Lindb.) Warnst. – A (reported by Ireland et al. (2006). Dick Andrus observed specimens at CONC (33090, 33091, 33093) and concluded they belong to an undescribed taxon in section *Cuspidata*).
Sphagnum cf. *subsecundum* Nees – A
Splachnobryum obtusum (Brid.) Müll.Hal. – C
Symblepharis krausei (Lorentz) Ochyra & Matteri – A, B, N (Syn. *S. luteovirens* (E.B.Bartram) Ochyra & Matteri; Syn. *Oncophorus luteovirens* E.B.Bartram).
Syntrichia breviseta (Mont.) M.J.Cano & M.T.Gallego – **A (31213, 33022, 33029, 33402, 33450, 33574, 33689)**, B, C (30896, 32880, 34010, 34035), N (32625, 32637, 32658, 32693)
+*Syntrichia costesii* (Thér.) R.H.Zander – **N (35838, 35842, 35893)**
Syntrichia epilosa (Broth. ex Dusén) R.H.Zander – A, **B (34842)**, C, N

- Syntrichia fragilis* (Taylor) Ochyra – **A (33661, 33676)**, B, C, N
Syntrichia glacialis (Kunze ex Müll.Hal.) R.H.Zander – A, B, C, N
Syntrichia laevipila Brid. – A, **B (32048, 35020, 35204)**, C, N
Syntrichia papillosa (Wilson) Jur. – A, C
Syntrichia princeps (De Not.) Mitt. – B
Syntrichia pseudorobusta (Dusén) R.H.Zander – A, B, C, N
Syntrichia robusta (Hook. & Grev.) R.H.Zander – A, B, C, N
 var. *recurva* (Lightowlers) R.H.Zander – C, N
Syntrichia ruralis (Hedw.) F.Weber & D.Mohr – A, B, N
Syntrichia scabrella (Dusén) R.H.Zander – **A (33181, 33784)**, **B (34293, 35202)**, C, N
Syntrichia scabrinervis (Müll.Hal.) R.H.Zander – A, B, C (**32092, 32112, 32182**),
 N (**32437, 32552, 32689, 34639, 35774**)
Syntrichia serrulata (Hook. & Grev.) M.J.Cano – A, B, C, N
+*Syntrichia socialis* (Dusén) R.H.Zander – **B (35954)**
Syntrichia squarripila (Thér.) Herzog – **A (32963, 33247, 33575, 33679)**, B, C
 (**30941, 31464, 31931, 31936, 32082, 32133, 32143, 32158, 32159, 32164,**
 32181, 32256, 32256a, 32258, 32274, 32280, 32881, 33855, 34009, 34032,
 34041, 34042), N
Thamniopsis incurva (Hornsch.) W.R.Buck – C
Thamnobryum fasciculatum (Sw. ex Hedw.) I.Sastre – A, B, C, N
Thuidiopsis dusenii (Broth.) Broth. – A
Thuidiopsis furfurosa (Hook.f. & Wilson) M.Fleisch. – A
Thuidiopsis sparsa (Hook.f. & Wilson) Broth. – A, B, N
Tortella tortuosa (Hedw.) Limpr. – B
Tortula jaffuelii Thér. – A, C, N
Tortula muralis Hedw. – A, B, C, N
Tortula platyphylla Mitt. – C
Tortula truncata (Hedw.) Mitt. – B, C
Trichostomum elliottii Broth. ex Dusén – C
Triquetrella patagonica Müll.Hal. – A, B, C, N
 fo. *filicaulis* (Dusén) Herzog – C
Ulota macrodontia Dixon & Malta – A, N
Ulota rufula (Mitt.) A.Jaeger – A, B, N
Vittia pachyloma (Mont.) Ochyra – A, B, C, N
Warnstorfia exannulata (Schimp.) Loeske – A
Weissia controversa Hedw. – A, B, C, N
Weymouthia cochlearifolia (Schwägr.) Dixon – A
Weymouthia mollis (Hedw.) Broth. – A
Willia brachychaete (Dusén) R.H.Zander – **A (32960, 33453, 33728)**, B, N
Zygodon hookeri var. *leptobolax* (Müll.Hal.) Calabrese – A, B, C, N
Zygodon obtusifolius Hook. – A (Syn. *Bryomaltaea obtusifolia* (Hook.) Goffinet)
Zygodon papillatus Mont. – A, B, C, N
Zygodon pentastichus (Mont.) Müll.Hal. – A, B, C, N

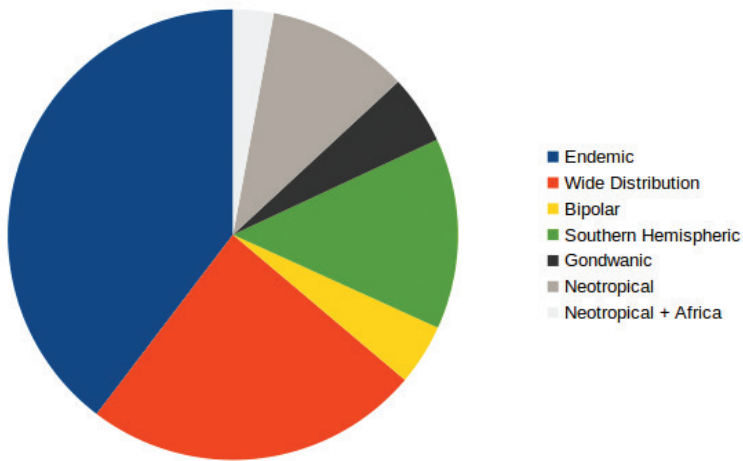


Figure 2. Proportion of the biogeographic components in the total moss flora of Bío-Bío Region.

Biogeographical analyses of the Bío-Bío mosses

From the biogeographical analyses of the taxa found in the Bío-Bío Region, 39.65% of the taxa are endemic to southern South America and adjacent areas, 24.19% of the taxa are bipolar, 13.7% are Southern Hemispheric taxa, 10.2% correspond to Neotropical taxa, 4.95% are Gondwanic taxa, and only 2.91% of the taxa are shared between southern South America, the Neotropics and Africa (Fig. 2).

In terms of the distribution of mosses within the Bío-Bío Region, we have seen that the most diverse province is Ñuble with 226 taxa, followed by Bío-Bío Province (210), Concepción Province (200), and Arauco Province (197). These numbers may change with the more collecting still needed in all the four provinces.

Discussion

After the examination of more than 6,000 collections from Bío-Bío Region, a total of 343 moss taxa are reported in this paper. This number represents a major increase from the 190 taxa reported by He (1998) in the last checklist done before the beginning of this project. Several taxa had to be reevaluated, several names had to be changed and updated due to recent revisionary studies made by colleagues worldwide, and some taxa previously reported for the region had to be excluded from the Bío-Bío moss flora. A number of our colleagues identified difficult groups, like the Pottiaceae (María Jesús Cano, Mayte Gallego, Juan Jiménez, Richard Zander), *Fissidens* (Ron Pursell †), Bryaceae (John Spence), Dicranaceae (J.-P. Frahm †), and *Bartramia*, *Sematophyllum* (Bruce Allen).

As it has been noted elsewhere (Seki 1974, Villagrán et al. 2003, Larraín 2005, 2016), the dominating biogeographical component in any central or southern Chile

region corresponds to the endemic element, reaching almost the 40% of taxa for the mosses of the Bío-Bío region. The second most represented element is the widely distributed species, that includes several recently introduced taxa or species mostly associated with human disturbances. As it happens in other regions of Chile with the mosses, it is interesting that the Southern Hemisphere plus the Gondwanic elements sum up almost twice the number of taxa that shows a southern South America-Neotropical distribution. Finally, there is a small number of species ($n=10$) shared between southern South America and the African continent.

Three taxa are still troublesome for us but they have been included in the list. One of these is *Andreaea rupestris*, a species that has been excluded from the Southern Hemisphere by both Vitt (1980) and Murray (2006). The latter authors suggest that the records reported as *A. rupestris* from the Southern Hemisphere might correspond to *Andreaea mutabilis* Hook.f. & Wilson or some other taxon with ecostate leaves. Another doubtful taxon is *Plagiothecium denticulatum*, reported for the first time for Chile by Mitten (1869), as *P. donnianum* (Sm.) Mitt. from Cape Horn, and subsequently reported several times by other authors (Müller 2009a). This taxon is not even mentioned in the monograph of Plagiotheciaceae for the Flora Neotropica project (Buck & Ireland 1989), and presently it is considered to be a boreal taxon. The third problematic taxon is *Thamniopsis incurva*, a widespread Neotropical species whose type was apparently collected in Chile by Chamisso (judging from the label of the type), but it has never been found again in Chile. It is possible that the original specimen of Chamisso was mislabeled and collected somewhere else along the South American coast.

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A new species of *Heliconia* (Heliconiaceae) with pendent inflorescence, from Chucantí Private Nature Reserve, eastern Panama

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Abstract

Heliconia berguidoi (Heliconiaceae), a new species from premontane forest of eastern Panama, is described, illustrated and its conservation status evaluated. *H. berguidoi* bears pink flowers, an uncommon color in this group. It differs from the Colombian species *Heliconia rhodantha* and *Heliconia sanctae-theresae*, the most similar taxa, by the combination of a petiole glabrous except for the woolly base, a very long peduncle, the perianth pubescent at the apex and staminode with cuspidate apex. *H. berguidoi* is also similar to *Heliconia pogonantha* in all four of its varieties and to *Heliconia ramonensis* in two of its four varieties, but differs by a combination of the long peduncle, pink flowers and staminode with cuspidate apex. Fifty-six *Heliconia* species have been found in Panama, eighteen of them endemic.

Resumen

Heliconia berguidoi (Heliconiaceae), una nueva especie de bosque premontano del este de Panamá, es descrita, ilustrada y su estado de conservación evaluado. *H. berguidoi* tiene flores rosadas, color poco común en este grupo. Difiere de las especies de Colombia *Heliconia rhodantha* y *Heliconia sanctae-theresae*, taxones más similares, por la combinación de un pecíolo glabro aunque lanudo en la base, pedúnculo muy largo, ápice del perianto pubescente y estaminoide con el ápice cuspidado. *H. berguidoi* es también similar a *Heliconia pogonantha* en sus cuatro variedades y a *Heliconia ramonensis* en dos de sus cuatro variedades, pero difiere por la combinación de su largo pedúnculo, el color rosado de las flores y el estaminoide con ápice cuspidado. En Panamá se han encontrado cincuenta y seis especies de *Heliconia*, dieciocho de ellas endémicas.

Keywords

Barbatae, Cerro Chucantí, *Griggsia*, *Heliconia*, Heliconiaceae, Serranía de Majé, Zingiberales

Palabras claves

Barbatae, Cerro Chucantí, *Griggsia*, *Heliconia*, Heliconiaceae, Serranía de Majé, Zingiberales

Introduction

Heliconia L. is the only genus in the plant family Heliconiaceae, which is included in the order Zingiberales (Berry and Kress 1991, APG IV 2016). This family is native to tropical America (Caribbean islands, Mexico, Central America and South America) with a small number of species in the Old World tropics, distributed from Samoa, westward to the central Indonesian island of Sulawesi (Kress 1984, Kress 1990b, Berry and Kress 1991). *Heliconia* has been formally and informally divided into five subgenera: *Taeniostrobis* (Kuntze) Griggs, *Heliconia*, *Stenochlamys* Baker, *Griggsia* L.Andersson and *Heliconiopsis* (Miq.) Kress (Andersson 1985, 1992; Kress 1984, 1990a).

The total number of *Heliconia* species is still unclear, although in a recent account Ferreira de Castro et al. (2007) registered 176 for the Neotropical region and 6 in the Pacific islands, for a total of 182 species distributed in five (5) subgenera and twenty-three (23) sections. Kress and Betancur (2009) recently described one more new species from Colombia which makes a total of 183 recognized species. In Panama, 55 *Heliconia* species and infraspecific taxa have been reported and the country has the third largest number of endemics (17), after Colombia (36) and Ecuador (21) (Kress 2003, Correa et al. 2004, Ferreira de Castro et al. 2007, TROPICOS 2016).

The new *Heliconia berguidoi* has been found in the premontane forests of Chucantí Private Nature Reserve, at around 800 m, in disturbed and mature forest. Seven other *Heliconia* species occur in the area: *H. latispatha* Benth., *H. pogonantha* Cufod., *H. metallica* Planch. & Linden ex Hook., *H. nutans* Woodson, *H. wagneriana* Petersen, *H. platystachys* Baker and *H. spathocircinata* Aristeg.

Chucantí Private Nature Reserve (404 hectares) is located on the border of Panama and Darién Provinces, on the eastern edge of Serranía de Majé, an isolated mountain range about 60 km long. It is 30 km south of the continental divide across the valley of the Bayano River and 15 km inland from the Pacific (Figure 1). The range rises gradually towards the east, with the highest point, Cerro Chucantí (1,439 m) at the eastern end (BirdLife International 2016). The reserve, which extends from around 800 m to the highest summit, harbors premontane and lower montane rain forests (Holdridge et al. 1971). According to the ecoregion classification system (WWF 2016), Chucantí is part of the Eastern Panamanian montane forests ecoregion. It has been designated an Important Bird Area (IBA) in Danger (Angehr 2003), as the extensive loss of forests due to cattle ranching activities is putting in peril the existence of several endemic bird species.

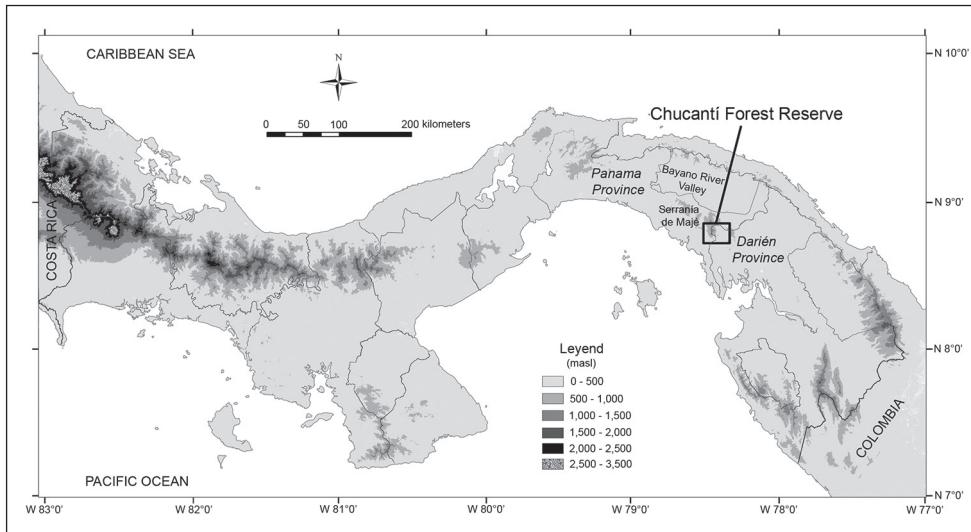


Figure 1. Elevation map of Panama with location of Chucantí Private Forest Reserve.

As part of a floristic inventory of the region carried out by two of the authors (Flores and Ibáñez, unpublished), ca. 250 species have been identified from more than 500 collections. At least 6 of them have been recognized as species new to science (Ortiz et al. 2016; Flores et al., submitted; Valdespino et al. in prep.), including the new *Heliconia* described here. Endemic species of fauna have also been recently described from the area (Batista et al. 2014, Bezark et al. 2013, Miranda and Bermúdez 2010). All of these novelties highlight the importance for conservation of this undercollected region of Panama. Discovering, describing and conserving biodiversity is the purpose of the *Asociación Adopta el Bosque Panamá*, owner of the Chucantí Private Nature reserve.

Materials and methods

One live plant of *H. berguidoi* was collected in Chucantí Private Nature Reserve (2006) and was grown at Finca las Chichicas (Chiriquí Province). Ten years later, a specimen from the original plant was photographed, studied under cultivation, collected, illustrated and deposited at the Herbarium of the University of Panama (PMA). Some flowers and fruits were stored in 70% ethanol and studied using a stereomicroscope.

In March 2011, a specimen of *H. berguidoi* was collected in Chucantí Private Nature Reserve as part of a general floristic inventory of the area.

Each type specimen of subgenus *Griggsia* L.Andersson was reviewed in the JSTOR Global Plants webpage (JSTOR 2016). Some specimens of those species deposited in PMA Herbarium were also reviewed. Maps were made with the program ArcGIS version 10.1. The IUCN Red List Categories and Criteria (IUCN 2012) was used to determine the conservation status of the new species.

Taxonomic treatment

Heliconia berguidoi R.Flores, C.Black & A.Ibáñez, sp. nov.

urn:lsid:ipni.org:names:77160178-1

Figs 2–4

Diagnosis. This species is distinguished from other species of *Heliconia* by the combination of the long petioles (up to 180 cm), glabrous but woolly at the base; blade splitting into narrow lateral segments; peduncle red, woolly with golden hairs, very long (125–150 cm); slightly flexuous rachis; bracts spirally arranged; pink flowers, perianth pubescent at the apex and staminode with cuspidate apex.

Type. PANAMÁ. Provincia de Darién: Reserva privada Chucantí, Sendero al filo (roca grande). Bosque premontano. 900 m. 8°47'33.46"N, 78°27'6.72"W, 26 agosto 2006, individuo colectado por Carla Black. Floreció en cultivo el 12 de marzo de 2016, Finca las Chichicas, corregimiento de Volcán, distrito de Bugaba, Provincia de Chiriquí. Col. R. Flores, O. Ortiz y C. Black, 3855 RF (Holotype PMA!, Isotype, MO!, SEL!, UCH!, US!).

Description. Herb with *Musa*-like habit, 4.5–5 m tall, leafy shoots to 5 stems per group. Pseudostem green with brown lenticular spots, 160–180 cm tall, 6.5–7.5 cm in diameter; sheath glabrous but woolly on the margin. Leaves 4 per shoot, held more or less in horizontal position; petiole green, glabrous, woolly at the base, ca. 180 cm long, 2 cm in diameter; symmetrical blades splitting into narrow lateral segments with the base truncate, unequal, splitting into narrow lateral segments, apex acuminate, the upper surface green, midrib light green and glabrous, the lower surface light green, midrib green-reddish, glabrous, the largest blades up to 160 cm long and ca. 48 cm wide (Figures 2A, 4A, C).

Inflorescence pendent, up to 220 cm long; peduncle red, woolly with golden hairs, 125–150 cm long, 2 cm in diameter; rachis red, slightly flexuous, velutinous with golden hairs, 1.5 cm in diameter at the base (Figures 2, 4B).

Cincinnal bracts spirally arranged, ca. 25 per inflorescence, oriented ca. 120° to axis of the inflorescence, normally a sterile bract inserted in the peduncle, basal bracts separated ca. 3 cm and 1.5 cm between terminal bracts, the basal bract more elongated, outer surface pink at the base, turning red at the apex, totally velutinous with golden hairs, inner surface whitish, glabrous at the base with a few grouped hairs on both sides of the base, pink and hirsutulous with golden hairs at the margins and in the middle of the bract, ca. 12 cm long, ca. 5 cm wide at the base, l/w= 2.4 (Figures 3A, 4D).

Floral bracts persistent, 4.2–5.5 cm long, 1.5–2.6 cm wide at the base, pink, carinate, base of the abaxial surface glabrous to slightly tomentose at the apex, adaxial surface slightly tomentose at the base, inner surface glabrous (Figures 3B, 4F).

Flowers (5-)11–21 per cincinnus; pedicel pink, white at the base, pubescent, 12–20 mm long; ovary 10–11 mm long, 5 mm in diameter, lavender, glabrous; perianth 4.5–5.5 cm long, 0.6–0.8 cm in diameter, at anthesis curved 80° and sigmoid, slightly



Figure 2. **A** Habit of *Heliconia berguidoi* **B** Inflorescences touching the ground **C** Plant with two of the authors (R. Flores and C. Black). Photos: **A**, **C** – R. Flores; **B** – C. Black.

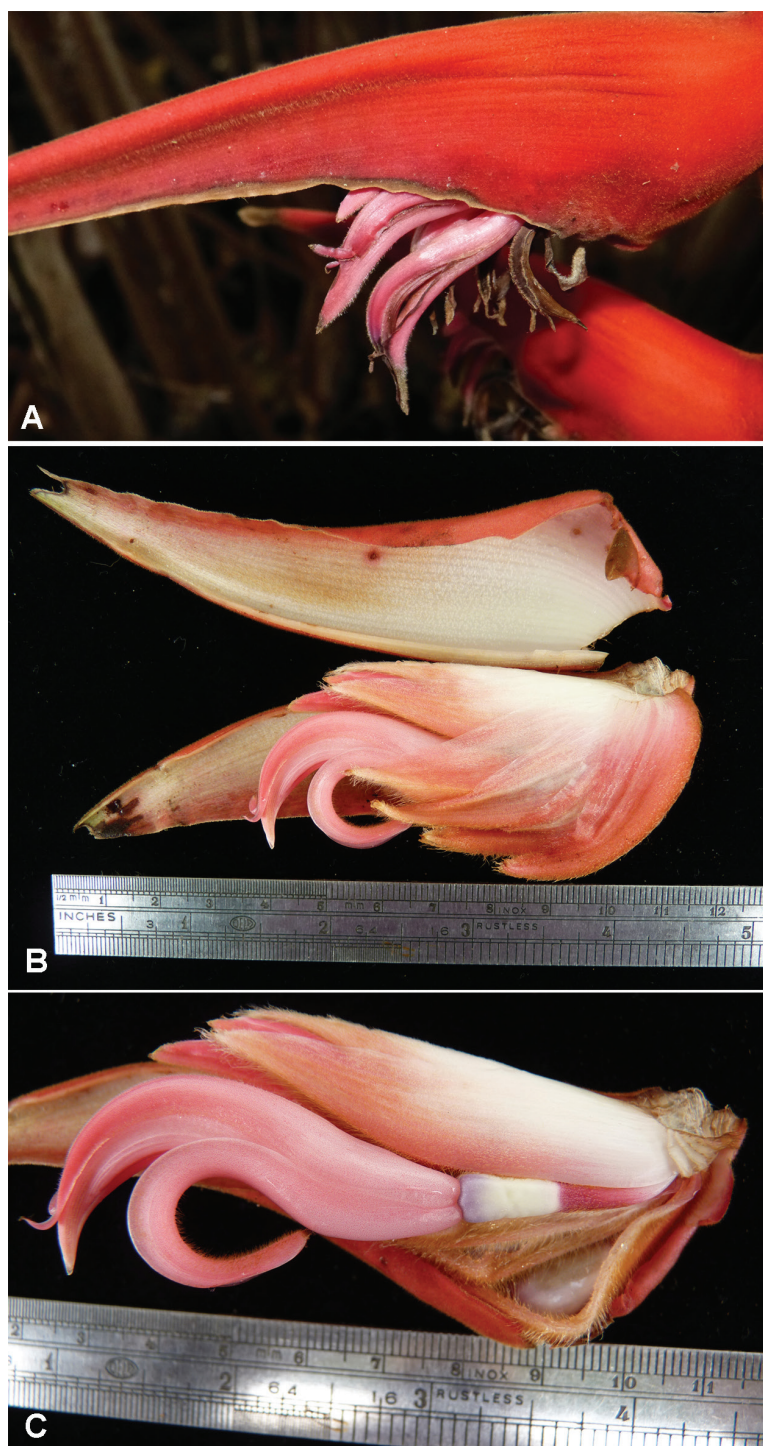


Figure 3. **A** Inflorescence segment of *H. berguidoi* **B** Cinninal bracts opened, showing floral bracts **C** Flower. Photos: **A** – R. Flores; **B, C** – C. Black.

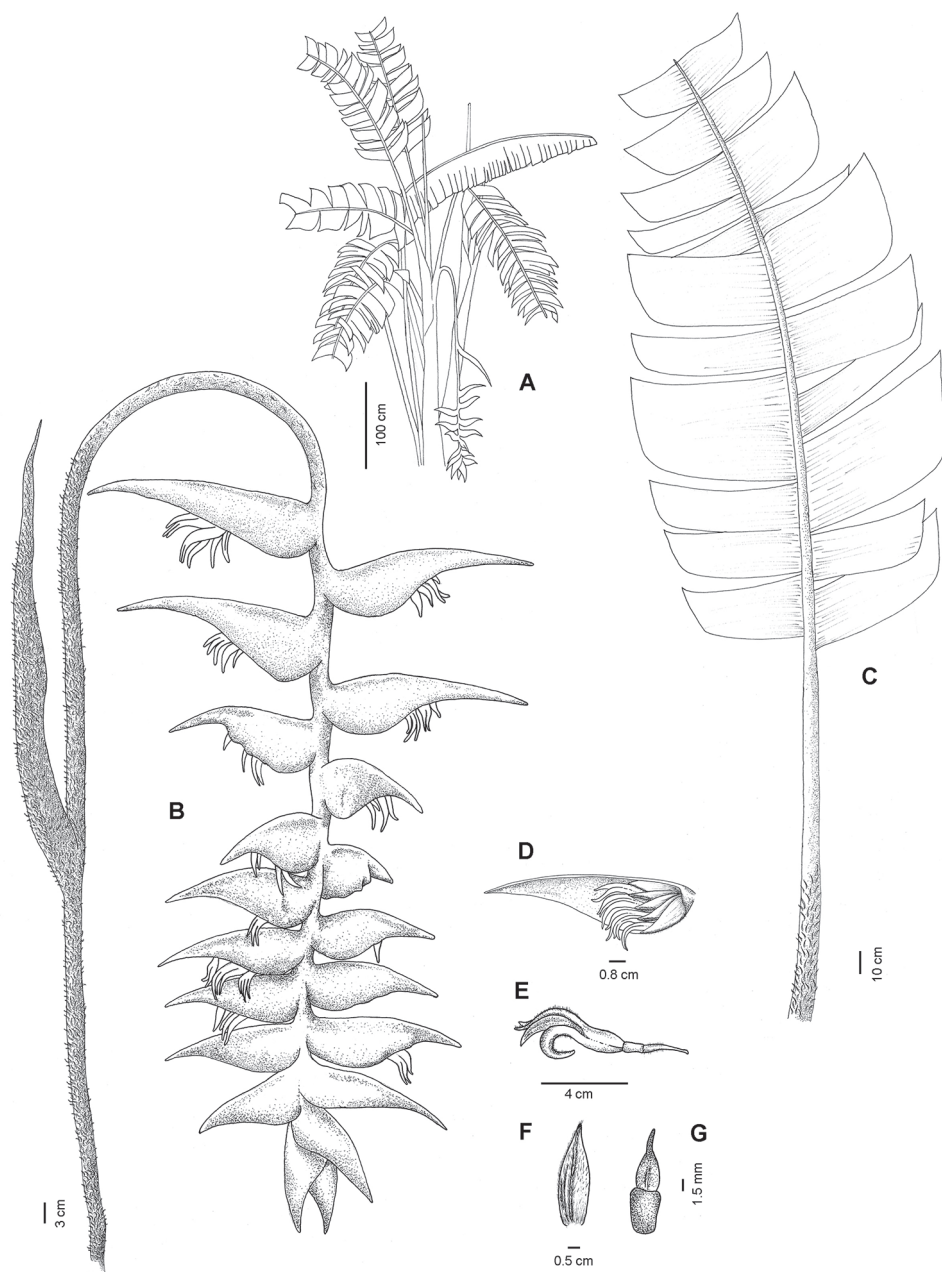


Figure 4. *Heliconia berguidoi* R.Flores, C.Black & A.Ibáñez. **A** Habit **B** Inflorescence **C** Leaf **D** Cincinnal bract open and flowers **E** Flower **F** Flower bract **G** Staminode.

pink at the base, dark pink at the apex, glabrous except for pubescence at the apex of the perianth; free sepal reflexed, fused sepals with apices reflexed (Figures 3C, 4E); staminode 7.0–7.5 by 2.5–3.0 mm, white, fused to the perianth tube 12 mm above the base,

elliptic with cuspidate apex (Figure 4G); stamens with anthers connivent and inside corolla apex. Drupes glabrous, bright blue 10–14 mm long, 9 mm wide.

Distribution, habitat and ecology. *Heliconia berguidoi* is endemic to the Serranía de Majé, eastern Panama. It is known only from the Chucantí Private Nature Reserve (Figure 1), where it inhabits premontane forest at ca. 800 m. The canopy in this area attains a height of 20–35 m; some common canopy species are *Oreomunnea pterocarpa*, *Ocotea* sp. nov. ined., *Magnolia* sp. nov. ined., *Quercus humboldtii*, *Podocarpus guatemalensis* and *Peltogyne purpurea*. One population of *H. berguidoi* has been found growing in early secondary forest regenerating from previous clearance or treefall gaps. It also appears in mature forest. Mature flowers were collected *in situ* in March, while *ex situ* the species seems to flower all year round. Mature fruits have not been collected *in situ*. *Ex situ* they appear all year round.

Conservation status. *Heliconia berguidoi* is known only from one population in the type locality, Chucantí Private Nature Reserve. Human activities such as agriculture, cattle ranching and logging are the main threats to other populations of this species that probably exist in the forests around the reserve. These areas belong to farmers engaged in the activities mentioned above or else are public lands prone to colonization. Because of the restricted area of occupancy (AOO) estimated at 4 sq. km, and the severe threats, we consider that *H. berguidoi* fits the category of Critically Endangered [CR B2ab (ii, iii, iv)] of the IUCN Red List and criteria (IUCN 2012).

Etymology. The specific epithet, *berguidoi*, honors the Panamanian biologist Guido Cesar Berguido F., who first brought national attention to Cerro Chucantí after witnessing not only its natural splendor, but the rampant ongoing deforestation. He mustered support from family and friends to purchase a property and set it aside for conservation before the previous owners could burn the forest to ashes. He received further private support and acquired more lands to create the Chucantí Private Nature Reserve. Mr. Berguido continues to invite fellow biologists to study the flora and fauna of Cerro Chucantí, which has resulted in the discovery of various species new to science. He recently founded the *Asociación Adopta el Bosque Panamá*, Adopt a Panama Rainforest, ADOPTA (www.chucanti.org) to further his conservation mission. It is an honor to thus recognize Mr. Berguido's contributions to increased biological knowledge and his great efforts to conserve the unique forests of Cerro Chucantí. His generous logistical assistance to the authors was invaluable.

Paratypes. PANAMÁ. Provincia de Darién. Cerro Chucantí, 800 m, 8°47'15.84"N, 78°27'13.57"W, 3 marzo 2011, fl., R. Flores & K. Morales. 595 RF (PMA!).

Discussion

The new species of *Heliconia* described here belongs to the section *Barbatae* J.Kress ined., characterized by having the inflorescence, parts of it and/or the flowers densely pubescent with colored hairs (Kress et al. 1999, Kress and Betancur 2009) and to sub-

genus *Griggsia* L.Andersson characterized by a pendent inflorescence (Kress 1990a). It is the first species of both subgenus and section found in Panama with pink flowers and very long peduncle, which occasionally makes the inflorescence touch the ground. Very few species in the genus *Heliconia* have pink flowers.

It resembles the Colombian species *Heliconia rhodantha* and *Heliconia sanctae-theresae* in the pink flowers. Also, *H. rhodantha* is similar to *H. berguidoi* in the length and width of the leaf and the truncate and unequal leaf base. Nevertheless, the three species differ in several ways. *H. berguidoi* has petioles up to 180 cm long with a woolly base vs. petioles that do not exceed 110 cm long and totally glabrous in *H. rhodantha*, and up to 220 cm and totally glabrous in *H. sanctae-theresae*. Inflorescences of *H. berguidoi* reach 220 cm long with a wooly peduncle and a slightly flexuous, velutinous rachis; the cincinnal bracts are spirally arranged and velutinous with apex not early necrotic vs. inflorescences up to 135 cm long, pubescent, velvety peduncle and a flexuous, finely pubescent rachis; cincinnal bracts distichous and finely pubescent with apex early necrotic in *H. rhodantha*, and inflorescences up to 67 cm long, velvety peduncle, flexuous rachis and cincinnal bracts distichous in *H. sanctae-theresae*. The perianth of *H. berguidoi* is pubescent at the apex and the elliptic staminode has a cuspidate apex vs. perianth glabrous and staminode completely linear in *H. rhodantha*, and perianth finely pubescent and staminode ovolanceolate in *H. sanctae-theresae*.

H. berguidoi is similar to *H. pogonantha* in its four varieties, mainly in the habit: leaves held more or less in horizontal position, leaves with unequal bases, blade splitting in segments, cincinnal bracts spirally arranged and the apex of the perianth pubescent. Additionally, it is similar to one of the varieties of *H. pogonantha* (*H. pogonantha* var. *pubescens*) in the combination of usually woolly peduncles and the rachises and cincinnal bracts velutinous.

H. berguidoi differs clearly from *H. pogonantha* in its four varieties by the petioles woolly towards the base, leaf with acuminate apex, long peduncle (125–150 cm), slightly flexuous rachis, pink flowers and staminode with cuspidate apex vs. petioles glabrous, leaf with acute apex, shorter peduncle (10–60 cm), flexuous rachis, yellow flowers and staminode with acuminate apex in *H. pogonantha*. Additionally, the inflorescence is one-colored in *H. berguidoi* vs. two-colored in three of the four varieties of *H. pogonantha*.

With the combination of similar habit, blade splitting in segments, woolly peduncle, monochromatic cincinnal bracts and pubescent sepal apices, *H. berguidoi* is very close to two of the four varieties of *H. ramonensis* (*H. ramonensis* var. *ramonensis* and *H. ramonensis* var. *xanthotricha*) but it is clearly differentiated by the longer peduncle (125–150 cm), slightly flexuous rachis and pink flowers vs. shorter peduncle (10–60 cm), flexuous rachis and yellow flowers.

With the description of *H. berguidoi*, fifty-six native *Heliconia* species grow in Panama, eighteen of them endemic. This new species adds to a total of 178 species in the Neotropical region and 184 worldwide.

Key to Panamanian *Heliconia* sect. *Barbatae* ined. with inclusion of *H. rhodantha* and *H. sanctae-theresae*, Colombian species. Based on Kress (1984) with modifications:

- 1 Flowers pink, staminode totally linear, ovolanceolate or apex of staminode cuspidate.
- 2 Peduncle absent or to up 14 cm, staminode ovolanceolate ... *H. sanctae-theresae*
- 2' Peduncle 50–150 cm long, staminode linear or apex of staminode cuspidate.
- 3 Perianth pubescent at the apex, staminode with the apex cuspidate *H. berguidoi*
- 3' Perianth glabrous, staminode linear *H. rhodantha*
- 1' Flowers yellow, apex of staminode acuminate or cuspidate
- 4 Peduncle, rachis, and cincinnal bracts essentially glabrous.
- 4' Peduncle and rachis red or yellow, cincinnal bracts entirely red or red and yellow; floral bracts and perianth with golden hairs *H. pogonantha*
- 5 Peduncle, rachis, and cincinnal bracts rose-red; floral bracts and perianth with bright yellow hairs *H. ramonensis*
- 5' Peduncle, rachis, and/or cincinnal bracts densely velutinous to woolly.
- 6 Cincinnal bracts two-colored, red and yellow, velutinous *H. pogonantha*
- 6' Cincinnal bracts one-colored, not red and yellow, velutinous to woolly.
- 7 Inflorescence orange to rose-red, with orange hairs; perianth with orange or buff to rusty orange hairs.
- 8 Inflorescence pink to rose-red, with rusty orange hairs; perianth with rusty orange hairs *H. ramonensis*
- 8' Inflorescence orange-red with orange (fresh) or buff (dried) hairs *H. danielsiana*
- 7' Inflorescence burgundy with golden to burgundy hairs or yellow with yellow hairs; perianth with golden or yellow hairs.
- 9 Inflorescence deep red to burgundy, with golden to burgundy hairs; perianth with golden hairs *H. magnifica*
- 9' Inflorescence bright yellow-green with yellow hairs; perianth with bright yellow hairs *H. xanthovillosa*

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Impatiens bokorensis (Balsaminaceae), a new species from Cambodia

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Abstract

Impatiens bokorensis, a new species of family Balsaminaceae from Phnum Bokor National Park in southwestern Cambodia, is described and illustrated. The species is similar to *I. patula*, but is readily distinguished by the orbicular-obovate dorsal petal, shorter pedicels and larger seeds.

Keywords

Phnum Bokor National Park, Endemic species, *Impatiens*, Cambodia

Introduction

Balsaminaceae is a family consisting of about 1,000 species mainly distributed in tropical Africa, Madagascar, southern India and Sri Lanka, the eastern Himalayas and southeastern Asia and is absent from Australia and South America (Song et al. 2003, Yuan et al. 2004, APG III 2009). This family includes annual or perennial herbs (more or less succulent) to sub-shrubs. It is distinguished from other families by strongly zygomorphic flowers with a spur on the adaxial sepal and a fleshy explosive-dehiscent capsule (Chen et al. 2007, APG III 2009). It comprises two genera: *Hydrocera* Blume ex Wight & Arn. (monotypic) and *Impatiens* L. with the most species.

Impatiens is classified into two subgenera (subgenus *Impatiens* Warb. and subgenus *Acaulimpatiens* Warb.) based on the presence or absence of cauline leaves. These two subgenera comprise 14 sections (subgenus *Acaulimpatiens*, two sections and subgenus *Impatiens*, 12 sections) mainly segregated by phyllotaxy, inflorescence and spur characters (Warburg and Reiche 1895, Utami 2009). Nonetheless, in a recent molecular phylogenetic study based on a nuclear ribosomal internal transcribed spacer (ITS) and plastid *atpB-rbcL* and *trnL-F* (Yu et al. 2015), *Impatiens* was classified into two subgenera (subgenus *Clavicarpa* S.X. Yu ex S.X. Yu & Wei Wang and *Impatiens*) with the subgenus *Impatiens* composed of seven sections (sect. *Semeiocardium*, sect. *Racemosae*, sect. *Fasciculatae*, sect. *Tuberosae*, sect. *Scorpioidae*, sect. *Uniflorae* and sect. *Impatiens*).

In Indochina, there are around 120 species of *Impatiens* and the present count includes approximately 40 species from Vietnam (Tardieu 1944, Ho 1999, Vietnam Plant Data Center 2016), around 60 species from Thailand (Grey-Wilson 1971, Shimizu 2000, Shimizu and Suksathan 2004, Chayamarit et al. 2006, Suksathan and Triboun 2009, Ruchisansakun et al. 2014) and 18 from Laos (Tardieu 1944, Newman et al. 2007, Newman 2008, Souvannakhommane and Suksathan 2015). In Cambodia, at the beginning of the 20th century, six species were described, namely *Impatiens cardiophylla* Hook.f., *I. diffusa* Hook.f., *I. notoptera* Hook.f., *I. relaxata* Hook.f., *I. vagans* Hook.f. and *I. zygosepala* Hook.f. (Hooker 1908, 1909a, 1909b, 1911), whereas eight species are reported in the present account (Cho et al. 2016).

Except for *I. balsamina* and *I. cardiophylla*, most species in Cambodia have been considered endemic species, with *I. relaxata*, *I. vagans* and *I. zygosepala* restricted to a local area with only a very small number of specimens. There is a need to re-evaluate and resurvey areas of the previous collection of specimens through a detailed taxonomic study of each species.

During the recent floristic survey, one species of *Impatiens* was collected at Bokor National Park in Southwestern Cambodia that does not appear to be similar to previously reported species (Figures 1 & 2). It is most similar to *Impatiens patula* Craib from Thailand (Craib 1926, Shimizu 1970), but a comparison with the type specimens and descriptions revealed that it differs from *I. patula* and is therefore described here as a new species.

Taxonomy

***Impatiens bokorensis* S.H.Cho & B.Y.Kim, sp. nov.**

urn:lsid:ipni.org:names:77160179-1

Figures 1, 2

Type. CAMBODIA. Kampot Province, Phnum Bokor National Park, sandstone tables in evergreen forest margin, 10°38'20.8"N, 104°00'16.0"E, a.s.l. 1,050 m, 24 August 2015, with flowers, Cho S.H., Kim B.Y., Park H.S., Chhang Phourin CB-3112 (holotype HHU!, isotypes KB!, KRIB!, RUPP!).

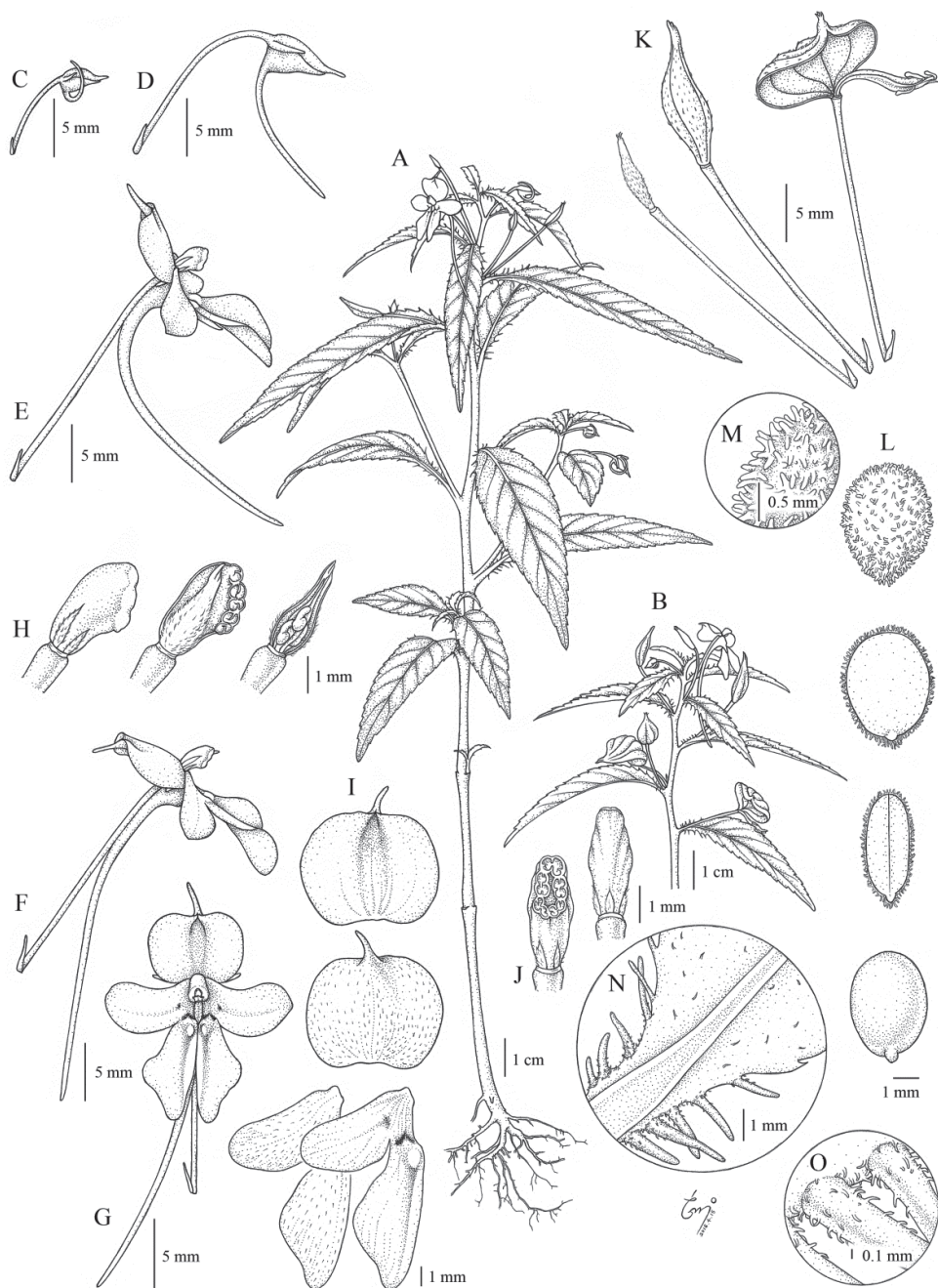


Figure 1. *Impatiens bokorensis* **A** Flowering individual **B** Fruiting individual **C–D** Developing flower bud **E** Mature flower (before pollination) **F–G** Mature flower (after pollination) **H** Developing gynoecium **I** Petals **J** Androecium **K** Developing fruit **L–M** Seed **N–O** strigose-ciliate at leaf base: Cho et al. CB-3112, 3432. Illustration by Hye-Woo Shin.

Table 1. Comparison of key features of *Impatiens bokorensis* and *I. patula*.

| Taxonomic traits | <i>Impatiens bokorensis</i> | <i>I. patula</i> |
|--------------------------|---|--|
| Leaf | | |
| upper surface | pubescent | pubescent with scurfy hairs |
| lower surface | glabrous to sparsely pubescent | pubescent on nerves only or tomentose all over |
| strigose-ciliate at base | 1–2.7 mm | 1–1.4 mm |
| Pedicel | 1.4–2.0 cm | 2.3–3(–5) cm |
| Dorsal petal | orbicular-obovate, ca. 6 × 8 mm, horned at apex, horn 2.2–2.3 mm long | cordate, 7 mm long, horned at apex, horn 3 mm long |
| Seeds | 3.8–4.6 × 2.6–3.2 mm | 3.5 × 2.5 mm |

Diagnosis. *Impatiens bokorensis* is most similar to the Thailand endemic species *I. patula* Craib in habit but is readily distinguished from the latter by the orbicular-obovate dorsal petal, shorter pedicels and larger seeds (Table 1).

Description. Herbs, annual, terrestrial, hermaphroditic. Stems erect, 15–40 cm tall, tinged purplish red, branched, glabrous or sparsely puberulous on the upper part. Leaves simple, alternate; petioles subsessile to 1.4 mm; leaf blade lanceolate to ovate-lanceolate, apex acuminate, base narrowly cuneate to attenuate, 2.5–7.0 × 0.6–2.0 cm, upper surface pubescent, lower surface glabrous to sparsely pubescent, secondary veins pinnate, 6 to 8 on each side of mid-vein, margin serrate, teeth mucronate and purple tinged, strigose-ciliate at base; strigose-ciliate, 4–14, 1–2.7 mm long, purple to purplish black, minutely puberulous at base. Flowers axillary, solitary, rarely 2 fascicled, zygomorphic, minutely puberulous; pedicels slender, erect, purplish red, 1.4–2.0 cm long, glabrous, bracteate at base; bracts linear, up to 4 mm; lateral sepals 2, linear-lanceolate, 2.5–3 mm long, glabrous; lower sepal funnel-form, pink, ca. 5 mm long, ca. 3 mm deep; spur 17–23 mm long, slightly curved; dorsal petal, orbicular-obovate, ca. 6 × 8 mm, horned at apex, horn 2.2–2.3 mm long; lateral united petals separate, bilobed, ca. 11 mm long; upper petals oblong, 6.0–6.5 × ca. 3.0 mm, minutely apiculate; lower petals, 9.0–9.3 × 3.5–3.8 mm; androecium ca. 2.8 × 1.6 mm; stamens 5, connate, surrounding gynoecium; filaments ca. 0.7 mm; ovary fusiform, pubescent, ca. 2.5 × 1.0 mm; style glabrous, ca. 0.2 mm long; stigma 5, ca. 0.25 mm long. Fruit a capsule, fusiform, ca. 15 × 6 mm, pubescent with scurfy hairs, 3[4]-seeded. Seeds obovoid, slightly compressed, 3.8–4.6 × 2.6–3.2 mm, pubescent with spirally sculptured hairs.

Specimen examined. CAMBODIA. 16 November 2015, with fruits, Cho et al. CB-3432 (HHU!, KRIB!); 2 September 2016, with flowers, Kim et al. CB-3537 (HHU!)

Phenology. Flowering specimens were collected in August and fruiting specimens in November.

Distribution and habitat. *Impatiens bokorensis* grows on sandstone tables in ever-green forest margins at 1,050 m a.s.l.. Endemic to southwestern Cambodia, *I. bokorensis* is at present known only in the type locality.

GenBank Accession No. Cho et al. CB-3432: KX171761 (ITS).

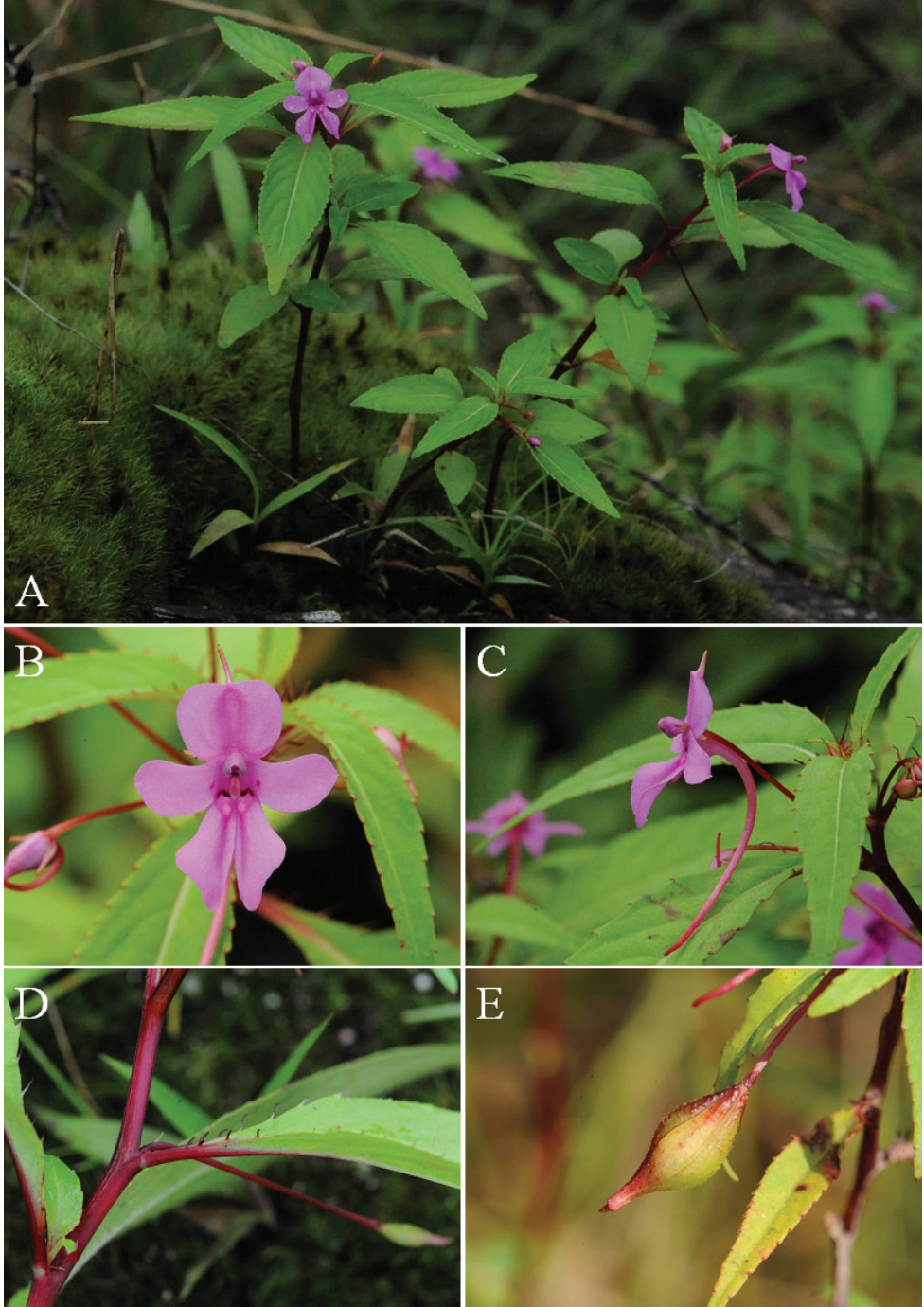


Figure 2. A–E *Impatiens bokorensis* A Habit B–C Flower D strigose-ciliate at leaf base E Capsule: Photos by Seong-Hyun Cho.

Conservation status. *Impatiens bokorensis* was collected in Phnum Bokor National Park in southwestern Cambodia. Until now, only one population, consisting of ca. 200 individuals, has been discovered in the park area; therefore, it is preliminarily classified as data deficient (DD) according to the IUCN Red List criteria (IUCN 2001).

Acknowledgements

We thank Ms. Hye-Woo Shin (<http://www.hyewoo.com/>) for preparing the line drawing. This work was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR201604201). Also, We would like to thanks Dr. Rajeev Singh and Dr. Mike Skinner for their valuable comments and suggestions.

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Dataset of herbarium specimens of threatened vascular plants in Catalonia

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Abstract

This data paper describes a specimens' dataset of the Catalanian threatened vascular plants conserved in five public Catalanian herbaria (BC, BCN, HGI, HBIL and MTTE). Catalonia is an administrative region of Spain that includes large autochthon plants diversity and 199 taxa with IUCN threatened categories (EX, EW, RE, CR, EN and VU). This dataset includes 1,618 records collected from 17th century to nowadays. For each specimen, the species name, locality indication, collection date, collector, ecology and revision label are recorded. More than 94% of the taxa are represented in the herbaria, which evidence the paper of the botanical collections as an essential source of occurrence data.

Keywords

Catalonia, conservation, Cormophyta, herbarium, northeastern Iberian Peninsula, specimen, threatened flora

Introduction

For the maintenance of ecosystem processes, effective conservation is essential (Rands et al. 2010) and natural history collections have been recognized as a valuable source of data for applied these conservation efforts (Krupnick et al. 2009) due they are permanent and well-documented distribution records of taxa through time and space. There

are many studies that show how the specimens stored in herbaria are useful for better knowledge of endangered flora; for instance, to evaluate the impact of over-collecting in the past for nowadays extinct plants (Aedo et al. 2015), to prioritize regionally rare plants for conservation (Kricsfalussy and Trevisan 2014) or to evaluate threatened flora hotspots (Mendoza-Fernández et al. 2015). But not only the primary data included in the label is useful for biodiversity studies, Greve et al. (2016) shows how other information related to the specimen's environment can provide distribution maps of soils types or vegetation; and Calinger et al. (2013) demonstrate changes on the flowering phenology due to climate change from the visual examination of the specimen's flowers.

Project description

Purpose

The aim of this project is (1) to join the specimens' data of endangered plants in Catalonia in a unique dataset, (2) to improve the accessibility of this data for conservation purposes, (3) to describe the taxonomical, chorological and temporal diversity of this dataset and (4) to evaluate if it is representative of this kind of flora. Five public herbaria have participated and all their data have been published through GBIF in a unique dataset. The herbaria included are those who already have these specimens informatized but in the future we plan to include more collections.

Some of these herbaria have yet evaluated their specimens of threatened plants in previews works. In the herbarium of the Botanic Institute of Barcelona (BC) the specimens of some collections have been analyzed to assess if the threatened but also the endemic taxa of Catalonia were well represented in the herbarium (Nualart et al. 2012). Results showed that specimens from Catalonia conserved in BC represented 82.24% of the 304 endemic and threatened taxa, a high percentage that demonstrates that this herbarium has a good representation of this flora. We expect that the representation of threatened flora in the present project would grow significantly as the number of collections studied increases.

Study area

Catalonia is an administrative region in the northeastern corner of Spain in the Mediterranean Coast that covers approximately 32,000 km² (Figure 1). It includes a large biogeographic, physiographic and orographic diversity due to the presence of the Pyrenees in the north and the Mediterranean Sea in the east. The most abundant climate is Mediterranean, characterized by warm winters and hot and drought summers. The annual average temperature ranges between 1°C above 2,000 m in the Pyrenees and 18°C below 50 m. Annual precipitation ranges from 200 mm in the Catalan Central Depression to more than 1,250 mm in some areas of the Pyrenees.

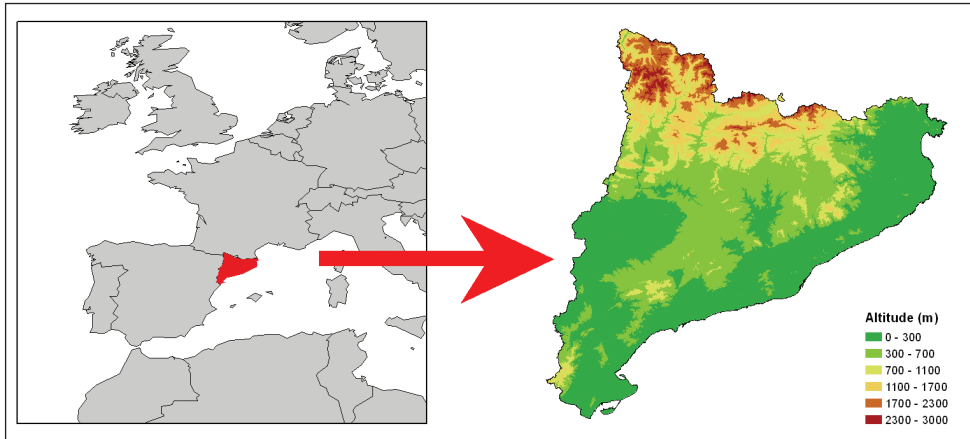


Figure 1. Location of Catalonia and elevation map of the study area.

The vascular flora of Catalonia includes 4,831 taxa (Font 2016) that constitute a relevant part of the Western Mediterranean flora. There are plants from three principal biogeographic regions (Bolòs and Vigo 1984): (a) the Mediterranean flora, characterized by sclerophyllous forests and shrubs, (b) the Euro-Siberian (including Atlantic and Sub-Mediterranean) elements that reach the rainy mountains and are characterized by deciduous forests and mesic grasslands, and (c) the Boreo-Alpine elements of the mountains highlands, with subalpine forests and alpine grasslands.

Design description: threatened taxa

In this project, we have compiled the records of the threatened taxa specimens included in the Catalonia Red List (Sáez et al. 2010: 772). This Red List includes species and subspecies which are in a higher or lower risk of extinction, and those that have become extinct nowadays. It includes 199 threatened taxa according to the IUCN categories (IUCN 2012). The 45.72% are vulnerable (VU), with a high risk of endangerment, the 27.13% are endangered (EN), with a high risk of extinction and the 18.59% are critically endangered (CR), with an extremely high risk of extinction. The rest are extinct, either regionally or globally; the 8.04% are locally extinct in this region (RE)—although one (*Marsilea quadrifolia*) is only extinct in the wild thanks to a cultivated population in the area (RE (EW))—and finally there is an endemic taxon considered totally extinct (EX), *Festuca paucispicula*.

Design description: herbaria

This project includes the specimens conserved in the following public herbaria of Catalonia: (1) BC of the Botanical Institute of Barcelona, (2) BCN of the University of

Barcelona, (3) HGI of the University of Girona, (4) HBIL of the Public Foundation *Institut d'Estudis Ilerdencs* and (5) MTTE of the museum *Museu de les Terres de l'Ebre*. The BC herbarium (<http://www.ibb.bcn-csic.es/en/documentacio/herbari/>) is the largest collection of plants in Catalonia, and the second in Spain. This collection, with about 800,000 specimens, is specialized in western Mediterranean flora and has served as reference for the main floras of this region. In this project we have included the general collection and also historical collections as the Salvador's herbarium from 17th and 18th century, the collections of F. Trèmols (1831–1900) and E. Vayreda (1848–1901) from 19th century and those of J. Cadevall (1846–1921) and Fr. Sennen (1861–1937) from 19th to early 20th century, which allows a very high temporal representation. The BCN herbarium (<http://crai.ub.edu/ca/coneix-el-crai/CeDocBiV/herbari>) hosts more than 400,000 specimens, with a great representation of all the major groups of plants. This herbarium has a wide range of specimens from the Pyrenees, the Ebre Basin, the Mediterranean coastal areas and some tropical South American. As for historical collections, the most outstanding are those of J. Planellas (1821–1888), J. Teixidor (1836–1885), Fr. Sennen, P. Font Quer (1888–1964) and T.M. Losa (1893–1965). HGI herbarium, created in 1976, stores about 23,200 specimens mainly of the Girona province and also includes a historical collection of Isern's herbarium from 19th century, and the collection of L. Pericot (1899–1978). The HBIL herbarium was created in 1942 and stores more than 15,000 sheets of vascular plants collected basically from the Lleida province. The MTTE herbarium includes near 3,500 specimens of the Ebre delta regional area.

Although some of these specimens are already available in GBIF portal (CeDoc de Biodiversitat Vegetal: BCN-Cormophyta <http://www.gbif.org/dataset/834f1756-f762-11e1-a439-00145eb45e9a>; Institut Botanic de Barcelona, BC <http://www.gbif.org/dataset/838475f4-f762-11e1-a439-00145eb45e9a>; Universitat de Girona: HGI-Cormophyta <http://www.gbif.org/dataset/835727b6-f762-11e1-a439-00145eb45e9a>), this new dataset includes specimens not yet published and summarizes the data from all these herbaria. The information provides a joint and overall vision of all the specimens that will be useful for conservation policy and scientific research.

Data published through GBIF

<http://www.gbif.es/ipt/resource?r=threatenedcat>

Herbarium coverage

The searching of endangered plants in the herbaria allowed us to find 1,618 specimens from Catalonia. Although in these herbaria there are also many specimens collected in other Spanish regions or other countries, we have only recorded those collected in Catalonia. Table 1 shows the number of taxa and the specimens founded for each

Table 1. Representation of the Catalanian threatened taxa in the dataset.

| | Taxa | | | Specimens |
|--------------|----------|-----------|--------|-----------|
| | Red List | Herbarium | % | |
| VU | 91 | 90 | 98.90 | 927 |
| EN | 54 | 53 | 98.15 | 455 |
| CR | 37 | 33 | 89.19 | 182 |
| RE + RE (EW) | 16 | 11 | 68.75 | 48 |
| EX | 1 | 1 | 100.00 | 6 |
| TOTAL | 199 | 188 | 94.47 | 1,618 |

Table 2. Number of taxa according to the specimens' range and the IUCN category.

| | Number of specimens | | | | | | |
|----------------|---------------------|-------|-------|-------|-------|-------|------|
| | 1–5 | 6–10 | 11–15 | 16–20 | 20–25 | 25–30 | > 30 |
| VU | 43 | 19 | 12 | 5 | 2 | 2 | 7 |
| EN | 27 | 11 | 6 | 7 | 1 | . | 1 |
| CR | 20 | 8 | 3 | 2 | . | . | . |
| RE + RE (EW) | 8 | 2 | 1 | . | . | . | . |
| EX | . | 1 | . | . | . | . | . |
| TOTAL | 101 | 41 | 22 | 14 | 3 | 2 | 8 |
| Percentage (%) | 52.13 | 21.28 | 11.70 | 7.45 | 1.60 | 1.06 | 4.26 |

IUCN categories. More than 94% of the 199 taxa are represented in the herbaria, which evidences the paper of the botanical collections as an essential source of occurrence data. Only the regionally extinct taxa (RE) are less present in the herbaria due to the old bibliographic cites without voucher specimens. However, the 96.70% of the endangered taxa (VU, EN and CR) have almost one specimen, which demonstrates the good representativeness of this dataset per this kind of flora.

Table 2 shows the number of taxa according to the number of specimens stored in the herbaria and the IUCN category. The taxa with more than 30 specimens only represent the 4.26% of all the taxa included in the dataset, while more than 50% of the taxa have a few number of them (20 taxa only with a single specimen). We can see a general trend of the number of taxa decline as the number of specimens increases (from left to right of the table), and another general trend of the number of specimens decline as the threat degree increases (from top to down of the table), already observed in Nualart et al. (2012). These trends evidence that taxa with lower risk of extinction are more collected than the more endangered ones. This fact is due because usually these last taxa are infrequent, often with a small population size, a restricted and/or fragmented distribution area and come from difficult access habitats. Furthermore, many of these taxa have some type of protection that prohibits their gathering according to the Catalogue of Endangered Flora (DOGC 2008; 2015). These characteristics could explain the difficulty in their gathering and therefore, their small number of specimens.

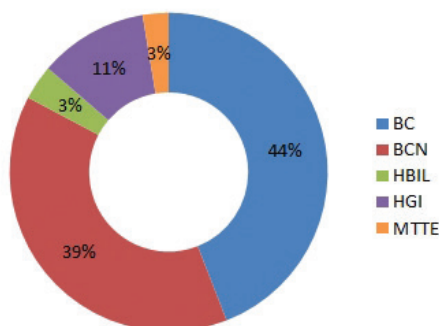


Figure 2. Origin herbarium of the specimens included in the dataset.

Figure 2 shows the herbarium origin of all the specimens included in this dataset and as it is expected, the number of specimens is proportional to the herbarium volume. But it is important to note that some taxa are only present in one herbarium and are missing in the rest: 20 in BCN, 18 in BC, four in HGI (*Filago lusitanica*, *Isoetes velatum*, *Polygonum romanum* ssp. *gallicum* and *Ranunculus nodiflorus*), two in HBIL (*Hesperis laciniata* and *Teucrium campanulatum*) and two in MTTE (*Atropa baetica* and *Asplenium majoricum*). These taxa are generally rare with few localities in the study area, and have been only collected once or a few times; this explains why they are only present in one herbarium, usually the closest herbarium of the taxon's distribution. This fact highlights the importance of the small herbaria as representatives of local floras.

Taxonomic coverage

The scientific names of this dataset are those accepted in the Catalonia Red List, which follow mainly *Flora dels Països Catalans* (Bolòs and Vigo 1984–2001) and *Flora iberica* (Castroviejo 1986–2009). The arrangement into families and orders has followed the APG III classification (APG III 2009).

This dataset includes 1,618 records of threatened vascular plants (106 Pteridophyta, 6 Equisetophyta, 36 Lycopodiophyta, 11 Coniferophyta and 1,459 Magnoliophyta). Figure 3 shows the families with more specimens, that usually also have a high number of taxa (families with only three or less taxa have not been represented in the figure). The highest number of records is from Plumbaginaceae with 213 specimens; this family has also the largest number of threatened taxa with 11 species: nine *Limonium*, one *Limoniastrum* and one *Myriolepis*. It is important to note that this family has doubled the number of specimens of the second family more represented, Brassicaceae, with 77 specimens. Plumbaginaceae is a complex group with many endemisms described in the Mediterranean region with non-clear taxonomic status. Its specimens have been collected by many botanists during a large period of time, between 1866 and 2015. Almost 100 specimens have been collected by A. Curcó from 1989 to 1990,

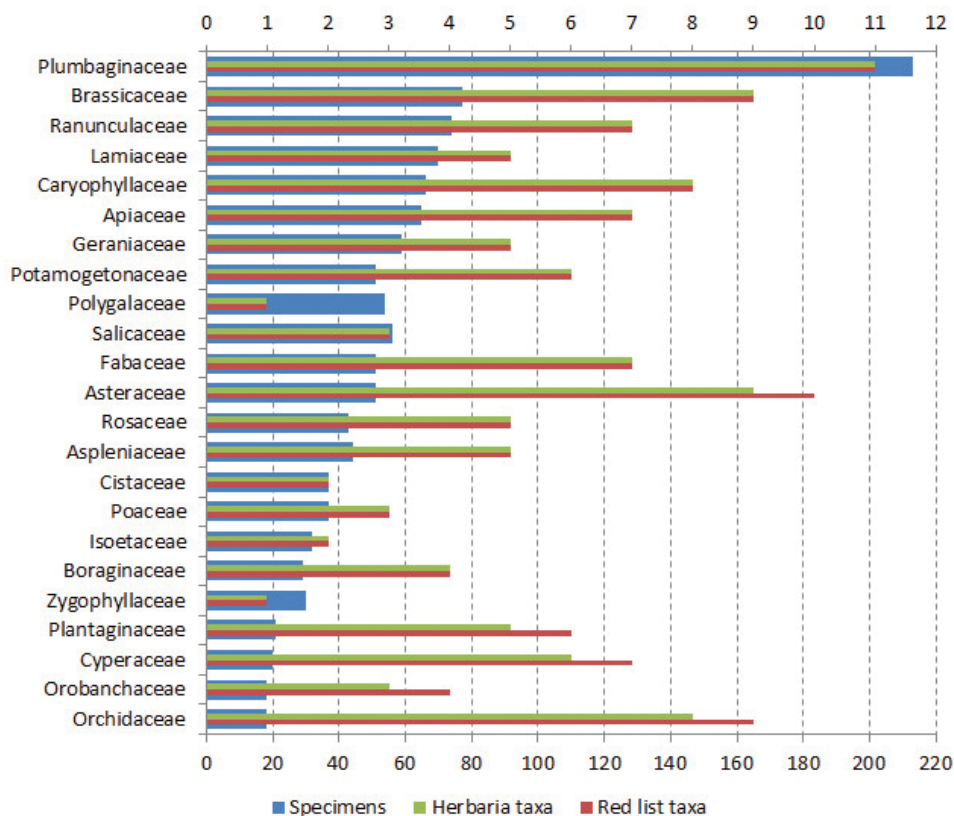


Figure 3. Families with 18 or more specimens (number of the taxa in the upper axis and number of specimens in the lower axis).

during his study of the *Limonium* genus in the Ebre river delta (Curcó 1992). Moreover, there are two species of *Limonium* among those with more than 30 specimens (Table 3). Highlight *Limonium densissimum* (57 specimens, some of them duplicates), a halophyte plant of the W-Mediterranean coast present in the Ebre river delta.

Some families are overrepresented in the dataset, like Polygalaceae with only one threatened taxon (*Polygala vayredae*) with 54 specimens (see Table 3) and Zygophyllaceae with also a single taxon (*Tetraena alba*) with 30 specimens. *P. vayredae* is a local endemism that occupies only an area of 12 km² but it is very abundant in this area; this taxon was described in 1877 and since then many local botanists have collected it (between 1877 and 2013).

On the contrary, some families with many threatened taxa (seven or more) have few specimens (less than 50), so they are not well represented in the dataset. It is the case of Orchidaceae (nine taxa but only 18 specimens), that are usually not well represented in the herbaria due they are difficult to well press and their flowers quickly lose their color. The low presence of Cyperaceae (seven taxa but only 20 specimens) may be due to the difficulty of the identification of the *Carex* species, and the scarce

Table 3. Taxa with more than 30 specimens.

| Family | Taxon | Spec. | IUCN |
|----------------|---|-------|------|
| Geraniaceae | <i>Erodium sanguis-christi</i> | 37 | VU |
| Cistaceae | <i>Halimium halimifolium</i> ssp. <i>halimifolium</i> | 34 | VU |
| Plumbaginaceae | <i>Limonium bellidifolium</i> | 39 | VU |
| Plumbaginaceae | <i>Limonium densissimum</i> | 57 | VU |
| Brassicaceae | <i>Maresia nana</i> | 40 | VU |
| Polygalaceae | <i>Polygala vayredae</i> | 54 | VU |
| Salicaceae | <i>Salix tarraconensis</i> | 47 | VU |
| Lamiaceae | <i>Stachys maritima</i> | 42 | EN |

presence of the threatened species in Catalonia—they only appear in a few localities in the Pyrenees. Asteraceae (10 taxa and 51 specimens) is one of the families with more threatened taxa and also the richest within plants in the Mediterranean region. The low representation of this family in the herbaria could be explained because five of the ten threatened taxa have three or less specimens; they are endemic species with a narrow distribution area (*Centaurea loscosii*, *Hieracium recoderi* or *Hieracium vinyasianum*) and species recently found in Catalonia as *Filago lusitanica* (Font and Corominas 2005) and *Galatella aragonensis* (Arrufat et al. 2008).

The taxa with more specimens in the herbaria (Table 3) are in the most part vulnerable (VU), the UICN category with the lower threat degree, except *Stachys maritima* that is endangered (EN). This species is characteristic of the coastal sand dune vegetation and has suffered a very strong decline due to its habitat transformation; there are 24 old specimens before 1950 when the species was more or less abundant on the Catalan coast (Barriocanal and Blanché 2002). Also *Maresia nana*, a sand dune plant and *Halimium halimifolium* ssp. *halimifolium*, a sandy substrates shrub were more or less abundant in the past as certify the 36 and 27 specimens collected before 1950 respectively. The rest of the taxa included in Table 3 are currently more or less abundant in their area, despite their threatened degree. For instance, *Salix tarraconensis*, an endemism of the Catalanian south mountains, has some populations with more than a thousand of reproductive plants and since its description in 1915 many local botanist have collected it.

The taxa with only a single specimen are shown in Table 4. All these taxa are rare and have in Catalonia only few populations in one or two localities, which explain the low representativeness in the herbaria. Only *Cochlearia glastifolia* and *Cypripedium calceolus* are more abundant than the others. *Cochlearia glastifolia* is an extinct plant in Catalonia that has been found in three localities and it has not been rediscovered since 1949, just the collection year of the BC specimen. *Cypripedium calceolus* has a wider distribution but also a high protection at regional and international level that prohibits its collection.

It is important to note that some specimens have been collected at the beginning of the 21st century, and in some cases they are the testimony of the first plant citation in

Table 4. Taxa with only one specimen. The herbarium and the collection year of each specimen are indicated.

| Family | Taxon | IUCN | Herb. | Year |
|------------------|--|------|-------|------|
| Aspleniaceae | <i>Asplenium majoricum</i> | VU | MTTE | 2010 |
| Aspleniaceae | <i>Asplenium trichomanes</i> ssp. <i>inexpectans</i> | CR | BCN | 1994 |
| Cyperaceae | <i>Carex diandra</i> | EN | BCN | 1987 |
| Cyperaceae | <i>Carex lachenalii</i> ssp. <i>lachenalii</i> | VU | BC | 2007 |
| Asteraceae | <i>Centaurea loscosii</i> | EN | BC | 1917 |
| Boraginaceae | <i>Cerithe glabra</i> | CR | BCN | 2005 |
| Brassicaceae | <i>Cochlearia glastifolia</i> | RE | BC | 1949 |
| Orchidaceae | <i>Cypripedium calceolus</i> | VU | BCN | 1986 |
| Brassicaceae | <i>Hesperis laciniata</i> | VU | HBIL | 1990 |
| Plantaginaceae | <i>Linaria oligantha</i> ssp. <i>oligantha</i> | RE | BC | 1919 |
| Asparagaceae | <i>Maianthemum bifolium</i> | CR | BCN | 1986 |
| Orchidaceae | <i>Orchis cazorlensis</i> | CR | BC | 1915 |
| Orchidaceae | <i>Orchis spitzelii</i> | CR | BCN | 1997 |
| Ericaceae | <i>Phyllodoce caerulea</i> | VU | BCN | 1995 |
| Polygonaceae | <i>Polygonum romanum</i> ssp. <i>gallicum</i> | VU | HGI | 1995 |
| Potamogetonaceae | <i>Potamogeton gramineus</i> | CR | BC | 1980 |
| Ruppiaceae | <i>Ruppia drepanensis</i> | RE | BC | . |
| Saxifragaceae | <i>Saxifraga fragosoi</i> | VU | BC | 1993 |
| Amaryllidaceae | <i>Sternbergia colchiciflora</i> | CR | BCN | 2005 |
| Lamiaceae | <i>Teucrium campanulatum</i> | EN | HBIL | 2009 |

Catalonia. It is the case of *Asplenium majoricum*, an endemism of Northern Mallorca and the Eastern Iberian Peninsula, recently founded in the south of Catalonia (Curto et al. 2012). Also *Cerithe glabra*, a south European orophyte, was found for the first time in Catalonia in 2005 (Aymerich 2008); although Masip and Polo (1987) have mentioned some specimens in the collection of BC-Vayreda that have to be attributed to *C. major*. Likewise, the Mediterranean plant *Sternbergia colchiciflora* was found in Catalonia in 2005 for the first time (Molero et al. 2006) and in 2008 a second population has been found (Buirat et al. 2009). Finally, another Mediterranean plant, *Teucrium campanulatum*, was first cited in Catalonia in 2009 (Pedrol and Conesa 2009).

There are 11 taxa of the Catalanian Red List that do not have any specimen from the study area (Catalonia) in the herbaria included (Table 5). It should be noted that, for some of them, there are specimens in those herbaria but from outside of Catalonia (either from other regions of Spain or other countries of Europe or the N of Africa), and therefore not included in this dataset. In many cases, they are plants which Catalonia represents the limit of their distribution. It is the situation of *Anthericum ramosum*, *Carex brachystachys*, *Epipogium aphyllum* and *Trapa natans*, where Catalonia is in the south limit of their distribution; *Colchicum triphyllum* and *Linaria pedunculata* in the north limit or *Pilularia globulifera* in the east limit. There are some old bibliographic cites of *Anthericum ramosum* by Vayreda (1882) but the

Table 5. Taxa without specimens in the herbaria included in the dataset. Catalanian specimens in other herbaria are indicated.

| Family | Taxon | IUCN | Other Catalanian spec. |
|----------------|---------------------------------|------|--|
| Asparagaceae | <i>Anthericum ramosum</i> | CR | . |
| Cyperaceae | <i>Carex brachystachys</i> | VU | . |
| Colchicaceae | <i>Colchicum triphyllum</i> | RE | . |
| Orchidaceae | <i>Epipogium aphyllum</i> | CR | . |
| Asteraceae | <i>Hieracium recoderi</i> | CR | MA-553699 P-04302573 (holotype) VAL-85707 VAL-85735 VAL-75322 VAL-24946 L. Sáez, herb. pers. |
| Plantaginaceae | <i>Linaria pedunculata</i> | RE | . |
| Marsileaceae | <i>Pilularia globulifera</i> | RE | MA-2360 |
| Orobanchaceae | <i>Rhinanthus angustifolius</i> | VU | L. Sáez, herb. pers. (4 specimens) |
| Lythraceae | <i>Trapa natans</i> | RE | MAF-POURRET-770 |
| Verbenaceae | <i>Verbena supina</i> | RE | . |
| Woodsiaceae | <i>Woodsia pulchella</i> | CR | MAF-130204 MAF-130205 L. Sáez, herb. pers. |

identification of the herbarium material showed that they should be attributed to *Anthericum liliago*. This example reveals the importance of conserve voucher specimens, as they could be revised by specialists who could verify the plant identification. For some of these taxa we have found specimens in other herbaria not included in the dataset due they aren't Catalanian herbaria or public collections. It is the case of *Pilularia globulifera* that Font et al. (1996) found it mixed with *Isoetes durieui* in a specimen collected by Sennen in 1912; this citation is the unique occurrence of this plant in Catalonia so, it is considered locally extinct. Sáez and Benito (2000) and Guardiola et al. (2013) cite some specimens of *Rhinanthus angustifolius*. The ancient presence of *Trapa natans* in Catalonia is confirmed by a Pourret's specimen collected in 18th century (Mercadal 2016).

On the other hand, *Hieracium recoderi* is an endemic taxon of Catalonia with very few localities and in GBIF there are some Catalanian specimens in other herbaria. *Woodsia pulchella* is an alpine orophyte with a single locality in the Pyrenees and there exists only some specimens (Aymerich and Sáez 2013). Finally, *Verbena supina* has been cited in Catalonia in 1902 and 1935 but any herbarium specimen has been found to support this cites.

Taxonomic ranks

Kingdom: Plantae

Phylum: Coniferophyta, Equisetophyta, Lycopodiophyta, Magnoliophyta, Pteridophyta

Class: Equisetopsida, Filicopsida, Lycopodiopsida, Magnoliopsida (Monocotyledones and Dicotyledones), Pinopsida, Polypodiopsida

Order: Alismatales, Apiales, Asparagales, Asterales, Brassicales, Caryophyllales, Ceratophyllales, Equisetales, Ericales, Fabales, Gentianales, Geraniales, Hydropteridales, Isoetales, Lamiales, Liliales, Lycopodiales, Malpighiales, Malvales, Nymphaeales, Ophioglossales, Pinales, Poales, Polypodiales, Ranunculales, Rosales, Saxifragales, Solanales, Zygophyllales

Family: Alismataceae, Amaranthaceae, Amaryllidaceae, Apiaceae, Araceae, Araliaceae, Asparagaceae, Aspleniaceae, Asteraceae, Berberidaceae, Boraginaceae, Brassicaceae, Butomaceae, Caryophyllaceae, Ceratophyllaceae, Cistaceae, Convolvulaceae, Cupressaceae, Cyperaceae, Droseraceae, Dryopteridaceae, Elatinaceae, Equisetaceae, Ericaceae, Euphorbiaceae, Fabaceae, Gentianaceae, Geraniaceae, Hydrocharitaceae, Hypericaceae, Iridaceae, Isoetaceae, Juncaceae, Lamiaceae, Lentibulariaceae, Liliaceae, Lycopodiaceae, Malvaceae, Marsileaceae, Nymphaeaceae, Ophioglossaceae, Orchidaceae, Orobanchaceae, Plantaginaceae, Plumbaginaceae, Poaceae, Polygalaceae, Polygonaceae, Potamogetonaceae, Pteridaceae, Ranunculaceae, Resedaceae, Rosaceae, Rubiaceae, Ruppiaceae, Salicaceae, Saxifragaceae, Scrophulariaceae, Solanaceae, Thelypteridaceae, Thymelaeaceae, Violaceae, Woodsiaceae, Xanthorrhoeaceae, Zosteraceae, Zygophyllaceae

Geographic coverage

The present dataset covers all the area of Catalonia (for a description of this area see “Study area” in “Project description”). The 96.48% of the records in the dataset are georeferenced. The coordinate system used is MGRS (UTM squares) and the accuracy of the grids is 10 km² (the coordinates have been generalized to blur sensitive locality information due to the threatened degree of these taxa).

The collecting intensity map (Figure 4) permits to evaluate the regions where threatened plants have been more prospected. The areas with more than 40 specimens (the last category of the legend map) are situated in the littoral regions of Cap de Salou in the south, Delta del Llobregat in the center and Cap de Creus and Aiguamolls de l'Empordà in the north of Catalonia; and in the northeastern mountainous region of Alta Garrotxa and Serra de l'Albera.

Aiguamolls de l'Empordà is the most prospected area and also the region with the maximum number of endangered taxa (Table 6). The botanical interest of this region is high as evidence the different floristic studies done in this area during different periods

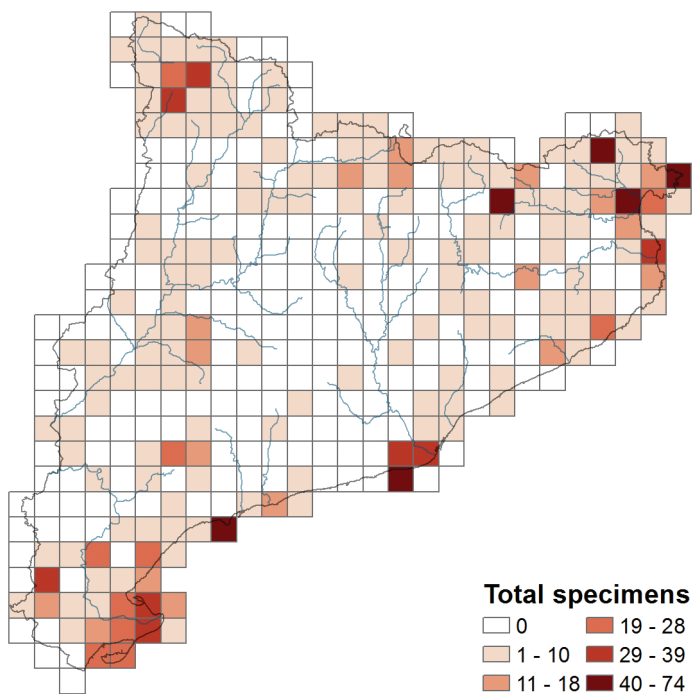


Figure 4. Distribution map of the number of specimens for UTM grid of 10 km².

Table 6. Number of specimens and taxa of the most prospected areas, with more than 40 specimens.

| UTM (regions) | Dataset | | Catalonia Red Book |
|-----------------------------------|---------|------|--------------------|
| | Spec. | Taxa | |
| 31TEG07 (Aiguamolls de l’Empordà) | 72 | 16 | 19 |
| 31TEG28 (Cap de Creus) | 59 | 10 | 7 |
| 31TDG57 (Alta Garrotxa) | 57 | 2 | 2 |
| 31TDG99 (Serra de l’Albera) | 58 | 12 | 13 |
| 31TDF16 (Delta del Llobregat) | 52 | 6 | 7 |
| 31TCF44 (Cap de Salou) | 47 | 8 | 7 |

(eg. Vayreda 1883, Malagarriga 1976, Farràs and Velasco 1994, Gesti 2006). The 80% of the specimens have been collected before 1925, as many of these taxa are now locally extinct in this area. Serra de l’Albera has also a large number of threatened taxa but unlike the previous region, has been visited fewer times as the 70% of the specimens were collected during the study by Font (2000). Cap de Creus is a peninsula of great floristic diversity with abrupt and rocky relief and has been visited by different botanists between 1869 and 2011. Delta del Llobregat has the 86% of the specimens collected before 1935 when this region was more natural and less urbanized than today.

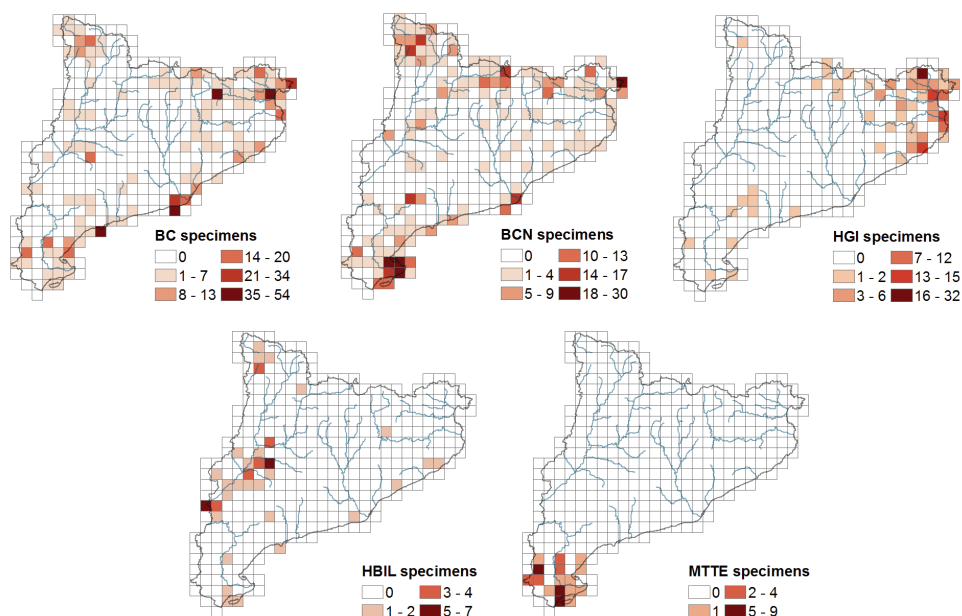


Figure 5. Distribution map of the specimens for UTM grid of 10 km² for each herbarium.

On the other hand, the region of Alta Garrotxa since only two threatened taxa lives in this region has been over-collected: *Oplismenus undulatifolius* with 6 specimens and the regional endemism *Polygala vayredae*, with 51 specimens yet explained above (see Table 3).

If we evaluate the collecting intensity map separated for each herbarium (Figure 5) we can see that local herbaria like HGI, HBIL and MTTE host a good representation of specimens from its surrounding area. In the case of the biggest herbaria (BC), the regions most prospected match those indicated in Table 6: Aiguamolls de l'Empordà, Delta del Llobregat, Cap de Salou and Alta Garrotxa. However, in BCN herbarium the most prospected area is Delta de l'Ebre, with 100 specimens collected during the floristic study of this region by Curcó (2003), although there are also a high number of specimens from Cap de Creus collected during the studies of Franquesa (1995) and Sáez (1997).

Table 7 shows the number of specimens and taxa of hotspot areas (with elevated number of threatened taxa) designated as Important Plant Areas (IPA) in the Red Book of Catalonia. In fact, all they have different protect regulation included in the Plan for Spaces of Natural Interest (PEIN, DOGC 1992) except the region of Empúries-l'Armentera situated in the littoral, with any protection directive. The most restricted protection is for Aigüestortes, situated in the east of the Catalanian Pyrenees and catalogued as National Park in 1955, so legal permits are needed to collect plants. But in

Table 7. Number of specimens and taxa of the hotspot areas defined in the Red Book of Catalonia; only squares with more than 8 taxa are recorded.

| UTM | Catalonia Red Book | Dataset | |
|-----------------------------------|--------------------|---------|------|
| | | Spec. | Taxa |
| 31TEG07 (Aiguamolls de l'Empordà) | 19 | 72 | 16 |
| 31TEG15 (Montgrí - baix Ter) | 13 | 35 | 13 |
| 31TDG99 (Serra de l'Albera) | 13 | 58 | 12 |
| 31TEG06 (Empúries - l'Armentera) | 12 | 14 | 10 |
| 31TCF00 (Delta de l'Ebre) | 12 | 19 | 6 |
| 31TCH32 (Naut Aran) | 11 | 33 | 8 |
| 31TCH21 (Aiguestortes) | 11 | 32 | 7 |
| 31TEG17 (Cap de Creus) | 10 | 20 | 11 |
| 31TBF72 (Massís del Port) | 10 | 37 | 10 |
| 31TBE99 (Delta de l'Ebre) | 10 | 24 | 9 |
| 31TCE09 (Delta de l'Ebre) | 10 | 21 | 4 |
| 31TCH22 (Naut Aran) | 9 | 22 | 7 |
| 31TDF27 (Delta del Llobregat) | 9 | 35 | 9 |
| 31TBF90 (Delta de l'Ebre) | 9 | 17 | 7 |
| 31TCF55 (Tarragona) | 9 | 10 | 5 |
| 31TBF71 (Massís del Port) | 9 | 11 | 5 |
| 31TCG31 (Ivars d'Urgell) | 8 | 17 | 6 |

fact, only 22% of the specimens have been collected before this regulation and the 69% have been collected between 1978 and 2009 by the University of Barcelona botanist team that studied this region (Carrillo and Ninot 1992, Guardiola et al. 2009).

Another important region is Ivars d'Urgell (31TCG31), a small area of halophilous and gypsum vegetation with 8 threatened taxa and included in the PEIN; this region is represented in the herbaria by 6 taxa and 17 specimens.

On the other hand, some UTM squares with a high number of threatened taxa have a poor presence in the herbaria. In some cases because they are littoral squares with a large part of the area in the sea like 31TBE99 and 31TCE09 from Delta de l'Ebre and 31TEG17 from Cap de Creus. But in other, the prospecting intensity is too low relating the number of threatened taxa; for instance, 31TCF55 in the littoral of Tarragona with only 10 specimens collected between 1893 and 1993 and 31TBF71 in the mountainous Massís del Port in the south with 11 specimens collected between 1917 and 2008.

In Tables 6 and 7 we can see that in some cases the number of taxa included in the dataset for each UTM square is lower or higher than the one of the Red Book, Figure 6 shows these differences. In the 34.26% of the squares the difference is zero (grey color), indicating that all the taxa cited in this book have minimum a specimen in the herbaria studied. The 45.37% of squares have a positive difference (colored yellow to

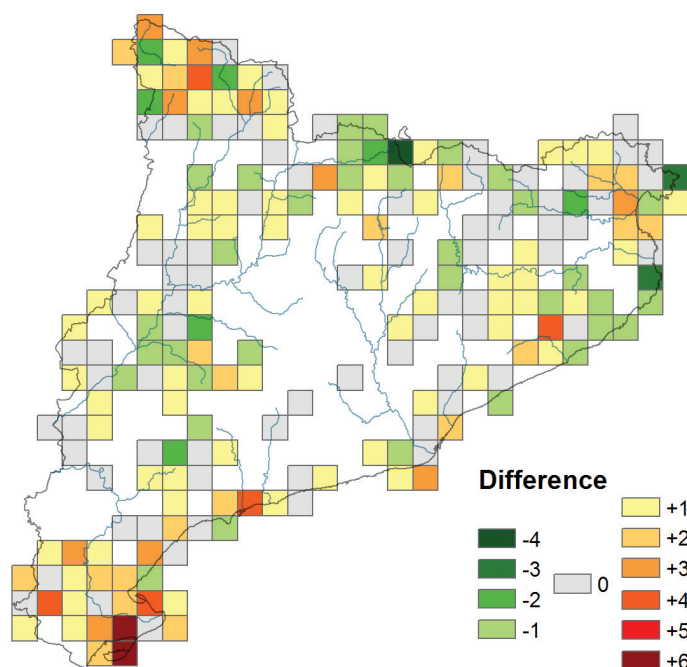


Figure 6. Comparative map of the number of taxa of the dataset and that according to Sáez et al. (2010: 733). Gray color indicates that all the taxa cited in this book have a specimen in the herbaria studied; yellow-red color indicates that the dataset doesn't include all the taxa published in this book and green color indicates that there are more taxa in the dataset than those published in this book.

red), meaning that the dataset doesn't include all the taxa published in this book. The regions less representatives in the herbaria (red squares) are in the south: two squares in Delta de l'Ebre yet indicated in Table 7.

The 20.37% of the squares have a negative difference (green color), indicating that there are more taxa in the dataset than in the Red Book. This is due, on one hand, to new citations published by different local botanists after the Red Book publication in 2010. For instance, in the UTM square 31TDG19, situated in La Cerdanya in the center of the Catalanian Pyrenees, the dataset includes specimens of *Gagea pratensis* and *Gagea reverchonii* published by Aymerich (2013) and so not indicated in the Red Book published three years before. This fact shows that herbaria are dynamic libraries of taxa if we compare with books that may become obsolescent once published. On the other hand this negative difference may also be due to some specimens that can provide new citations and are still to be studied and published. This second fact demonstrates that herbaria are important sources of hidden data.

Finally, highlight that for more of the 50% of the squares (difference zero or negative) all the taxa have almost a specimen which indicates the good representativeness of this kind of flora in the herbaria.

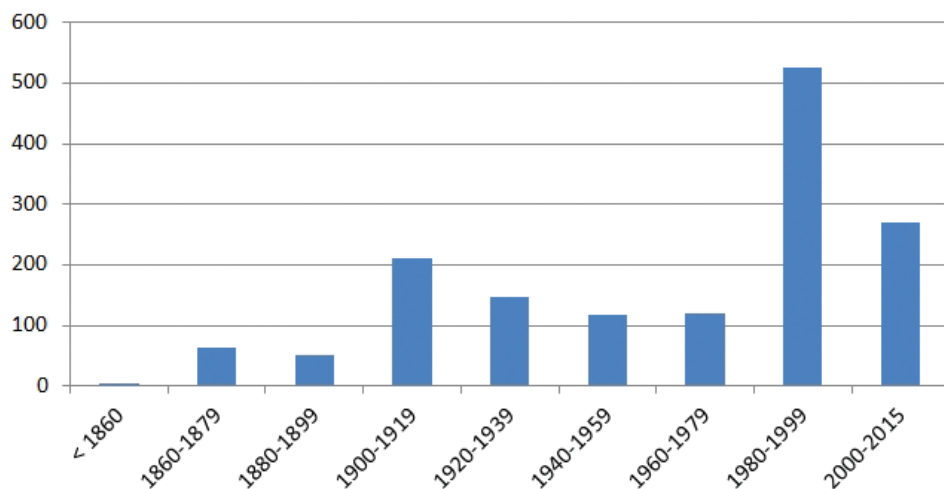


Figure 7. Collecting years according the specimens labels.

Temporal coverage

The 92.27% of the specimens have the collecting year indicated in the label. Among this, the temporal coverage is between 1861 and 2015 (Figure 7). There are 6 specimens from the Salvador's collection conserved in the BC herbarium, collected between 17th and 18th century (Ibáñez 2006), but without specific year in the label (in the figure are indicated as before 1860). In some cases, these old specimens are the testimony of the presence of a taxon in an extinct locality as the specimens of *Hydrocotyle vulgaris* and *Stachys maritima* from the coast of Barcelona.

The maximum number of specimens was collected since 1980 when the number of botanists dedicated to floristic studies significantly increases. After the regulation of the threatened flora in Catalonia with the publication in 2008 of the Catalogue of Endangered Flora (DOGC 2008) the specimens collected have been declined and there are only 112 specimens between 2009 and 2015 when legal permits are needed (the 6.92% of the whole dataset).

On the other hand, Figure 8 shows that the most part of specimens have been collected in spring and summer, when almost all the taxa are in flowering state in the study area.

Methods

Step description

The creation of this dataset has included different processes: (1) specimens searching, (2) specimens digitalization, (3) dataset documentation, (4) dataset unification and

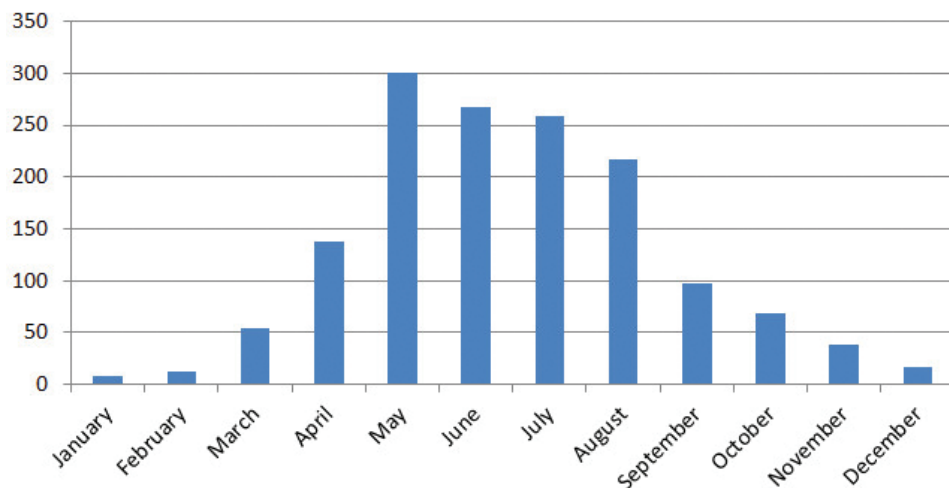


Figure 8. Collecting months according the specimens labels.

analysis and (5) dataset publication at the GBIF portal. The first three steps have been done by the responsibility of the curator of each herbarium.

1. The search of all the specimens of the Catalanian threatened taxa has been done exhaustively thanks to a list of synonyms prepared in Nualart et al. (2012) since specimens may be stored in the herbaria under different synonymous names.
2. The digitalization of the specimens has been done by different programs that allow the inclusion in the database of all the information in the label. In BC herbarium this step is managed with Herbar (Pando et al. 1994-2010), in BCN with an own application developed in Access, in HGI with an own program developed in File Maker Pro 2.0 by Macintosh (Campos et al. 1995) and in MTTE with MuseumPlus by ZetCom (<http://www.zetcom.com/en/products/museumplus/>) (the program used by all the Museums in Catalonia).
3. The dataset documentation includes all the revisions that have been taken place to improve the information of each specimen, such as check the locality of collecting thanks to information from the botanists' documentation and the database. Also the names of the collectors have been checked—when they were not clear—according to the calligraphy in the label. Moreover, all the localities have been geo-referenced wherever possible using coordinates UTM 10 Km² (MGRS system) from Catalonia geographical viewer (<http://www.icc.cat/vissir3>). In those specimens with more precise coordinates in the label, the coordinates have been generalized to blur sensitive information due to the threatened degree of these taxa. Furthermore, the locality information has been completed indicating wherever possible, the province and the municipality according to ICC (2009). Finally, the indication of the country and province has been standardized following the ISO 3166.

4. For the dataset unification a list of fields has been decided considering the maximum possible number of common fields in the different herbaria databases. This list includes the following information: (1) the catalog number, (2) the taxon name, (3) the information about the identification (date and researcher), (4) the locality information (country, province, municipality, locality name, UTM coordinates and altitude in meters), (5) the ecology and (6) the gathering information (date, collector, collector number and exsiccate or field campaign). Each curator has prepared its dataset in an Excel table and finally all the records of each herbarium have been unified in a single dataset. The analysis for describe the dataset (tables and graphics presented in this paper) have been carried out in Excel from this unique dataset. Distribution maps have been created using ArcGis 10.2.
5. For the publication in the GBIF portal all the data have been accommodated to fulfil the Darwin Core Standard (Wieczorek et al. 2012). The Darwin Test (Ortega-Maqueda and Pando 2008) has been used to convert coordinates from UTM to decimal degrees which are used in the Darwin Core format. The Integrated Publishing Toolkit (IPT v2.0.5) of the GBIF.es (<http://www.gbif.es:8080/ipt>) has been used to upload the Darwin Core Archive and to fill out the metadata.

Quality control description

Once the dataset has been completed (after the forth step of the methodology) a revision of the data has been carried out by comparing the distribution map obtained from the herbarium data of each taxon with that published in the Red Book and in the “Biodiversity data bank of Catalonia” (Font 2016). The specimens’ observations not recorded in these published distribution maps have been subjected to an accurate revision to ensure its validity. In these cases, the geospatial information has been checked and herbarium specimens have been reviewed to confirm taxonomic identification. This process has enabled to debug data and remove those specimens not well identified.

Other processes of quality control have been implemented in the third step yet explained in the methodology.

Dataset description

Object name: Darwin Core Archive Threatened plants of Catalonia.

Character encoding: UTF-8

Format name: Darwin Core Archive format

Format version: 1.0

Distribution: <http://www.gbif.es/ipt/resource?r=threatenedCAT>

Licenses of use: This Dataset is made available under the Open Data Commons Attribution

License: <http://www.opendatacommons.org/licenses/by/1.0>

Metadata language: English

Date of metadata creation: 2016-19-12

Hierarchy level: Dataset

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***Garcinia hopii* (Clusiaceae), a new species from Bidoup Nui Ba National Park, southern Vietnam**

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Abstract

A new species, *Garcinia hopii* H.Toyama & V.S.Dang is described from Bidoup Nui Ba National Park, southern Vietnam. This species is similar to *Garcinia hendersoniana* Whitmore but differs from that species in having larger leaves, clustered pistillate flowers, a greater number of sterile anthers and a larger stigma of young fruits. A description, preliminary conservation assessment, illustration, photographs and DNA barcodes of the new species are provided, as well as an updated key to *Garcinia* sect. *Hebradendron* in Indochina.

Keywords

Flora, Indochina, *matK*, *rbcL*, taxonomy

Introduction

The genus *Garcinia* L. (Clusiaceae) comprises about 260 species of usually dioecious small shrubs or trees up to 30 m tall which are common components of lowland tropical forests worldwide (Stevens 2007). The genus exhibits a remarkable diversity

in floral morphology which is used for delimiting the genus and constructing its infrageneric classification (Sweeney 2008). The latest monograph, published more than a century ago by Vesque (1893), classifies 180 species into 9 sections based on floral morphology. Among the sections by Vesque (1893), *G. sect. Hebradendron* with 19 species is distinguished from other sections by tetramerous flowers and multithecous anthers which are completely or incompletely dehiscent by a circumference slit. The most recent worldwide sectional treatment of *Garcinia* was performed by Jones (1980) in an unpublished PhD dissertation, in which she classified 31 species in *G. sect. Hebradendron* by adding species newly described after Vesque (1893) and partially correcting the statement on anthers which are peltate with one theca dehiscing by a circumscissile slit or multithecous dehiscing by each pore. The nucleotide-based phylogenetic analysis supported the monophyly of *G. sect. Hebradendron* (Sweeney 2008).

In Indochina, six species have been recorded in *G. sect. Hebradendron*: *Garcinia bonii* Pit., *G. elliptica* Wall. ex Wight, *G. gaudichaudii* Planch. & Triana, *G. hanburyi* Hook.f., *G. oligantha* Merr. and *G. poilanei* Gagnep. (Pierre 1880; Pitard 1910; Gagnepain 1943; Hô 1999; Dy Phon 2000; Li et al. 2007; Newman et al. 2007; Pooma and Suddee 2014). However, specimens of *G. bonii* in HN (*Phuong* 1535), K (*Tsang* 29824) and P (*Butreau* 39 & *Petelot* 4825) have tetramerous flowers and 4-angled stamens which are characteristic traits of *G. sect. Oxycarpus* (Vesque 1893). Gagnepain (1943) also noted that the male flowers of *G. bonii* are the same as in *G. cochinchinensis* Choisy (*G. sect. Oxycarpus*). Therefore, here we removed *G. bonii* from *G. sect. Hebradendron*.

From 2014 to 2016, botanical field surveys were carried out in Bidoup Nui Ba National Park, southern Vietnam, and a species of *G. sect. Hebradendron* that was distinct from any of the known species was found. Here, this plant is described as a new species, *G. hopii* H.Toyama & V.S.Dang, and a key for identification of all species of *G. sect. Hebradendron* in Indochina is provided. This conclusion is based on observations of specimens in the herbaria BKF, E, HN, K, KAG, KEP, KYO, L, P, RAF, TI and VNM and specimen images on the website of JSTOR Global Plants (<https://plants.jstor.org/>). DNA sequences of two DNA barcode regions have also been provided; the partial genes for the large sub-unit ribulose-1,5-bisphosphate carboxylase oxygenase (*rbcL*) and maturase K (*matK*) (CBOL Plant Working Group 2009); established protocols were used to determine the sequences of these regions (Kress et al. 2009; Dunning and Savolainen 2010).

Taxonomy

Garcinia hopii H.Toyama & V.S.Dang, sp. nov.

urn:lsid:ipni.org:names:77160927-1

Figures 1, 2

Diagnosis. This species is similar to *Garcinia hendersoniana* Whitmore (endemic to Peninsular Malaysia) in elliptic-orbicular coriaceous leaves but differs from that species

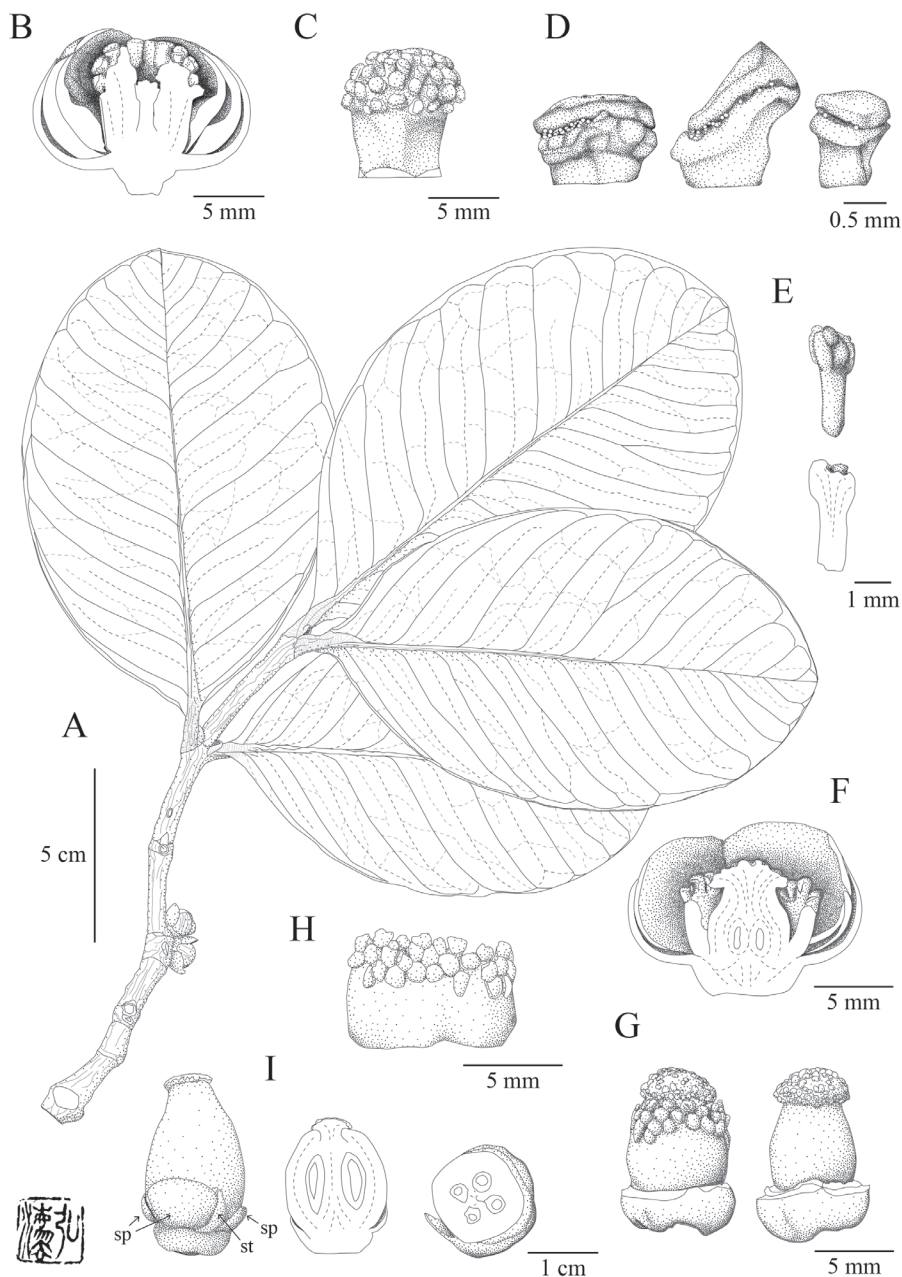


Figure 1. *Garcinia hopii* H.Toyama & V.S.Dang, sp. nov. **A** branch with pistillate flower **B** longitudinal section of staminate flower **C** lateral view of staminate flower, tepals removed **D** free part of stamens **E** lateral view (upper) and longitudinal section (lower) of pistillode **F** longitudinal section of pistillate flower **G** pistillate flower, tepals removed (left) and tepals and staminodes removed (right) **H** staminodes cut in half longitudinally **I** immature fruit (left) with sepals (sp) and staminodes (st) and its longitudinal (middle) and transverse (right) section. **A, F–H** from Toyama et al. V4475 (KYO) **B–E** from Toyama et al. V4476 (FU) **I** from Tran & Dang dv127 (FU). Drawn by H. Toyama.

in relatively larger leaves ($10\text{--}23.5 \times 6.5\text{--}15.5$ cm vs. $8\text{--}14 \times 5.5\text{--}8.5$ cm), clustered pistillate flowers (2–4 vs. solitary), a greater number of sterile anthers of pistillate flowers (40–64 vs. ca. 25) and a larger stigma of young fruits (4–6 mm vs. 3–4 mm in diam.).

Type. VIETNAM. Lam Dong Province, Bidoup Nui Ba National Park, montane evergreen forest, alt. 1781 m, $12^{\circ}11.41'N$, $108^{\circ}42.81'E$ (DDM), 27 February 2016, *H. Toyama, H. Nagamasu, S. Tagane, VS. Dang, VN. Nguyen & J. Wai V4475* [female fl. & young fr.] (holotype KYO!; isotypes DLU!, FU!, NTUF!, VNM!)

Description. Dioecious evergreen trees up to 10 m tall, all parts glabrous; trunk pale grey-brown to brown, with pale yellow-orange latex; twigs reddish green or green and slightly tetragonous when young, turning to greenish brown or dark-brown and terete when aging, with pale yellow latex. Leaves opposite; petioles 1.0–2.0 cm long; blade elliptic to orbicular, $(4\text{--})10\text{--}23.5 \times (3.2\text{--})6.5\text{--}15.5$ cm, length/width ratio 1.2–1.9, thickly coriaceous, obtuse to rounded at base, acute to rounded at apex, margin entire, slightly recurved when dried; mid-ribs slightly prominent above and prominent below; lateral veins 10–18 pairs, prominent and distinct on both surfaces when dried, joining into a weak intra-marginal vein that is ca. 2 mm apart from the margin; tertiary venation slightly visible on both surfaces when dried. Inflorescence of staminate flowers axillary, fascicles of (1–)2–9 flowers. Staminate flowers tetramerous; pedicels ca. 2 mm long; sepals 4, ovate-orbicular, outer sepals $6.5\text{--}9 \times 7\text{--}9.5$ mm, inner ones $7\text{--}9 \times 8\text{--}10$ mm wide, apex rounded, dark red when young, turning yellowish green when aging; petals 4, ovate-orbicular, outer petals $7\text{--}9.5 \times 9\text{--}13$ mm, inner ones $7\text{--}9 \times 8\text{--}12$ mm, thicker than sepals, apex rounded, bright yellow to yellow-orange; stamens 46–55, pharangiate, surrounding pistillode; free part of stamens $0.7\text{--}1.5 \times 0.5\text{--}1$ mm; free part of filaments ca. 0.5 mm long; anthers with one theca, peltate, dehiscing by a circumscissile slit; pistillode present, ca. 3.5 mm long, ca. 1 mm in diam. Inflorescence of pistillate flowers axillary, fascicles of (1–)2–4 flowers. Pistillate flowers tetramerous; pedicels ca. 2 mm long; sepals ovate-orbicular, outer sepals $6\text{--}9 \times 8\text{--}10$ mm, inner ones $7\text{--}8 \times 9\text{--}10$ mm, apex rounded, dark red when young, turning yellowish green when aging; petals ovate-orbicular, outer petals $8\text{--}9.5 \times 8.5\text{--}11.5$ mm, inner ones $6\text{--}8.5 \times 8\text{--}10$ mm, thicker than sepals, apex rounded, bright yellow or pale dark red; staminodes present, 40–64, united in a ring surrounding pistil, $5\text{--}6 \times 18\text{--}22$ mm when open, connate into a receptacle; free part of filaments almost sessile; pistil 5.5–10 mm long, 5–7 mm in diam.; ovary ovoid, 3–6 mm long, 4.8–7 mm in diam., 4-locular; style ca. 1–2 mm long, 3–4.5 mm in diam.; stigma convex, 2–2.5 mm long, 4–5.5 mm in diam., papillose. Young fruits (*Toyama et al. V4475, Tran & Dang dv127*) solitary, ellipsoid or flask-shaped, 1.1–2.0 cm long, 1.3–1.4 cm in diam., yellow green with red gradient, sepals and staminodes persistent at base, stigma persistent at apex, ca. 1 mm long, 4–6 mm in diam., slightly convex when young, turning to flat when aging; pedicels ca. 3 mm long. Mature fruits unknown. Seeds unknown.

Other specimen examined. VIETNAM. Lam Dong Province, Bidoup Nui Ba National Park, $12^{\circ}11'N$, $108^{\circ}43'E$, 23 April 1997, *L. Averyanov, NQ. Binh & NT. Hiep VH4229* [female fl.] (HN!); *ibid.*, alt. 1644 m, $12^{\circ}11.21'N$, $108^{\circ}42.87'E$ (DDM), 19

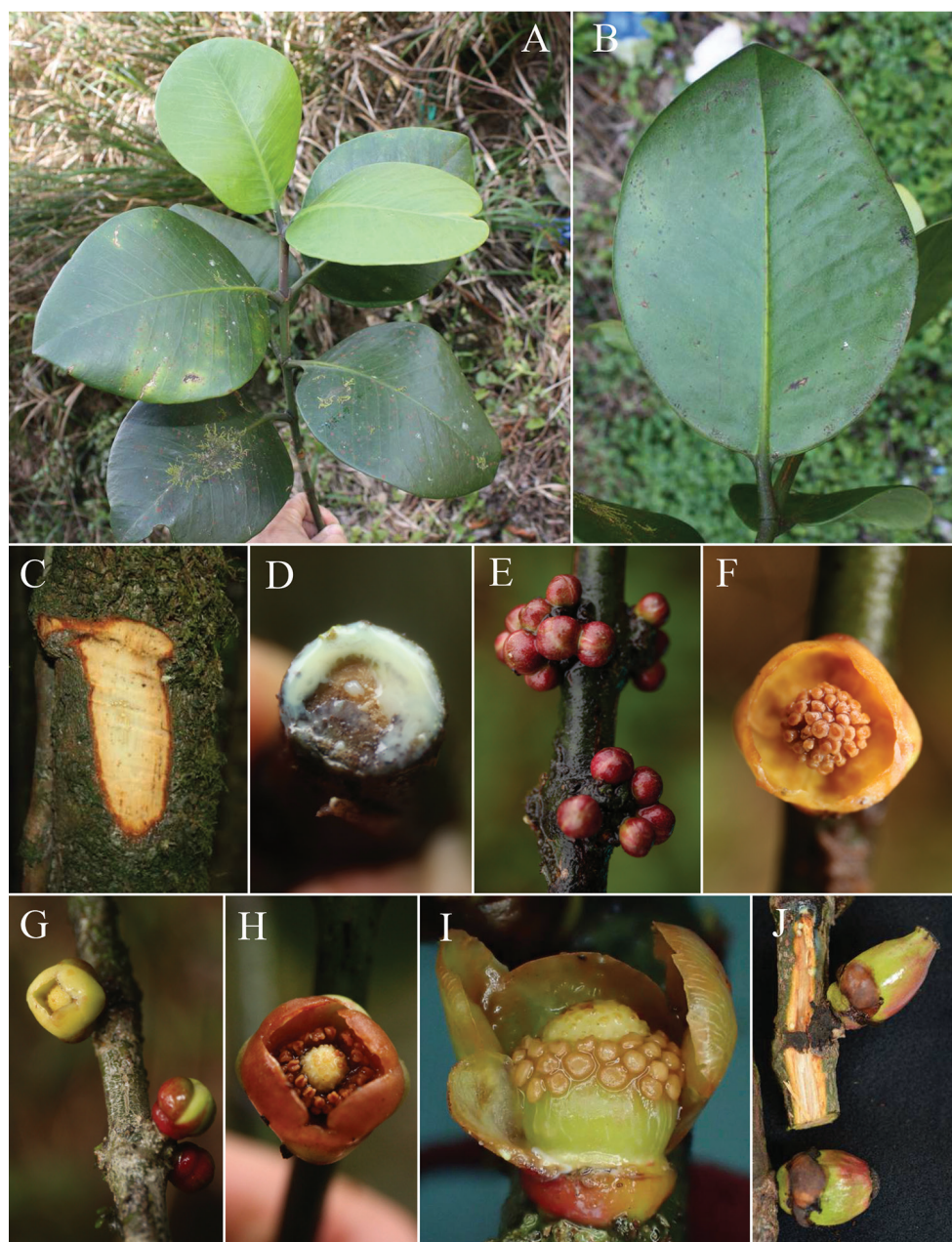


Figure 2. *Garcinia hopii* H.Toyama & V.S.Dang sp. nov. **A** branch with leaves **B** abaxial surface of leaf **C** trunk **D** latex **E** staminate flower buds **F** staminate flower **G** pistillate flower and buds **H** pistillate flower **I** pistillate flower, some tepals removed **J** immature fruits. **A–C** photographed on 22 January 2015 **E** photographed on 19 November 2014 **D, F–I** photographed on 27 February 2016, **J** photographed on 24 April 2015.

November 2014, *H. Toyama, S. Tagane, VS. Dang, H. Nagamasu, A. Naiki, H. Tran, C.J. Yang, NQ. Cuong, HNP. Hieu & XN. Loi V1891* [male fl. buds] (FU!, VNM!); *ibid.*, alt. 1644 m, 12°11.21'N, 108°42.87'E (DDM), 24 April 2015, *H. Tran & VS. Dang dv127* [male fl. & young fr.] (KYO!, VNM!); *ibid.*, alt. 1807 m, 12°11.47'N, 108°42.78'E (DDM), 23 February 2016, *S. Tagane, H. Nagamasu, A. Naiki, VS. Dang, VN. Nguyen & J. Wai V4174* [male fl.] (DLU!, FU!, NTUF!, VNM!); *ibid.*, alt. 1807 m, 12°11.47'N, 108°42.78'E (DDM), 27 February 2016, *H. Toyama, H. Nagamasu, S. Tagane, VS. Dang, VN. Nguyen & J. Wai V4476* [male fl.] (DLU!, FU!, NTUF!, VNM!)

Distribution and habitat. *Garcinia hopii* is only known from Bidoup Nui Ba National Park, southern Vietnam. It is common in moist evergreen forests dominated by *Quercus poilanei* Hickel & A. Camus, *Neolitsea umbrosa* (Nees) Gamble, *Podocarpus neriifolius* D. Don, *Polyosma nhatrangensis* Gagnep. and *Symplocos sulcata* Kurz at alt. 1640–1810 m.

Phenology. Flower buds were observed in November. Flowers were observed in February and April. Immature fruits were observed in April.

Etymology. *Garcinia hopii* is named after Prof. Hop Tran, University of Science Ho Chi Minh City, who collected the flowering and fruiting specimens [*Tran & Dang dv127* (FU, VNM)].

Preliminary conservation status. *Garcinia hopii* is commonly found at Hon Giao Ridge area in Bidoup Nui Ba National Park. There are many reproductive trees and the forest is well protected. Therefore, this species is assessed as Least Concern (LC) according to IUCN Red List Categories (IUCN 2012).

Note. In Indochina, *Garcinia hopii* is similar to *G. poilanei*, but differs from that species in having larger leaves (10–23.5 × 6.5–15.5 cm vs. 8–11 × 5–5.5 cm), clustered staminate flowers (2–9 vs. solitary), pistillode present (vs. absent), short pedicellate flowers (pedicels ca. 2 mm long vs. sessile) and a greater number of anthers of staminate flowers (46–55 vs. 15–18).

GenBank Accession No. *Toyama et al. V1891*, LC198063 (*rbcL*), LC198064 (*matK*).

A key to the species of *Garcinia* sect. *Hebradendron* in Indochina

- 1 Length/width ratio of lamina > 2 2
- Length/width ratio of lamina < 2 3
- 2 Lamina 5–9 × 1.5–3.5 cm; petioles 4–12 mm long; secondary veins 5–6 pairs *G. oligantha*
- Lamina 11–14 × 3–3.5 cm; petioles 10 mm long; secondary veins 10–20 pairs *G. elliptica*
- 3 Pedicels 0–3 mm long in staminate flowers 4
- Pedicels 10–12 mm long in staminate flowers *G. hanburyi*
- 4 Staminate flowers in fascicles with pedicels 2–3 mm long 5
- Staminate flowers solitary, sessile; stamens 15–18; pistillode absent *G. poilanei*

- 5 Stamens 10–25 in staminate flowers; pistillode absent. Pistillate flowers solitary; staminodes 13–19..... *G. gaudichaudii*
- Stamens 46–55 in staminate flowers; pistillode present. Pistillate flowers in fascicles; staminodes 40–64..... *G. hopii*

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Distribution of the invasive plant species *Heracleum sosnowskyi* Manden. in the Komi Republic (Russia)

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Abstract

Occurrences of the invasive plant species *Heracleum sosnowskyi* Manden. in the Komi Republic (northeastern part of European Russia) were recorded and published in the Global Biodiversity Information Facility (GBIF <http://www.gbif.org>) using the RIVR information system (<http://ib.komisc.ru/add/rivr/en>). RIVR stands for “*Rasprostraneniye Invasionnykh Vidov Rasteniy*” [Occurrence of Invasion Plant Species]. This citizen science project aims at collecting occurrence data about invasive plant species with the help of citizen scientists. Information can be added by any user after a simple registration (concept) process. However, the data published in GBIF are provided only by professional scientists. The total study area is approximately 19,000 km². The GBIF resource contains 10894 *H. sosnowskyi* occurrence points, each with their geographical coordinates and photographs of the plants in the locus of growth. The preliminary results of species distribution modelling on the territory of European North-East Russia presented.

Keywords

Occurrence, human observation, *Heracleum sosnowskyi*, hogweed, invasive, geotagged photographs, Komi Republic, European North-East Russia

Project details

Project title

“Ecophysiological modelling of invasive plant species distribution. The case of *Hera-
cleum sosnowskyi* in the taiga zone of the European part of Russia”

Funding

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Study area description

The Komi Republic is located in the north-east of the Russian Plain and the western slopes of the northern Ural Mountains. It is a large and an important biogeographic boundary that separates the flora and fauna of two continents – Europe and Asia.

On the plain territory of the Komi Republic, a pronounced latitudinal-nature zonation occurs. The extreme north-east is taken by a subzone of the southern tundra. The forest-tundra is a transition zone between the tundra and taiga. In the Pechora Province, it has a width of 100–120 km forming the southern periphery of the territory that has the Bolshezemelskaya tundra. The main type of vegetation in the Republic of Komi is the boreal (taiga) forest. The taiga zone is divided into the following subzones: Extreme northern, Northern, Middle, and Southern. The eastern edge of the Republic is occupied by the Ural Mountains, where altitudinal zonation occurs with distinct Mountain forest, Alpine tundra, and Cold deserts zones (Gorchakovskij 1975).

A large part of the republic has a climate similar to that of the Atlantic-Arctic region with a cold temperate (boreal) climate (Brattsev et al. 1997). The territory is a zone of excessive moisture, widespread marshes, and wetlands. The annual precipitation exceeds the evaporation and decreases from south to north, from 700 to 550 mm. A significant difference in the climate is observed across the length of the republic from south to north and from west to east. The duration of the winter in the south of the republic is 170–180 days and that in the north is 230–250 days. The average temperature in January (the coldest month) in the south is 15 °C whereas that in the north-east is –22 °C. Summers are short and warm; the average temperature in July (the warmest month) is approximately 10°C in the north-east and 17°C in the south. The prevailing wind directions in winter are south and south-west, and north in summer. The monthly average wind speed in the taiga zone is 3–4 m/s and that in the tundra area is 6.5 m/s.

Biological diversity of the Komi Republic region includes 929 fungi, 1217 vascular plants, 653 moss, 1020 lichen, 2,000 algae, more than 3,500 arachnid, more than 6,000 insect, 50 fish, six amphibian, five reptile, 265 bird, and 57 mammal species. There are 237 forest, floristic, meadow, marsh, ichthyological, ornithological, and geo-

logical reserves and natural monuments on the territory of Komi. The Pechora-Ilych State Reserve and the Yugyd Va National Park occupy 13.5% of the total territory of the republic (Ponomarev and Tatarinov 2012).

Design description

The project design combines an experimental approach and analysis of results of the observations. The responses of *H. sosnowskyi* plants to the changes in the abiotic environmental parameters were obtained by instrumental measurements of the morphological and physiological parameters (including CO₂/H₂O gas exchange, chlorophyll fluorescence, and heat dissipation) in the plants grown in climatic chambers and experimental plots. The data of the optimal and critical values of the environmental factors (heat, light, rainfall, and soil) required for the survival and reproduction of the plants were used for a joint analysis along with the geographically referenced data of these factors. The results were arranged in a raster map showing the potential areas of *H. sosnowskyi*. The resulting map was verified by a direct comparison with the data of the field observations of the habitats of this species and with the correlation simulation of their geographical distribution.

Data published through

GBIF: http://ib.komisc.ru:8088/ipt/resource?r=heracleum_occurrence

Taxonomic coverage

General taxonomic coverage description

The resource contains occurrence data only for one species – *H. sosnowskyi* Manden.

Taxonomic ranks

Kingdom: Plantae

Phylum: Tracheophyta

Class: Magnoliopsida

Order: Apiales

Family: Apiaceae

Genus: *Heracleum*

Species: *Heracleum sosnowskyi*

Common names: Sosnowsky's hogweed, plants, vascular plants, flowering plants, carrot family, hogweed

Spatial coverage

General spatial coverage

The geographical coverage is essentially limited to the Komi Republic territory located in the European part of Russia. Currently, all populations of *H. sosnowskyi* in this area are invasive. This species was introduced into this region in the second half of the 20th century as a forage crop. Since 2012 varieties of this species are excluded from the register of the breeding achievements of the Russian Federation (Official bulletin 2012; http://gossort.com/bullets/pdf/bull_176.pdf). This species is also included in the “specialised catalogue of weeds” (Information letter 2015; <http://antibor.ru/sites/526a0b00d7e1e49744000002/assets/56fa0dcdd7e1e4c087062929/pismo1-2.jpg>).

Coordinates

59°22.48'N and 66°7.12'N Latitude; 48°56.24'E and 60°20.24'E Longitude

Temporal coverage

28 July 2012 - 23 August 2016

Methods

Method description

Photographs of plants were taken using consumer cameras. Videos were recorded with a Car DVR Camera (video 1280×960 pixels at 30 frames/second), mounted on the car windshield (height from the road surface was 170 cm). The survey was conducted at speeds of 60–90 km/h. The GPS track was simultaneously recorded with GPS navigators. The time on the cameras and video recorders were synchronised with the time displayed on the GPS navigation device.

All the images were geotagged by a GPS track log with “GPS Correlate” software (v 1.6.1, <https://github.com/freefoote/gpscorrelate>) according to the methods described in the OpenStreetMap Project documentation (Geotagging Source Photos 2016; http://wiki.openstreetmap.org/wiki/Geotagging_Source_Photos). The video files were broken into frames (one frame per second) and the frames were saved as “jpeg” files with the program FFmpeg (v 3.1.4 <http://www.ffmpeg.org>) followed by geotagging of these files similar to that of the photographs. The array of images was hand sorted into two groups: images that contained *H. sosnowskyi* plants and images

without these plants. The coordinates of the photographs obtained from a Car DVR Camera were corrected in the Quantum GIS Geographic Information System (QGIS) program (v 2.16.3 <http://www.qgis.org>, QGIS Development Team 2016) by shifting the group of points on the side of the road. All geotagged *H. sosnowskyi* images were uploaded to the online database “Occurrence of invasive plant species *Heracleum sosnowskyi* Manden.” (RIVR 2016).

Study extent description

The occurrence data of *H. sosnowskyi* were collected from an area of approximately 19, 000 km² (Figure 1). Most of the data were collected from the capital area of Komi, Syktyvkar (61°39.95'N, 50°49.53'E) as well as along the roads at a distance of 300 km from Syktyvkar, the directions of which coincide with the flow direction of the major rivers Vychegda and Sysola belonging to the Northern Dvina basin. A separate cluster of the data was collected from a 664 km (orthodromic) distance in the territory and suburb of Inta city, located near the Arctic Circle (66° 1.87'N, 60° 8.72'E). A pronounced sampling bias should be considered before using the data for the species distribution modelling. Data were collected close to the settlements or the roads connecting them, which is a travel time bias (Fourcade et al. 2014). In the case of *H. sosnowskyi*, such a sampling bias may coincide with the actual factors determining the dispersal of the plants of this species. In most cases, roadsides are the optimal habitats for this species as they are open and well-lighted with adequate moisture due to the roadside drainage systems. Moreover, the air flow creates favourable conditions for the spread of the plants.

Sampling description

The occurrence data consist of the presence data only. Two methods were used for the creation of occurrence records, which include the data collection along transects (7130 points) and mapping of *H. sosnowskyi* boundaries that were later converted to regular points sample (3764 points). The regular points sample coordinates were generated using the QGIS Desktop software (v 2.16.3). The points were created with a 25 m point spacing within polygon layers that indicated the *H. sosnowskyi* population boundaries. The occurrences were labelled with a tag “Generated Regular Sample” written in the “occurrence remarks” field. The “associated media” field contained the URL of the locality map showing the generated point pattern with the scale bar and the north end on top of the map.

Data along transects were collected by recording a video of *H. sosnowskyi* plants growing along the roadsides and by taking photographs in the direction perpendicular to the road at a distance of up to 5 km.

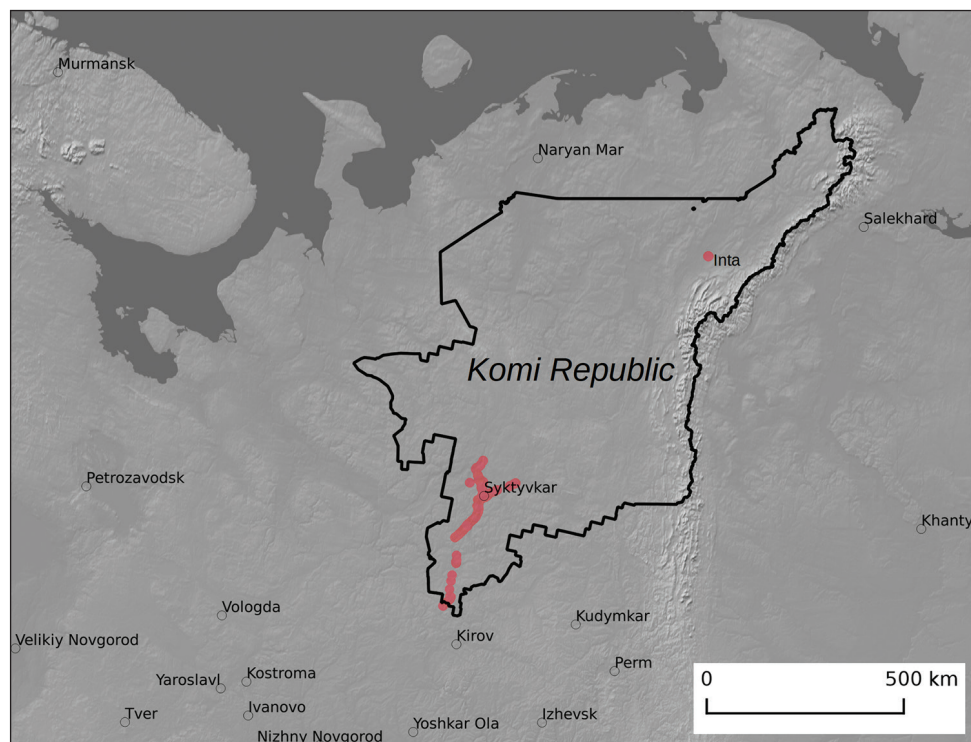


Figure 1. Study area. Red points indicate occurrences of *Heracleum sosnowskyi* described in the data paper.

Quality control description

The published data collected by professional scientists with sustainable skills for the identification of *H. sosnowskyi* and its differences from other similar species in its habitats were published in GBIF whereas that collected by volunteers were accumulated in the RIVR system. Before publication, data were checked for gross errors in georeferencing by visual inspection of the overlay points on the map with the borders of Russian regions in OpenStreet in the QGIS Desktop.

The presence of duplicate records was checked by running a special SQL script. The records were counted as duplicated if three fields were the same: the coordinates, the date of the event, and the file name of the photograph. For many data points (1080 of 10894 points, 10%), the same dates and coordinates were detected; however, they presented a series of photographs (2 to 13). These data were saved in the system as they could be of interest for the assessment of the landscape and the evaluation of plants in the *H. sosnowskyi* habitat.

Species distribution modelling

The described dataset was used for *H. sosnowskyi* species distribution modelling (SDM). The SDM was performed for two plots. Plot 1 was a rectangular, limited by latitudes:

61.0088°N, 62.1387°N and longitudes: 49.5013°E, 51.5941°E. The area of Plot 1 was 9 180 km². The Plot 2 was a rectangular, limited by latitudes: 57.0000°N, 70.0000°N, 42.0000°E, 68.0000°E. The area of Plot 2 was 1 857 586 km². All coordinates were given in the WGS84 projection (EPSG: 4326).

Two groups of predictors were used. Group 1: the state of the earth's surface, with a spatial resolution of 1 second (≈ 30 m) per pixel (data was collected for Plot 1 only): VEG = vegetation cover map derived from classification of satellite images (20 classes); ROAD = proximity map to the nearest road; AGRO = proximity map to the nearest borders of agricultural areas. Group 2: bioclimatic variables are derived from the monthly temperature and rainfall values obtained from WorldClim (Hijmans et al. 2005; <http://www.worldclim.org/bioclim>) with resolution of 30 second (≈ 1000 m) per pixel (data was collected for Plot 1 and Plot 2): BIO1 = Annual Mean Temperature; BIO2 = Mean Diurnal Range; BIO3 = Isothermality; BIO4 = Temperature Seasonality; BIO5 = Max Temperature of Warmest Month; BIO6 = Min Temperature of Coldest Month; BIO7 = Temperature Annual Range (BIO5-BIO6); BIO8 = Mean Temperature of Wettest Quarter; BIO9 = Mean Temperature of Driest Quarter; BIO10 = Mean Temperature of Warmest Quarter; BIO11 = Mean Temperature of Coldest Quarter; BIO12 = Annual Precipitation; BIO13 = Precipitation of Wettest Month; BIO14 = Precipitation of Driest Month; BIO15 = Precipitation Seasonality (Coefficient of Variation); BIO16 = Precipitation of Wettest Quarter; BIO17 = Precipitation of Driest Quarter; BIO18 = Precipitation of Warmest Quarter; BIO19 = Precipitation of Coldest Quarter.

All data were obtained from open sources, either directly or as a result of raw data processing in geographic information systems. The rights to use the Komi Republic agriculture area map were acquired under a license agreement with the State Organization "Syktyvkar Agrochemical Service Station".

The presence data of *H. sosnowskyi* occurrences were obtained as a random sample of GBIF dataset described in this article. Five hundred randomly chosen presence points were taken for modelling at Plot 1 and 1000 points for modelling at Plot 2. Furthermore, 500 (for Plot 1) and 1000 (for Plot 2) randomly distributed points were used as a background point.

SDM was performed with generalized linear multiple regression model in R (R Core Team 2014) with dismo package (Hijmans et al. 2017).

Model fitting with the predictors VEG, ROAD and AGRO showed statistically significant ($p < 0.0001$) relationship with the dependent variable (*H. sosnowskyi* presence in the given point). ROC analysis showed that AUC value for the regression model was 0.92). These results were supported by field observations, invasion history and ways of *H. sosnowskyi* seed dispersal. The plant occupies habitats with disturbed soil cover, spreading rapidly along roads, due to the transfer of seeds by air flow, avoids shaded and dry habitats (Fig. 2).

Model fitting at Plot 1 and Plot 2 with bioclimatic predictors revealed a statistically significant relationship with eight predictors: BIO2, BIO4, BIO5, BIO6, BIO7, BIO10, BIO12 and BIO17. The model with all these predictors showed AUC value 0.99. Prediction with the model obtained within Plot 2 allowed to iden-

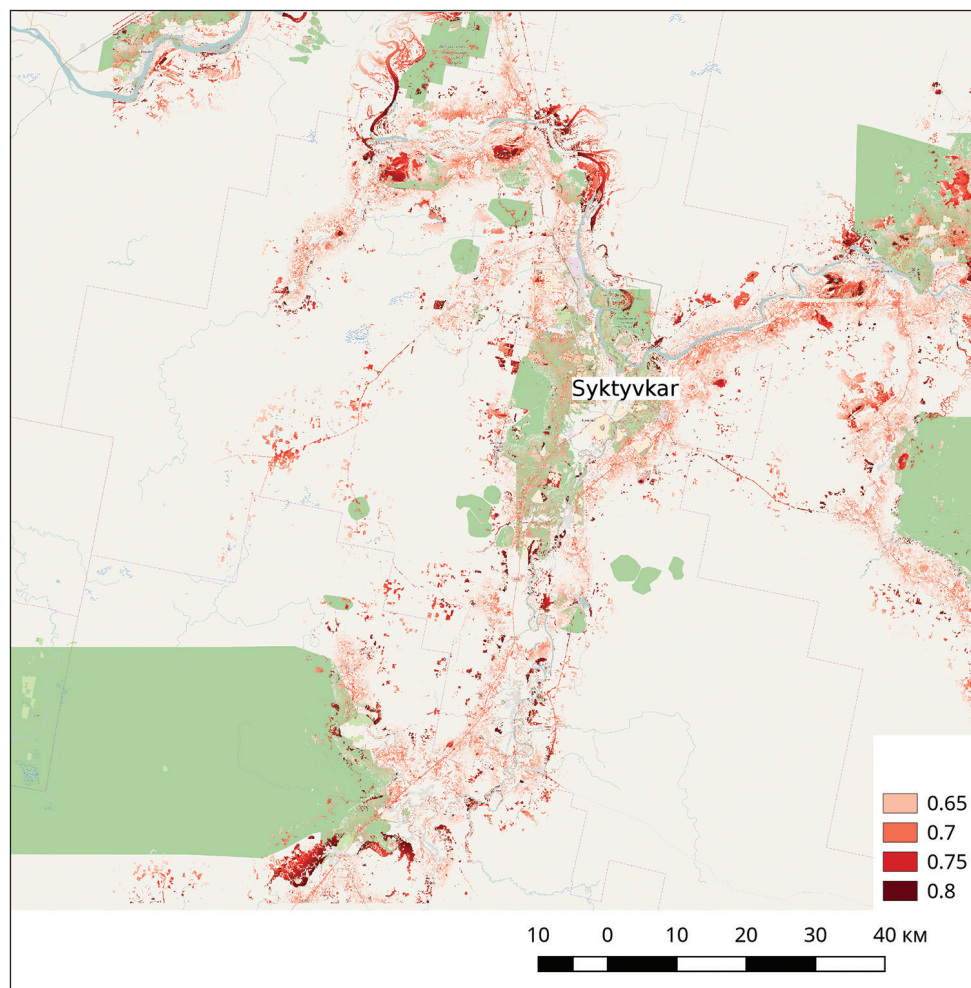


Figure 2. The prediction map of *Heracleum sosnowskyi* habitats prepared with the species distribution model based on vegetation cover map, nearest road proximity map, proximity map to the borders of agricultural areas. The colour scale shows the probability *H. sosnowskyi* presence.

tify the putative northern *H. sosnowskyi* range boundary — 67.2000°N , within the borders of the valley of the Pechora river (Fig. 3). According to the model, the values of bioclimatic variables in the areas with maximum probability of *H. sosnowskyi* presence were as follows (mean and standard deviation): BIO2: $8.3 \pm 0.2^{\circ}\text{C}$, BIO4: $112 \pm 1^{\circ}\text{C}$, BIO5: $21.2 \pm 0.6^{\circ}\text{C}$, BIO6: $-21.9 \pm 0.3^{\circ}\text{C}$, BIO10: $3.6 \pm 0.6^{\circ}\text{C}$, BIO12: $567 \pm 24\text{ mm}$.

The presence of *H. sosnowskyi* invasive plants in the northern forest-tundra sub-zone (66.0000°N) was confirmed by field observation on the territory of Inta city (Komi Republic). *H. sosnowskyi* plants formed monostand and showed high enough seed productivity (up to 12 000 seeds per plant) in this area.

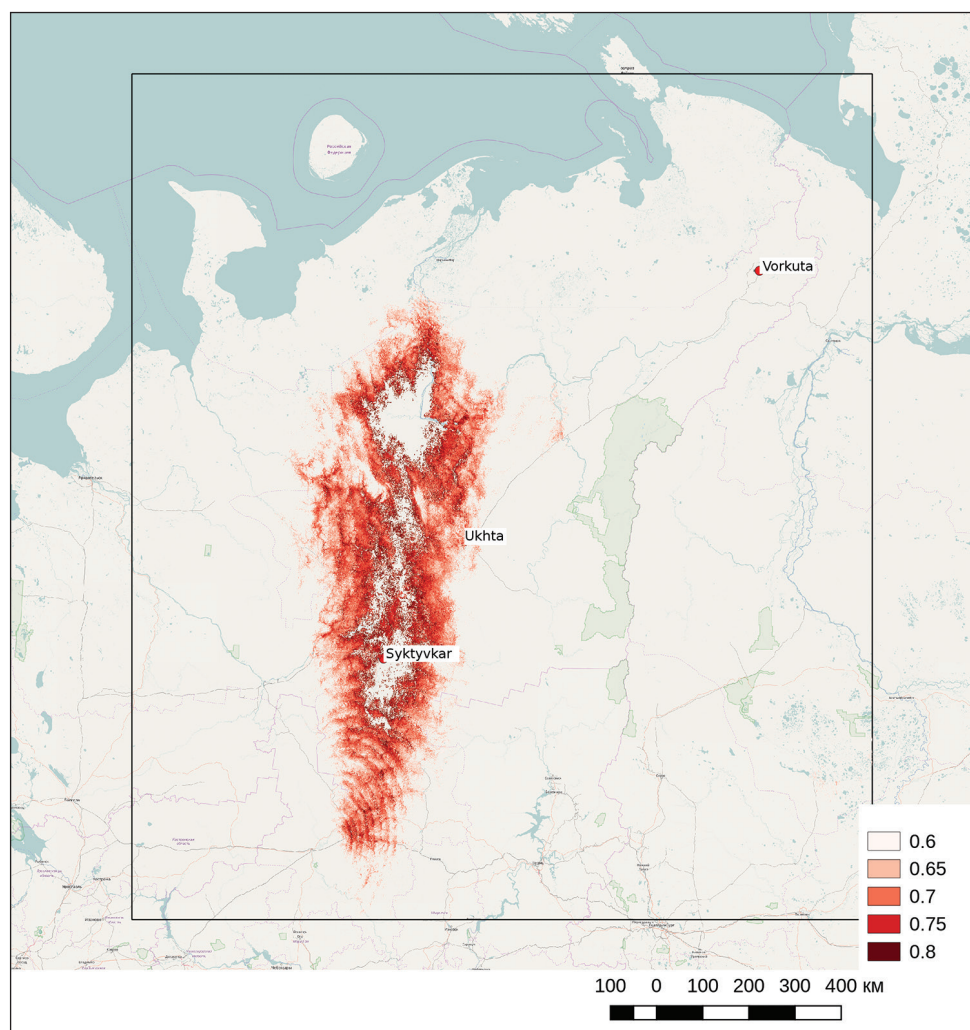


Figure 3. The prediction map of *Heracleum sosnowskyi* habitats prepared with the species distribution model based on bioclimatic predictors. The borders of Plot 2 within which the model prediction was made. The colour scale shows the probability *H. sosnowskyi* presence.

Datasets

Dataset description

Object name: Darwin Core Archive Occurrences of the invasive plant species *Heracleum sosnowskyi* Manden. in the Komi Republic (European North-East Russia)

Character encoding: UTF-8

Format name: Darwin Core Archive format

Format version: 1.0

Distribution: http://ib.komisc.ru:8088/ipt/archive.do?r=heraclueum_occurrence

Publication date of data: 2016-10-19

Language: English

Licences of use: This work is licensed under a Creative Commons Attribution (CC-BY) 4.0 License.

Metadata language: English

Date of metadata creation: 2016-09-07

Hierarchy level: Dataset

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Four new synonyms and a new combination in *Parnassia* (Celastraceae)

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Abstract

Parnassia yunnanensis had been previously described based on mixed specimens containing materials partially belonging to *P. cacuminum*, which makes the application of *P. yunnanensis* ambiguous. Therefore, we lectotypified *P. yunnanensis* and meanwhile synonymized *P. lanceolata* var. *oblongipetala* under it. *P. yunnanensis* var. *longistipitata* was found more similar to *P. cacuminum* rather than *P. yunnanensis*, thus a new combination, *P. cacuminum* var. *longistipitata* **comb. nov.** was proposed. Furthermore, other three names (*P. vevusta*, *P. degeensis* and *P. kangdingensis*) were reduced to synonyms of *P. cacuminum* too.

Keywords

Taxonomy, lectotypification, *Parnassia*, morphology

Introduction

Parnassia L. is a genus containing approximately 70 species (Ku and Hultgård 2001) which are predominantly distributed in arctic and temperate zones of the northern hemisphere and are mostly diverse in China and the Himalayas (Simmons 2004).

Parnassia yunnanensis Franch. (1896: 266) was described from Heqing, Yunnan province in China in 1896 which based on two collections (*Delavay* 710 and *Delavay s.n.*). Four duplicates of *Delavay* 710 were successfully traced from P and K (herbaria acronyms following Thiers 2016). However, one of these duplicates deposited in P (barcode number P00709380, Figure 1a) is a mixed specimen: an individual indicated by a circle bears obovate petals (magnified as Figure 1b, d), while the rest

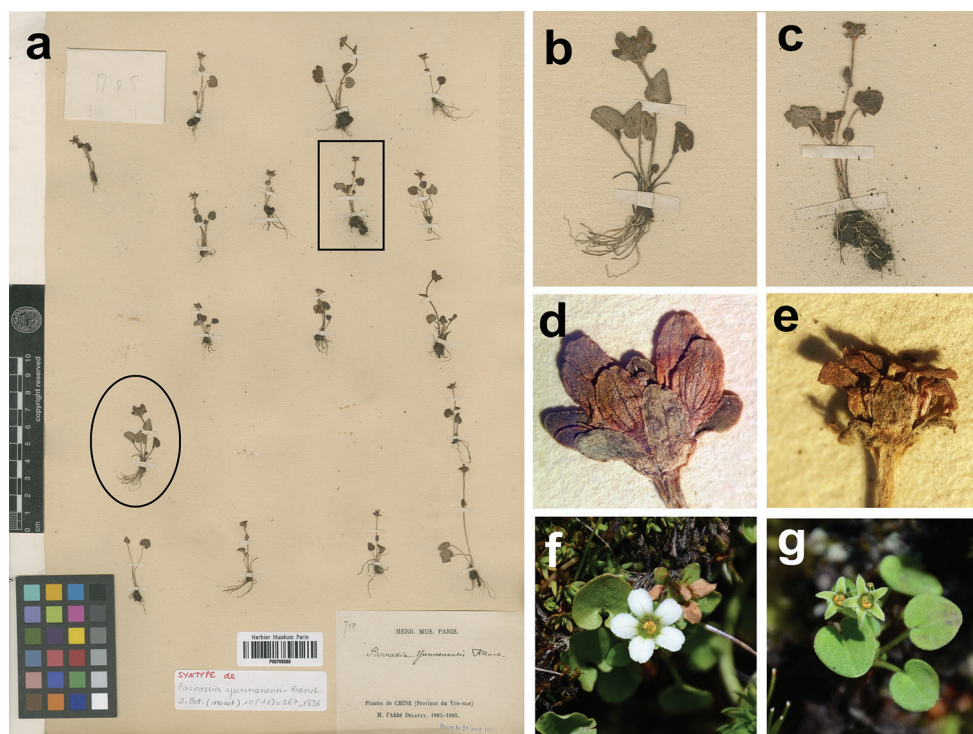


Figure 1. A mixed type specimen of *Parnassia yunnanensis*. The sheet of Delavay 710 with barcode P 00709380 (a), the individual indicated with a circle and magnified should be determined as *P. cacuminum* (b, d), an individual represents the rest, indicated with a square and magnified (c, e), *P. cacuminum* (f) and *P. yunnanensis* (g) in the wild.

possess lanceolate petals (Figure 1c, e, magnified from the individual indicated by a square). Obviously, they are different taxa, the individual with obovate petals should be *P. cacuminum* Hand.-Mazz. (1931: 433). Franchet used ‘oblonga’ to describe the shape of petals in the protologue of *P. yunnanensis*, that made this name ambiguous, some new names were published to be closely related to *P. yunnanensis* but were actually close to or conspecific with itself or *P. cacuminum*.

Pan described *P. longipetaloides* J.T. Pan (1985: 222) based on *Jinshajing Exped.* 6105 in KUN collected from Eryuan, Yunnan in 1963 and this name was placed in synonymy of *P. yunnanensis* in *Flora Yunnanica* (Chuang 2006). According to T.T. Yu 7429A collected from Muli, Sichuan province in 1937, *P. lanceolata* T.C. Ku (1987: 34) was described by Ku and soon after, she proposed a new variety, *P. lanceolata* var. *oblongipetala* T.C. Ku (1991: 82) based on an isotype of *P. longipetaloides*, *Jinshajing Exped.* 6105 stored in PE. Wu et al. (2008) reduced *P. lanceolata* to a synonym of *P. yunnanensis*, but they did not mention var. *oblongipetala*.

Parnassia yunnanensis var. *longistipitata* Z.P. Jien (1963: 255) was proposed in 1963. This variety has white petals which are significantly different from *P. yunnanensis* but closer to *P. cacuminum*. *Parnassia venusta* Z.P. Jien (1963: 257), *P. degeensis*

T.C. Ku (1987: 30) and *P. kangdingensis* T.C. Ku (1987: 35) are three taxa that are morphologically close to *P. cacuminum*, but the authors compared them to some other taxa in the protologues when published them. Further studies in collections and field expeditions have been carried out to synonymise them in this paper.

Methods

This paper is based on the critical review of the protologues and examination of specimens in herbaria BJFC, CDBI, K, KUN, P, PE, HNWP, SM, SZ and online on Jstor Global Plants (<https://plants.jstor.org/> accessed on 12 December 2016). The measurements provided herein were mostly taken from dried herbarium specimens, and certain features such as colours were supplemented with the information from field observation. By applying Art 9.1 and 9.2 of the ICN (McNeill et al. 2012) strictly, the lectotype was selected. Specimens examined were listed alphabetically.

Results and discussion

Since the syntypes of *P. yunnanensis* belong to more than one taxon, a lectotype needs to be designated for it. Wu et al. (2008) cited the type of *P. yunnanensis* in their taxonomic work as “*China. Yunnan, Hokin, Delavay 710 (holotype K!); Sichuan, near Tatchienlu, Pratt 542 (syntype, BM!)*”. As Franchet did not mention *Pratt 542* in the protologue when he described this new name, *Pratt 542* should not be regarded as a syntype of *P. yunnanensis*. In addition, they did not use the phrase “designated here” or the term “lectotype” in the statement. According to Art. 7.10 and 9.23 of the ICN, their typification of *P. yunnanensis* was not effective. Franchet worked at P (Stafleu and Cowan 1976), so we select a well-presented specimen with barcode P00709378 that contains most individuals as the lectotype.

Ku stated in the protologue of *P. lanceolata* var. *oblongipetala* that it differs from the typical variety in having oblong petals, obtuse at the apex, and *P. lanceolata* differs from *P. longipetaloides* in having 3-lobed staminodes while the latter have obscure 4–6 dentate ones. By taxonomic revision of this variety, we determined that the type specimen of this name was indistinguishable from that of *P. yunnanensis* in terms of taxonomically important morphological characters (shapes of petals and staminodes, Figures 1g, 2a–d) and their general distribution ranges (both type specimens were collected from Mt. Maer between Hoqing and Eryuan). Thus we treated this variety as a new synonym of *P. yunnanensis*.

Parnassia venusta was described based on *T.T. Yu 22666* collected from Gongshan, Yunnan by Jien. As concluded from the protologue, he thought that this species differs from *P. cacuminum* in two characters: leaves reniform, petals lanceolate-obovate, slightly fimbriated at the base (Figure 2i) while *P. cacuminum* has cordata leaves, petals late obovate, erose or slightly fimbriated at the base (Figures 1f, 2e, f). The difference

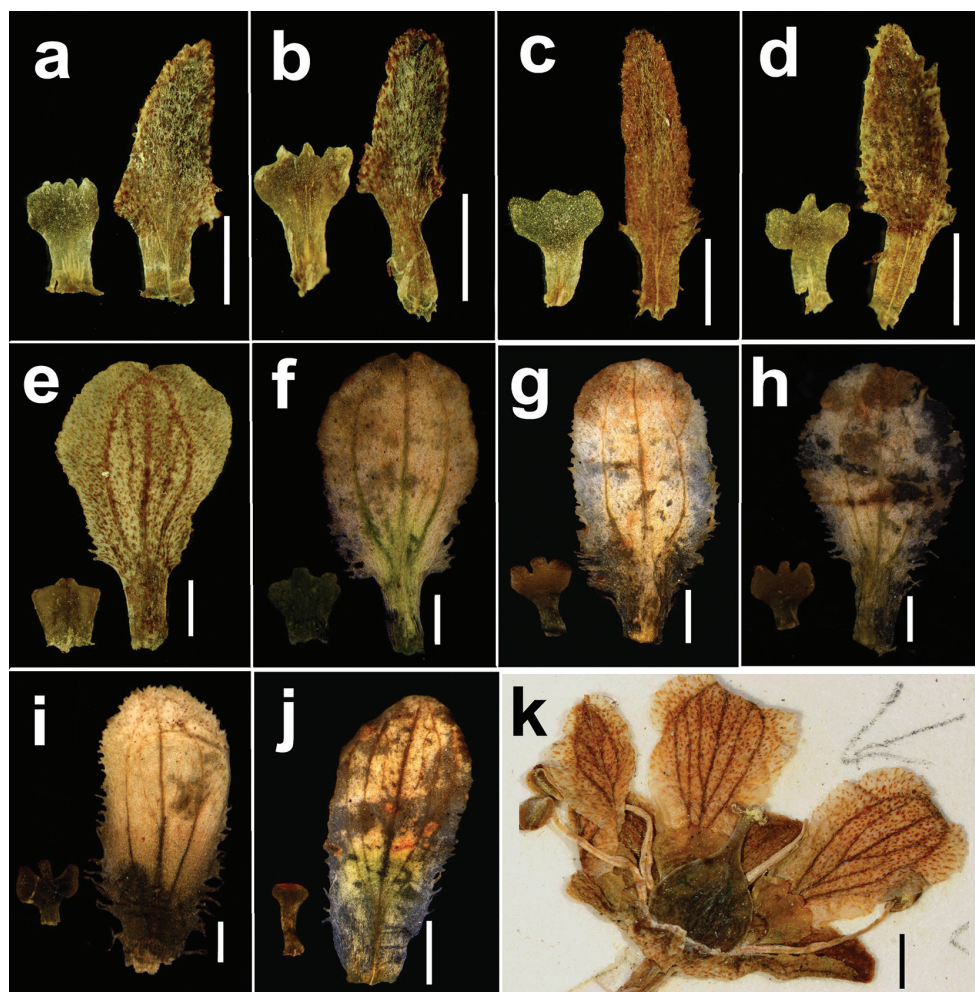


Figure 2. Morphology of the petals and staminodes in *Parnassia*. *P. lanceolata* var. *oblongipetala* (a, b *Jinshajinag Exped.* 6105, the holotype), *P. yunnanensis* (c, d T.T. Yu 7429), *P. cacuminum* (e T.T. Yu 12254 f Y.M. Shu et al. sz286), *P. kangdingensis* (g, h Y.M. Shu et al. sw365), *P. venusta* (i Y.M. Shu et al. sw365), *P. cacuminum* var. *longistipitata* (j Y.M. Shu et al. sw459), *P. degeensis* (k Y.W. Tsui 4997, the holotype). Scale bar = 1 mm.

in the shape of the leaves was observed and we found it do not held good; reniform to cordate leaves always occur within a population even within a single individual. *Parnassia cacuminum* has obovate petals, but it is variant, 4–9 mm in length by 2–5 mm in width are observed in the sample specimens, and no dividing line can be found amongst lanceolate-obovate, obovate and late obovate. Hence, we treated *P. venusta* as a new synonym of *P. cacuminum*.

In 1987, Ku proposed two new species, *P. degeensis* and *P. kangdingensis* from Dege and Kangding respectively. *P. degeensis* was described based on Y.W. Tsui 4997, which has only one sheet containing one individual with two flowers. Ku described the

staminodes of this name as undulate or 5–7 dentates at the apex and compared it with *P. farreri* W.E. Evans (1921: 174), which differed significantly in the shape of petals. We examined the holotype of *P. degeensis* (Figure 2k); the petals were obovate with distinct veins, staminodes 3 lobed at the apex and that agreed well with *P. cacuminum*. Ku stressed in the protologue of *P. kangdingensis* that this new taxon was closely related to *P. lanceolata*. However, from the description, it could be concluded that this name was quite different from *P. lanceolata* (obovate white petal vs. lanceolata green petal) but close to *P. cacuminum* by the numerical characters which Ku used to distinguish them, such as heights of individuals and length of petals. As we examined the type specimens and observed the populations in Kangding (Figure 2g, h), variations of height from 2–9 cm and length of petals from 3–6 mm were found within a population. Therefore, we propose to recognise *P. degeensis* and *P. kangdingensis* as synonyms of *P. cacuminum*.

Not far from the location where *P. kangdingensis* was described in Kangding, a new variety, *P. yunnanensis* var. *longistipitata* was proposed. This variety has cordate leaves, elliptic to obovate white petals and flat, linear staminodes with entire or obscure 3 dentate apices (Figure 2j). All these characters made it different from *P. yunnanensis* but close to *P. cacuminum*. The only difference between it and *P. cacuminum* is the linear shaped staminodes. The field observation found that these linear shaped staminodes were easily distinguished from those of *P. cacuminum* and they were stable within populations. Thus, it was proposed to recognise this taxon as a variety of *P. cacuminum*.

Taxonomic treatment

***Parnassia yunnanensis* Franch., J. Bot. (Morot) 10(16): 266. 1896.**

Parnassia longipetaloides J.T. Pan, Acta Phytotax. Sin. 23(3): 222. 1985.

Type: China. Yunnan: Eryuan, Mt. Maer, elev. 3600 m, 25 Jul 1963, Jinshajinag Exped. 6105 (holotype: KUN [KUN0437666!]; isotype: KUN!).

Parnassia lanceolata T.C. Ku, Bull. Bot. Res. 7(1): 34. 1987.

Type: China. Sichuan: Muli, elev. 3900 m, 28 Jul 1937, T.T. Yu 7429A (holotype: PE [PE01842934!]; isotypes: PE!, KUN!, E [image!]).

Parnassia lanceolata T.C. Ku var. *oblongipetala* T.C. Ku, Acta Phytotax. Sin. 29(1): 82. 1991.

Type: China. Yunnan: Eryuan, Mt. Maer, elev. 3600 m, 25 Jul 1963, Jinshajinag Exped. 6105, **syn. nov.** (holotype: PE [PE01842922!]).

Type. China. Yunnan: Heqing (Hokin), Kowa-la-po, in the shrub, 26 Aug 1884, Delavay 710 (Lectotype, designated here: P [P00709378!]; isolectotypes: P [P00709379!, P00709380! (exclude the individual with obovate petals)], K [K000739471!]).

Specimens examined. CHINA. Gansu: Lintan, 26 Jul 2013, C. Shang I”-218 (BJFC); Sichuan: Jiulong, elev. 3800 m, 15 Jul 1979, T.C. Wei 20512 (CDBI); Jiulong, elev. 3800 m, 25 Aug 1980, Z.A. Liu 22993 (CDBI); Kangding, elev. 4010 m, 5

Aug 2015, Y.M. Shu et al. sw447 (BJFC); Kangding, elev. 3600 m, 6 Jul 1974, N.Z. Zhang 4801 (PE, CDBI); Kangding, elev. 3080 m, 25 Jul 1934, C.S. Liu 883 (PE, SZ); **Yunnan**: Dali, elev. 3800 m, 31 Jul 2014, Y.M. Shu et al. sz072 (BJFC); Dongchuan, 18 Jul 2009, Huang 1529 (KUN); Lijiang, elev. 4000 m, 17 Aug 2003, D. Wu et al. 3005 (KUN); Lijiang, elev. 4000 m, 26 Aug 2002, D. Wu et al. 2005 (KUN).

***Parnassia cacuminum* Hand.-Mazz., Symb. Sin. 7(2): 433. 1931.**

Parnassia venusta Z.P. Jien, Acta Phytotax. Sin. 8(3): 257. 1963.

Type: China. Yunnan: Gonshan Hsien, Sawalunba, elev. 4000 m, 3 Sep 1938, T.T. Yu 22666, **syn. nov.** (holotype: PE [PE01842930!]; isotypes: PE!, KUN!).

Parnassia degeensis T.C. Ku, Bull. Bot. Res. 7(1): 30. 1987.

Type: China. Sichuan: Dege, Haizikou, 24 Jul 1951, Y.W. Tsui 4997, **syn. nov.** (holotype: PE [PE01896065!]).

Parnassia kangdingensis T.C. Ku, Bull. Bot. Res. 7(1): 35. 1987.

Type: China. Sichuan: Kangding, 28 Jul 1951, W.P. Fang et al. 10632, **syn. nov.** (holotype: PE [PE01842917!]; isotype: SZ!).

Type. China. Sichuan: Muli, elev. 4450–4500 m, 30 Jul 1915, Handel-Mazzetti 7338 (holotype: WU [WU0046641 image!])

Specimens examined. CHINA. Qinghai: Yushu, elev. 4250 m, 23 July 1964, Yushu Exped. 587 (HNWP, PE); **Sichuan:** Baoxing, elev. 4000 m, 1 Aug 2015, Y.M. Shu et al. sw365 et sw370 (BJFC); Baoxing, elev. 4048 m, 2 Jul 2010, C.S. Chang et al. SI0933 (PE); Daofu, elev. 3100 m, 17 Jul 1979, s.n. 1203 (SM); Dege, elev. 4000 m, 2 Jul 1979, s.n. 311 (SM); Dege, elev. 4100 m, 23 Jun 1974, Sichuan Zhibei Exped. 7121(CDBI); Dege, elev. 4300 m, 19 Jun 1974, Qingzang Exped. 63 (PE); Dege, elev. 4100 m, 23 Jun 1974, s.n. 7121 (PE); Jiulong, elev. 4110 m, 19 Jul 2012, L. He et al. PH20120719-03 (BJFC); Jiulong, 30 Jun 1974, Z.G. Liu 4730 (PE, CDBI); Jiulong, elev. 4100 m, 16 Jun 1984, W.L. Chen et al. 6345 (PE); Kangding, elev. 3730 m, 15 Jul 2012, L. He et al. PH20120715-06 (BJFC); Kangding, elev. 3700 m, 20 Jun 1984, W.L. Chen et al. 6541 (PE); Kangding, C.S. Liu 940 (PE); Kangding, 1 Aug 1963, West Sichuan Exped. 1414 (PE); Luhuo, elev. 3900 m, 5 Jul 1974, Q.H. Li et al. 6446 (PE, CDBI); Muli, 18 Aug 1937, T.T. Yu 7795 (KUN); Muli, Jun 1928, J.F. Rock 16564 (IBSC); Muli, elev. 4333 m, May 1932, J.F. Rock 23749 (PE); Muli, elev. 3700 m, 21 Jun 1937, T.T. Yu 6528 (PE, KUN); Muli, elev. 3400 m, 18 Aug 1937, T.T. Yu 7795 (PE); Rangtang, elev. 4300 m, 16 Jul 1979, s.n. 783 (SM); **Xizang:** Bomi, elev. 4300 m, 5 Sep 1982, B.S. Li et al. 00673 (PE); Chayu, elev. 3800 m, 8 Sep 1982, Qingzang Exped. 10118 (PE); Chayu, elev. 4100 m, 9 Sep 1982, Qingzang Exped. 10231 (PE, KUN); Chayu, elev. 3800 m, 19 Jul 2010, X.H. Jin et al. STET0551 (PE); Chayu, elev. 4100 m, 16 Jul 2010, X.H. Jin et al. STET0806 (PE); Chayu, elev. 3700 m, Aug 1935, T.W. Wang 65980 (PE); Cuona, elev. 4500 m, 19 Jul 1975, Z.Y. Wu et al. 75-1119 (KUN); Gongjue, elev. 4220 m,

15 Aug 2010, Kangzang Exped. 10-1966 (PE); Milin, elev. 4300 m, 28 Jul 1983, B.S. Li et al. 5960 (PE); Lasa, elev. 4952 m, 8 Jul 2012, L.M. Gao GLM-123788 (KUN); Linzhi, 23 Jul 2014, L. He PH20140723-10 (BJFC); **Yunnan:** Bijiang, elev. 4300 m, 12 Sep 1964, S.K. Wu 8790 et 8810 (KUN); Deqin, elev. 4300 m, 19 Jul 2014, Y.M. Shu et al. sz 286 (BJFC); Deqin, elev. 4300 m, 31 Jul 2003, H. Wang et al. 3066 (KUN); Deqin, elev. 4300 m, 15 Jul 2004, J. Cai et al. 4209 (KUN); Deqin, elev. 4100 m, 10 Jul 1983, Hengduan Mt. Exped. 4576 (PE); Deqin, elev. 3200 m, Aug 1935, C.W. Wang 64943 et 64974 (PE); Deqin, elev. 3500 m, 6 Jul 1937, T.T. Yu 8758 (PE, KUN); Deqin, elev. 4000 m, 9 Sep 1938, T.T. Yu 22245 (PE, KUN); Deqin, elev. 3600 m, 4 Aug 1940, K.M. Feng 5921 (KUN); Deqin, 15 Aug 1976, J.S. Yang 8573 (KUN); Deqin, elev. 3800 m, 1 Aug 1940, K.M. Feng 6209 (KUN); Eryuan, elev. 3700 m, 20 Jul 1963, Jinshajiang Exped. 63-6118 (KUN); Lijiang, elev. 4100 m, 14 Aug 2005, D. Wu et al. 5012 (KUN); Qiaojia, elev. 3800 m, 17 Jul 1973, B.X. Sun et al. 1032 (KUN); Weixi, elev. 3500 m, Jul 1935, C.W. Wang 64660 (PE); Weixi, elev. 3600 m, Aug 1935, C.W. Wang 68611 (PE); Xiangelila, elev. 4658 m, 3 Sep 2010, Kangzang Exped. 10-3237 (PE); Xiangelila, elev. 3600 m, 18 Jul 1937, T.T. Yu 12254 (PE, KUN); Xiangelila, 25 Jul 1939, K.M. Feng 1802 (PE); Xiangelila, elev. 4000 m, 6 Jul 2006, W.B. Yu et al. 5052 et 5053 (KUN); Xiangelila, elev. 3700 m, 12 Jul 1937, T.T. Yu 12085 (PE, KUN); Xiangelila, elev. 4000 m, 25 Jul 2003, D. Wu et al. 3028 (KUN); Yangbi, elev. 2600 m, 30 Jul 2003, D. Wu et al. 326 (KUN).

***Parnassia cacuminum* Hand.-Mazz. var. *longistipitata* (Z.P. Jien.) Y.M.Shu & Z.X.Zhang, comb. nov.**

urn:lsid:ipni.org:names:77161383-1

Basionym. *Parnassia yunnanensis* Franch. var. *longistipitata* Z.P. Jien, Acta Phytotax. Sin. 8(3): 255. 1963.

Type. China. Sichuan: Kangding, Mt. Che To, 6 Aug 1934, C.S. Liu 1028 (holotype: PE [PE01842918!])

Specimens examined. CHINA. Sichuan: Kangding, elev. ca. 4200 m, 6 Aug 2015, Y.M. Shu et al. sw459 et sw463 (BJFC); Kangding, elev. 4187 m, 12 Aug 2015, Y.M. Shu et al. sw505 (BJFC); Kangding, 7 Aug 2011, S.X. Yu 5008 (PE); Kangding, 10 Aug 2009, WPW 108 (KUN); Kangding, elev. 4000 m, 14 Jul 1981, Z.J. Zhao 114906 (SZ); Qianning, elev. 4300 m, 4 Jul 1974, Sichuan zhibei Exped. 5497 (PE, CDBI).

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Nine species from Madagascar are moved from *Vernonia* to *Distephanus* (Compositae, Vernonieae)

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Abstract

The genus *Distephanus* is native to Madagascar, the Mauritius, central and southern Africa, Yemen (Socotra Island), and China. The majority of the diversity is found in Madagascar. Here we provide new combinations for nine species of *Vernonia* that belong in *Distephanus*, all from Madagascar. All of the species were formerly placed in the large genus *Vernonia*, now greatly reduced.

Keywords

Asteraceae, Asterids, flowering plants, Madagascar, *Vernonia*

Introduction

As we continue to emerge from the “Dark Ages of Lumping” it should come as no surprise to any student of the Compositae that morphological and molecular data are being used (separately and together) to address generic limits. As a result we are seeing the breakup of many large non-monophyletic genera. In one such case, the genus *Vernonia* Schreb., of the tribe Vernonieae, has shrunk to about 20 species from North America and the remaining 1000 or so species from that genus are in the process of being assigned to other genera. Many of these “new” genera were previously described and subsequently sunk into *Vernonia*, but others needed new names and descriptions. An overview of the tribe was presented by Keeley and Robinson (2009) and major overhauls have taken place for the Americas (Robinson 1999), China (Robinson and

Skvarla 2010), Thailand (Bunwong et al. 2014) and Southern Africa (Swelankomo and Manning 2014; Robinson et al. 2016). Still awaiting work are the Vernonieae of Madagascar, tropical Africa, India, and SE Asia.

As part of a larger more comprehensive work on the Vernonieae of Madagascar this effort concerns the establishment of proper limits for the genus *Distephanus* Cass. Described by Cassini based on a type removed from *Conyza* (Astereae), *Distephanus* has long been recognized as distinctive (trees, shrubs or woody vines; yellow or orange flowers; tri-nervate leaf venation) even when it was considered part of *Vernonia* (herbs or subshrubs; purple, pink or white flowers; pinnate leaf venation). In addition to the type species three other species were described in *Distephanus* and therefore do not need to be transferred and a number of combinations have already been made: 24 by Robinson and Kahn (1986), one by Robinson (2009), two by Robinson (2012), one by Robinson and Funk (in Funk et al. 2012) and one by Boon and Glen (2013) for a total of 33 species currently in *Distephanus*. However, because of a lack of available herbarium material some of the Madagascar species names were left as *Vernonia*. After examining herbarium material from the Muséum National d'Histoire Naturelle (P), nine additional combinations can now be made. The following combinations are needed at this time because of upcoming entries in GenBank and determinations on specimens from a recent field trip in September-October of 2016. Descriptions and synonymy can be found in Humbert (1960: Volume 1, 121–171). With these additions, the number of species in *Distephanus* now stands at 42 with possible new species to be described based on material collected during the aforementioned field trip.

Vernonia* species from Madagascar transferred into *Distephanus

***Distephanus bakeri* (Vatke) V.A.Funk & H.Robinson, comb. nov.**

urn:lsid:ipni.org:names:77161439-1

Vernonia bakeri Vatke. Bremen Abh. Natuewiss. Vereins Bremen 9: 119. 1885.

***Distephanus capuronii* (Humbert) V.A.Funk & H.Robinson, comb. nov.**

urn:lsid:ipni.org:names:77161440-1

Vernonia capuronii Humbert, Mem. Inst. Sci. Madagascar, Sér. B., Biol. Veg. 6: 152. 1955.

***Distephanus grevei* (Drake) V.A.Funk & H.Robinson, comb. nov.**

urn:lsid:ipni.org:names:77161442-1

Vernonia grevei Drake. Bull. Soc. Bot. France 46: 240. 1900 [dt. 1899; publ. early1900]

***Distephanus ibityensis* (Humbert) V.A.Funk & H.Robinson, comb. nov.**

urn:lsid:ipni.org:names:77161443-1

Vernonia ibityensis Humbert, Notul. Syst. (Paris) 13(4): 313. 1949 [dt. Apr 1948; publ. early 1949]

***Distephanus poissonii* (Humbert) V.A.Funk & H.Robinson, comb. nov.**

urn:lsid:ipni.org:names:77161444-1

Vernonia poissonii Humbert, Notul. Syst. (Paris) 8(1): 6. 1939.

***Distephanus polytricholepis* (Baker) V.A.Funk & H.Robinson, comb. nov.**

urn:lsid:ipni.org:names:77161445-1

Vernonia polytricholepis Baker, J. Linn. Soc., Bot. 21: 415. 1885

***Distephanus quartziticola* (Humbert) V.A.Funk & H.Robinson, comb. nov.**

urn:lsid:ipni.org:names:77161446-1

Vernonia quartziticola Humbert, Notul. Syst. (Paris) 13(4): 305. 1949 [dt. Apr 1948; publ. early 1949]

***Distephanus rhodopappus* (Baker) V.A.Funk & H.Robinson, comb. nov.**

urn:lsid:ipni.org:names:77161447-1

Vernonia rhodopappa Baker, J. Linn. Soc., Bot. 22: 487. 1887

***Distephanus spiciformis* (Klatt) V.A.Funk & H.Robinson, comb. nov.**

urn:lsid:ipni.org:names:77161448-1

Vernonia spiciformis Klatt, Ann. Nat. Hofmus. Wien 7: 296. 1892

Acknowledgements

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appreciate the comments from two reviewers and the subject editor. As usual we made use of the IPNI website (<http://www.ipni.org>) and we thank Kanchi Gandhi (GH) for helping us locate the actual publication dates of some original literature.

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Cousinia waldheimiana (Asteraceae) a new record from Uzbekistan (Central Asia)

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Abstract

During the study of plant specimens in the Central herbarium, Academy of Sciences of Uzbekistan Institute of the gene pool of plants and animals (TASH) one new record for the flora of Uzbekistan (*Cousinia waldheimiana*) was identified. This species is the fourth member of *Cousinia* sect. *Jurineopsis* collected in the Uzbek part of the Northern Alay range.

Keywords

Asteraceae, *Cousinia* sect. *Jurineopsis*, Uzbekistan, Kyrgyzstan, Alay

Introduction

The genus *Cousinia* Cass. with ca. 600–700 species (Attar et al. 2001; Assadi 2010; Attar and Maroofi 2010; Mehregan et. al. 2010) is the second largest genus of Asteraceae, after *Senecio* L. (Memariani and Joharchi 2011). *Cousinia* (tribe *Cardueae*) is subdivided into three subgenera (Tscherneva 1962, 1974) and ca. 70 sections (Kadereit and Jeffrey 2007, Mehregan and Kadereit 2009). The genus is unique for its high level of diversity and penchant for narrow-range endemism. (Tscherneva 1974, Rechinger 1986). Eight major centers of species diversity have been defined for the genus in South West Asia and Central Asia (Mehregan 2008). The most important center of species diversity is

situated in Pamir-Alay and Tien Shan ranges in the Central Asia with ca. 230 species, of which 150 are endemics (Tscherneva 1974). The Turkman-Iranian mountainous province in North East Iran and South Turkmenistan can be considered as the second important center of diversity for *Cousinia*, with approximately 100 species, of which 70 species are considered endemic to the area (Rechinger 1972, 1979).

As part of the project “Botanical and geographical regionalization of Uzbekistan and creation of a database of plant diversity. Part II. Turan province” herbarium specimens stored in TASH of the genus *Cousinia* were processed. The process of working with more than 3000 specimens showed that some specimens had not been previously recorded for some Central Asian countries. This paper presents the results of processing the specimens relating to *Cousinia* sect. *Jurineopsis* (Juz.) Tscherneva.

Cousinia sect. *Jurineopsis* is an endemic section of 11 species found in the Central Asia Mountains (Tscherneva 1993). Earlier Tscherneva (1962) recognized three species - *C. dubia* Popov, *C. krauseana* Regel et Schmalh., *C. submutica* Franch. for this region in the flora of Uzbekistan. During the processing of the specimens in this section at TASH a further species *Cousinia waldheimiana*, hitherto known only from outside of the Uzbek borders in North East Kyrgyzstan (Central and Western Tien Shan), was identified. This is a new record for the flora of Uzbekistan.

Materials and methods

The identification was based on consultation of published accounts of *Cousinia* (Tscherneva 1974; Zare et al. 2012; Mehregan and Kadereit 2008; Sennikov 2010, 2011; Mabberley 1990; Heffner 2000; Susanna et al. 2003; Djavadi 2012; Sheidai et al. 2006) and herbarium specimens stored in the TASH.

Results

New record

***C. Waldheimiana* Bornm. 1916, Beih. Bot. Centrl. XXXIV. II. 140. (1916).**

urn:lsid:ipni.org:names:199419-1

Fig. 1

Description. Biennial plant. Stem erect, 30–80 cm tall, subglabrous, basally covered in brownish thinly-arachnoid hairs; branches elongated, mid-corymbosa, patulous, monocephalous. Leaves coriaceous, glabrous above, green, tomentose below; basal leaves pinnatisected, cauline sessile, semiamplexicaul, narrowly lanceolate or lanceolate, drawn to the apex, almost smooth-edged, just at the base of usual with 2–4 pairs of teeth; branches of the leaves strongly diminished. Capitula ovate-conical, slightly arachnoid, 2.5–3 cm in diameter, (without acidotus) monocephalous. Phyllaries are



Figure 1. Representative specimen of *C. waldheimiana*.

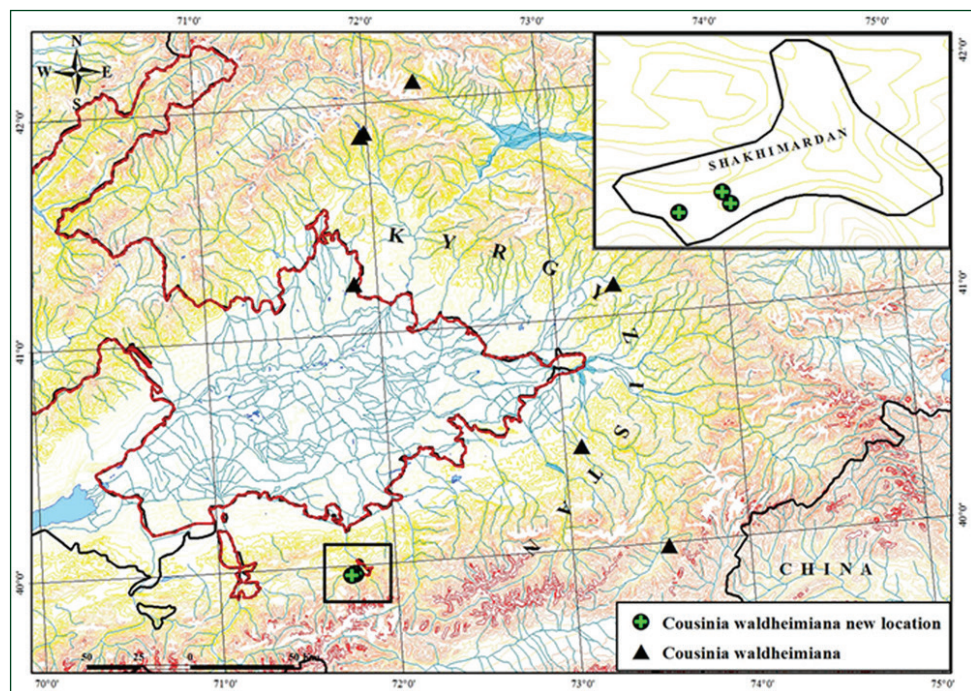


Figure 2. Distribution map of *C. waldheimiana* in Uzbekistan and the neighboring territories (according to the specimens examined).

numerous in number 90–100, except internal, with a slightly arcuately reflect acidotus; internal protruding up, lanceolate; scarious on top, acerous in a very thin, short the barb, usually brownish; setula receptacle above advanced, asperous. Corolla pink. Achenes ca. 3.5–4.0 mm long, obovate, glabrous and smooth.

Phenology. Flowering from June to July, fruiting from July to August.

Habitat. On the rubbly-fine earth slopes, shale rocks in the middle belt of mountains.

Distribution. Previously considered endemic to the Western Tien Shan Mountains to distribution in Chatkal, Fergana, Uzunakhmat and Atoynak ranges. This range is now extended to the Alay Range, Uzbekistan (Fig. 2).

Specimens seen. Uzbekistan. Alay Range (North side): Fergana Valley, above the Shakhimardan resort on the slopes of the river Jordan. 02.08.1954, *Korotkov* 4569 (TASH); Alay Range. River basin Shakhimardan, neighborhood of village Jordan. Stony NE slope of the upper terrace of the right bank of the river. Ak-su. Tree and shrub belt. 16.07.1961, *Pyataeva* 118 (TASH); S slope of the Alay range. River basin. Shakhimardan, neighborhood of village Jordan. 1600 m. NE slope of the right bank of the river. Ak-suv. 16.07.1961, *Abdullayev* 66 (TASH).

Other specimens examined. Kyrgyzstan. Jalal-Abad region. Kyrg. SSR. Upper river of the Hodge-ata. On the pass and the lake Sary-Chelek. 31.07.1949, *Bondarenko* 1197 (TASH); Central Tien Shan. Ketmen-Tyube region. Valley Uzun-Akhmat. Wormwood steppe. 21.07.1927, *Abolin* 455 (TASH); Central Tien Shan. Ketmen-

Tyube region. Ayukty river, the hole Almaly. The stony slope. 2007.1927. *Abolin 414* (TASH); The Ferghana Valley. Fergana mountain range near the village Dmitrievka (river Kugart). 29.06.1955, *Korotkov 4894* (TASH).

Species recognition. Very close to the *C. margaritae* Kult., differing mainly by the color of the corolla (from *C. margaritae* corolla whitish or pale yellow in *C. waldheimiana* corolla pink or purple). However, color of the corolla in the herbarium of poorly stored, making difficulties to define plant, why the geographical boundary of these species are currently unclear (Tscherneva 1962).

Discussion

The species with the areal in Chatkal, Fergana, Uzunakhmat and Atoynak ranges of Western Tien Shan. Its indicated only for the flora of Kyrgyzstan (Tscherneva 1965, 1993). The herbarium specimens from Uzbekistan reported on here were collected from the northern slopes of the Alay range within the Fergana Valley:

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Morphological characteristics and genetic evidence reveals a new species of *Manihot* (Euphorbiaceae, Crotonoideae) from Goiás, Brazil

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Abstract

During botanical expeditions between 2010 and 2015, as part of a taxonomic study of *Manihot* in the Midwest region of Brazil, approximately 500 specimens of the genus were collected. Some of these specimens presented similarities to *M. irwinii*. However, after careful morphological analyses, associated with genetic evidence, we propose here *M. pulchrifolius* as a new species. The new species is described, illustrated, and compared to *M. irwinii*, its most similar species. Furthermore, geographic distribution, conservation status, and period of flowering and fruiting of the novel species are also provided.

Keywords

Endemism, Manihoteae, mountainous areas, speciation, taxonomy

Introduction

Manihot Mill. encompasses over 100 Neotropical species, and therefore stands out as one of the largest genera of Euphorbiaceae in Brazil, with ca. 80 species (Silva 2014). In the Cerrado Biome, over 50 species of *Manihot* have already been documented,

among which 40 are endemic (Silva et al. 2013). Nevertheless, recent studies of the genus in the Chapada dos Veadeiros region, in the state of Goiás, Brazil, revealed some new species (Silva et al. 2013, Silva 2014, Silva and Sodré 2014, Silva 2015a, b, Silva et al. 2016a, b), which demonstrates that there is still a lot to discover about this genus, whose taxonomy remains relatively poorly known in the Cerrado Biome. Some species of *Manihot* endemic to the Cerrado Biome have leaves that are considerably diverse morphologically, a fact that has aroused the interest of botanists and geneticists (Duputié et al. 2011, Silva et al. 2016b).

During botanical expeditions to the Serra Dourada State Park, in the state of Goiás, Brazil, since October 2010, as part of a floristic survey of Euphorbiaceae, approximately 500 specimens of *Manihot* were collected, some of them showing similarities to *M. irwinii* D.J. Rogers & Appan regarding habit and foliage type. After careful morphological analyses of these collections, associated with genetic evidence, we propose herein the new species *Manihot pulchrifolius*. A detailed description, comments on flowering, fruiting, distribution, environmental preferences, conservation status, and comparisons with morphologically similar species are provided.

Materials and methods

Morphological Studies

The description of the new taxa was based on observations of populations in the field since 2010, analyses of available specimens from herbaria UFG, NY, K, RB, and UB (acronyms follow Thiers continuously updated), and review of the literature (Rogers and Appan 1973, Allem 1989). The terminology used to describe the types of inflorescences and leaves follows Rogers and Appan (1973). The illustrations were based on fresh material fixed in alcohol 70% during collection in the field. Holotypes of the new species are deposited at UFG, and isotypes are going to be sent to NY, K, RB, and UB. Photographs of natural populations were taken in the field. The conservation status of the species follows IUCN (2016).

Taxon sampling, DNA extraction, PCR, and sequencing for genetic studies

Leaves were sampled from 126 plants known as *Manihot irwinii* D.J. Rogers & Appan, collected in four localities in the state of Goiás (Table 1). DNA was extracted from silica-dried leaf tissues (Doyle and Doyle 1987) and amplified microsatellite markers by polymerase chain reaction (PCR) using primers GA-12, GA-16, GA-21, GA-126, GA-131, GA-134, and GA-136 developed for *M. esculenta* Crantz by Chavarriaga-Aguirre et al. (1998). The amplification was done in 10 µL reactions containing 3 µL of template DNA (1.5 ng/µL), 3 µL of each primer (0.9 µM), 1 µL 10X enzyme buffer containing 2.5 mM MgCl₂ (500 mM KCl, 100 mg/mL Tris-HCl, pH 8.4, 1%

Table 1. *Manihot irwinii* sensu lato collected per site and their geographic coordinates.

| Municipalities/Localities | Number of specimens | Voucher/Herbarium | Geographic coordinates/elevation |
|--|---------------------|---------------------|-------------------------------------|
| Mossâmedes/Serra Dourada State Park | 29 | M.J. Silva 5801/UFG | 16°05'35.4"S, 50°11'4.5"W, 972 m |
| Corumbá de Goiás/100 m above the waterfall Salto de Corumbá | 33 | M.J. Silva 5805/UFG | 15°50'25"S, 48°46'7"W, 1,067 m |
| Pirenópolis/Serra dos Pireneus, near Serra dos Pireneus State Park | 37 | M.J. Silva 6389/UFG | 15°43'15"S, 49°2'45"W, 730 m |
| Cocalzinho de Goiás/after Serra dos Pireneus State Park | 27 | M.J. Silva 6406/UFG | 15°46'55"S, 48°50'00"W, 1,157 m |
| Total | 126 | | |

Triton X-100), 1.3 µL bovine serum albumin (10 mg/mL), 0.9 µL 2.5 µM dNTP, and 5 units/µL Taq DNA polymerase, completing the volume with 0.65 µL ultrapure deionized water. PCR parameters were: 94°C for 5 min, 30 cycles of 94°C for 1 min, 56°C for 1min, 72°C for 1 min, and 72°C for 45 s. The forward primers were fluorescently labeled for the observation of fragments of DNA using the Applied Biosystems™ 3500 genetic analyzer (Thermo Fisher Scientific Inc., Waltham, MA, USA) in two multiplex genotyping systems. The genotypes were determined using GeneMapper® Software Version 5.0 (Applied Biosystems™, Thermo Fisher Scientific Inc., Waltham, MA, USA) with default settings.

Data analysis

The genetic diversity of the populations studied was assessed based on estimates of the average number of alleles per locus (A), rarefied allelic richness (AR), observed heterozygosity (Ho), expected heterozygosity under Hardy-Weinberg equilibrium (He), and intrapopulation fixation index (f). The genetic structure of the populations was evaluated according to Weir and Cockerham (1984). These analyses were conducted using the package Hierfstat for the statistical software R (Goudet 2005). The genetic structure was assessed by a Bayesian approach, conducted using the software STRUCTURE 2.3.4 (Pritchard et al. 2000), assuming a model that allows mixing alleles between populations for four independent runs, with K values ranging from one to ten. The tests were performed using the Markov Chain Monte Carlo (MCMC) method, with periods of burn-in of 10,000 and 1,000,000 replicas. The average of likelihood values for each K for all runs was determined by the statistical ΔK developed by Evanno et al. (2005).

The pattern of differentiation among populations was evaluated by calculating the genetic distance between pairs of populations, based on estimates of pairwise by fixation index (F_{ST}). To visualize the pattern of differentiation among populations, the genetic distance matrix was subjected to a cluster analysis using the unweighted pair-

group method with arithmetic averages (UPGMA). To assess the degree of representativeness of the dendrogram, the cophenetic correlation coefficient was estimated with 10,000 permutations. These analyses were conducted using R Hierfstat (Goudet 2005) and *adegenet* (Jombart 2008).

Taxonomic treatment

Manihot pulchrifolius M.J.Silva, sp. nov.

urn:lsid:ipni.org:names:77161449-1

Figures 1, 2

Type. BRAZIL. Goiás: Mossâmedes, Serra Dourada State Park, near Pedra Goi-ana, Cerrado rupestre, on rocky crevices, 16°04'40,5"S, 50°11'20.8"W, 988 m, 21/XI/2014, fl., *M. J. Silva & A. A. Alonso* 6232 (holotype: UFG; isotypes: NY, F, K, UB).

Diagnosis. Shrubs up to 2.5 m tall, erect, glabrous; young branches and young leaves reddish to purplish, green-vinaceous to violet; adult leaves 5-lobed at the plant base, 3-lobed along the stem, or rarely unlobed near inflorescence; long racemes or panicles (up to 27 cm long), erect to pendent, axes reddish to purplish; calyx of staminate flowers reddish or purplish with yellow margins, filaments pubescent; bracts and bracteoles of flowers of both sexes reddish to purplish; fruits dark green with violet to purplish wings.

Description. Shrubs 1–2.5 m tall, monoecious, erect; stems and adult branches robust, cinereous, glabrous, waxy, and glossy; young branches and young leaves reddish to purplish, green-vinaceous to violet, including axes of inflorescences and petioles; branches dichotomously branched near apex, sometimes pendent in specimens taller than 1.2 m; latex yellowish, copious; petiole 4.5–13 cm long, robust, canaliculated above, dark purplish to violet. Stipules 1.9–2 cm long, linear, entire to discreetly serrate, caduceus. Leaves in alternate spiral arrangement; lamina firmly chartaceous, glabrous on both surfaces, the basal ones 5-lobed, the others 3-lobed, or unlobed near inflorescence, lobes conspicuously overlapping at sinus, 8.4–15 × 4.5–10 cm, widely oblong-obovate, elliptic-obovate to obovate, apex cuspidate, sometimes oblique, base cordate; venation camptodromous-brochydromous, primary and secondary veins pinkish, purplish, violet, or rarely yellowish, the primary ones prominent on both surfaces, the secondary ones subparallel to the midrib, impressed on both surfaces, bifurcate or not at apex; adaxial surface dark green and opaque in adult leaves, or light green, castaneous, reddish to purplish in young leaves; abaxial surface opaque green to cinereous with a smooth wax pattern; racemes 5–17 cm long, or panicles 17–24 cm long, lax, terminal or in the dichotomy of the branches, solitary or in clusters of 2 or 3, erect to pendent, bisexual; if racemes, they have two opposite pistillate flowers at the base and another staminate; if panicles, the secondary axes are similar to racemes, but sometimes without pistillate flowers at the base of secondary axes. Staminate flowers 21–25 mm long; buds 9–10 mm long, globoid to orbicular, reddish, obtuse at apex, glabrous

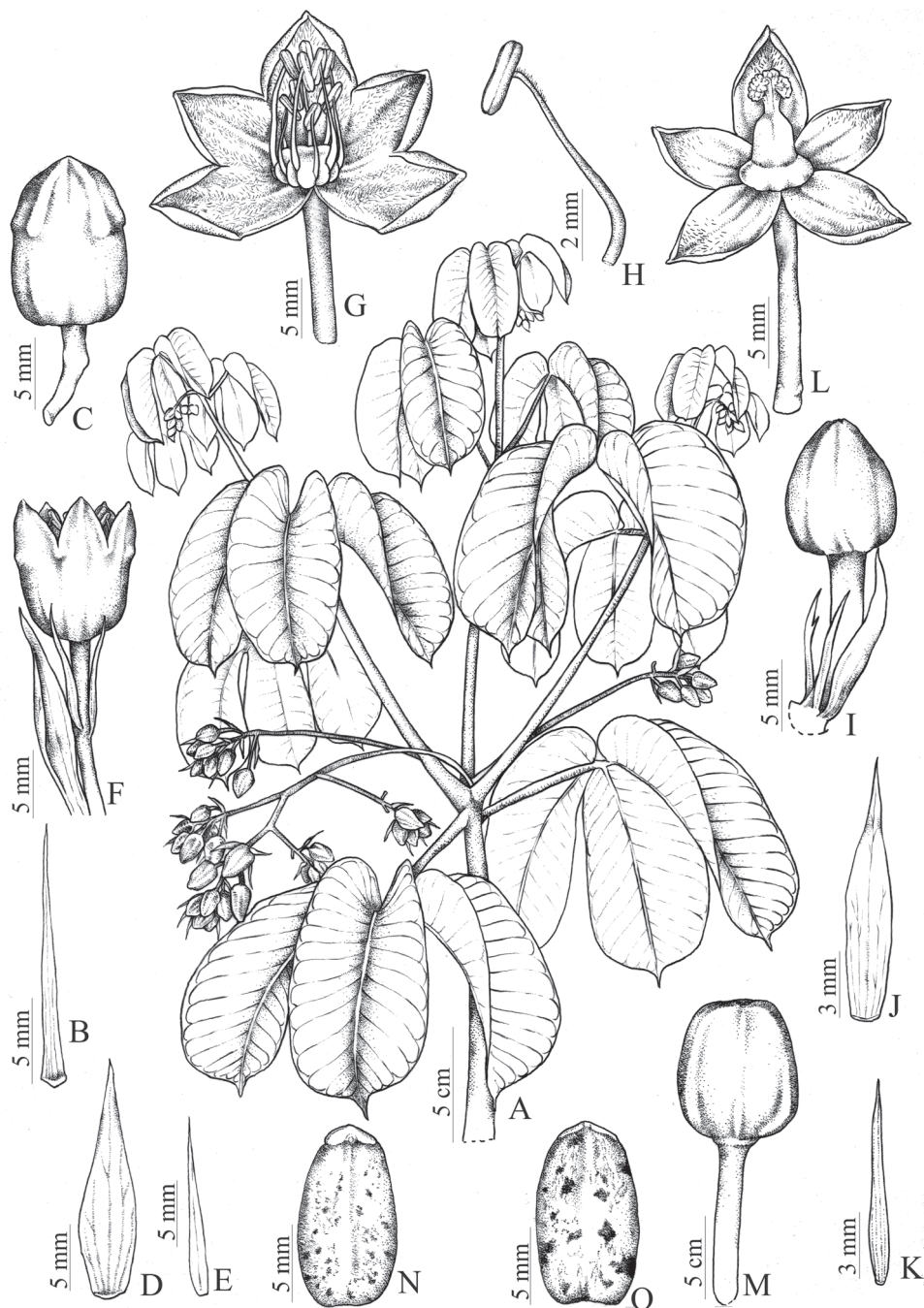


Figure 1. *Manihot pulchrifolius*. **A** Flowering branch **B** Stipule **C** Staminate bud **D** Staminate bract **E** Staminate bracteole **F** Staminate flower **G** Staminate flower with calyx split and open **H** Stamen **I** Pistillate bud **J** Pistillate bract **K** Pistillate bracteole **L** Pistillate flower **M** Fruit **N** Seed, ventral side **O** Seed, dorsal side. Drawn by Cristiano Gualberto from the holotype.



Figure 2. *Manihot pulchrifolius*. **A** Habit; note the plant growing between rocky crevices **B** Habit; detail of the waxy stem **C** Portion of the stem showing inflorescences in clusters at the dichotomy of the branches **D** Adult panicle **E** Portion of the panicle showing the staminate buds and flowers with vinaceous calyx and yellow margins **F** Staminate flowers **G** Pistillate flowers **H** Mature fruits; note the violet wings.

and waxy externally; bracts 11–12 × 2.5–3.3 mm, oval, elliptic, entire, acuminate at apex, reddish, persistent, glabrous on both surfaces; bracteoles 5.7–7 × 1–2 mm, linear, subalternate, distributed on the lower third of the pedicel, glabrous on both surfaces, margins entire, not ciliate, caduceous; pedicels 8.5–12 mm long, cylindrical, reddish to purplish, waxy, glabrous; calyx 12–15 × 10–11 mm, widely campanulate, reddish with yellowish margins, glabrous externally and shortly tomentose internally, lobes widely triangular to ovate, apex obtuse; stamens 10, in two whorls of five, filaments 8–8.2 mm long, pubescent distally, anthers 3–3.2 mm long, oblongoid, yellowish; disk 10-lobed, dark yellow, lobes rounded. Pistillate flowers 19–25 mm long; buds 6–7 mm long, ovoid, glabrous, yellowish with reddish spots; bracts 8–15 × 2.4–3 mm, oval-lanceolate to lanceolate, vinaceous to purplish, entire, acuminate at apex, persistent, glabrous, not ciliate; bracteoles 10–12 × 2–3.5 mm, lanceolate, margin discreetly serrate, similar to the bracts in color; pedicels 13–16 mm long, cylindric-clavate, glabrous, greenish, sepals 8.2–11 × 3.3–5 mm, ovate to oval-elliptic, rarely lanceolate or triangular, shortly pubescent in the upper third internally, apex obtuse, yellowish with reddish pigmentation, margins involute; ovary 3–3.2 × 2–2.1 mm, oblongoid to globoid, glabrous, not winged, green, disk discreetly lobed, yellowish, styles 3, conspicuously united at the base, free portion 2.1–2.2 mm long, with papilose apex. Capsules 12–14 × 16–17 mm, globoid, smooth, glossy, winged, with septicidal and loculicidal dehiscence, green to purplish, slightly glossy. Seeds 8–10 × 4–5 mm, oblongoid, cinereous, with dark spots; caruncle 0.9–1 mm long, sessile, reniform, cream to whitish.

Distribution and Ecology. *Manihot pulchrifolius* is endemic to the state of Goiás, where it was found growing in Serra Dourada (Figure 3), one of the most beautiful and preserved mountainous areas in the state. This mountain range encompasses the Serra Dourada State Park, an area of over 30,000 hectares protected by law since 1965. The species grows in Cerrado *sensu stricto*, on rocky outcrops, rocky slopes, and Cerrado rupestre, in clayey, clayey-stony, and sandy soils, or even on rocky crevices, between 900 m and 1,000 m.

Phenology. The species has been collected with flowers and fruits from November to July. However, the flowers are more usual from January to March, whereas the fruits are more abundant from April to July.

Etymology. The specific epithet “*pulchrifolius*” alludes to the beautiful foliage of the species, especially in the leaf flushing stage, when the leaves are reddish or purplish to green-vinaceous to violet.

Conservation status. Given that the populations have more than 50 individuals and the vegetation where they grow is commonly found in the central part of the state of Goiás (in the municipality of Goiás and neighboring municipalities), we consider *M. pulchrifolius* as Least Concern (LC) according to IUCN (2016).

Specimens examined. BRAZIL. Goiás: Mossâmedes, Serra Dourada State Park, on the way to Pedra Goiana, 9 Dec 2009, fl., *A. M. Teles* 658 (UFG); *ib.*, 30 Oct 2010, fl., *M. J. Silva et al.* 3138 and 3139 (UFG); *ib.*, near Pedra Goiana, 16°04'34.7"S, 50°11'28"W, 994 m, 21 Nov 2014, fl., *M. J. Silva & A. A. Alonso* 6234 and 6235 (UFG); *ib.*, 16°04'40.5"S, 50°11'20.8"W, 988 m, 21 Nov 2014, fl., *M. J. Silva & A.*

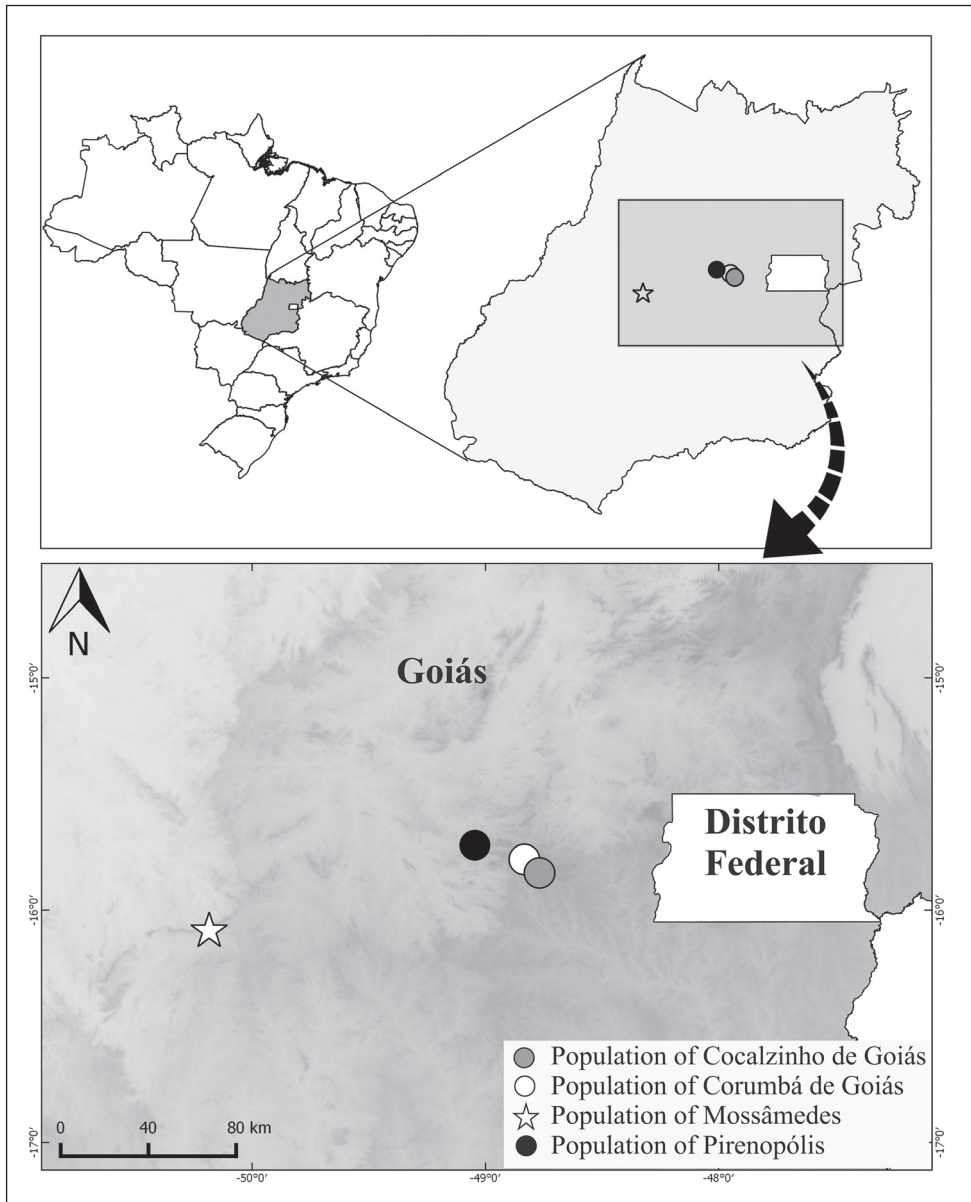


Figure 3. Distribution map of sampled populations highlighting the population of Mossâmedes (= *Manihot pulchrifolius*). The other populations correspond to *Manihot irwinii*.

A. Alonso 6230 and 6231 (UFG); District of Mirandópolis, Rildo Nogueira farm, 27 Nov 2010, fl., *M. J. Silva* 3194 and 3198 (UFG); *ib.*, near the first gate that leads to the park headquarters, 16°04'46,9"S, 50°11'28,4"W, 985 m, 29 Jan 2011, fl., fr., *M. J. Silva* 3372 (UFG); *ib.*, 4 km above the Piçarrão stream, 16°04'17,4"S, 50°11'26,1"W, 993 m, 30 Apr 2011, fl., fr., *J. E. C. Júnior* 15 and 18 (UFG); region after Areal, 16°04'00,9"S, 50°10'8,9"W, 953 m, 28 May 2011, fr., *J. E. C. Júnior* 51 (UFG).

Discussion

Remarks

Manihot pulchrifolius was identified by Rogers and Appan (1973) as *M. irwinii* according to the collections Irwin *et al.* 12959 (B, F, G, GH, MO, NY, SP, UB, US, and W), Irwin *et al.* 11752 (B, F, G, GH, MO, NY, SP, UB, US, and W), and Macedo 3476 (NY, S, and US). In a taxonomic survey of *Manihot* in the Serra Dourada State Park, Carmo Júnior *et al.* (2013) adopted the same concept of Rogers and Appan (1973), probably because they were not aware that *M. irwinii* is a little known species, scarcely represented in Brazilian herbaria (UB, CEN, HPB, and UFG), and with distribution restricted to the Serra dos Pireneus and neighboring areas where it grows in open areas of Cerrado *sensu stricto* in clayey soils. However, in the last two years, morphological and genetic studies developed by the authors of this paper have shown that populations from Serra dos Pireneus and the Serra Dourada State Park previously identified as *M. irwinii* present differences regarding leaf, inflorescence, and flower morphology, as well as genetic structure as described below. Therefore, we concluded that the specimens from the Serra Dourada State Park belong to a new species, herein named *M. pulchrifolius*. Both species share a shrubby habit, leaves with lobes overlapping basally, midrib veins thickened, secondary veins subparallel, flowers of both sexes with sepals pubescent internally, and winged fruits.

Manihot pulchrifolius has leaves that are 5-lobed at the base of the stem, 3-lobed above the base of the plant or along the plant, or rarely unlobed near the inflorescence, with robust petiole, reddish to dark violet, and leaf blade cinereous, green-opaque, or reddish on lower surface (vs. 3-lobed leaves, and commonly unlobed near inflorescence, thin petiole, greenish, and leaf blade whitish in *M. irwinii*), racemes and panicles 5–17 cm and 17–24 cm long, respectively (vs. racemes 7–12 cm long), floral buds reddish (vs. yellowish green to greenish), staminate flowers 21–25 mm long, calyx widely campanulate, filaments pubescent distally, staminate bracts and bracteoles reddish, 11–12 × 2.5–3.3 and 5.7–7 × 0.1–0.2 mm, respectively (vs. staminate flowers 14–15 mm long, calyx narrowly campanulate, filaments glabrous, staminate bracts and bracteoles yellowish green with discreet purplish spots, 11–12 × 2.5–3.3 and 5.7–7 × 0.1–0.2 mm, respectively).

Systematically, the new species can be situated in *Manihot* section *Quinquelobae* Pax according to Silva (2014), by having a shrubby habit, leaves widely spaced along the branches, basal petiole attachment, deeply lobed leaf blade, lobes of various shapes (but not linear), monoecious racemose or panicked inflorescences, foliaceous or setaceous bracts and bracteoles, winged or wingless fruits. However, since *M. quinquelobae* belongs to a polyphyletic group (Silva *et al.* unpublished), we prefer not to ascribe *M. pulchrifolius* to any sections of the genus.

Genetic studies

A total of 50 alleles were found for the seven loci evaluated in populations of *M. irwinii* *sensu lato*, ranging from three to eleven alleles per locus. The populations studied showed

Table 2. Genetic diversity parameters estimated for four populations of *Manihot irwinii* sensu lato, based on seven microsatellite loci.

| Municipality | A | AR | He | Ho |
|------------------------------|-------|-------|-------|-------|
| Mossâmedes (n = 29) | 3.714 | 3.38 | 0.454 | 0.389 |
| Corumbá de Goiás (n = 33) | 2.429 | 2.17 | 0.321 | 0.368 |
| Pirenópolis (n = 37) | 4.286 | 3.76 | 0.578 | 0.574 |
| Cocalzinho de Goiás (n = 27) | 3.143 | 2.952 | 0.434 | 0.464 |

n: number of individuals selected in each population; A: average number of alleles per locus; AR: rarefied allelic richness; He: expected heterozygosity under Hardy-Weinberg equilibrium; Ho: observed heterozygosity.

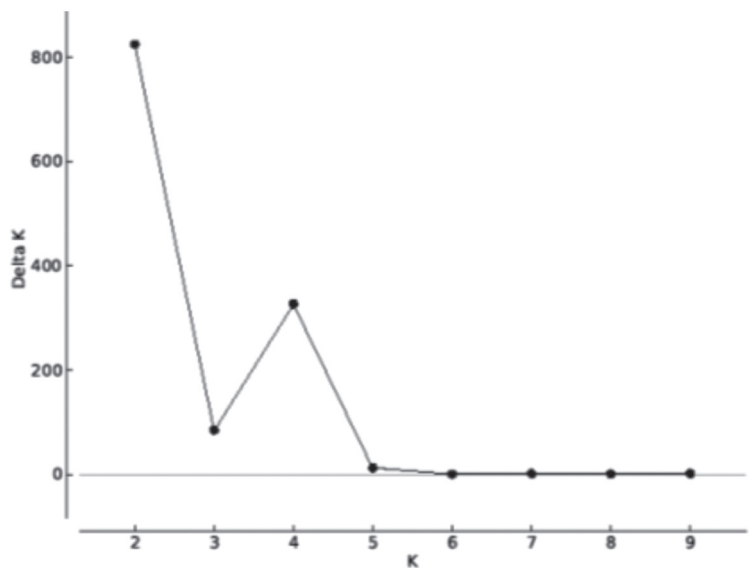


Figure 4. Genetic groups (K) estimated by attribution analysis using the software STRUCTURE. The highest ΔK indicates the most probable number (K) of groups formed by individuals sampled from putative populations of *Manihot irwinii* sensu lato herein analyzed using seven microsatellite markers.

high and similar genetic diversity, which was also observed in other species of the genus (Roa et al. 2000). Only the population of the municipality of Corumbá de Goiás presented genetic diversity values significantly smaller than the others, suggesting that the population may be suffering from a fragmentation of its habitat since it grows in an area surrounded by agriculture and disturbed by anthropic actions related to tourism. The inbreeding values estimated in the four populations were not significant, indicating adherence to the frequencies expected by Hardy-Weinberg equilibrium for the evaluated loci (Table 2).

The population genetic structure analysis showed an estimated value of θ of 0.363, indicating that 36.3% of the genetic diversity is in the component between populations. This level of genetic structure is considered very strong (Wright 1978), especially taking into account the geographical distance among the assessed populations (Figure 3) and

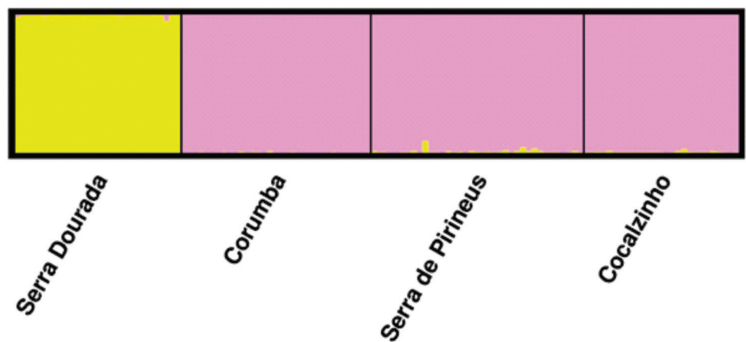


Figure 5. Genetic assignment of four populations of *Manihot irwinii* sensu lato evaluated with seven microsatellite markers, based on Bayesian statistics using the software STRUCTURE.

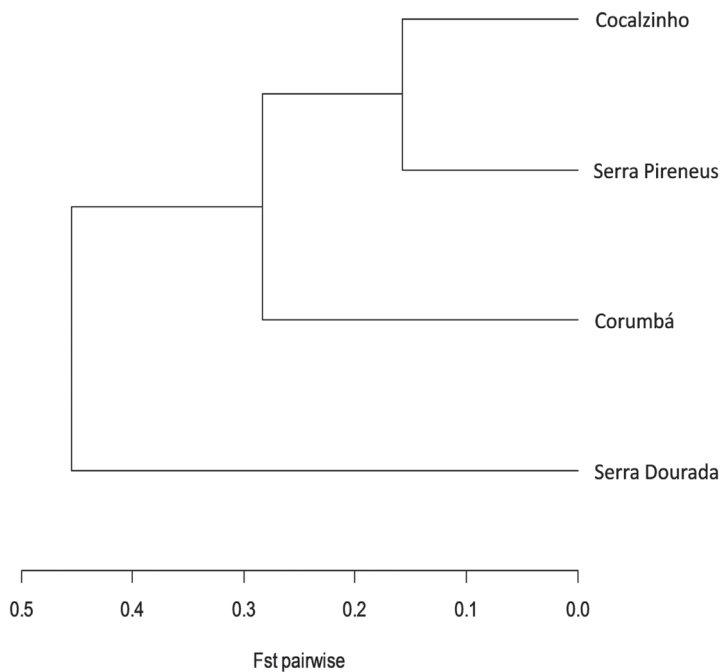


Figure 6. Dendrogram constructed from the F_{ST} pairwise matrix of four populations of *Manihot irwinii* sensu lato evaluated with seven microsatellite markers. The cophenetic correlation was 0.8933.

the fact that *M. irwinii* sensu lato is probably allogamic (Loveless and Hamrick 1984). The estimated values of F (0.359) and f (-0.006, not significant) show that the observed genetic structure is related to the effect of genetic drift and low gene flow between populations and not to the reproductive system of the plant. A strong pattern of genetic structure was also observed in the analysis using the Bayesian approach, which was determined in the formation of two genetic groups ($K = 2$, Figure 4). The first group determined by STRUCTURE is restricted to the population found in Serra Dourada,

municipality of Mossâmedes, whereas the second group contains the other three populations studied (Figure 5). The pattern of attribution of the individuals to the groups was very similar to the patterns observed for different species of the genus *Quercus* that present lack of gene flow between groups (Valencia-Cuevas et al. 2015).

This pattern of genetic differentiation between populations can be observed in the dendrogram constructed from the F_{ST} pairwise matrix, which clearly points out the separation from the population collected in Serra Dourada in a distinct group (Figure 6). This result, associated with the strong genetic structure detected, suggests that populations of *M. irwinii* sensu lato are quite distinct from each other, particularly from *M. pulchrifolius* (population from Serra Dourada), which seems to be genetically isolated.

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