

# ***Manihot takape* sp. nov. (Euphorbiaceae), a new tuberous subshrub from the Paraguayan Chaco**

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## **Abstract**

*Manihot takape* De Egea & Peña-Chocarro, **sp. nov.** is described and illustrated as a new species from the Paraguayan Chaco. It was collected while carrying out fieldwork related to the study of the most important Wild Crop Relatives of the country's flora. Morphological characteristics that differentiate this species from closely related taxa, as well as its habitat, geographical distribution and conservation status are provided.

## **Keywords**

Paraguay, dry Chaco, *Manihotae*, endemism

## **Introduction**

*Manihot* Mill. (Euphorbiaceae) is a Neotropical genus, most likely of Mesoamerican origin, which diversified secondarily throughout South America, colonising all available types of lowland and seasonally dry environments (Deputié and Salick 2011), with the greatest centre of diversity in Brazil (Silva and Sodré 2014). The taxonomy of *Manihot* was first studied by Pohl (1827) and Pax (1910), but it was not until Rogers and Appan (1973) that the most complete taxonomic study of the genus was carried out. They recognised 98 species organised into 19 sections and distributed from Texas

to Argentina. Several new species, however, have been described in recent years, mainly from Brazil and Bolivia, increasing this number to more than 120 species (Mendoza 2014, Mendoza 2016, Silva 2014, Silva 2015, Inocencio and Silva 2016, Silva et al. 2017, Lopes Martins et al. 2018). In Paraguay, the genus is represented by 15 taxa, of which 6 are endemic to the country (Rogers and Appan 1973, Peña-Chocarro and De Egea in press). The majority of them are found in the Oriental region of the country, while only four occur in the Chaco region.

During botanical expeditions to the Chaco region, while carrying out research on the most important genera of Wild Crop Relatives of the Paraguayan flora, a collection of *Manihot* was made that could not be assigned to any known species. Later, herbarium specimens with similar diagnostic characters were found and these had been misidentified as another species of *Manihot*. In this paper, we assign these specimens to a new taxon, which we describe under the name *Manihot takape* De Egea & Peña-Chocarro. The species is illustrated and its geographical distribution, ecology, phenology and conservation status are included. The new species is compared with *M. anomala* Pohl subsp. *glabrata* Chodat & Hassl. and *M. populifolia* Pax, which, in morphological terms, are the most similar taxa amongst the species found within Paraguay.

## Materials and methods

The description of this new species is based on field observations of wild populations and the examination of herbarium specimens deposited in BM, CTES, F and FCQ. Specimens of *Manihot* from Paraguay deposited in K and MA were also reviewed, but this species was not found. The holotype collection was deposited in FCQ and duplicates can be found in BM, CTES and G. The terminology used for general morphology is in compliance with Rogers and Appan (1973).

The geographic distribution map was made using ArcGIS 10.5, using georeferenced collection records. The conservation status was determined based on field observations and applying the IUCN Red List Category Criteria (IUCN 2014) and the extent of occurrence (EOO) and area of occupancy (AOO) were calculated with the Geospatial Conservation Assessment Tool (GeoCAT, <http://geocat.kew.org>).

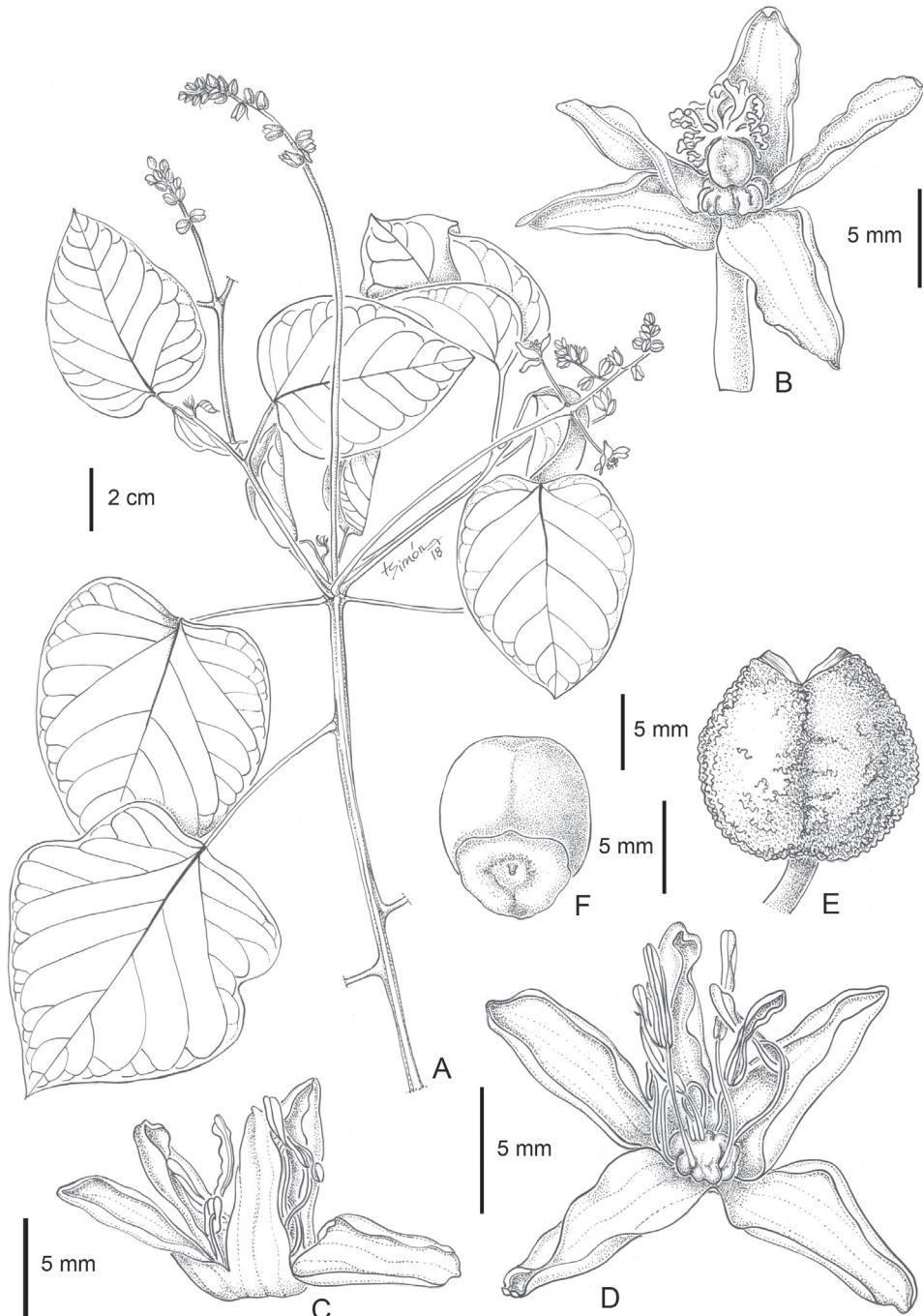
## Taxonomic treatment

### *Manihot takape* De Egea & Peña-Chocarro, sp. nov.

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Figs. 1, 2 and 3

**Type.** PARAGUAY. Boquerón: Neuland, Parque Valle Natural, 22°34'21"S; 60°05'31"W, 19 Feb 2018, fr., J. De Egea, F. Mereles & S. Fernández 1793 (holotype: FCQ; isotypes: BM, CTES, G).



**Figure 1.** *Manihot takape*. **A** Habit (Krapovickas & Cristóbal 44224) **B** Pistillate flower with calyx open (Krapovickas & Cristóbal 44224) **C** Staminate flower (Aquino & Quarti 470) **D** Staminate flower with calyx split and open (Aquino & Quarti 470) **E** Dried capsule (J. De Egea et al. 1793) **F** Seed, ventral side (J. De Egea et al. 1793). Drawn by Laura Simón.

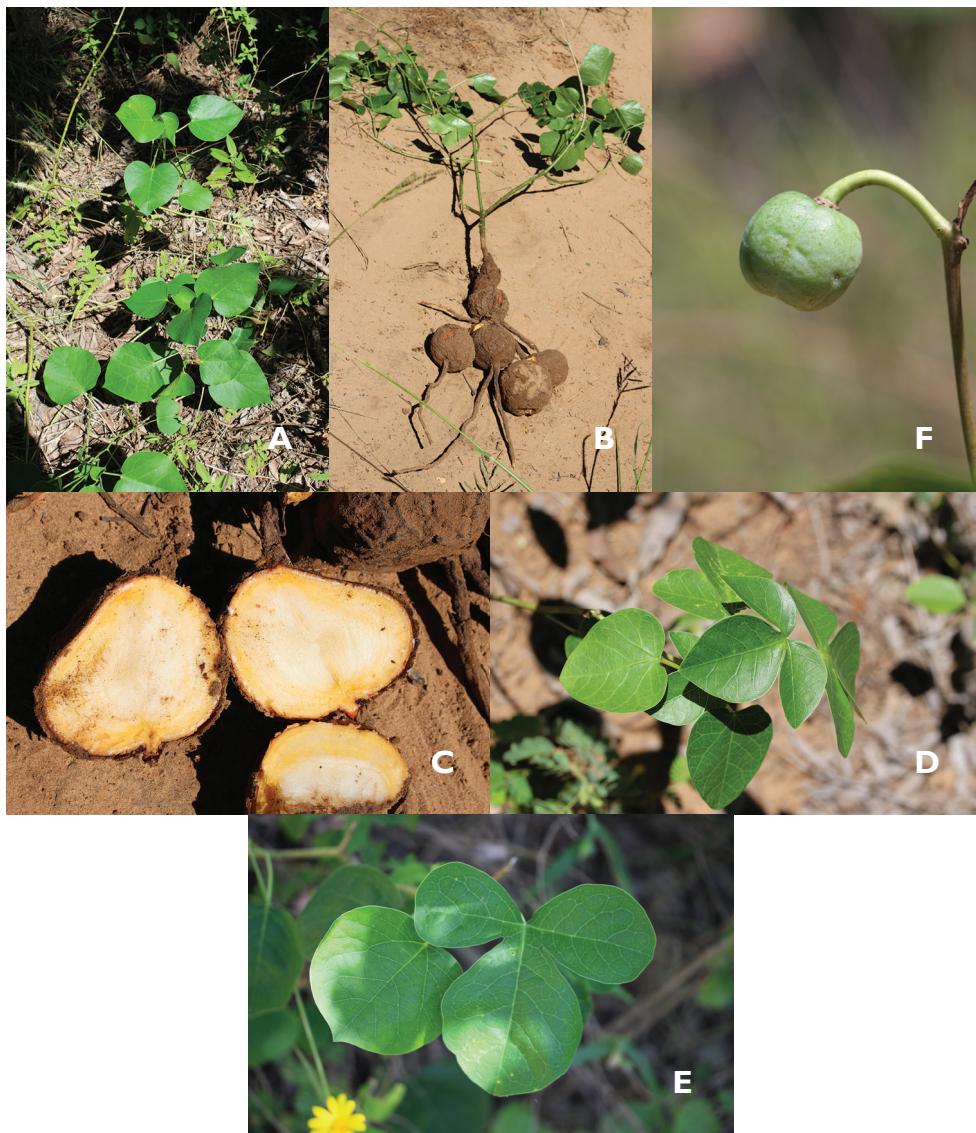
**Diagnosis.** Subshrubs 0.5–0.8(–1) m tall, all parts glabrous; stems branched from base, suberect to decumbent; petiole attachment basal to occasionally narrowly peltate (less than 0.2 cm from lamina base), lamina unlobed or shallowly to deeply 3(–5)-lobed, several intermediate states found in the same plant; inflorescence a cluster of 2–6 subspicate racemes 14–33 cm long; flowers creamy-white, occasionally reddish, glabrous; pistillate flowers geminate, long pedicellate, sepals distinct, disc plicate; staminate flowers numerous, subsessile, sepals connate 1/4 their length, disc lobulate; capsules light green, unwinged, smooth when fresh, rough when dried.

**Description.** Subshrubs 0.5–0.8(–1) m tall. Roots slender with scattered subglobose to slightly elongated tubers, 5–10 cm diameter, ligneous outside, starchy, fibrous and creamy-white inside. Latex white. Stems branched from base, suberect to decumbent, leaning on adjacent vegetation, hollow, glabrous, green, occasionally reddish. Leaves alternate, widely spaced on stem, light green; stipules 0.2–0.3 cm long, narrowly lanceolate to filiform, margins entire, glabrous, caducous; petioles 1.5–8(–10) cm long, terete, glabrous, petiole attachment basal to occasionally narrowly peltate (less than 0.2 cm from lamina base); lamina membranaceous, smooth and glabrous on both sides, with a tuft of hairs on the adaxial side at the point of attachment of petiole, venation camptodromous; lamina unlobed to shallowly or deeply 3-lobed, sometimes with 2 additional smaller basal lobes, several intermediate states found in the same plant; sinus never reaching the lamina base, width of lamina between lamina base and sinus > 0.5 cm. Unlobed laminas 3–9(–11) × 2.5–7(–10) cm, ovate to suborbicular, base obtuse, truncate or subcordate, rarely acute, margins entire or slightly sinuate, apex acuminate; leaves mostly unlobed, especially those near the inflorescence. Lobed leaves: medial lobes 4–7 × 3–6 cm, elliptic, ovate or obovate, sometimes pandurate, apex acuminate, rarely obtuse. Inflorescence bisexual, terminal; a cluster of 2–6 racemes arising from a common base, all parts glabrous; racemes subspicate, 14–33 cm long; bracteoles and bractlets 2–3 mm long, 1 mm wide, setaceous, narrowly lanceolate, margins entire. Pistillate flowers 2, restricted to the base of the inflorescence, geminate, all parts glabrous; pedicels ca. 1–2 cm long; sepals 5, distinct, 1 cm long, creamy-white, occasionally with reddish pigmentation; disc lobed, 1 mm thick, creamy-white; ovary 3-carpellate, subglobose, styles very shortly connate, stigmas 3, profusely lobulate. Staminate flowers numerous, aggregated toward the apex of the inflorescence; pedicels 0.5 mm; buds ovoid-ellipsoid; sepals 5, connate 1/4 length, 1 cm long, creamy-white, occasionally with reddish pigmentation; disc lobed, 1 mm thick, creamy-white; stamens 8–10, filaments 3.5–5 mm long, subequal, anthers 4 mm long, oblong. Capsules 7.5–15 mm diameter, surface rough in dried specimens, to 20–23 mm diameter and smooth in fresh specimens, subglobose to slightly elongated, unwinged, apex rounded to depressed, dehiscence septicidal and loculicidal. Seeds 9–11 × 7–8 mm, 4–5 mm depth, oblong-elliptic, light glaucous greenish-grey, smooth and slightly lustrous, with few 1–2 mm dark spots towards the sides; caruncle usually prominent, light brownish-grey, opaque, extending obliquely from apex to 4 mm on the ventral side.

**Distribution and ecology.** This species has been collected in dry areas of the Paraguayan Chaco, more specifically within the Departments of Boquerón and Presidente

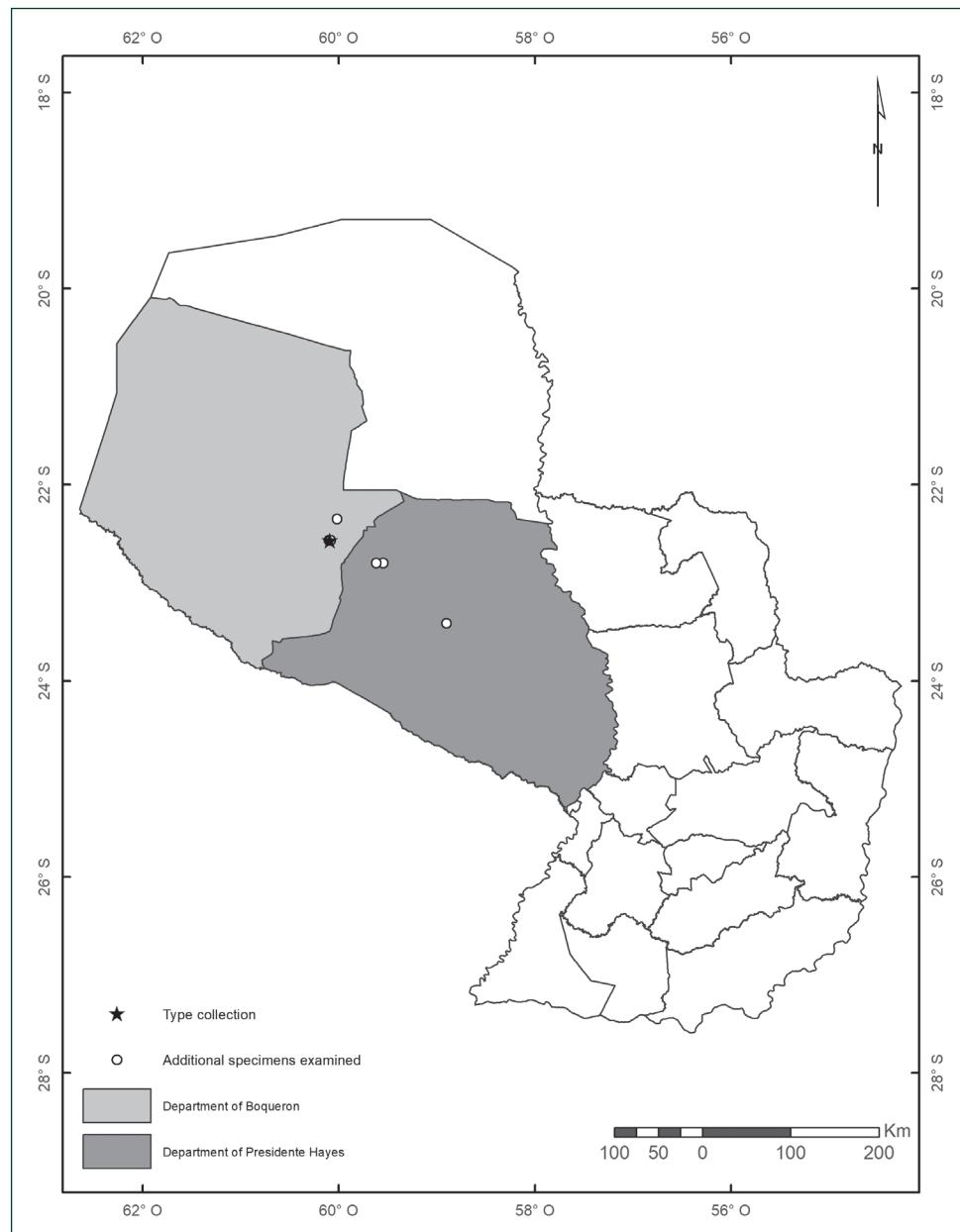


**Figure 2.** *Manihot takape*. Herbarium specimen showing different leaf forms and a particularly long inflorescence (Krapovickas & Cristóbal 44223). Image used with permission and provided by the Instituto de Botánica del Nordeste (CTES).



**Figure 3.** *Manihot takape* (J. De Egea et al. 1793). **A** Habit **B** Uprooted plant **C** Roots in cross-section **D–E** Leaves - note the variability in leaf forms **F** Immature fruit.

Hayes (Fig 4). These areas are characterised by sandy and loose soils (regosols) resulting from silted palaeo-riverbeds of the Pilcomayo river delta. The species is frequent in open wooded savannahs, locally called espartillares, dominated by the grass *Elionurus muticus* (Spreng.) Kuntze (espartillo) and scattered with tree species such as *Schinopsis cornuta* Loes. (Anacardiaceae), *Astronium fraxinifolium* Schott (Anacardiaceae), *Jacaranda mimosifolia* D.Don (Bignoniaceae) and *Tabebuia aurea* Benth. & Hook.f. ex S.Moore (Bignoniaceae). Based on the data available so far, the restricted distribution



**Figure 4.** Map of Paraguay showing the known records of *Manihot takape*.

of *Manihot takape* could represent an endemism of the dry Chaco. However, more surveys and collections will be needed to confirm the extension of the species distribution range.

**Phenology.** The species has been collected with flowers and fruits from November to February and with fruits only from January to February.

**Etymology.** The specific epithet stems from the vernacular name takape (Guarani language). This word is used for a particular habitat characterised by a wooded savannah or open woodland (Bertoni 1940). The word is also applied to small woody plants (i.e. subshrubs). This is based on the word takā (twig or branch) and the suffix ‘pe’ (short or dwarf). Both meanings fit the newly described species of *Manihot*.

**Conservation status.** A preliminary conservation assessment with the GeoCat Tool indicates that *M. takape* can be initially considered as Endangered, with an extent of occurrence of 1,887 km<sup>2</sup> and an area of occupancy of 28 km<sup>2</sup> (based on an IUCN default cell width of 2 km). Furthermore, with only 5 locations known to this date and considering the high deforestation and land use changes in the Paraguayan Chaco (Arévalos et al. 2018, Cardozo et al. 2013, Huang et al. 2009, Mereles and Rodas 2014, Yanosky 2013), the preliminary IUCN category proposed for this species is Endangered B1ab(iii)+2ab(iii). It is worth mentioning that the type locality, known as *Parque Valle Natural* in Neuland, Boquerón, is a private reserve of approximately 0.5 km<sup>2</sup> that harbours a small population of the new species. The current conservation status of the remaining four locations is unknown. Further field observations and collections are strongly recommended to achieve a more conclusive conservation assessment.

**Additional specimens examined.** PARAGUAY. Boquerón: Colonia Fernheim, Colonia 22 (Neuwiese), 22°21'S, 60°01'W, 9 Nov 1987, P. Arenas 3313 (FCQ); Neu-land, Parque Valle Natural, 22°34'S; 60°06'W, 18 Jan 1993, L. Pérez, S. Bertoni, M. Quintana, B. Benítez, G. Marín & G. Rubira 2736 (CTES); Parque Valle Natural, 25 km S de Filadelfia, 22°34'S; 60°05'W, 7 Dec 1992, A. Krapovickas & C.L. Cristóbal 44223 (CTES); Parque Valle Natural, 25 km S de Filadelfia, 22°34'S; 60°05'W, 7 Dec 1992, A. Krapovickas & C.L. Cristóbal 44224 (CTES, F), Parque Valle Natural, 12 km S de Filadelfia 22°34'S; 60°05'W, 28 Feb 1991, R. Vanni, A. Radovancich & A. Schinini 2455 (CTES). Presidente Hayes: Colonia Menno, Paz del Chaco, 23°25'S; 58°54'W, 15 Nov 1987, P. Arenas 3336 (FCQ); Estancia Yrendá, 22°48'S; 59°33'W, 15 Feb 1993, L. Pérez, S. Bertoni, T. Florentín & A. Bogado 3042 (CTES); Estancia Yrendá, 22°48'S; 59°33'W, 15 Feb 1993, L. Pérez, S. Bertoni, T. Florentín & A. Bogado 3043 (CTES); Tte. 1ºIrala Fernández, próximo al centro urbano, 22°48'01"S; 59°37'05"W, 19 Feb 2012, O. Aquino & A. Quarti 470 (FCQ).

## Discussion

*Manihot takape*, as far as known, is restricted to a particular area of the Paraguayan dry Chaco and its diagnostic characteristics and ecological associations are consistent amongst all 10 specimens examined. It stands out from other *Manihot* species of the region (taking into consideration the entire Paraguayan territory and border areas) by its predominantly unlobed leaves, the particularly long, glabrous inflorescences and its subshrubby, decumbent or “clambering” habit; the latter term, following Rogers and Appan (1973), refers to plants with stems that start erect, but may later drop over.

**Table 1.** Key morphological characters used to separate *Manihot takape* sp. nov., *M. anomala* subsp. *glabrata*, and *M. populifolia*.

Character	<i>M. takape</i> sp. nov.	<i>M. anomala</i> subsp. <i>glabrata</i> <sup>†</sup>	<i>M. populifolia</i> <sup>†</sup>
Habit	Subshrubs to 0.8(–1) m tall, stems suberect, decumbent or clambering, branched from base	Shrubs to 3 m tall, stems erect, generally not branched from base	Subshrubs to 0.8 m tall, stems ascending, branched from base
Indumentum	All parts glabrous, except for a tuft of hairs on the adaxial side at petiole attachment	Moderately pubescent to glabrescent. Conspicuous tuft of hairs on the adaxial side at petiole attachment	All parts glabrous, except for a tuft of hairs on the adaxial side at petiole attachment
Leaf form types	Unlobed and shallowly to deeply 3(–5) lobed	Unlobed and deeply 3(–5) lobed	Unlobed, rarely 3-lobed
Nonlobed leaves	Probably main type of leaf form, distributed in all parts of the plant, alternating with lobed leaves	Generally associated with inflorescence, close to terminal nodes	Main type of leaf form
Petiole attachment	Basal or essentially so; < 2 mm from petiole insertion to lamina base	Basal	Peltate; 2–5(–8) mm from petiole insertion to lamina base
Lamina texture	Membranaceous	Membranaceous	Membranaceous to coriaceous, with notably thickened and yellowish margin
Bracteoles and bractlets	Setaceous, 2–3 mm long, 1 mm wide	Setaceous to semifoliaceous, less than 10 mm long, 2 mm wide	Setaceous, less than 5 mm long, 1 mm wide
Inflorescence	Cluster of subspicate racemes, each 14–33 cm long	Cluster of subspicate racemes, each ca. 15 cm long	Single or cluster of 2–3 racemes, each 10(–20) cm long
Pistillate flowers	Glabrous, pedicels ca. 1–2 cm long, sepals 1 cm long	Densely pubescent to velutinous, pedicels ca. 1–2 cm long, sepals to 1–2 cm long	Glabrous, pedicels ca. 1 cm long, sepals 1 cm long
Staminate flowers	Glabrous, subsessile (pedicels 0.5 mm long), sepals 1 cm long, connate 1/4 length	Densely pubescent to velutinous, short pedicellate (pedicels 1–2 mm long), sepals 1–2 cm long, connate 1/2 length	Glabrous, pedicel length not known, sepals 1 cm long, connate 1/2 length

<sup>†</sup> Based on Rogers and Appan (1973) and herbarium and field observations.

Due to the presence of both lobed and unlobed leaves and the basal (or nearly so) petiole attachment, the new species is morphologically most similar to *Manihot anomala* Pohl subsp. *glabrata* (Chodat & Hassl.) D.J.Rogers & Appan, from which it differs by the characters shown in Table 1. *M. anomala* subsp. *glabrata* is an erect and taller plant, frequently with a shrubby or tree-like habit up to 3 m, with mostly lobed leaves except for the ones close to the inflorescence, and inflorescences normally to 15 cm long with flowers densely pubescent to velutinous. In terms of habitat, *M. anomala* can be found in a wide range of vegetation types: subhumid and xerophytic

forests, cerrado vegetation and quite frequently modified environments such as forest and trail edges, on sandy soils of variable texture and grain size. Consequently, it can be considered as a coloniser of anthropogenic environments. It has been recorded in the centre and north of the Oriental region and in all three departments of the Chaco region.

Due to its subshrubby habit and predominance of unlobed leaves, *Manihot takape* can also be mistaken for *M. populifolia* Pax, from which can be easily differentiated by the petiole insertion, which is basal or essentially so in the former and peltate in the latter. In addition, the species also have different habitat preferences, with *M. populifolia* being a species known from cerrados of the Amambay and Concepción departments in the Oriental region, where it also seems to have a restricted distribution range (Zuloaga and Belgrano 2018). There is one record of *M. populifolia* from Chuquisaca, Bolivia (Jørgensen et al. 2015 onwards), but the specimen (Pensiero & Marino 4380, MO) could not be examined to confirm its determination. However, based on examination of the digitised image of this specimen available from TROPICOS, we believe it might be misplaced within *M. populifolia* and that it could actually be a collection of *M. takape*.

Similarities between *Manihot takape* and the two aforementioned species indicate that the new species could belong to one of their sections, *Sinuatae* or *Peltatae*, respectively, according to Rogers and Appan (1973). However, recent molecular evidence (Deputié and Salick 2011) highlights the need for a major reclassification of the genus *Manihot*. According to their results, cerrado shrubs are placed in a well supported clade that includes *M. anomala*. Undoubtedly, molecular data are needed for a complete assessment on the infrageneric placement of the newly described species.

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## References

- Arévalos F, Ortiz E, Báez M, Benítez C, Allegretti L, Duré A (2018) Monitoreo Mensual del Cambio de Uso y Cobertura de la Tierra, Incendios y Variación de la Cubierta de Aguas en el Gran Chaco Americano; Enero 2018. Guyra Paraguay. <http://guyra.org.py/informe-deforestacion>
- Bertoni MS (1940) Diccionario Botánico Latino-Guaraní-Latino con un glosario de vocablos y elementos de la nomenclatura botánica. Editorial Guaraní, Asunción, 99–100.
- Cardozo R, Palacios F, Rodas O, Yanosky A (2013) Cambio en la cobertura de la tierra del Gran Chaco Americano en el año 2012. *Paraquaria Natural* 1(2): 43–49. <http://guyra.org.py/paraquaria-2013/>
- Deputié A, Salick J (2011) Evolutionary biogeography of *Manihot* (Euphorbiaceae), a rapidly radiating Neotropical genus restricted to dry environments. *Journal of Biogeography* 38(6): 1033–1043. <https://doi.org/10.1111/j.1365-2699.2011.02474.x>
- Huang G, Kim S, Song K, Townshend JRG, Davis P, Altstatt A, Rodas O, Yanosky A, Clay R, Tucker CJ, Musinsky J (2009) Assessment of Paraguay's forest cover change using Landsat observations. *Global and Planetary Change* 67(1–2): 1–12. <https://doi.org/10.1016/j.gloplacha.2008.12.009>
- Inocencio LS, Silva MJ (2016) A vine-like species of *Manihot* (Euphorbiaceae) from the state of Mato Grosso, Brazil. *Systematic Botany* 41(4): 983–988. <https://doi.org/10.1600/036364416X694107>
- IUCN (2014) Guidelines for using the IUCN red list categories and criteria (Ver. 11). IUCN, Gland, Switzerland and Cambridge. <http://cmsdocs.s3.amazonaws.com/RedListGuidelines.pdf>
- Jørgensen PM, Nee MN, Beck SG (2015 onwards) Catálogo de las plantas vasculares de Bolivia. Missouri Botanical Garden. <http://www.tropicos.org/projectwebportal.aspx?pagename=Home&projectid=13> [accessed: 29.04.2018]
- Lopes Martins ML, Lemos de Carvalho PC, da Silva Ledo CA, Amorim AM (2018) *Manihot alternifolia* and *M. elongata* spp. nov. (Euphorbiaceae) and the rediscovery of *M. quinquefolia* in Caatinga (semiarid) vegetation in Brazil. *Nordic Journal of Botany* 36(3): 1–8. <https://doi.org/10.1111/njb.01615>
- Mendoza FJM (2014) *Manihot* (Euphorbiaceae) en Bolivia: Parte I: Tres especies nuevas y un nuevo registro. *Brittonia* 66(2): 107–117. <https://doi.org/10.1007/s12228-013-9303-3>
- Mendoza FJM (2016) Taxonomic novelties in *Manihot* (Euphorbiaceae) from Bolivia and adjacent areas. *Revista de la Sociedad Boliviana de Botánica* 9(1): 7–16.
- Mereles F, Rodas O (2014) Assessment of rates of deforestation classes in the Paraguayan Chaco (Great South American Chaco) with comments on the vulnerability of forest fragments to climate change. *Climatic Change* 127(1): 55–71. <https://doi.org/10.1007/s10584-014-1256-3>
- Pax F (1910) *Manihot* Adans – Das Pflanzenreich IV. 147 II, Heft 44, ed. HGA Engler. Wilhelm Engelmann, Leipzig, 21–111.
- Peña-Chocarro MC, De Egea J (in press) Checklist of endemic vascular plants of Paraguay. *Phytotaxa*.

- Pohl J (1827) *Plantarum Brasiliae Icones and Descriptions*. 1: 17–56.
- Rogers DJ, Appan SG (1973) *Manihot* and *Manihotoides* (Euphorbiaceae). A computer assisted study. Flora Neotropica (Monograph no. 13). Hafner Press, New York.
- Silva MJ (2014) *Manihot veadeirensis* (Euphorbiaceae s. s.): A new species from the Brazilian Cerrado. Systematic Botany 39(4): 1161–1165. <https://doi.org/10.1600/036364414X682625>
- Silva MJ (2015) *Manihot apanii* (Euphorbiaceae s.s.) a new species from Brazil, and a key to the species with unlobed or very shortly lobed leaves. Systematic Botany 40(1): 168–173. <https://doi.org/10.1600/036364415X686477>
- Silva MJ, Inocencio LS, Sodré RC, Alonso AA (2017) Morphological and anatomical evidence support a new wild cassava: *Manihot fallax* (Crotonoideae, Euphorbiaceae), from Mato Grosso, Brazil. PhytoKeys 91: 139–156. <https://doi.org/10.3897/phytokeys.91.21465>
- Silva MJ, Sodré RC (2014) A dwarf species of *Manihot* Mill. (Euphorbiaceae s. s.) from the highlands of Goiás, Brazil. Systematic Botany 39(1): 222–226. <https://doi.org/10.1600/036364414X678134>
- Yanosky A (2013) The challenge of conserving a natural Chaco habitat. Paraquaria Natural 1(1): 32–34. <http://guyra.org.py/paraquaria-2013/>
- Zuloaga FO, Belgrano JM (2018) Catálogo de plantas vasculares del Cono Sur. <http://www.darwin.edu.ar/proyectos/floraargentina/fa.htm> [accessed: 29.04.2018]

# Begonia medogensis, a new species of Begoniaceae from Western China and Northern Myanmar

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## Abstract

*Begonia medogensis* JianW.Li, Y.H.Tan & X.H.Jin, a new species of Begoniaceae, is described and illustrated by colour photographs. *Begonia medogensis* is distributed in western China and northern Myanmar. It has erect stems, is tuberless, has many triangular to lanceolate leaves, base slightly asymmetric, margins remotely and irregularly denticulate; staminate flowers have 4 perianth segments, with outer 2 segments broadly ovate, inner 2 spathulate; pistillate flowers have 5 perianth segments, unequal, outer 4 broadly ovate, inner 1 spathulate. The new species is assigned to section *Platycentrum* and can easily be distinguished from the other species in the section.

## Keywords

*Begonia*, *Begonia medogensis*, sect. *Platycentrum*, new species, China, Myanmar

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\* These authors contributed equally to this work.

## Introduction

*Begonia* L. (1753) is amongst the largest genera in the angiosperms, with more than 1800 species widely distributed in the tropical and subtropical areas of the world (Ku et al. 2007; Chen et al. 2018) and numerous hybrids and cultivars popular in the horticultural market (Gregório et al. 2015). South America and Asia have the richest diversity of *Begonia*, with many new species still being described (such as Chen et al. 2018a, Camfield and Hughes 2018).

During our botanical survey to Medog County, Tibet, western China in late 2017, *Begonia* specimens, including DNA samples, were collected. The DNA samples were kept in a freezer and specimens were deposited in HITBC and PE for further study. The same species has been discovered in our botanical survey of Kachin State, northern Myanmar, in 2017. Results from our study indicate that it is a species new to science, which we describe here.

This new species belongs to section *Platycentrum* (Klotzsch) A. DC., characterised by terrestrial plants, tubers usually absent, rhizomatous or with upright stems, leaves more than 2, not peltate, usually simple, flower usually without bracteoles, male flower with 4 (rarely 2) free perianth segments, female flower with 4–6 (rarely 3 or 8) free perianth segments, ovary with 3 very unequal wings, locules 2. Besides this new species, there are 171 other species of *Begonia* section *Platycentrum* (Klotzsch) A. DC. distributed in Asia (Moonlight et al. 2018), of which 4 caulescent species are distributed in Himalayan areas (Doorenbos et al. 1998), i.e. *Begonia goniotis* C.B. Clarke (Hooker, 1879), *B. griffithiana* (A.DC.) Warb. (Warburg 1894; basionym: de Candolle 1859), *B. nepalensis* (A.DC.) Warb. (Warburg 1894; basionym: de Candolle 1859) and *B. sandalifolia* C.B. Clarke (Hooker, 1879).

## Taxonomy

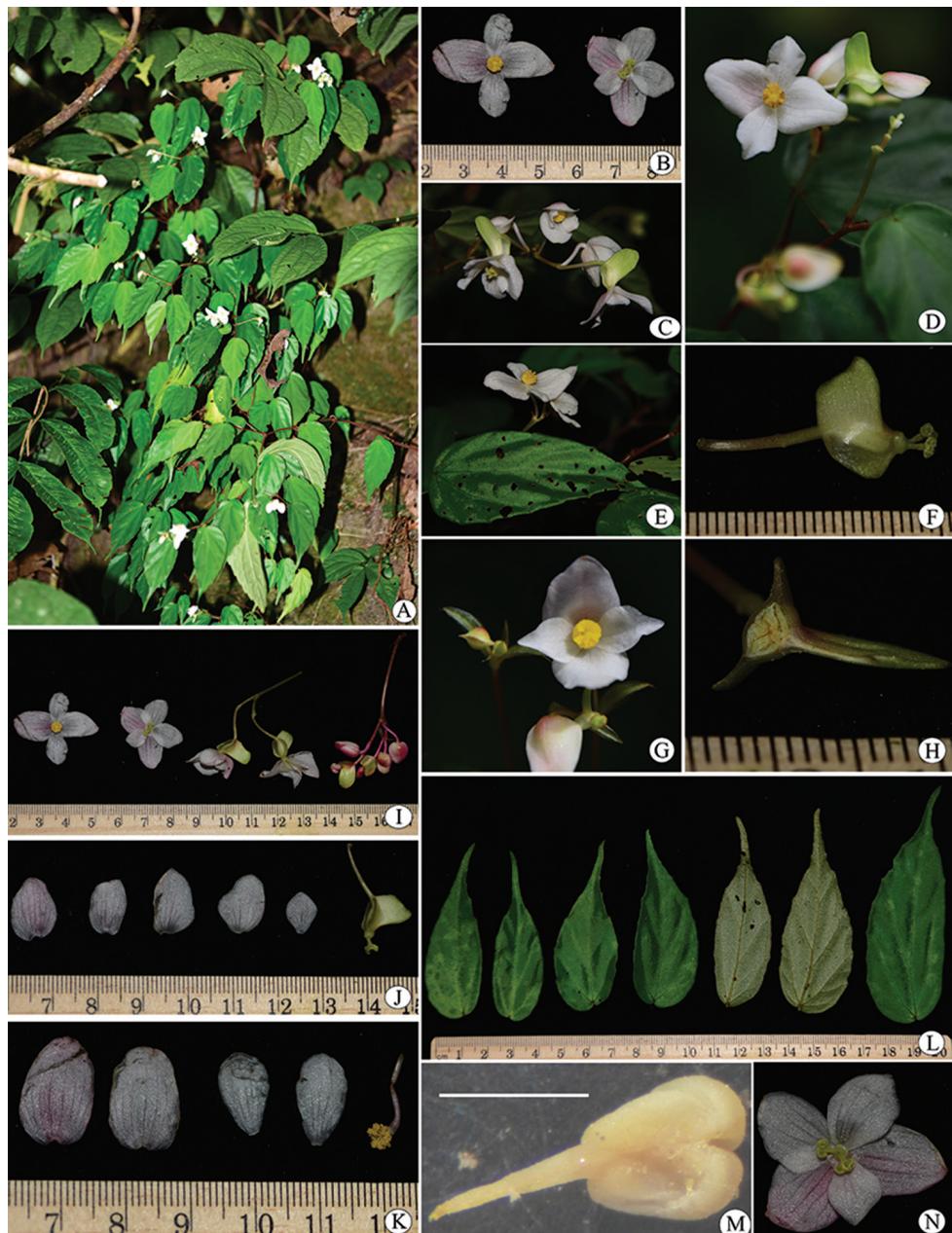
### *Begonia medogensis* JianW.Li, Y.H.Tan & X.H.Jin, sp. nov.

urn:lsid:ipni.org:names:77186060-1

Figure 1

**Diagnosis.** *Begonia medogensis* is morphologically similar to *B. goniotis*, *B. griffithiana*, *B. nepalensis* and *B. sandalifolia*, but can be easily distinguished from them by having leaves ovate-lanceolate, 6.0–8.0 × 1.5–2.5 mm, base slightly asymmetric, margins remotely and irregularly denticulate; triangular to lanceolate stipules; staminate flowers with outer 2 segments broadly ovate, inner 2 spathulate; pistillate flowers with perianth segments unequal, outer 4 larger, broadly ovate, inner 1 smallest, spathulate; cylindroid ovary, larger wing oblong, apex truncate.

**Type.** CHINA. Tibet, Medog County, Beibeng town, semi-evergreen forest in a subtropical area, 29°15'09"N, 95°13'31"E. 1381 m a.s.l., 16 November 2017, flowering, Xiaohua Jin, Jianwu Li, Xilong Wang & Chengwang Wang 19331 (holotype: HITBC!, isotype: HITBC!, PE!, K!)



**Figure 1.** *Begonia medogensis* JianW.Li, Y.H.Tan & X.H.Jin. (photographed by Jian-Wu Li). **A** Habitat **B-E** Flowers **F** Pedicel and ovary (showing large wing) **G** Male flowers (face view) **H** Ovary (showing loculus) **I** Flowers **J** Dissection of female flower **K** Dissection of male flower **L** Leaves **M** Anther with filament (under dissection mirror, bar = 1 mm) **N** Female flower (face view).

**Table I.** Differences between *Begonia medogensis*, *B. goniots*, *B. griffithiana*, *B. nepalensis* and *B. sandalifolia*.

Character	<i>B. medogensis</i>	<i>B. goniots</i>	<i>B. griffithiana</i>	<i>B. nepalensis</i>	<i>B. sandalifolia</i>
Stem	internode 6–15 cm long	internode 4–10 cm long	internode 3–9 cm long	internode 4–11 cm long	internode 9–20 cm long
Stipules	persistent, triangular to lanceolate, 6.0–8.0 × 1.5–2.5 mm	persistent, ovate, 6–13 × 4–10 mm	persistent, lanceolate, 4–13 × 1–2 mm	deciduous, lanceolate	persistent, oblong, 6–10 × 2–4 mm
Leaves	petiole 1.2–1.7 cm long, ovate-lanceolate, base slightly asymmetric, 6.0–10.0 × 2.0–3.7 cm, margins remotely and irregularly denticulate, apex caudate-acuminate	petiole 1.0–4.6 cm long, lanceolate, base strongly asymmetric, 10–15 × 0.6–2.5 cm, margins entire or serrate near apex, apex long acuminate	petiole 0.2–1 cm long, oblong-lanceolate to lanceolate, base strongly asymmetric, 5–18 × 2–5 cm, margins serrulate or with small teeth at ends of the main veins, apex acuminate	petiole 1–3 cm long, ovate-lanceolate, base strongly asymmetric, 15–17 × 4–11 cm, margins shallowly denticate, apex caudate- acuminate	petiole 0.7–1.3 cm long, ovate to oblong, base strongly asymmetric, 10–15 × 3–5 cm, margins entire or serrate, apex acuminate
Male flower	tepals 4, outer 2 broadly ovate, 15– 17 × 12–14 mm, tinted with pink, inner 2 spathulate, 11–14 × 6–8 mm, white, stamens 60–80, anthers broadly lorate	not seen	tepals 4, outer 2 orbicular to oblong, 4–14 × 2–11 mm, pale pink to white, inner 2 lanceolate to linear, 3–9 × 1–4 mm, pale pink, stamens 20–30, anthers elliptic-globose	tepals 2, ovate, 7–10 × 7–9 mm, pale pink to white, stamens 20–40, anthers elliptic globose	tepals 4, outer 2 round, 18 × 18 mm, inner 2 oblong, stamens ca. 50, anthers obovoid
Female flower	tepals 5, unequal, outer 4 broadly ovate, the outmost 2 tinted with pink, 12–14 × 9–12 mm, other 2 slightly larger, 13–15 × 10–12 mm; the inner 1 smallest, spatulate, 8–10 × 7–9 mm	not seen	tepals 5–6, equal, 3–4 larger and 1–2 smaller, oblong elliptic to obovate orbicular, outer tepals 6–11 × 5–7 mm, pale pink to white, inner tepals smaller	tepals 4–5, equal, outer tepals 10–15 × 7–10 mm, pale pink to white, inner tepals smaller	tepals 4–5, equal, outer tepals 12–15 × 6 mm, larger wing oblong, 15–23 mm broad, apex truncate
Ovary	cylindroid, 5–8 × 1.5–2.5 mm, larger wing oblong, 7–9 mm broad, apex truncate	ellipsoid, 10–13 × 6 mm, larger wing oblong, 10–16 mm broad, apex rounded	oblong-ellipsoid, 5–7 × 2–3 mm, larger wing triangular, 12–18 mm broad, apex obtuse	narrowly ellipsoid, 12–15 × 5 mm, larger wing oblong, 15–23 mm broad, apex truncate	ellipsoid, 13–16 × 6 mm, larger wing oblong, 13–16 mm broad, apex rounded

**Description.** Perennial herbs, caulescent, erect. Rhizomes short, stout. Stems red-dish-purple, densely pubescent, 0.3–1.0 m tall, with internode 6–15 cm long, upper part well-branched, with internode 2–5 cm long. Leaves cauline; stipules persistent, triangular to lanceolate, 6.0–8.0 × 1.5–2.5 mm, apex acuminate to cuspidate; petiole 1.2–2.7 cm long, densely pubescent; leaf blade ovate-lanceolate, slightly asymmetric, 6.0–10.0 × 2.0–3.7 cm, adaxially green, slightly hairy, abaxially greenish-white, hairy on venation, venation palmate-pinnate, 5–8-veined, base slightly oblique, rounded to subcordate, margins remotely and irregularly denticulate, apex caudate-acuminate. Inflorescences terminal and axillary, sub-corymb, monoecious, to 6 cm, sub-pendulous, peduncles 2.7–4.0 cm long, secondary 0.5–1.0 cm long, terminally with 1–5 flowers; floral bracts lanceolate to ovate-lanceolate, 5.0–10.0 × 1.7–5.0 mm, thickly papery, glabrous, apex acuminate. Staminate flowers: pedicel 10–15 mm long; tepals 4, white, outer 2 broadly ovate, 15–17 × 12–14 mm, tinted with pink, glabrous, apex rounded; inner 2 spathulate, 11–14 × 6–8 mm, glabrous, apex obtuse to rounded; stamens 60–80; filaments free, 0.5–1.2 mm long, sub-equal, fused at base into a column; anthers broadly lorate, 0.8–1.1 mm long, apex emarginate. Pistillate flowers: pedicel 11–20 mm long, tepals 5, white, unequal, glabrous, outer 4 broadly ovate, the outmost 2 tinted with pink, 12–14 × 9–12 mm, apex rounded, other 2 slightly larger, 13–15 × 10–12 mm, apex obtuse to rounded; the inner 1 smallest, spathulate, 8–10 × 7–9 mm, apex rounded; ovary glabrous, 2-loculed; placentae axile, bilamellate; styles 2, fused at base; stigmas 2-cleft, spiralled. Capsule sub-pendulous, cylindroid, 5.0–8.0 × 1.5–2.5 mm; wings 3, adaxial 1 larger, oblong, 7–9 mm broad, apex truncate, lateral 2 less developed, 2–3 mm broad.

**Phenology.** Flowering from October to December.

**Distribution and habitat.** This new species grows in subtropical areas in Beibeng town, Medog County, Tibet, China, at an elevation of 700–1400 m and in Putao district, Kachin state, Myanmar, at an elevation of 600–1200 m.

**Etymology.** The species is named after the holotype locality, Medog County, in Tibet, China.

**Additional specimens examined (paratype).** MYANMAR. Putao district, Kachin state, in tropical montane forest, 27°37'15"N, 97°53'14"E. 900 m a.s.l., 1 December 2016, flowering, *Myanmar Exped. M0727* (HITBC!).

**Note.** Morphologically, the new species is similar to *B. goniotis*, *B. griffithiana*, *B. nepalensis* and *B. sandalifolia*, but differs from them by the shape of stipules and leaves, base and margins of leaves, both male and female flowers having unequal perianth segments, cylindroid ovary etc. (see Table 1).

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## References

- Camfield R, Hughes M (2018) A revision and one new species of *Begonia* L. (Begoniaceae, Cucurbitales) in Northeast India. European Journal of Taxonomy 396: 1–116. <https://doi.org/10.5852/ejt.2018.396>
- Chen WH, Jin XH, Shui YM (2018) Rediscovery and amended descriptions of *Begonia kingdom-wardii* (Begoniaceae) from North Myanmar. In: Jin XH, Shui YM, Tan YH, Kang M (Eds) Plant diversity in Southeast Asia. Phytokeys 94: 59–64. <https://doi.org/10.3897/phytokeys.94.21753>
- Chen WH, Radbouchoom S, Nguyen HQ, Nguyen HT, Nguyen KS, Shui YM (2018a) Seven new species of *Begonia* (Begoniaceae) in Northern Vietnam and Southern China. In: Jin XH, Shui YM, Tan YH, Kang M (Eds) Plant diversity in Southeast Asia. Phytokeys 94: 65–85. <https://doi.org/10.3897/phytokeys.94.23248>
- de Candolle ALPP (1859) Mémoire sur la famille des Begoniaceae. annals des sciences naturelles. Botanique 4(11): 93–149. <http://biodiversitylibrary.org/page/41585740> [accessed May 2009]
- Hooker JD (1879) Flora of British India. 2: 648–649. <https://biodiversitylibrary.org/page/357216>
- Doorenbos J, Sosef MSM, de Wilde JJFE (1998) The sections of *Begonia* including descriptions, keys, and species lists (studies in Begoniaceae VI). Wageningen Agricultural University Papers 98: 1–266.
- Gregório BS, Costa JAS, Rapini A (2015) Three new species of *Begonia* (Begoniaceae) from Bahia, Brazil. PhytoKeys 44: 1–13. <https://doi.org/10.3897/phytokeys.44.7993>
- Ku TC, Peng CI, Turland NJ (2007) Begoniaceae. In: Wu ZY, Raven PH (Eds) Flora of China. Science Press, Beijing; Missouri Botanical Garden Press, St. Louis, Vol. 13, 153–207.
- Linnaeus C (1753) Species plantarum. Laurentii Salvii, Holmiae (Stockholm). <https://doi.org/10.5926/bhl.title.727>
- Moonlight PW, Ardi WH, Padilla LA, Chung KF, Fuller D, Girmansyah D, Hollands R, Jaramínez A, Kiew R, Leong WC, Liu Y, Mahardika A, Marasinghe LDK, Connor MO, Peng CI, Pérez ÁJ, Phutthai T, Pullan M, Rajbhandary S, Reynel C, Rubite RR, Sang J, Scherberich D, Shui YM, Tebbitt MC, Thomas DC, Wilson HP, Zaini NH, Hughes M (2018) Dividing and conquering the fastest-growing genus: Towards a natural sectional classification of the mega-diverse genus *Begonia* (Begoniaceae). Taxon 67(2): 267–323. <https://doi.org/10.12705/672.3>
- Warburg O (1894) Begoniaceae. In: Engler A, Prantl KAE. Die Natürlichen Pflanzenfamilien nebstd ihren Gattungen und wichtigeren Arten, insbesondere den Nutzpflanzen, unter Mitwirkung zahlreicher hervorragender Fachgelehrten begründet. Teil 3: Abteilung 6 und 6a: 121–150. Engelmann, Leipzig. <https://doi.org/10.5962/bhl.title.4635>

# **Odontochilus putaoensis (Cranichideae, Orchidaceae), a new species from Myanmar**

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## **Abstract**

*Odontochilus putaoensis*, a new species of Orchidaceae, is described and illustrated from Putao Township, Kachin State, Myanmar. *Odontochilus putaoensis* is close to *O. duplex*, but can be easily distinguished from the latter by having a light yellow lip, a bisaccate hypochile with a small, erect, blade-like and emarginate callus within each sac, a mesochile with a pair of dentate-pectinate flanges and a bilobed epichile with a pair of widely diverging lobes that are erect and concave. An identification key to the Southeast Asian species of *Odontochilus* and colour photographs of *O. putaoensis* are provided. A preliminary conservation assessment according to the IUCN Red List Categories and Criteria is given for the new species.

## **Keywords**

Cranichideae, Kachin State, key, new species, southeast Asia, terrestrial orchid

## **Introduction**

*Odontochilus* Blume (1858) (Orchidaceae, Orchidoideae, Cranichideae) consists of approximately 40 species, distributed from tropical Asia, Pacific islands to Japan, subtropical mainland Asia and eastern Himalayas (Pridgeon et al. 2003, Chen et al. 2009, Pedersen et al. 2011, Chase et al. 2015, Tang et al. 2016). Most species of *Odontochilus* are small terrestrial plants, usually found in humid evergreen broadleaved forests.

The generic delimitation of *Odontochilus* has been confused for a long time with its relative *Anoectochilus* Blume (1825). As both genera share some floral characters such as pectinate mesochile, ventral column wings and two stigma lobes, they were usually considered as one genus (Lang 1999, Pridgeon et al. 2003). Morphologically, *Odontochilus* is distinguished from *Anoectochilus* by its saccate and non-extruded spur enclosed by the lateral sepals and two parallel stigma lobes positioned under the rostellum, whereas *Anoectochilus* has a conical spur extruded beyond the lateral sepals and two remote stigma lobes (Lin and Hsu 1976, Pridgeon et al. 2003, Chen et al. 2009, Pedersen et al. 2011). Recent results of molecular systematics indicated that *Odontochilus* is closely related to *Chamaegastrodia* and *Rhomboda*, whereas *Anoectochilus* is closely related to *Ludisia* (Li et al. 2016).

In the continental part of southeast Asia, there are nine species of *Odontochilus* (Seidenfaden 1992, Schuiteman et al. 2008, Chen et al. 2009, Pedersen et al. 2011, Kurzweil and Lwin 2014, Averyanov et al. 2015, Tang et al. 2016). Although there is no recorded species of *Odontochilus* in the checklist of Kress et al. (2003), there are several species listed as occurring in Myanmar in the floristic documents of Chen et al. (2009), Pedersen et al. (2011) and Kurzweil and Lwin (2014). During our fieldwork in Putao Township, Kachin State, northern Myanmar, in October 2014, a new species of *Odontochilus* was discovered and is described below.

## Material and methods

All measurements of the new *Odontochilus* species were taken from dried herbarium specimens and field notes. In the description, length and width are represented as length × width. In total, four living plants and one dried specimen of the new species were examined. All measurements of *O. duplex* (Holttum) Ormerod (Peninsular Thailand and Peninsular Malaysia) were based on literature (Seidenfaden and Wood 1992, Ormerod 2005, Pedersen et al. 2011).

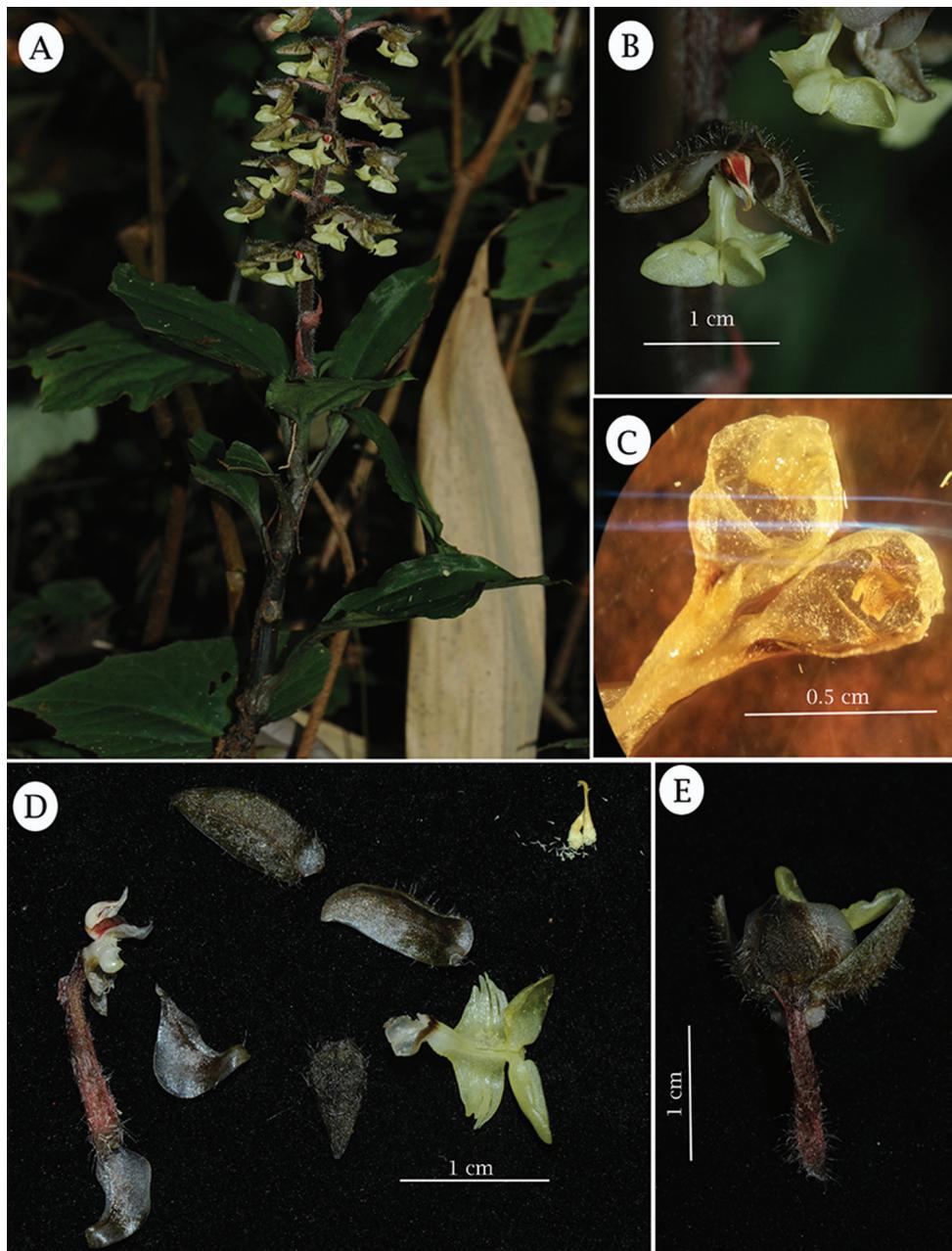
## Taxonomic treatment

### *Odontochilus putaoensis* X.H. Jin, L.A. Ye & A.T. Mu, sp. nov.

urn:lsid:ipni.org:names:77186066-1

Figure 1

**Diagnosis.** *Odontochilus putaoensis* is similar to *O. duplex*, but can be easily distinguished from the latter by having a light yellow lip composed of a bisaccate hypochile with a small, erect, blade-like and emarginate callus within each sac, a mesochile with a pair of dentate-pectinate flanges and bilobed epichile with a pair of widely diverging lobes that are erect and concave.



**Figure 1.** *Odontochilus putaoensis* X.H.Jin, L.A.Ye & A.T.Mu. **A** Habit of *Odontochilus putaoensis*. **B** Front view of flower, showing lip epichile with a pair of erect and concave lobes. **C** Hypochile of *Odontochilus putaoensis*, indicating small, erect, blade-like, emarginate callus within each sac. **D** Dissected flower, showing pedicel and ovary, column, sepals, petals, lip and a pair of clavate pollinia. **E** Dorsal view of flower, showing dorsal sepal forming a hood with petals. Photographed by X.H. Jin.

**Type.** MYANMAR. Kachin State: Putao Township, Hponkanrazi Wildlife Sanctuary, subtropical, evergreen, broad-leaved, montane forest, 2000 m a.s.l., 20 October 2014, Xiaohua Jin et al., PT-ET 959 (Holotype, PE!).

**Description.** Plants autotrophic, terrestrial, 40–60 cm tall. Stem ascending, pubescent, 2–6-leaved. Leaves dark green, ovate-lanceolate, 6–7.5 × 3.2–4 cm, attenuate at apex, blade glabrous; petiole-like base and tubular sheath ca. 2.8 cm long. Peduncle pubescent, with 1 or 2 sheathing bracts, reddish-brown, ovate-lanceolate, 12–15 × 4–5 mm, pubescent, long acuminate; rachis pubescent, sub-densely 16-flowered; floral bracts reddish-brown, ovate-lanceolate, ca. 9 × 4 mm, as long as ovary, abaxially pubescent, long acuminate at apex. Flowers resupinate; dorsal sepal forming a hood with petals, dark greenish-brown, ovate, ca. 6 × 3 mm, acute at apex, abaxially pubescent; lateral sepals greenish-brown, elliptic, oblique, ca. 8 × 4 mm, acute at apex, abaxially pubescent. Petals obliquely ovate-falcate, ca. 6 × 3 mm, membranous, glabrous; lip light yellow, T-shaped, shallowly grooved along the mid-line, ca. 1 cm long; hypochile bisaccate, sac sub-globose, ca. 2 mm in diameter, containing a low median keel and a small, erect, blade-like and apically emarginate callus on each side; mesochile ca. 4 mm long, with a pair of dentate-pectinate flanges, each flange composed of three narrow filaments, ca. 4 mm long and one broad blade-like posterior filament, ca. 3 mm long; epichile bilobed, lobes erect, diverging at obtuse angle to each other, elliptic, ca. 5 × 3 mm, margin involute and consequently resulting in concave lobes, obtuse at apex. Column ca. 1 mm long, stout; anther acuminate in front, ca. 4 mm long; pollinia 2, clavate; stigma lobes confluent; ovary and pedicel cylindric, twisted, sparsely pubescent.

**Etymology.** The new species is named after Putao, the northernmost town of Myanmar, near which it was discovered in a vast area of undisturbed mountain forest.

**Distribution and habitat.** *Odontochilus putaoensis* grows in shaded and damp humus in humid, broad-leaved, evergreen forest, at an elevation of about 1500–2000 m. At present, *O. putaoensis* is only known from the type locality.

**Conservation status. Least Concern (LC).** *Odontochilus putaoensis* was collected in the Hponkanrazi Wildlife Sanctuary, Putao Township, Kachin State, northern Myanmar. Until now, only one population, consisting of ca. 200 individuals, has been discovered in the vast reserve of 2704 km<sup>2</sup>. As there is no threat currently affecting the quality of its habitat and there is also a considerable number of mature individuals, the species is here preliminarily assigned a status of Least Concern (LC) according to the guidelines for using the IUCN Red List Categories and Criteria (IUCN Standards and Petitions Subcommittee, 2017).

#### Key to *Odontochilus* in the continental part of southeast Asia

- |    |   |                    |
|----|---|--------------------|
| 1  | Plant without green leaves, all leaves reduced to sheaths. Flowers usually not resupinate ..... | <i>O. poilanei</i> |
| 1' | Plant with green leaves, leaves fully differentiated. Flowers usually resupinate                |                    |

2	Epichile not deeply bilobed, broadly obovate to transversely oblong	
3	Mesochile with a pair of entire flanges (or slightly dentate), epichile nearly as wide as long .....	<i>O. macranthus</i>
3'	Mesochile with a pair of dentate flanges (or slightly dentate), epichile about twice as wide as long .....	<i>O. uniflorus</i>
2'	Epichile deeply bilobed	
4	Mesochile with two pairs of lacinate flanges.....	<i>O. duplex</i>
4	Mesochile with one pair of dentate-pectinate flanges	
5	Ovary usually glabrous	
6	Bracts finely erose-ciliate, flowers usually yellow.....	<i>O. lanceolatus</i>
6'	Bracts entire, flowers usually white.....	<i>O. brevistylis</i>
5'	Ovary (glandular-) pubescent, sometimes sparsely so	
7	Epichile bilobed with a pair of widely diverging lobules that are erect and concave.....	<i>O. putaoensis</i>
7'	Epichile bilobed with a pair of diverging and flat lobules	
8	Leaves reddish-brown, labellum twisted .....	<i>O. tortus</i>
8'	Leaves green above, labellum not twisted .....	<i>O. elwesii</i>

## Discussion

Myanmar lies in southeast Asia and is well endowed with biodiversity-rich areas such as tropical evergreen rainforest, coastal mangrove forest and subtropical montane forest. The northern part of Myanmar is situated in the ecological transition area of three global biodiversity hotspots, the Indo-Burma hotspot, Mountains of southwest China hotspot and Himalaya hotspot (Myers et al. 2000, Sodhi et al. 2004, Mittermeier et al. 2011, Khine et al. 2017, Jin et al. 2018). However, the biodiversity of northern Myanmar is far less understood due to the absence of scientific research. Recently, biodiversity research activities in northern Myanmar have been jointly conducted in cooperation with international research institutions, resulting in discoveries of new species of fauna and flora, such as *Aristolochia sinoburmanica* Y.H.Tan & B.Yang, *Bulbophyllum putaoensis* Q.Liu, *Coelogynne putaoensis* X.H.Jin, L.A.Ye & Schuit, *Gastrodia kachinensis* X.H.Jin & L.A.Ye, *G. putaoensis* X.H.Jin, *Hedychium putaoense* Y.H.Tan & H.B.Ding, *Kerivoula kachinensis*, *Muntiacus putaoensis*, *Oreoglanis hponkanensis*, *Rhinopithecus strykeri*, *Selliguea kachinensis* Hovenkamp, S.Linds. & Fraser-Jenk. and so on (Amato et al. 1999, Bates et al. 2004, Geissmann et al. 2011, Khine et al. 2016, Aung et al. 2017, Chen et al. 2017, Jin and Kyaw 2017, Liu et al. 2017, Aung and Jin 2018, Ding et al. 2018, Yang et al. 2018).

*Odontochilus putaoensis* is a very distinctive species in having easily identifiable floral features such as a pair of erect and concave epichile lobes. Having such distinctive floral features, *O. putaoensis* can be easily distinguished from its closely related species, *O. duplex*, although both species are more or less similar in their vegetative as well as floral characters. In addition, their altitudinal range and habitat type are

relatively comparable: *O. putaoensis* was collected at 1500–2000 m elevation and *O. duplex* at ca. 750 m elevation (Pedersen et al. 2011). *Odontochilus putaoensis* grows in subtropical broad-leaved, evergreen forest in northern Myanmar, whereas *O. duplex* in the upper tropical rainforest in Peninsular Thailand and Peninsular Malaysia (Pedersen et al. 2011). As well, *O. putaoensis* flowers in October while *O. duplex* in May (Pedersen et al. 2011).

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## References

- Amato G, Egan MG, Rabinowitz A (1999) A new species of muntjac, *Muntiacus putaoensis* (Artiodactyla: Cervidae) from northern Myanmar. *Animal Conservation* 2(1): 1–7. <https://doi.org/10.1111/j.1469-1795.1999.tb00042.x>
- Aung YL, Jin XH, Schuiteman A (2017) *Coelogyne putaoensis* (Orchidaceae), a new species from Myanmar. *PhytoKeys* 82: 27–34. <https://doi.org/10.3897/phytokeys.82.13172>
- Aung YL, Jin XH (2018) *Gastrodia kachinensis* (Orchidaceae), a new species from Myanmar. In: Jin XH, Shui YM, Tan YH, Kang M (Eds) *Plant diversity in Southeast Asia*. *PhytoKeys* 94: 23–29. <https://doi.org/10.3897/phytokeys.94.21348>
- Averyanov LV, Nguyen KS, Tich NT, Nguyen PT, Nong VD, Nguyen VC, Xuan CC (2015) New orchids in the flora of Vietnam. *Wulfenia* 22: 137–188.
- Bates PJJ, Struebig MJ, Rossiter SJ, Kingston T, Oo SSL, Mya KM (2004) A new species of *Kerivoula* (Chiroptera: Vespertilionidae) from Myanmar (Burma). *Acta Chiropterologica* 6(2): 219–226. <https://doi.org/10.3161/001.006.0203>
- Blume CL (1825) Ludwig von Bijdragen tot de flora van Nederlandsch Indië 8: 411. <http://dx.doi.org/10.5962/bhl.title.395>
- Blume CL (1858) Collection des orchidées les plus remarquables de l'archipel Indien et du Japon. Sulphe, Amsterdam, icons, 360 pp.
- Chase MW, Cameron KM, Freudenstein JV, Pridgeon AM, Salazar G, van den Berg C, Schuiteman A (2015) An updated Classification of Orchidaceae. *Botanical Journal of the Linnean Society* 177(2): 151–174. <https://doi.org/10.1111/boj.12234>
- Chen XQ, Gale SW, Cribb PJ, Ormerod P (2009) *Odontochilus*. In: Wu ZY, Raven PH, Hong DY (Eds) *Flora of China* (Vol. 25). Science Press, Beijing and Missouri Botanical Garden Press, St. Louis, 80–84.

- Chen XY, Qin T, Chen ZY (2017) *Oreoglanis hponkanensis*, a new sisorid catfish from north Myanmar (Actinopterygii, Sisoridae). ZooKeys 646: 95–108. <https://doi.org/10.3897/zookeys.646.11049>
- Ding HB, Bin Y, Zhou SS, Li R, Maw MB, Kyaw WM, Tan YH (2018) *Hedychium putaoense* (Zingiberaceae), a new species from Putao, Kachin State, Northern Myanmar. In: Jin XH, Shui YM, Tan YH, Kang M (Eds) Plant diversity in Southeast Asia. PhytoKeys 94: 51–57. <https://doi.org/10.3897/phytokeys.94.22065>
- Geissmann T, Lwin N, Aung SS, Aung TN, Aung ZM, Hla TH, Grindley M, Momberg F (2011) A New Species of Snub-Nosed Monkey, Genus *Rhinopithecus* Milne-Edwards, 1872 (Primates, Colobinae), From Northern Kachin State, Northeastern Myanmar. American Journal of Primatology 73(1): 96–107. <https://doi.org/10.1002/ajp.20894>
- Standards IUCN, Petitions Subcommittee (2017) Guidelines for Using the IUCN Red List Categories and Criteria. Version 13. Prepared by the Standards and Petitions Subcommittee. <http://www.iucnredlist.org/documents/RedListGuidelines.pdf> [accessed: May 30, 2017]
- Jin XH, Kyaw M (2017) *Gastrodia putaoensis* sp. nov. (Orchidaceae, Epidendroideae) from North Myanmar. Nordic Journal of Botany 35: 730–732. <https://doi:10.1111/njb.01581>
- Jin XH, Tan YH, Quan RC (2018) Taxonomic discoveries bridging the gap between our knowledge and biodiversity. In: Jin XH, Shui YM, Tan YH, Kang M (Eds) Plant diversity in Southeast Asia. PhytoKeys 94: 1–2. <https://doi.org/10.3897/phytokeys.94.23887>
- Khine PK, Lindsay S, Fraser-Jenkins C, Kluge J, Kyaw M, Hovenkamp P (2016) *Selliguea kachinensis* (Polypodiaceae), a new fern species of uncertain affinity from Northern Myanmar. PhytoKeys 62: 73–81. <https://doi.org/10.3897/phytokeys.62.8101>
- Khine PK, Fraser-Jenkins C, Lindsay S, Middleton D, Miehe G, Thomas P, Kluge J (2017) A Contribution Toward the Knowledge of Ferns and Lycophytes from Northern and Northwestern Myanmar. American Fern Journal 107(4): 219–256. <https://doi.org/10.1640/0002-8444-107.4.219>
- Kress J, Robert A, DeFilipps E, Kyi YY (2003) A Checklist of the Trees, Shrubs, Herbs, and Climbers of Myanmar. <http://www.botany.si.edu/myanmar> [accessed: May 30, 2017]
- Kurzweil H, Lwin S (2014) A guide to orchids of Myanmar. Natural History Publications (Borneo), Kota Kinabalu, 196 pp.
- Lang KY (1999) *Odontochilus*. In: Lang KY, Chen SC, Luo YB, Zhu GH (Eds) Flora Reipublicae Popularis Sinicae (Vol. 17). Science Press, Beijing, 205–227.
- Li MH, Zhang GQ, Lan SR, Liu ZJ, China Phylogeny Consortium (2016) A molecular phylogeny of Chinese orchids. Journal of Systematics and Evolution 54(4): 349–362. <https://doi.org/10.1111/jse.12187>
- Lin TP, Hsu CC (1976) Orchid Genera, *Anoectochilus* and *Odontochilus* of Taiwan. Taiwania 21(2): 229–236.
- Liu Q, Zhou SS, Li R, Zhang MX, Zyaw M, Lone S, Quan RC (2017) *Bulbophyllum putaoensis* (Orchidaceae: Epidendroideae; Malaxideae), a new species from Kachin State, Myanmar. Phytotaxa 305(1): 57–60. <https://doi.org/10.11646/phytotaxa.305.1.9>
- Mittermeier RA, Turner WR, Larsen FW, Brooks TM, Gascon C (2011) Global biodiversity conservation: the critical role of hotspots. In: Zachos FE, Habel JC (Eds) Biodiversity Hotspots. Springer Publishers, London, 3–22.

- Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. *Nature* 403(6772): 853–858. <https://doi.org/10.1038/35002501>
- Ormerod P (2005) Notulae Goodyerinae (II). *Taiwania* 50(1): 1–10.
- Pedersen HÆ, Kurzweil H, Suddee S, Cribb PJ (2011) *Odontochilus*. In: Santisuk T, Larsen K, Newman M (Eds) Flora of Thailand (Vol. 12, Part 1), Orchidaceae 1 (Cypripedioideae, Orchidoideae, Vanilloideae). Prachachon Co. Ltd. Press, Bangkok, 184–196.
- Pridgeon AM, Cribb PJ, Chase MW, Rasmussen FN (2003) Genera Orchidacearum, Volume 3. Orchidoideae (Part one). Oxford University Press, Oxford, 126–129.
- Schuiteman A, Bonnet P, Svengsuksa B, Barthélémy D (2008) An annotated checklist of the Orchidaceae of Laos. *Nordic Journal of Botany* 26: 257–316. <https://doi.org/10.1111/j.1756-1051.2008.00265.x>
- Seidenfaden G (1992) The Orchids of Indochina. *Opera Botanica* 114: 1–502.
- Seidenfaden G, Wood JJ (1992) The Orchids of Peninsular Malaysia and Singapore. The Royal Botanic Gardens, Kew & Botanic Gardens, Singapore and Olsen & Olsen, Fredensborg, 71–76.
- Sodhi NS, Koh LP, Brook BW, Ng PKL (2004) Southeast Asian biodiversity: an impending disaster. *Trends in Ecology and Evolution* 19(12): 654–660. <https://doi:10.1016/j.tree.2004.09.006>
- Tang H, Feng HZ, Huang YF (2016) *Odontochilus napoensis* sp. nov. (Orchidoideae: Orchidaceae) from southwestern Guangxi, China. *Nordic Journal of Botany* 34: 405–408. <https://doi.org/10.1111/njb.00944>
- Yang B, Ding HB, Zhou SS, Zhu X, Li R, Maw MB, Tan YH (2018) *Aristolochia sinoburmanica* (Aristolochiaceae), a new species from north Myanmar. In: Jin XH, Shui YM, Tan YH, Kang M (Eds) Plant diversity in Southeast Asia. *PhytoKeys* 94: 13–22. <https://doi.org/10.3897/phytokeys.94.21557>

# Updated checklist of *Poa* in the Iberian Peninsula and Balearic Islands

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## Abstract

Based on our study of 4,845 herbarium sheets of the genus *Poa* from the area covered by *Flora iberica*, namely, the Iberian Peninsula and the Balearic Islands, we recognise 24 taxa (17 species, 1 subspecies and 8 varieties), mostly perennials. Most of these taxa have wide global and/or European distributions, while two (*P. legionensis* and *P. minor* subsp. *nevadensis*) are Spanish endemics and two have restricted distributions (*P. ligulata*, Iberia–North Africa; *P. flaccidula*, Iberia–North Africa and the Balearic Islands, extending to Provence, France). We have studied the original publications of more than 225 names considered as synonyms, with those more historically cited in *Flora iberica* taken into account in this paper; a total of 26 are new synonyms. The following names are typified: *P. alpina* var. *involucrata* Lange, *P. annua* var. *lanuginosa* Sennen, *P. minor* subsp. *nevadensis* Nannf., *P. paui* Font Quer, *P. sulcata* Lag. and *P. trivialis* var. *flaccida* Willk. ex J.J. Rodr. We include *P. compressa* L. in the flora of Portugal for the first time and present detailed illustrations of three very interesting taxa (*P. legionensis*, *P. minor* subsp. *nevadensis* and *P. ligulata*). In addition to a general species key, we provide the following information for each taxon: synonyms, types, typification, the most relevant iconography, regional flowering time, regional and general distribution and, as supplementary material, the number of sheets examined and a list of selected materials.

## Keywords

Checklist, *Flora iberica*, Gramineae, Poaceae, *Poa*, Portugal, Spain, taxonomy, typification

## Introduction

The genus *Poa* L., included within subfamily Pooideae, supertribe Poodae and subtribe Poinae (Soreng et al. 2015), is considered to be monophyletic. This monophyly is supported by analyses of plastid and nuclear DNA markers (Gillespie et al. 2008). In addition, evidence for reticulation between this genus and other genera in Poinae has been uncovered; the same is true within the genus itself (e.g. *P. annua*) (Soreng et al. 2010). The genus comprises approximately 550 annual and perennial species (Soreng et al. 2017) of cosmopolitan distribution, primarily in cold and temperate regions. Most species are polyploids, but 9% are diploids, with an additional 4%–6%, mostly in Europe and rarely in Asia, having both diploid and polyploid populations (Soreng et al. 2010, Giussani et al. 2016). Many species are important weeds (e.g. *P. annua*), while others are cultivated for forage (e.g. *P. pratensis*) or used in pastures (e.g. *P. trivialis*, *P. alpina* and *P. bulbosa*) or lawns and golf courses (e.g. *P. nemoralis* and *P. pratensis*) (Watson and Dallwitz 1992).

The genus is characterised by a great diversity of sexual systems and its species can be strictly hermaphroditic, the most common reproductive system, or diclinous (Giussani et al. 2016). Apomictic reproduction by seeds, either facultative or obligate, is common in some species (reviewed in Soreng and Peterson 2012). The production of pseudoviviparous/bulbiferous spikelets occurs in some species, such as *P. bulbosa* and, to a lesser extent, *P. alpina*.

The first taxonomic treatment of *Poa* on the Iberian Peninsula, by Willkomm (1870), was remarkable: he recognised 15 species and numerous varieties in the territory of Spain and later increased this total by two (Willkomm 1893). In the 20<sup>th</sup> century, 19 of the 53 species and subspecies recognised by Edmonson (1980) in Europe were included in *Flora iberica*, a publication also encompassing the Balearic Islands. Of these, slightly less than half were listed for Portugal (see also Franco and Rocha 1998). The latest revision to *Poa* on the peninsula was carried out by Hernández Cardona (1978), who basically followed Edmonson. In this revision, Hernández Cardona also defined a new section (*Flaccidula* Á.M. Hern.) to accommodate *P. flaccidula* and recognised 19 species and subspecies plus two varieties.

In a recently completed revision of the genus *Poa* for a future volume (XIX) of *Flora iberica*, we recognised 18 species and subspecies and 8 varieties. The main aim of the present paper was to present an updated checklist of the genus. The information provided includes a general key to accepted taxa as well as a list of their most important synonyms, many of which are unknown outside of the Iberian Peninsula because they are found only on herbarium sheets or published in works of limited distribution. Some of the synonyms and an accepted name are typified and updated information on the ecology and flowering characteristics of each taxon in the covered territory is given along with its regional and worldwide distribution.

## Methods

The taxonomic classification scheme followed in this paper, which begins with the type species *P. pratensis*, reflects currently understood relationships amongst recognised sections in the genus. An infrageneric classification of accepted species of *Poa* in the Iberian flora is also presented in the Results section.

We reviewed 4,845 sheets housed in the following herbaria: BC, BC-Sennen, C-Lange, COI, COI-Willk., G-Boiss., GDA-GDAC, HGM, HSS, JACA, MA, MAF, MGC, SALA-SALAF, SEV, UPP-Nannf. and UNEX (acronyms according to Thiers, continuously updated). We studied the most important synonyms of each accepted name and consulted the original publications, with a special focus on names directly related to the territory covered by *Flora iberica*. For each accepted taxon, we recorded synonyms, types (type protologue) and, in some cases, the typification. After studying the herbarium sheets, we obtained updated information on flowering phenology and the ecology of the area. We also researched the worldwide distribution of each taxon and its presence or absence in each province covered by *Flora iberica*, including the territories of Andorra (And.), Portugal (Port.) and continental Spain (Spa.) plus the Balearic Islands. In the taxonomic treatment that follows, those provinces are ordered alphabetically using the same abbreviations given in *Flora iberica* (<http://www.floraiberica.es/>; see Fig. 1). If the name of a province appears in parentheses, a bibliographic citation exists but no herbarium sheet was studied to confirm it, while a question mark indicates that



**Figure 1.** Map of distribution of the provinces covered by *Flora iberica* (<http://bibdigital.rjb.csic.es/spa/Libro.php?Libro=476&Pagina=27>).

the bibliographic citation is not entirely reliable. A selected list of herbarium sheets studied from each province is provided in the Suppl. material 1. Finally, some observations are included as explanatory notes for most species and subspecies.

## Results and discussion

Currently, a total of 24 taxa are recognised: 17 species, 1 subspecies and 8 varieties. All are perennials except for *P. annua* and *P. infirma*, which are annuals.

### Key to the species of *Poa* in Flora iberica

- |   |   |                               |
|---|---|-------------------------------|
| 1 | Plant annual, sometimes multicaulous .....  | <b>2</b>                      |
| — | Plant perennial, cespitose, rhizomatous and/or stoloniferous.....   | <b>3</b>                      |
| 2 | Spikelets (1.6–)4–7.7(–9) mm; anthers (0.6–)0.7–1.3 mm, much longer than wide; caryopsis 1.3–2.1 mm .....   | <b>12. <i>P. annua</i></b>    |
| — | Spikelets 2.8–4.8 mm; anthers 0.2–0.4(–0.6) mm, the same as or slightly longer than the width; caryopsis 1–1.4 mm .....   | <b>13. <i>P. infirma</i></b>  |
| 3 | Plant cespitose, without rhizomes and almost always without stolons, usually with basal bulbils and/or stems with thickened bases covered by old sheaths, these often split in fibres .....                     | <b>4</b>                      |
| — | Plant cespitose, with rhizomes and/or stolons, lacking bulbils or strongly thickened stem bases surrounded by old sheaths or, if present, then with the ligule of basal leaves 0.15–0.4(–0.8) mm, truncate..... | <b>9</b>                      |
| 4 | Lemma with 5 prominent veins and base very hairy, with hairs longer than the width of the lemma.....  | <b>1. <i>P. pratensis</i></b> |
| — | Lemma with 5 inconspicuous veins and base glabrous or with hairs much shorter than the width of the lemma.....  | <b>5</b>                      |
| 5 | Plant without stolons, bulbils or stems thickened at the base, glaucous; glumes lanceolate .....  | <b>5. <i>P. glauca</i></b>    |
| — | Plant with short stolons rooting at the nodes or with bulbils or thickened stem bases covered by old sheaths, green or glaucous; glumes lanceolate or the lowermost one narrowly subulate .....                 | <b>6</b>                      |
| 6 | Plant cespitose, rarely with short stolons rooting at the nodes, without basal bulbils or thickened stem bases; lower glume narrowly subulate.....  | <b>6. <i>P. nemoralis</i></b> |
| — | Plant cespitose, with basal bulbils and/or strongly thickened stem bases covered by old fibrous sheaths; lower glume lanceolate or ovate-lanceolate .....   | <b>7</b>                      |
| 7 | Basal and shoot leaves with ligule 0.3–2(–3.8) mm, the oldest 0.3–0.7 mm, ± truncate, blade (0.7–)1.5–4.5(–7.5) mm wide, flat .....   | <b>17. <i>P. alpina</i></b>   |
| — | Basal and shoot leaves with ligule 2–10.5 mm, ± oblong or triangular, often lacinate in acute triangular segments, blade 0.4–3.5(–4) mm wide, flat, conduplicate or convolute .....                             | <b>8</b>                      |

- 8 Plant with basal bulbils, frequently also present in the inflorescence; basal and shoot leaves filiform or linear, less frequently lanceolate; ligule membranous-hyaline; tuft concoloured, green or brown..... **15. *P. bulbosa***
- Plant without basal bulbils or bulbils in the inflorescence; basal and shoot leaves linear or lanceolate; ligule pearly white; tuft bicoloured, green and white because of the brightness of the ligules ..... **16. *P. ligulata***
- 9 Branches of the inflorescence and/or spikelet peduncles smooth or nearly so, glabrous ..... **10**
- Branches of the inflorescence and/or spikelet peduncles antorse-scabrid... **14**
- 10 Ligule of the basal leaves 0.15–0.7(–0.8) mm, truncate ..... **11**
- Ligule of the basal leaves 0.6–3.4(–4.3) mm, more or less ovate or triangular-ovate, not truncate ..... **12**
- 11 Upper leaves with ligule 0.3–0.6(–0.8) mm, truncate-dentate; lemma base with hairs longer than the width of the lemma; plant cespitose-rhizomatous. .... **2. *P. legionensis***
- Upper leaves with ligule 0.7–2.5(–4.7) mm, more or less truncate or ovate, sometimes split into 2 or several parts; lemma base glabrous; plant densely cespitose ..... **17. *P. alpina***
- 12 Palea with keels appressed-hairy or ciliate, rarely smooth and glabrous; anthers (1.2–)1.6–2.1 mm; branches of the inflorescence patent or reflexed after anthesis; upper flower of the spikelet female..... **14. *P. supina***
- Palea with keels antorse-scabrid, never appressed-hairy or ciliate; anthers 0.7–1.7 mm; branches of the inflorescence erect or erect-patent; upper flower of the spikelet hermaphroditic ..... **13**
- 13 Anthers 0.7–1.2 mm; branches of the inflorescence 0.15–0.2 mm in diameter, sulcate, ± rigid, glabrous and smooth; spikelets with peduncle glabrous, smooth, having 2–4 flowers ..... **8. *P. laxa***
- Anthers 0.8–1.7 mm; branches of the inflorescence c. 0.05–0.15 mm in diameter, not sulcate, ± flexuous, glabrous and smooth, sometimes very loosely antorse-scabrid; spikelets with peduncle glabrous or sometimes laxly antorse-scabrid, having 4–7 flowers..... **9. *P. minor***
- 14 Stems compressed ..... **15**
- Stems not or only slightly compressed..... **21**
- 15 Lemma and palea with hairy surfaces between veins ..... **11. *P. flaccidula***
- Lemma and palea with glabrous surfaces between veins ..... **16**
- 16 Ligule of the upper leaf lanceolate, generally acute, longer than the width of the blade..... **10. *P. trivialis***
- Ligule of the upper leaf truncate, obtuse, shorter or subequal to the width of the blade..... **17**
- 17 Lemma with conspicuous veins..... **18**
- Lemma with inconspicuous veins..... **19**
- 18 Stems with base 2.5–9 mm wide, usually very compressed; lemma with 5 glabrous veins; blade of the basal leaves (3.5–)5.5–11.2 mm wide, lanceolate

- or oblong-lanceolate ..... **4. *P. chaixii***
- Stems with base 1.5–2.5(–3.5) mm wide, slightly compressed; lemma with 5 veins, the central and marginal ones appressed-hairy; blade of the basal leaves 0.5–3.8 mm wide, lanceolate, linear or setaceous ..... **1. *P. pratensis***
- 19 Usually with two keels in the stems; glumes lanceolate or ovate-lanceolate, ± convergent; spikelet with rachilla usually glabrous; inflorescence with 1–2(–5) branches in the basal node, short and appressed ..... **7. *P. compressa***
- Without keels in the stems; glumes subulate or lanceolate-subulate, straight and ± divergent; spikelet with rachilla glabrous or pubescent; inflorescence with 2–5 branches in the basal node, short or long, erect, rarely erect-patent or non-appressed on the axis ..... **20**
- 20 Plant rhizomatous; leaves of the shoots usually distichous; spikelets 4.5–7(–7.6) mm; lower glume (2.8–)3.2–4.2 mm, lanceolate ..... **3. *P. cenisia***
- Plant without rhizomes, sometimes with short stolons; leaves of the shoots non-distichous, sparse; spikelets 3–4.8(–5.5) mm; lower glume 2–3.5 mm, subulate ..... **6. *P. nemoralis***
- 21 Lemma and palea with surfaces between veins hairy ..... **11. *P. flaccidula***
- Lemma and palea with surfaces between veins glabrous ..... **22**
- 22 Ligule of the upper leaf usually lanceolate, acute or acuminate, longer than the width of the blade; stems usually retrorse-scabrid around the nodes; plant stoloniferous; callus of lemma with hairs longer than the width of the lemma, very rarely glabrous ..... **10. *P. trivialis***
- Ligule of the upper leaf ovate or oblong, obtuse, truncate or dentate, much shorter or subequal to the width of the blade; stems smooth around the nodes; plant rhizomatous, rarely with stolons; callus of lemma without hairs or with hairs larger or smaller than the width of the lemma ..... **23**
- 23 Plant cespitose, sometimes with short stolons; glumes subulate or lanceolate-subulate, glossy; lemma with base glabrous or with hairs of much shorter length than the width of the lemma; ligule of the upper leaves 0.2–0.6(–0.8) mm ..... **6. *P. nemoralis***
- Plant rhizomatous; glumes lanceolate, dull; lemma with base hairy, with hairs shorter or longer than the width of the lemma; ligule of the upper leaves usually 1–3.1 mm ..... **24**
- 24 Plant ± glaucous; shoots usually with leaves distichous; culms usually scabrous below nodes; glumes subequal, ± straight or slightly converging with each other, 3-veined; lemma with 5 inconspicuous veins, with hairs at the base shorter or longer than the width of the lemma; palea with keels antrorse-scaberulous or ciliolate, often something curly in the basal area ..... **3. *P. cenisia***
- Plant usually green; shoots usually with non-distichous leaves; culms smooth below nodes; glumes unequal, curved or converging with each other, the lower with 1 or 3 veins; lemma with 5 conspicuous veins, with hairs at the base longer than the width of the lemma; palea with keels antrorse-scaberulous... ..... **1. *P. pratensis***

## Checklist of *Poa* in the Iberian Flora

The species of *Poa* present in *Flora iberica* are classified into three subgenera and nine sections as indicated below. These taxonomic placements are provisional because some taxa (indicated by \*) have not yet been subjected to DNA sequencing:

*Poa* subgen. *Poa* supersect. *Poa* sect. *Poa*: *P. pratensis*, \**P. legionensis*, *P. cenisia*; supersect.

*Homalopoa* (Dumort.) Soreng & L.J. Gillespie sect. *Homalopoa*: *P. chaixii*.

*Poa* subgen. *Stenopoa* (Dumort.) Soreng & L.J. Gillespie sect. *Stenopoa*: *P. glauca*, *P. nemoralis*; sect. *Tichopoa* Asch. & Graebn.: *P. compressa*; sect. *Oreinos* Asch. & Graebn.: *P. laxa*, *P. minor*; sect. *Pandemos* Asch. & Graebn.: *P. trivialis*; \*sect. *Flaccidula* Á.M. Hern.: \**P. flaccidula*.

*Poa* subgen. *Ochlopoa* (Asch. & Graebn.) Hyl. sect. *Micrantherae* Stapf: *P. annua*, *P. infirma*, *P. supina*; sect. *Arenariae* Stapf: *P. bulbosa*; sect. *Alpiniae* (Nyman) Stapf: *P. ligulata*, *P. alpina*.

The sequence of species in this checklist is not alphabetical, but instead starts with sect. *Poa* because that section includes the type species; species are then ordered according to phylogenetic relationships, an arrangement more or less the inverse of that adopted by other authors, i.e. from more derived clades to those in a more basal position (see Gillespie et al. 2008; Soreng et al. 2010, 2017).

### 1. *Poa pratensis* L., Sp. Pl. 67. 1753 subsp. *pratensis*

*Poa angustifolia* var. *pratensis* (L.) Simonkai, Enum. Fl. Transsilv. 580. 1886.

*Paneion pratense* (L.) Lunell, Amer. Midl. Nat. 4: 222. 1915.

III. var. *pratensis* [Soreng and Peterson (2012: 67, fig. 18C–J, sub *P. pratensis* subsp. *pratensis*); Devesa (1987: 261, sub *P. pratensis*)]; var. *minor* [Soreng and Peterson (2012: 67, fig. 18 A-B, sub *P. pratensis* subsp. *irrigata*)]; var. *angustifolia* [Ruiz (1991: 29, lam. II, sub *P. angustifolia*]; Soreng and Peterson (2012: 66, fig. 17H–I, sub *P. pratensis* subsp. *angustifolia*)].

**Type.** “Habitat in Europae pratis fertilissimis”. Typus: Russia, Prov. Sanct-Petersburg, 5 km australi-occidentum, versus a st. viae ferr. Mga. pratulum ad ripam dextram fl. Mga, 26 Jun 1997, N. N. Tzvelev N-257 (type conserved, designated by Soreng and Barrie 1999, pg. 157: BM-000576302; isolectotypes: B, C, CAN, CONC, H, K, KW, L, LE, LIV, MA, MO, MW, NSW, P, PE, PR, S, SI, TNS, US, W).

**Flowering.** April-August (September).

**Ecology.** Grasslands at edges of watercourses, ravines, ponds and alpine wetlands (“borreguiles”), walls, wet soils on slopes, ditches, cultivated fields, clearings surrounded by pines, holm oaks, Portuguese oaks and other oaks; edaphically indifferent; 0–2400 m a.s.l.

**Distribution.** Eurasia, N Africa and Macaronesia (Azores, Madeira and Canary Islands); introduced in N, C and S America and Australia. Scattered throughout much of the Iberian Peninsula and Balearic Islands. **And. Spa.:** A Ab Al Av B Bu C Cc Co CR Cs Cu Ge Gr Gu Hu J L Le Lo Lu M Ma Mu Na O Or P PM[Mll] (Po) S Sa Sg So SS (T) Te To V Va Vi Z Za. **Port:** AAl (BA) (BB) (BL) DL (E) Mi TM.

**Notes.** *Poa pratensis* is one of the most polymorphic taxa in the genus for a variety of reasons: its great morphological and cytological variation, the predominance of agamospermy, its vegetative propagation and wide distribution, the latter due in part to its introduction into many parts of the world for use on lawns, as fodder or for soil stabilisation (Soreng and Barrie 1999). At least 220 crop varieties are recognised (Stoneberg Holt et al. 2004).

In the territory covered by *Flora iberica*, three patterns of variation are recognised. Plants with scarcely any extravaginal shoots and possessing basal-leaf ligules with scattered or sometimes entangled apical hairs up to 0.4 mm and 0.2–0.5 mm on the back correspond to *Poa pratensis* var. *minor* Wahlenb., Fl. Upsal. 33. 1820. [Type: “Hab. in pratis et pascuis fertilibus plerisque frequenter”; *Poa humilis* Ehrh., Beitr. Naturk. 6: 84. 1791, nom. nud.; *P. humilis* Ehrh. ex Hoffm., Deutschl. Fl. 1: 45. 1800, type: “In cultis, ad vias; fl. Apr. Sept.”; *P. subcaerulea* Sm., Engl. Bot. 14, lam. 1004. 1802, basion., type: “Gathered in Anglesea by the Rev. H. Davies, flowering in June”; *P. depressa* J. Presl & C. Presl, Fl. Čech. 20. 1819, type: “Summa Sudetorum cacuminal”; *P. pratensis* var. *latifolia* Weihe ex Mert. & W.D.J. Koch, Deutschl. Fl. 1(2): 612. 1823, type: “Auf dünnen sandigen Hügeln, auf magern Grasplätzen und auf den Triften hoher Gebirge bleibt”; *P. pratensis* var. *subcaerulea* (Sm.) Sm., Engl. Fl. 1: 126 (1824); *P. pratensis* var. *humilis* (Ehrh. ex Hoffm.) Ehrh. ex Spenn., Fl. Friburg. 1: 130. 1825; *P. pratensis* subsp. *latifolia* (Weihe ex Mert. & W.D.J. Koch) Schübl. & G. Martens, Fl. Würtemberg 77. 1834; *P. pratensis* var. *depressa* (J. Presl & C. Presl) Opiz, Seznam Rost. Kvet. Cesk. 76. 1852; *P. pratensis* var. *maritima* Corb., Nouv. Fl. Normandie 655. 1894, type: “Sables maritimes et pelouses du littoral. C.”; *P. irrigata* Lindm., Bot. Not. 1905: 73, 88. 1905, type: “Hab. in uliginosis, pratis et viarum marginibus irrigatis, fossis graminosis, solo abiegnorum muscoso humido, haud raro in pratis litoralibus, hinc inde in pascuis solo duriore turfoso. Vidi specimina typica ex Ölandia (Borgholm), ....”; *P. irrigata* f. *rigens* Lindm., Bot. Not. 1905: 90. 1905, type: “Hab. In Lapponia”; *P. pratensis* “race” *subcaerulea* (Sm.) Rouy, Fl. France 14: 283. 1913; *P. pratensis* subsp. *irrigata* (Lindm.) H. Lindb., Exsicc. (Pl. Finland.) 2: 20. 1916; *P. pratensis* subsp. *subcaerulea* (Sm.) Hiitonen, Suomen Kasvio 205, fig. 5. 1933]. This variety is known from N and C Europe (introduced in N America) and also appears on N and SW portions of the Iberian Peninsula [**Spa.:** B H Na S SS (Z)], where it is found on grasslands, nitrified dunes and mountainous limestone rocks [0–1380 m a.s.l. May to September].

Two varieties with abundant extravaginal shoots and basal-leaf ligules without hairs or with hairs that are smaller than 0.15 mm, are recognised, although plants having intermediate characteristics are also frequently present. *Poa pratensis* var. *pratensis* [*Poa glabra* Ehrh., Beitr. Naturk. 6: 82. 1791, nom. nud.; *P. pratensis* var. *anceps* Gaudin, Agrost. Helv. 1: 215. 1811, type: “Hab. in paludibus torfaceis. Schleicher.

Perennis"; *P. pratensis* subsp. *anceps* (Gaudin) Lej. & Courtois, Comp. Fl. Belg. 82. 1828; *P. pratensis* a *vulgaris* Gaudin, Fl. Helv. 1: 258. 1828, nom. superfl.; *P. anceps* (Gaudin) Hegetschw., Fl. Schweiz 81. 1838, nom. illeg., non *Poa anceps* G. Forst., Fl. Ins. Austr. 8. 1786; *P. angustifolia* subsp. *anceps* (Gaudin) K. Richt., Pl. Eur. 1: 87. 1890; *P. pratensis* "race" *compressiformis* Rouy, Fl. France 14: 283. 1913, type: "HAB. — Prairies ombragées, tourbières. — Ça et là dans l'aire du type"; *P. pratensis* var. *humilis* sensu Coutinho, Fl. Portugal 1: 104. 1939, non *P. pratensis* var. *humilis* (Ehrh. ex Hoffm.) Spenn., Fl. Friburg. 1: 130. 1825, **syn. nov.**] includes plants in which the blade of most basal leaves is 1.2–3.8(–5.5) mm wide, lanceolate or linear-lanceolate, flat or conduplicate, usually delicate, flexible. This variety is distributed in Eurasia, N Africa and Macaronesia (Azores, Madeira and Canary Islands) and is naturalised in N America and Australia. It is widely dispersed on the Iberian Peninsula [(**And.**). **Spa.:** A Ab Al Av B Bu (C) Cc Co CR Cs (Cu) Ge Gr Gu Hu J L Le Lo Lu M Ma Mu Na O Or P (Po) S Sa Sg So SS (T) Te (To) V Va (Vi) Z Za. **Port:** AAI (BA) (BB) BL DL E Mi TM], where it appears in mountainous areas [650–2400 m a.s.l. (April) May to July (August)].

Finally, *Poa pratensis* var. *angustifolia* (L.) Sm., Fl. Brit. 1: 105. 1800 [*Poa angustifolia* L., Sp. Pl. 67. 1753, basion., type: "Habitat in Europa ad agrorum versuras" (lectotype designated by Soreng 2000, pg. 254: Herb. Linn. No. 87.12!, excluding second culm from left); *P. brizoides* Vill., Hist. Pl. Dauphiné 2: 126. 1787, nom. illeg., non L. fil., Suppl. Pl. 110. 1782, = *Eragrostis capensis*; *P. villarsii* J.F. Gmel., Syst. Nat., ed. 13, 2: 182. 1791, type: "not expressly indicated"; *P. setacea* Hoffm., Deutschl. Fl., ed. 2, 1: 44. 1800, nom. illeg., non Huds., Fl. Engl. 34. 1762; *P. strigosa* Hoffm., Deutschl. Fl., ed. 2, 1: 44. 1800, type: "In siicioribus elatis; fl. Maj. Iun"; *P. pratensis* subsp. *angustifolia* (L.) Lej., Comp. Fl. Belg. 82. 1828; *P. angustifolia* subsp. *brizoides* K. Richt., Pl. Eur. 1: 88. 1890; *P. pratensis* subsp. *atlantis* Maire, Fl. Afrique N. 3: 101. 1955, type: "Bords des ruisselets, prairies irriguées des collines et montagnes siliceuses, rare.- M. Grand Atlas, Mont Gourza vers 2800 m (M.)"], includes plants in which the blade of the basal and shoot leaves is 0.5–1.3 mm wide, linear or setaceous, convolute, usually rigid and brittle. Its distribution area extends across Europe, NW of Africa (Morocco), SW and S Asia and Macaronesia (Canary Islands and Madeira) and it is also introduced in N America. It is scattered over much of the territory covered by *Flora iberica* [**And. Port.:** BL (E) Mi TM. **Spa.:** A Ab Al Av B Bu C Cc Co CR Cu Ge Gr Gu Hu J L Le Lo Lu M Ma Mu Na O Or P PM [Mll] S Sa Sg So (T) Te To V Va Vi Z Za], blooming between April and July, from sea level to 2150 (2400) m.

For a representative list of studied materials, see Suppl. material 1.

## 2. *Poa legionensis* (Laínz) Fern.-Casas & Laínz in Laínz, Contr. Fl. Asturias 83. 1982

*Poa pratensis* var. *monticola* Merino, Fl. Galicia 3: 337. 1909, **syn. nov.** [Type: "La var. 2.<sup>a</sup> cerca de la cumbre de Peña Rubia (Ancares) á unos 1.700 m. s. m."]. (Type material probably disappeared).

*Poa pratensis* subsp. *legionensis* Laínz, Bol. Inst. Estud. Asturianos, Supl. Ci. 15: 43. 1970 [basion.]

*Poa alpina* subsp. *legionensis* (Laínz) Rivas Mart. & al., Veg. Alta Mont. Cantábrica 279. 1984.

III. Ruiz (1991: 31, lam. III); Fig. 2.

**Type.** “Ut videtur, diffusa per iuga silicea editissima, occidentalia, montium provinciae legionensis (León) et nonnullarum finitimarum. *Holotypus* in herbario meo hispanico boreo-occidental: iuxta montem Cornón, pr. Lumajo (Villablino, León), ad 1900 m, 1-VII-1959. Insuper specimina legi simillima, per tractum longum satis: in summo Cellón, pr. Arbas (Rodiezmo, León), ad 2000 m, et paulo inferius, ad 1800 m; item, iuxta lacunam celeberrimi Cueto de Arbas, ad 1750 m, supra Leitariegos (Cangas del Narcea, Asturias); denique, paulo infra summam Peña Trevinca, in ditione quidem zamorensi, ad 2075 m.”. [Holotype JBAG-11515-Laínz!].

**Flowering.** May to July (September).

**Ecology.** Wet, somewhat nitrified meadows, stony places, swampy areas and psychro-xerophilic pastures (“cervunales”), on granites or slates; 1560–2400 m a.s.l.

**Distribution.** Endemic to the CN of the Iberian Peninsula. **Spa.:** Av Cc Le Lu O Or (S) Sa (Za). For a representative list of studied materials, see Suppl. material 1.

### 3. *Poa cenisia* All., Auct. Fl. Pedem. 40. 1789

*Poa distichophylla* Gaudin, Alpina 3: 39. 1808. [Type: “Sie kommt ziemlich häufig am Ufer der Alpenbäche im Sand vor, .... Auf dem Lioson, auf dem Bonhomme in Savoyen, auf den Walliser Alpen u.s. w. §. Bl. im Jul. und Aug.”].

*Poa pallens* Haller fil. ex Gaudin, Alpina 3: 41. 1808. [Type: “Dieses zierliche Gras findet man auf den Weiden und an grasigen Felsen auf den höheren Bergen; auf dem großen Bernhard; auf Tzermotanaz au-dessus du val de Bagnes; auf dem Bernardin, unweit der Quelle des Hinter-Rheins, u. s. w. §. Bl. im Jul. un Aug.”].

*Brachypodium cenisium* (All) P. Beauv., Ess. Agrostol. 101, 155, 174. 1812.

*Poa halleridis* Roem. & Schult., Syst. Veg. 2: 539. 1817. [Type: “In alpibus Bernensisbus. Inn monte Stockhorn. in Valesia”].

*Poa cenisia* var. *halleri* Rchb., Icon. Fl. Germ. Helv. 1, ed. 2: 50. 1850. [Type: “In lapidosis rupibusque in Tiroli, Bavaria, Helvetia, Pedemontio”].

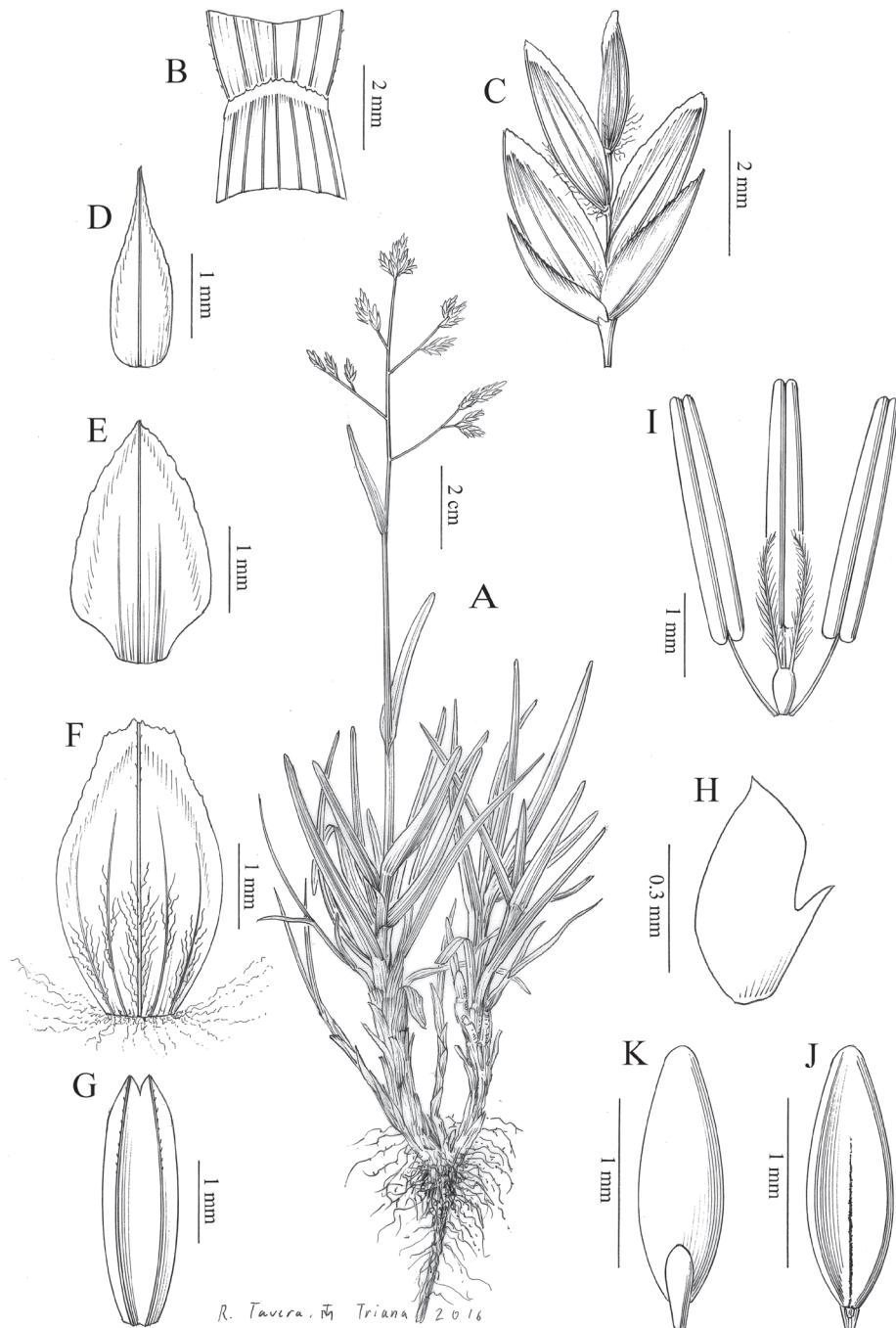
*Poa cenisia* subsp. *pallens* (Gaudin) Asch. & Graebn., Syn. Mitteleur. Fl. 2(1): 404. 1900.

*Poa fontqueri* Braun-Blanq., Bull. Soc. Pharm. Montpellier, Comm. SIGMA 87: 220. 1945. [Type: “Hab. In glareosis schistosis vel graniticis regionis subalpinae-alpinea pyrenaeorum orient. satis frequens. Typus: Pic Fontnègre 2650 m.”].

*Poa cenisia* subsp. *fontqueri* (Braun-Blanq.) Rivas Mart., Fern. Gonz. & Sánchez Mata, Itineria Geobot. 4: 117. 1990.

*Poa cenisia* var. *fontqueri* (Braun-Blanq.) Portal, Poa France Belgique Suisse 91. 2005

III. Bolòs and Vigo (2001: 384), Portal (2005: 88, 271, sub var. *cenisia*).



**Figure 2.** *Poa legionensis* (Laínz) Fern.-Casas & Laínz **A** Habit **B** Detail of the apex of the sheath and ligule, in adaxial view (upper leaf) **C** Spikelet **D** Lower glume, in abaxial view **E** Upper glume, in abaxial view **F** Lemma, in abaxial view **G** Palea, in abaxial view **H** Lodicule **I** Sexual verticils **J** Caryopsis, in adaxial view **K** Caryopsys, in abaxial view. Drawn from MA 314663 and MA 508371.

**Type.** “Secus torrentes sabulosos exsiccatos in monte Cenisio”. (Type material conserved in TO according to Kerguélen 1975, pg. 238).

**Flowering.** July to September.

**Ecology.** Grasslands, gravelly areas, rocky slopes and screes on shale, granite or limestone; edaphically indifferent; 1700–2900 m a.s.l.

**Distribution.** Mountainous areas of C and S Europe. Mountains of N Spain (Pyrenees, Cantabrian Mountains and N Iberian System). **And. Spa.:** Ge Hu L Le Lo (O) P (S) So Z. For a representative list of studied materials, see Suppl. material 1.

#### 4. *Poa chaixii* Vill., Fl. Delph. 7. 1785 [1786]

*Poa sylvatica* Chaix in Vill., Hist. Pl. Dauphiné 2: 128. 1787, nom. illeg., non *Poa sylvatica* Pollich, Hist. Pl. Palat. 1: 83. 1776.

*Poa sudetica* Haenke in Jirasek, Beobacht. Reis. Riesengeb. 120. 1791. [Type: “An dem Aupasturze im Thale”].

*Poa rubens* Moench, Methodus 187. 1794, nom. illeg., non *Poa rubens* Lam., Tabl. Encycl. 1: 184. 1791; = *Eragrostis unioloides*.

*Poa latifolia* Pohl, Tent. Fl. Bohem. 1: 94. 1810, nom. illeg., non *Poa latifolia* (Osbeck) G. Forst., Fl. Ins. Austr. 8. 1786; = *Centotheca lappaceae*.

*Poa sudetica* var. *rubens* DC. in Lam. & DC., Fl. Franç. éd. 3, 5: 272. 1815. [Type: “Habitat in Haffia inferior”]. *Poa sulcata* Lag., Gen. Sp. Pl. 3. 1816. [Type: “Legi in sylvis tractus Valgrande dicti, non procul à Pajares oppido”]. Typification supposedly carried out by Fernández Casas & Gamarra (1993: 93), but without establishing an effective lectotypification. Lectotype designated here: “Poa sulcata Lam. / *Poa sudetica*? / Lagasca iter astur / en Valgrande / Julio.” (label manuscr.): MA 209891].

*Cynodon sudeticus* (Haenke) Raspail, Ann. Sci. Nat. (Paris) 5: 302. 1825.

*Poa chaixii* var. *rubens* (DC.) Asch. & Graebn., Syn. Mitteleur. Fl. 2: 423. 1900.

*Poa haemi* F. Herm., Bull. Soc. Bot. Bulgar. 3: 43. 1929. [Type: “Habitat: Central-Balkan prope Tulovo Bulgariae, ubi legit lv. Mrkwička Sofia,. (Herbarium regale)”].

III. Pignatti (1982: 470), Portal (2005: 93, 273).

**Type.** “In sylvis & pratis alpestribus circa Chaudun prope Vapincum & ad Taillefer”. (Type material probably conserved in GRM, although doubtful according to Kerguélen 1975, pg. 238).

**Flowering.** June to August.

**Ecology.** Mountain meadows and grasslands, in brooms, heaths, beeches, oaks and hollies; edaphically indifferent; 1000–2380 (2780) m a.s.l.

**Distribution.** C and S Europe; naturalised in Finland. N Iberian Peninsula. **And. Spa.:** (Bu) Ge Hu L Le Lo Lu O (Or) P S (So) (Za). For a representative list of studied materials, see Suppl. material 1.

## 5. *Poa glauca* Vahl in Oeder, Fl. Dan. 6(17): 3. 1790 subsp. *glauca*

*Poa caesia* Sm., Fl. Brit. 1: 103. 1800. [Type: “Ang. Sea-green Meadow-grafs. In Scotiâ. D. Fairbairn. Mountains in Bredalbane. Mr. Mackay”].

*Poa nemoralis* var. *glauca* (Vahl) Gaudin, Agrost. Helv. 1: 182. 1811.

*Poa nemoralis* subsp. *glauca* (Vahl) Gaudin, Fl. Helv. 1: 240. 1828.

*Poa balfourii* Parnell, Ann. Mag. Nat. Hist., ser. 1: 10. 1842. [Type: “not expressly indicated”].

*Paneion glaucum* (Vahl) Lunell, Amer. Midl. Naturalist 4: 222. 1915.

III. Portal (2005: 98, 278, sub var. *glauca*).

**Type.** “Legi tantummodo in paroecia Wang Walders, ad pedes montium, in Finmarkia minus frequens. Prater aliis notis, praesertim colore glau.....”. (Holotype conserved in C according to PAF 2018: Norway: Oppland, Vang, “legi in alpibus Norvegiae Valders versus Vang”, leg. J. Vahl).

**Flowering.** (July) August to September.

**Ecology.** Rocky places and forest and scrub grasslands; (1500) 1900–2770 m a.s.l.

**Distribution.** Circumboreal: Eurasia (extending S to the Pyrenees, S Alps and N of Greece) and Arctic and alpine regions of N America; also Argentina. NE Spain. (**And.**).

**Spa.:** Ge Hu. For a representative list of studied materials, see Suppl. material 1.

## 6. *Poa nemoralis* L., Sp. Pl. 69. 1753 subsp. *nemoralis*

*Poa angustifolia* var. *nemoralis* (L.) Huds., Fl. Angl., ed. 2: 41. 1778.

*Paneion nemorale* (L.) Lunell, Amer. Midl. Naturalist 4: 222. 1915.

III. Portal (2005: 282).

**Type.** “Habitat in Europa ad radices montium umbrosas” (lectotype designated by Soreng 2000, pg. 255: icon in Scheuschzer, Agrostogr. Helv. Prodr. t. 2, 1708; epitype designated by Soreng and Edmondson in Soreng 2000, pg. 255: BM).

**Flowering.** April to August (November).

**Ecology.** Grasslands in shady, usually deciduous forests and in pastures, margins of alpine wetlands (“borreguiles”) and fissures of rocks; edaphically indifferent; (135) 550–2980 m a.s.l.

**Distribution.** Europe, temperate Asia and NW Africa (Morocco); introduced in other parts of the world (e.g. Canada, USA, Patagonia and Guatemala). N half and S third of the Iberian Peninsula. **And. Por.:** BA DL TM. **Spa.:** (A) (Ab) Al Av B Bu Ca Cc Cs Cu Ge Gr Gu Hu J L Le Lo Lu M (Ma) Na Or O P S Sa Sg So SS T Te To V Va Vi Z Za.

**Notes.** *Poa nemoralis* is a polymorphic species with two recognised patterns of variation and numerous transitional forms in the territory encompassed by *Flora iberica*. The first recognised variety, *Poa nemoralis* var. *nemoralis* [*Poa cinerea* Vill., Hist. Pl.

Dauphiné 2: 126. 1787, type: “Il vient au même endroit que le précédent -*Poa angustifolia-*.”; *P. debilis* Thuill., Fl. Env. Paris ed. 2: 43. 1799, type: “Habitat in pratis”; *P. miliacea* DC. in Lam. & DC., Fl. France ed. 3, 3: 64. 1805, type: “.. par M. Ramond, qui l'a trouvée dans les Pyrénées; ...”; *P. nemoralis* var. *montana* Gaudin, Alpina 3: 27. 1808, type: “In den Wältern des Jura Š. Bl. im Jun. un Jul.”; *P. nemoralis* subsp. *vulgaris* Gaudin, Agrost. Helv. 1: 179. 1811, nom. superfl.; *P. nemoralis* subsp. *firmula* Gaudin, Agrost. Helv. 1: 181. 1811, type: “In plantici dumetis non rara”; *P. nemoralis* subsp. *coarctata* Gaudin, Agrost. Helv. 1: 185. 1811, type: “In aridis apicisque, ad muros etiam alpinis hawd infrequens”; *P. nemoralis* var. *miliacea* (DC.) Godr. in Gren. & Godr., Fl. France 3: 541. 1856; *P. nemoralis* var. *eunemoralis* Hack. in Briq., Prodr. Fl. Corse 1: 141. 1910, nom. inval.], is widely distributed in the area covered by *Flora iberica* [And. Por.: BA DL TM. Spa.: Al Av B Bu Ca Cc Cs Cu Ge Gr Gu Hu J L Le Lo Lu M Ma Na Or O P S Sa Sg So SS T Te To V Va Vi Z Za]. This taxon includes plants that are usually green or sometimes glaucous, generally with smooth and flexible stems and with most leaves flat and flexible, linear or linear-lanceolate and erect or erect-patent. The other variety, *Poa nemoralis* var. *rigidula* Mert. & W.D.J. Koch, Deutschl. Fl. 1: 617. 1823 [type: “Auf Wiesen, im Gebüsche der Triften, am Saume der Wälder”], is dispersed throughout the region [And. Port.: TM. Spa.: (A) (Ab) Al Av Bu Cc Gr Hu L M Na P S Sg Te Z] and includes plants that are usually glaucous, with rigid and often rough stems and usually convolute leaves that are setaceous, linear or linear-lanceolate, ± rigid and erect. For a representative list of studied materials, see Suppl. material 1.

## 7. *Poa compressa* L., Sp. Pl. 69. 1753

*Poa planiculmis* Weber, Suppl. Fl. Holsat. 3. 1787. [Type: “Habitat in collibus prope Neumuhlen”].

*Poa compressa* var. *depauperata* Mutel, Fl. Franç. 4: 81. 1837. [Type: “plante étiolée, forêts des Alpes et du Jura”].

*Poa compressa* var. *langeana* (Rchb.) W.D.J. Koch, Syn. Fl. Germ. Helv. ed. 2: 932. 1844.

*Paneion compressum* (L.) Lunell, Amer. Midl. Naturalist 4: 222. 1915.

*Poa cenisia* subsp. *sardoa* E. Schmid, Vierteljahrsschr. Naturf. Ges. Zürich 78: 239.

1933. [Type: “Perdas Crapias am Gennargentu, 1820 m, Gneissfelsflur (22. VII.1923, b.) ...”].

III. Portal (2005: 95, 276), Soreng and Peterson (2012: 11, fig. I, F-M).

**Type.** “Habitat in Europae & Americae septentrionalis siccis, muris, tedis” (lectotype designated by Soreng 2000, pg. 255: LINN-87.41!).

**Flowering.** May to September (October).

**Ecology.** Meadows and grasslands, forests, gravelly areas, margins of roads and slopes; edaphically indifferent, although preferring basic substrates; (75) 540–1990 (2300) m a.s.l.

**Distribution.** Circumboreal (most of Europe, to SW Asia); introduced in N, C and S America (Peru, Argentina) and Australia. CN and E Spain, rarer in the south.

**And. Port.: TM. Spa.:** A (Ab) B (Bi) Bu (Cs) Cu Ge Gr Gu H Hu J L (Le) Lo (Lu) M Na (Or) P S Sa Sg So T Te (V) Va Vi (Z) Za. For a representative list of studied materials, see Suppl. material 1.

**Notes.** Plants of this species usually have a glaucous green colour. The lower (and sometimes higher) leaves of many studied herbarium specimens are missing their blades and are frequently fragmented with the ligule exposed. Inflorescences of *P. compressa* are frequently narrow and interrupted, with almost adpressed branches and spikelets are variable in size and number of flowers. The spikelets may be long, almost always entirely glabrous and glaucous, with 4–9 flowers or short and bear 2–5 flowers, and this variability may be present in the same population or even on the same plant. *Poa compressa* has not been previously listed in the flora of Portugal.

## 8. *Poa laxa* Haenke in J. Jirasek, Beobacht. Reis. Riesengeb. 118. 1791 subsp. *laxa*

*Poa laxa* & *pallida* Lange, nom. nud., in sched. (C 10022611; COI-Willk. 36552), **syn. nov.**  
**III.** Bolòs and Vigo (2001: 386), Portal (2005: 108, 281).

**Type.** “[Haenke 1791: 116, Schneekoppe] der kahle, steinigte Gipfel” [= the summit area of Mt Sněžka, NE Bohemia, at the Polish border] (lectotype designated by Kirschner et al. 2007, pg. 349: *Poa laxa* a me descripta in Actis Societ. Boh. Anno 1787. *Poa* Halleri historia Nr. 1457. Lecta in Sudetis et in Styriae Alpibus, T. Haenke (PR); epitype designated by Kirschner et al. 2007, pg. 349: Bohemia, the Krkonoše Mts, Mt Sněžka, scree site just below the summit plateau at the beginning of the track called Jubilejní cesta, 50°44'10"N, 15°44'25"E, 3 Jul 2007, J. Zahradníková&L. Harčáriková s.n: PRA 349; isoepitypes: PR, PRC).

**Flowering.** July to September.

**Ecology.** Rocky places, stony places and high mountain waterfalls, on shale, schist and granite; (1900) 2300–3150 m a.s.l.

**Distribution.** C and N of Europe, reaching the Carpathians, Balkans, Apennines and Pyrenees, and N America. N and NE Iberian Peninsula. **And. Spa.:** Ge Hu L (P). For a representative list of studied materials, see Suppl. material 1.

## 9. *Poa minor* Gaudin, Alpina 3: 44. 1808

*Poa laxa* subsp. *minor* (Haenke) Hooker fil., Stud. Fl. Brit. Isl., ed. 1: 444. 1870.

*Poa laxa* var. *minor* (Haenke) Fiori in Fiori & Paoletti, Fl. Italia 1: 86. 1898.

**III.** Bolòs and Vigo (2001: 387), Portal (2005: 111, 281).

**Type.** “Dieses schöne Gras findet man wie das vorige, auf hohen Gebirgen; auf dem Bernhard, auf den Bergen oberhalb Ber und Aigle u. s. w. Bl. im Jul. und Aug.”. (Type material conserved in LAU according to Kerguélen 1975, pg. 241).

**Flowering.** (July) August to September.

**Ecology.** Talus slopes, stony places and fissures of rocks, wet and sheltered grasslands, on limestone and schist; 2000–3350 m a.s.l.

**Distribution.** Mountains of S Europe: Sierra Nevada, Pyrenees, Alps, Balkans and Carpathians. N and SE Spain: Cantabrian Mountains, Pyrenees and Sierra Nevada. **(And.). Spa.:** Ge Gr Hu (Na) O S.

Two subspecies of *P. minor* are recognised in the territory encompassed by *Flora iberica*. A key to their identification is given below:

- 1      Blades of most leaves conduplicate, rarely flat, those of basal and shoot leaves 0.4–1.6(–2.1) mm wide; branches of the inflorescence flexuous; spikelets ovate-oblong; lemma hairy at the nerves and the base, hairs of the latter usually longer than the width of the lemma; anthers 0.8–1.1 mm ..... **a. subsp. *minor***
- Blades of most leaves flat, rarely conduplicate, those of basal ones 1.5–2.3 mm wide; branches of the inflorescence straight; spikelets oblong; lemma glabrous or only weakly hairy at the nerves; anthers (1–)1.2–1.7 mm ..... **b. subsp. *nevadensis***

#### **a. subsp. *minor***

*Poa supina* Panz. in Sturm, Deutschl. Fl. 34: 1. 1812, nom. illeg., non *Poa supina* Schrader, Fl. Germ. 289. 1806.

*Poa pyrenaica* Lange ex Willk. in Willk. & Lange, Prodr. Fl. Hispan. 1: 80. 1861, nom. inval., pro syn.

*Poa jacetana* gr. *laxa* P. Montserrat, nom. nud., in sched. (MA 291693), **syn. nov.**

**Flowering.** (July) August to September.

**Ecology.** Talus slopes, stony places and fissures of limestone rocks, wet and sheltered high mountain locations; rarely on schist; 2000–3207 m a.s.l.

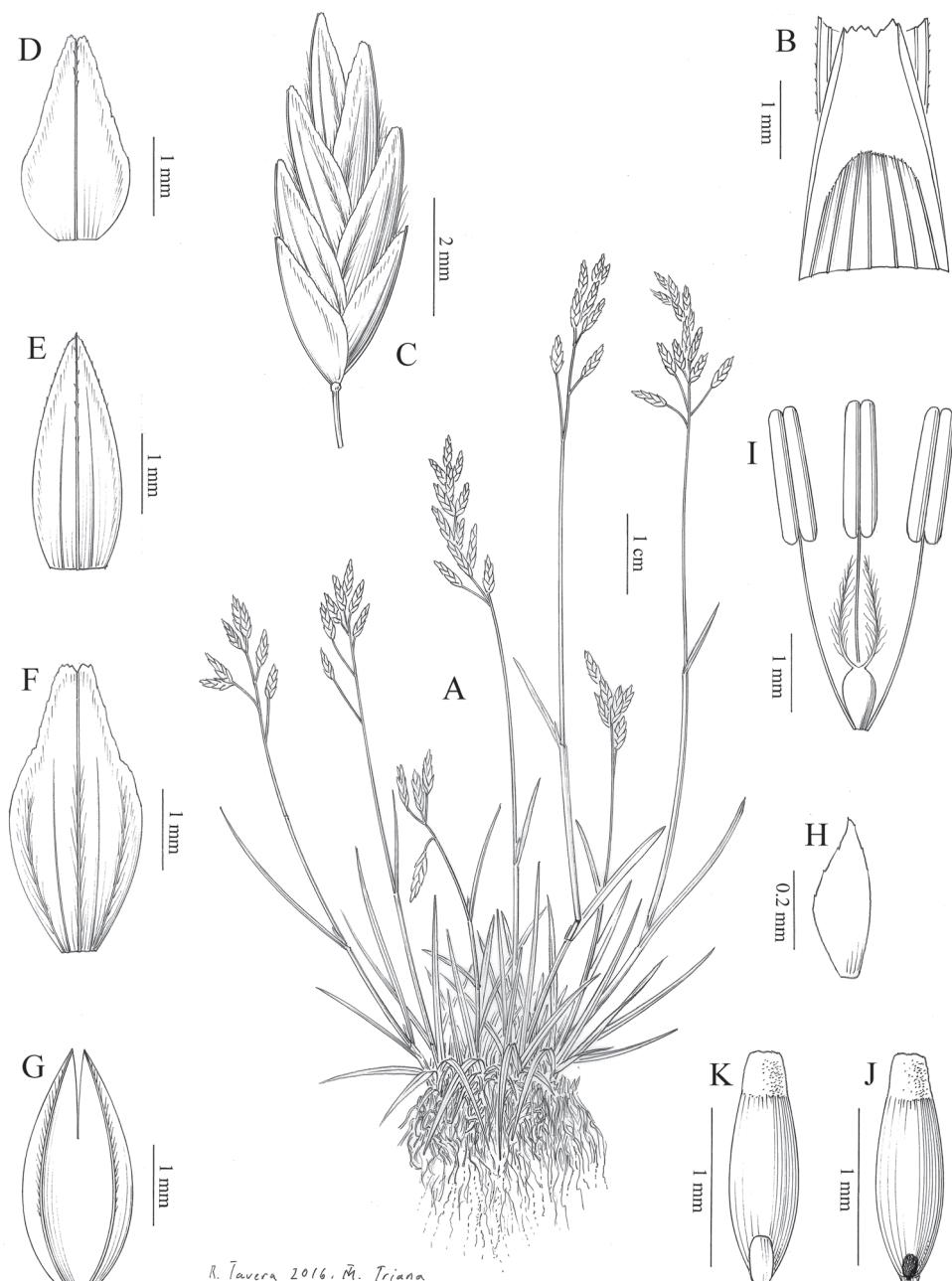
**Distribution.** Mountain systems of S Europe (Cantabrian Mountains, Pyrenees, Alps, Balkans and Carpathians). N Spain: Cantabrian Mountains and Pyrenees. **(And.). Spa.:** Ge Hu L Na O S. For a representative list of studied materials, see Suppl. material 1.

#### **b. subsp. *nevadensis* Nannf. in Font Quer, Exsicc. Fl. Iber. Select. Cent. 3: n. 201. 1935.**

*Poa laxa* sensu Boiss., Voy. Bot. Espagne 659. 1842, non *Poa laxa* Haenke in J. Jirasek et al., Beobacht. Reis. Riesengeb. 118. 1791.

*Poa minor* var. *nevadensis* (Nannf.) Á.M. Hern., Acta Bot. Malac. 2: 35. 1976, comb. inval., **syn. nov.**

**III. Fig. 3.**



**Figure 3.** *Poa minor* subsp. *nevadensis* Nannf. **A** Habit **B** Detail of the apex of the sheath and ligule, in adaxial view (upper leaf) **C** Spikelet **D** Lower glume, in abaxial view **E** Upper glume, in abaxial view **F** Lemma, in abaxial view **G** Palea, in abaxial view **H** Lodicule **I** Sexual verticils **J** Immature caryopsis, in adaxial view **K** Caryopsys, in abaxial view. Drawn from GDA 31029 and MA 422687.

**Type.** “Baetica: in schistosis montium Sierra Nevada, 1. Cerro de la Alcazaba dicto, ad 3000 m alt., Leg. Font Quer, 28 aug. 1923” (lectotype designated here: “Institut Botanicum Barcinonense / Flora Iberica Selecta / Cent. III Dec. 1935 / 201. Poa minor Gaud. / Fl. Helvet., I, p. 253 (1828). / ssp. nevadensis Nannf. nov. ssp. / Poa laxa Boiss., Voy. Bot. Esp., II, p. 659, non Haenke. / Baetica: in schistosis montium Sierra Nevada, l. Cerro de la Alca- / zaba dicto, ad 3000 m alt. Cotypus. / Leg. Font Quer, 28 aug. 1923. / Obs.: Differt a typo foliis tenuioribus, planis; ligulis brevioribus / (2 mm non excedentibus); spiculis angustioribus et longioribus; / floribus distantioribus; glumis valde inaequilibus; gl. I 2-2,5 mm / longis, gl. II 2,2-3,= mm; antheris paulo longioribus et angustiori- / bus (longit. 1,1-1,3 mm). J. A. Nannfeldt.” (label printed): UPS-V-873177, top specimen on the right; isolectotypes designated here: BC 990150, BC 87706, BC 87707; GDA 31029, 31030, 31031; MA 11385; MAF 28595).

**Flowering.** July to September.

**Ecology.** Pastures and wet stony places in high mountain locations, on schist; (2500) 3000–3350 m a.s.l.

**Distribution.** Endemic to SE Spain: Sierra Nevada. **Spa.:** Gr. For a representative list of studied materials, see Suppl. material 1.

## 10. *Poa trivialis* L., Sp. Pl. 67. 1753 subsp. *trivialis*

*Poa dubia* Leers, Fl. Herborn. 28, tab. 6, fig. 5. 1775. [Type: “H. in pratis humidiis culis ubique frequens; ad fossas; an der Dillae & Mühlbach copiose; etiam fissioribus locis gramineis pervulvaris”].

*Poa scabra* Ehrh., Beitr. Naturk. 6: 83. 1791, nom. inval.

*Poa stolonifera* Haller ex Muhl., Descr. Gram. 139. 1817, nom. illeg., non *Poa stolonifera* Bellardi, Mem. Reale Accad. Sci. Torino 5: 215. 1792.

*Poa trivialis* a *vulgaris* Rchb., Icon. Fl. Germ. Helv. 1: 37, fig. 1653, 1654. 1834, nom. superfl.

*Poa feratiana* Boiss. & Reut., Pugill. Pl. Afr. Bot. Hispan. 128. 1852. [Type: “Hab. In sylvâ Irati Pyrenaeorum occidentalium loco Erreca-Idorra (Férat in herb. Fauché!) Fl. Julio”] (lectotype designated by Burdet et al. 1981, pg. 577: specimen indicated with arrows, G00176550!).

*Poa sylvicola* Guss., Enum. Pl. Inarim.: 371, tab. 18. 1854. [Type: “In sylvaticis apricis ubique vulgatissima; nec non prope Neapolina, et Stabias”].

*Poa trivialis* var. *umbrosa* Balansa, Bull. Soc. Bot. France 21: 16. 1874. [Type: “Rhizè, dans les forêts, les lieux humides”].

*Poa trivialis* var. *sylvicola* (Guss.) Hack., Verh. K. K. Zool.-Bot. Ges. Wien 1890: 127. 1890.

*Poa attica* sensu Pérez Lara, Anales Soc. Esp. Hist. Nat. 15: 406 (1886), non *Poa attica* Boiss. & Heldr. in Boiss., Diagn. Pl. Orient. ser. 1, 13: 57 (1854).

*Poa attica* var. *gaditana* Pérez Lara ex Willk., Suppl. Prodr. Fl. Hispan. 22. 1893, **syn. nov.** [Type: « ...provinciae Gadit. Haud frequens (pr. Jerez in loco et Albaladejo et in Dehesa del Torongil; pr. Grazalema ad Huertas de Benamahona, PER. LARA!) »].

*Poa trivialis* var. *flaccida* Willk. ex J.J. Rodr., Fl. Menorca 152. 1904, **syn. nov.** [Type: “Barranco de Son Blanc en sitios frescos”] (lectotype designated here: first label: “Glumelle glabra. Ax. de l’epilles numi / à la base des glumelles inferieures d’un “faisceau de poile longe et soyeux. / Gaines sublisses. -illegible- noueux à / leur base, lisses au sommet. / = P. attica Boiss. Heldr. var. *flaccida*.” (manuscr.); second label: “J. J. Rodriguez. (printed) Plantas de Menorca. (Baleares.) (printed) / *Poa trivialis* L.? (manuscr.) / var. (?) *flaccida* Wk. ined (manuscr.) / Localidad (printed) Barranco de Son Blanc (Algar) (manuscr.) / Estacion (printed) Sitios frescos (manuscr.) / Epoca (printed) 28 mayo 1874 (manuscr.) / Leg. Rodríguez (impreso)”: COI-Willk. 36527; isolectotype designated here: HGM 3121-1).

*Poa trivialis* subsp. *sylvicola* (Guss.) H. Lindb. fil., Oefvers. Förh. Finska Vetensk.-Soc. 38(13): 9. 1906.

*Poa trivialis* “rasse” *majorica* [*majorcica*] F. Hermann, Verh. Bot. Vereins Prov. Brandenburg 54: 252. 1914, **syn. nov.** [Type: “An Rainen und Wegändern sammelte ...”].

*Poa trivialis* f. *majorica* (F. Hermann) Knoche, Fl. Balear. 1: 310. 1921, **syn. nov.**

*Poa trivialis* f. *flaccida* (Willk. ex J.J. Rodr.) Knoche, Fl. Balear. 1: 311. 1921, **syn. nov.**

*Poa trivialis* var. *obtusata* Maire, Fl. Afr. N. 3: 99. 1955, nom. inval.

*Poa trivialis* subsp. *feratiana* (Boiss. & Reut.) Á.M. Hern., Acta Bot. Malac. 2: 33. 1976.

*Poa portalii* H. Scholz, Willdenowia 42: 293 (2012), **syn. nov.** [Type: Holotype: France: Aquitaine, Pyrenees Atlantiques, Iraty, c. 50 m behind camping place on a wet depression at border of a foot path in woodland, 1150 m, 11.8.2010, Böhling 15255 (B, as “*Poa supina*”). Holotype B 100558216 (seen by Soreng in 2015, pers. comm.).

*Poa trivialis* var. *modesta* Caball., nom. nud., in sched. (MA 11644, MA 11627), **syn. nov.**

*Poa trivialis* f. *biflora* Bernis, Flora Maragata, nom. nud., in sched. (MA 11615; MA 11617), **syn. nov.**

*Poa verticillata* auct., non L. (MA 11631).

*Poa trivialis* var. *contracta* Pérez Lara, nom. nud., in sched. (MAF 28658, MAF 28569, MAF 28655), **syn. nov.**

**III.** Ruiz (1991: 29, lam. II), Devesa (1987: 263, sub *P. trivialis* subsp. *trivialis* and subsp. *sylvicola*).

**Type.** “Habitat in Europae pasenis” (neotype designated by Soreng 2000, pg. 256: Hudson 16, Herb. Linn. No. 87.9!).

**Flowering.** (March) April to July.

**Ecology.** Pastures, hygrophilous grasslands (stream edges, peat bogs, reed patches and meadows) and very wet soils of deciduous forests (e.g. alders, ashes, chestnuts and oaks); edaphically indifferent; 0–2000 (2150) m a.s.l.

**Distribution.** Europe, N Africa, Asia and Macaronesia (Azores, Madeira and Canary Islands); introduced in other parts of the world. Most of the Iberian Peninsula and Balearic Islands. **And. Port:** AAI Ag BA BB BL (BAL) DL E Mi R TM. **Spa.:** A Ab Al Av B Ba Bu C Ca Cc Co CR Cs Ge Gr Gu H Hu J L Le Lo Lu M Ma (Mu) Na O (Or) P PM[Mll Mn] Po S Sa Se Sg So (SS) (T) (Te) To V Va Vi Za (Z). For a representative list of studied materials, see Suppl. material 1.

**Notes.** *Poa trivialis* is variable with regard to habit, leaf size and inflorescence morphology. The most distinctive feature of this species is the elongated ligule, which is always longer than the width of the leaf blade, ovate or ± triangular in the basal leaves and irregularly dentate or bilobed with an acute apex in the uppermost ones. In addition, the spikelets have 2 or 3 flowers and the sharp, arched glumes converge around the lemma. The base of the lemma is very woolly or extremely rarely glabrous and the hairs are clearly longer than its width.

Some plants have somewhat thickened and constricted stolons, with a more or less moniliform appearance. These individuals were described as *Poa sylvicola* Guss. (= *P. attica* var. *gaditana* Pérez Lara ex Willk.; = *P. trivialis* var. *umbrosa* Balansa). According to Soreng (pers. comm.), *P. trivialis* subsp. *sylvicola* (Guss.) H. Lindb. fil. is common in the Mediterranean region, while subsp. *trivialis* is rather infrequent and, conversely, subsp. *sylvicola* is infrequent northwards. Other characteristics of subsp. *sylvicola* are smoother sheaths and the consistent presence of hairs on the lower part of the marginal lemma veins vs. their absence in subsp. *trivialis*. Practically speaking, the marginal vein is hairy in Mediterranean populations but glabrous or nearly so in northern ones. In both types of populations, however, the differing combinations of forms of these characters makes it almost impossible to delimit these two taxa. Consequently, we have opted not to recognise them as separate subspecies.

*Poa feratiana* Boiss. & Reut. is also included here as a synonym of *P. trivialis*. Plants labelled as *P. feratiana* on herbarium sheets had 2 flowers per spikelet, which is diagnostic for this species, but this characteristic is also very common on most studied sheets of *P. trivialis*. In addition—as indicated by Hernández Cardona (1976) after studying the type material (G-herbarium Boissier)—some of the characteristics attributed to this species in the original description were incorrect. For instance, the number of veins of the lemma is actually 5, not 3, a feature likely overlooked by the original authors because the marginal veins are usually very close to the edge. As another example, the lemma is indeed woolly at the base, as is common in *P. trivialis*.

Plants with some of their spikelets completely sterile and reduced to a set of whitish or hyaline membranes are also known.

## 11. *Poa flaccidula* Boiss. & Reut., Pugill. Pl. Afr. Bor. Hispan. 128. 1852

*Poa balearica* Porta, Nuov. Giorn. Bot. Ital. 19: 324. 1887. [Type: “M. Ad pedes rupium praeeruptarum m. Coma den Ar-bona” (lectotype designated by Rosselló and Sáez 2000, pg. 141, second on left specimen: G].

*Poa trivialis* subsp. *balearica* (Porta) Gand., Nov. Conspl. Fl. Eur. 506. 1910, **syn. nov.**

*Poa trivialis* f. *balearica* (Porta) Knoche, Fl. Balear. 310. 1921.

*Poa trivialis* var. *balearica* (Porta) O. Bolòs & Molinier, Collect. Bot. (Barcelona) 5: tab. 7. 1958, comb. inval., **syn. nov.**

*Poa zapateri* Gandojer, nom. in sched. (MA 11500). [Type: “Sierra de Albarracín”]

*Poa ventalloi* Sennen, nom. nud., in sched. (Sennen BC-966297).

III. Devesa (1987: 264).

**Type.** “Habitat in umbrosis septentrionalibus jugi Cerro de San Cristoval et Sierra de la Nieve ditionis Serrania de Ronda Junio 1849 (Boiss. et Reuter)” (lectotype designated by Hernández Cardona 1978, pg. 104-105, 337, left specimen on the sheet from Cerro de San Cristóbal, Reuter, 6-1849: G 00176652!).

**Flowering.** April to July.

**Ecology.** Stony places, cliffs, scrub clearings and understoreys, on limestone; (200) 700–2030 m a.s.l.

**Distribution.** W Mediterranean region (S France [Provence], peninsular Spain, Balearic Islands and NW Africa [Morocco and Algeria]). S and E half of peninsular Spain and Mallorca. **And. Spa.:** A (Ab) (Al) B Bu Ca (Co) CR Cs Cu Gr Gu Hu J L Ma (Mu) (Na) PM[Mll] (S) So (T) Te To V Z. For a representative list of studied materials, see Suppl. material 1.

**Notes.** Spikelets in this species usually have 2–3 flowers, but can have 3–7, a rare phenomenon observed more frequently in populations in NE Spain. The most distinctive characteristic of *Poa flaccidula* is the sericeous or appressed-hairy indumentum of the intervein zone of both the lemma and palea. This species is sometimes confused with *P. annua*, but, along with other differences, the latter is an annual, not a perennial. *Poa flaccidula* can also be confused with *P. trivialis*, which, like *P. flaccidula*, has a ligule that is longer than the width of the leaf blade and possesses hairs at the base of the lemma that are longer than its width; however, both the palea and the internerval surface of the lemma is glabrous in *P. trivialis*.

*P. flaccidula* subsp. *guadianensis* F.M. Vázquez, Folia Bot. Extremad. 9: 66 (2016) has recently been described from Extremadura (SW Spain), but examination of the type material (HSS 65616; COF 62937 isotypus) reveals that this taxon is in no way attributable to *P. flaccidula*. The most we can say, given the immaturity of the specimens, is that it may be of hybrid origin, with *P. bulbosa* possibly one of the parents.

## 12. *Poa annua* L., Sp. Pl. 68. 1753 subsp. *annua*

*Poa annua* var. *viridis* Lej. & Courtois, Comp. Fl. Belg. 1: 80. 1828. [Type: “not expressly indicated”].

*Poa ovalis* Tineo, Pl. Rar. Sicil., fasc. 2: 21. 1846. [Type: “In pascuis montosis, apricis, palustribus. Cotrano al Gurgo lo Drago”].

*Poa annua* var. *aquatica* Asch., Fl. Brandenburg 1: 844. 1864. [Type: “Provinz Brandenburg S. Altd. Sumpf hinter dem Pfarrgarten”].

*Poa annua* var. *typica* Beck, Fl. Nieder-Österreich: 84. 1890, nom, inval.

*Poa annua* var. *ovalis* (Tineo) Trab. in Batt. & Trab., Fl. Algérie (Monocot.) 2: 206. 1895.

*Poa annua* f. *plicata prostrata* Sennen, Pl. Espagne n. 605. 1908, nom. nud., in sched. (MA 11165), p.p., **syn. nov.**

*Poa annua* var. *lanuginosa* Sennen, Diagn. Nouv. sér. 1933: 209, n. 8980. 1936.

[Type: “Hab.- Maroc: Melilla à Rostrogordo. Leg. Hno. Mauricio”] (lectotype designated here: “1933.-Plantes d’Espagne. -F. Sennen / N° 8980 / Poa annua

L. / var. *lanuginosa* Sennen / Maroc: Melilla, à Rostrogordo / 2–III Leg. Hno. MAURICIO” (label printed): specimen upper on the left, BC 119353; isolectotype: MA 11155).

*Poa annua* f. *lanuginosa* Sennen & Mauricio, Cat. Fl. Rif Orient.: 132. 1934, nom. nud., **syn. nov.**

*Poa annua* var. *pilantha* Ronniger, Verh. Deutsch. Bot. Ges. Wien 88-89: 97. 1941. [Type: “not expressly indicated”, but the material was collected on the island of Zante, Ionian Islands, Greece].

*P. annua* subsp. *pilantha* (Ronniger) H. Scholz, Ber. Deutsch. Bot. Gesell. 81: 19. 1968.

*Ochlopoa annua* (L.) H. Scholz, Ber. Inst. Lanschafts- Pflanzenökologie Univ. Hohenheim, Beih. 16: 58. 2003.

*Ochlopoa annua* subsp. *pilantha* (Ronniger) H. Scholz & Valdés, Willdenowia 36: 661. 2006.

III. Ruiz (1991: 27, lam. I), Soreng and Peterson (2012: 14, fig. 2A–E), Devesa (1987: 261).

**Type.** “Habitat in Europa ad vias” (lectotype designated by Soreng 2000, pg. 254: right-hand plant, Herb. LINN No. 87.17!).

**Flowering.** All year.

**Ecology.** Pastures and grasslands along roads, fallow fields, gardens, margins of watercourses and more or less nitrified soils of all types; edaphically indifferent; 0–2100 m a.s.l.

**Distribution.** Cosmopolitan, although apparently of Mediterranean origin. Throughout the Iberian Peninsula and Balearic Islands. **And. Port:** AA1 Ag BA BAI BB BL DL E Mi (R) TM. **Spa.:** A Al Av B Ba Bi Bu C Ca Cc Co CR Cs Cu Ge Gr Gu H Hu J L Le Lo Lu M Ma Mu Na O (Or) P PM [Mll, Mn] Po S Sa Se Sg So SS T Te To V Va Vi Z Za. For a representative list of studied materials, see Suppl. material 1.

**Notes.** Plants are found in the territory covered by *Flora Iberica* that have hairy lemmas, at least towards the internerval basal zone, with this indumentum being more perceptible in apical flowers of the spikelet. This characteristic is usually accompanied by a very dense silky indumentum in the veins. In other cases, the spikelet has lemmas with a glabrous internerval surface, usually accompanied by a lower density of indumentum in the nerves, with sometimes even the medium ones being glabrous or glabrescent. The first variation corresponds to *Poa annua* var. *lanuginosa* Sennen (Diagn. Nouv. sér. 1933: 209, n. 8980. 1936), a name that prevails over the name *P. annua* var. *pilantha* Ronniger (Verh. Deutsch. Bot. Ges. Wien 88-89: 97. 1941). When Scholz in Ber. Deutsch. Bot. Gesell. 81: 19 (1968) raised Ronniger's taxon to the subspecies category, he stated that the distribution of this subspecies was Mediterranean (e.g. Greece, Italy, Spain and Morocco) and extra-Mediterranean for the type subspecies. Although plants of Mediterranean environments in the Iberian Peninsula tend to have hairier lemmas, we have also found specimens assignable to var. *annua* and, conversely, we have observed plants with hairy lemmas in typically Eurosiberian areas (e.g. Lugo, Minho, Oviedo and Santander) and even Macaronesia (e.g. Madeira).

In certain populations, some spikelets are completely sterile and reduced to a set of whitish or hyaline membranes. Although infrequent, plants with loosely antrorse-scabrid inflorescence branches have been detected, perhaps as a result of hybridisation with other species (e.g. MA 420475, MA 449625).

DNA sequence data support the hypothesis that *P. annua*, a tetraploid species, has arisen by hybridisation—and subsequent polyploidisation—between two Eurasian diploid species, the annual *P. infirma* Kunth and the rhizomatous perennial *P. supina* Schrad. (Soreng et al. 2010; Mao and Huff 2012), as suggested by Nannfeldt (1937).

### 13. *Poa infirma* Kunth in Humb., Bonpl. & Kuntz, Nov. Gen. Sp. 1: 158. 1816

*Megastachya infirma* (Kunth) Roem. & Schult., Syst. Veg. 2: 585. 1817.

*Eragrostis infirma* (Kunth) Steud., Nomencl. Bot. ed. 2, 1: 563. 1840.

*Poa annua* var. *exilis* Tomm. ex Freyn, Verh. K. K. Zool.-Bot. Ges. Wien 27: 469.

1878. [Type: “So auf sonnigen, trockenen Grasplätzen der Macchien, meist in Gesellschaft von Asterolinon, Euphorbia peploides, E. exigua und anderen Zwergpflanzen stellenweise häufig, bisher aber nur läng der Küste von Fasana bis Medolino; auch auf S. Marina (Tommasini 1872)”].

*Poa annua* var. *remotiflora* Hack. ex Batt. & Trab., Fl. Algérie Monocot. 206. 1895.

[Type: “Lieux humides et région montagneuse, Rouïba, Teniet-el-Haàd”].

*Poa annua* subsp. *exilis* (Tomm. ex Freyn) Murb. in Asch. & Graebn., Syn. Mitteleur. Fl. 2: 389. 1900.

*Poa remotiflora* (Hack. ex Batt. & Trab.) Murb., Acta Univ. Lund. 36 Afd. 2. n. 1: 22. 1900, nom. illeg., non *Poa remotiflora* Rupr., Fl. Samojed. Cisural. 63. 1845.

*Poa exilis* (Tomm. ex Freyn) Murb. ex Nannf., Acta Univ. Lund., ser. 2, 1(4): 73. 1906.

*Poa annua* f. *plicata prostrata* Sennen, Pl. Espagne n. 605. 1908, nom. nud., in sched. (MA 11165), p.p., **syn. nov.**

*Poa annua* var. *plicata* Sennen, Pl. d'Espagne w.n. 1908, nom. nud., in sched. (MA 11142).

*Poa annua* var. *laxiflora* Sennen, Pl. d'Espagne n. 606. 1908, nom. nud., in sched. (MA 11143).

*Poa annua* subsp. *remotiflora* (Hack. ex Batt. & Trab.) Jansen & Wachter, Fl. Nederl. 1(2): 78. 1951, nom. illeg.

*Poa annua* L. var. *spiciformis* Palau Ferrer, Pl. Baleares n. 793. 1955, nom. in sched. (GDA 30993; MA 168790), **syn. nov.**

*Ochlopoa infirma* (Kunth) H. Scholz, Ber. Inst. Landschafts-Pflanzenökologie Univ. Hohenheim Beih. 16: 59. 2003.

III. Ruiz (1991: 27, lam. I), Soreng & Peterson (2012: 14, fig. 2F–H), Devesa (1987: 262).

**Type.** “Crescit in frigidis regni Novogranatensis, inter Fontibon, Suba et Santa Fe de Bogota, alt. 1360 hexap. Floret Ausgusto”. [Holotypus P-HUMB; isotypus: B-WILLD-1974 pl. 223, LE-TRIN-2638.01 fragm. & illustr., US-1851276 fragm. ex P, US-2851277 fragm. ex P-HUMB] (designated by Soreng and Peterson 2012, pg. 43)].

**Flowering.** October to May (July).

**Ecology.** Therophytic pastures and ruderal places, preferably in sandy soils; edaphically indifferent; 2–1000 m a.s.l.

**Distribution.** W Europe, Mediterranean, Macaronesian and Irano-Turanian regions extending to India; introduced in Australia and the Americas. Scattered across the Iberian Peninsula and Balearic Islands. **Port:** AAI Ag BA BAL E Mi (R) TM. **Spa.:** A (Ab) Al Av B Ba (C) Ca Cc Co CR Ge Gr H Hu J (L) Lo M Ma (Mu) O (Or) (Po) PM [Mll Mn] S Sa Se Sg Te To V Va (Z) Za. For a representative list of studied materials, see Suppl. material 1.

**Notes.** This species is clearly differentiated from the previous one, not only by the small size of its anthers, but also by the smaller size of the leaves, which, in most cases, are not more than 2 mm wide and have margins that are barely scabrid or even smooth. Most populations comprise plants of small size (up to 22 cm).

Plants with some spikelets completely sterile and rudimentary, whitish or hyaline have been detected in some populations (e.g. province of Granada, GDA 15557).

#### 14. *Poa supina* Schrad., Fl. Germ. 1: 289. 1806

*Poa annua* var. *varia* Gaudin, Alpina 3: 29. 1808. [Type: “An den Bächen, auf den höheren Apen; auf der Scheideck. Seringe. Auf dem Gotthard häufig. Ø. Bl. im Sommer”].

*Poa annua* subsp. *varia* (Gaudin) Gaudin, Agrost. Helv. 1: 189. 1811.

*Poa annua* var. *supina* (Schrad.) Spenn., Fl. Friburg. 1: 127. 1825.

*Poa annua* subsp. *supina* (Schrad.) Husn., Graminées 51. 1898.

*Poa exigua* Foucaud & Mandon ex Husn., Gram. Fr. Belg. 88. 1899, nom. illeg., non *Poa exigua* Dumort., Gramin. Belg. 113. 1824.

*Poa annua* f. *macranthera* Lit. & Maire in Jahand. & Maire, Cat. Pl. Maroc 1: 66. 1931. [Type: “Sierra Nevada. Pyrénées. Corse. Alpes.”].

*Poa supina* f. *exigua* Gamisans, Candollea 29: 48. 1974. [Type: “Massif du Cinto, Capo al Berdato, versans SSW, pozzine de pente, 2320 m, 1.8.1969, Gamisans 2912 (fl.); cirque de Trimbolacciu, couloir de Pampanosa, pelouse, 1880 m, 6.8.1970, Gamisans 2913 (fl.)”].

*Ochlopoa supina* (Shrad.) H. Scholz & Valdés, Willdenowia 36: 662. 2006.

**III.** Pignatti (1982: 469).

**Type.** “In summis alpibus Salisburgensibus (Mielichhoffer)”. (Possible isotype conserved in LE according to PAF 2018).

**Flowering.** June to August (September).

**Ecology.** Perennial grasslands in wet places; edaphically indifferent; 1200–3481 m a.s.l.

**Distribution.** C and SW Europe, Apennines, Fennoscandia and NE Russia, extending to the Rif (Morocco). Pyrenees, Cantabrian Mountains, Central System and Sierra Nevada. **And. Port.:** (BA)? (Mi)? (TM)? **Spa.:** Av Ge Gr Hu L Le M Na P S. For a representative list of studied materials, see Suppl. material 1.

**Notes.** Plants from the Sierra Nevada tend to have glabrescent floral parts (lemmas and paleas) or an indumentum that is restricted to the basal zone of the central nerve; this contrasts with plants from some peripheral populations of this mountain massif (e.g. Lugros, Dehesa del Camarate, 2200 m, GDAC 41005) and other Iberian populations, none of which are usually glabrous. Although clearly corresponding to *P. supina*, the Sierra Nevada plants also resemble those of *P. rivulorum* Maire & Trab., Bull. Soc. Hist. Nat. Afrique N. 15: 395. 1924; *P. annua* var. *rivulorum* (Maire & Trab.) Lit. & Maire in Jahand. & Maire, Cat. Pl. Maroc 1: 66. 1931; *P. alpina* subsp. *atlantica* (Trab.) Romo, Treb. Inst. Bot. Barcelona 11: 40. 1987, **syn. nov.**, non *P. alpina* var. *atlantica* Trabut in Maire, Mém. Soc. Sci. Nat. Maroc 7: 147. 1924; *Ochlopoa rivulorum* (Maire & Trab.) H. Scholz & Valdés, Willdenowia 36: 662. 2006], a tetraploid species ( $n = 14$ ) endemic to Alto, Medio and Anti Atlas (Morocco), in that the flowers, as indicated by Maire (1955), are usually glabrous and rarely hairy at the base of the medial and marginal veins. The observed pattern in Sierra Nevada is perhaps simply infrapopulational variation.

### 15. *Poa bulbosa* L., Sp. Pl. 70. 1753 subsp. *bulbosa*

*Poa bulbosa* subsp. *eu-bulbosa* Hayek, Prodr. Fl. Penins. Balcan. 3: 259. 1932, nom. inval.

III. Ruiz (1991: 31, lam. III), Devesa (1987: 265).

**Type.** “Habitat in Gallia” (lectotype designated by Meikle 1985, pg. 1742; restricted by Soreng 2000, pg. 255: Hasselquist, Herb. Linn. No. 87.57!).

**Flowering.** January to July (December).

**Ecology.** Pastures and grasslands in wet and nitrified soils, less frequently in ephemeral pastures and dry places; edaphically indifferent; 0–3100 m a.s.l.

**Distribution.** Europe, SW, C and N Asia until W China, Africa and Macaronesia (Madeira and Canary Islands); introduced in the Americas, Australia and Pacific Islands. Entire Iberian Peninsula and Balearic Islands. **And. Port.:** Ag AAI BAI BA BB BL DL E Mi R TM. **Spa.:** A Al Ab Av B Ba Bu C Ca Cc (Cs) CR Co Cu Ge Gr Gu H Hu J L Le Lo Lu M Ma Mu Na Or O P PM[Mll (Me)] Po S Sa Sg Se So SS T Te To V Va Vi Z Za. For a representative list of studied materials, see Suppl. material 1.

**Notes.** According to Bolòs and Vigo (2001: 380), reports of *Poa bulbosa* subsp. *concinna* (Gaudin) Hayek, Repert. Spec. Nov. Regni Veg. Beih. 30(3): 260. 1932 [*P. concinna* Gaudin, Agrost. Helv. 1: 196. 1811, basion., type: “Hab. in arenosis Vale-siae inferioris, praecipue Seduni”; *P. perconcinna* J.R. Edmonson, Bot. J. Linn. Soc. 76: 330. 1978, type: based on *P. concinna* Gaudin] in E Spain are mistaken, as this taxon is actually only distributed from SE France to the Balkan Peninsula. That taxon differs from *P. bulbosa* by their smaller sizes and narrower leaves, 0.8–2.2 mm ligules and never-proliferating spikelets with 6–10 flowers. In a few peninsular populations, plants with spikelets bearing 9–10 flowers have been detected, but they coincide with *P. bulbosa* in all other characters.

Caryopses are formed in this species, but sexual reproduction is infrequent; more common propagation routes include the formation of bulbs at the base of the plant or bulbils at the inflorescence level. This latter phenomenon, pseudovivipary, is extraordinarily frequent in *P. bulbosa* and involves the formation of bulbils for vegetative multiplication in the place of normal flowers (“proliferated spikelets”; Ofir and Kigel 2014). These bulbils may or may not coexist with normal flowers on the same spikelet or plant or in the same population. The balance between clonal and sexual reproduction is controlled mainly by day length and temperature; short days and low temperatures usually promote proliferating inflorescences, whereas long days and high temperatures induce normal and seminiferous ones. The proliferating spikelets usually carry (1–) 2–3 bulbils and have deformed floral parts: the glumes are usually narrower, the lemma is typically long (up to 20 mm), thin and either glabrous or only hairy on the central and marginal veins and the palea is missing or fully integrated into the bulbil, similar to the lodicules. Stamens are also missing or very reduced in size. The bulbils tolerate desiccation, are dormant during the summer and are dispersed by wind and ants. Both the basal bulbs, which are also dormant during the summer and the inflorescence bulbils sprout at the peak of the winter rainy season (cf. Ofir and Kigel 2014).

Two varieties are distinguished in the flora. Plants with bulbils in the inflorescence are recognised as *Poa bulbosa* var. *vivipara* Koeler, Descr. Gram. 189. 1802 [Type: “prope Moguntiam in arenosis”; *Poa bulbosa* subsp. *vivipara* (Koeler) Arcang., Comp. Fl. Ital. 785. 1882; *Paneion bulbosum* var. *viviparum* (Koeler) Lunell, Amer. Midl. Naturalist 4: 222. 1915; *Poa bulbosa* f. *vivipara* (Koeler) Maire, Fl. Afrique N. 3: 86. 1955], a variety distributed in Europe, Africa and SW, C and N Asia to W China and introduced in the Americas, Australia and the Pacific Islands; it appears in practically all of the provinces of *Flora iberica* [**And. Port.:** AAI BAI BB BL E TM. **Spa.:** A Al Ab Av B Ba Bu Ca Cc CR Co Cu Ge Gr Gu H Hu J L Le Lo Lu M Ma Mu Na Or P PM[Mll] S Sa Sg Se So SS Te To V Va Vi Z Za], from sea level to 3100 m, with a preference for shady places. The other variety, *Poa bulbosa* var. *bulbosa* [*Poa crispata* Thuill., Fl. Env. Paris, ed. 2: 45. 1799, type: “Habitat in locis arenosis. Floret Maio”; *P. pasqualii* Heldr. ex Parl., Fl. Ital. 1: 343. 1850, nom. inval., pro syn.; *P. bulbosa* subsp. *perligulata* H. Scholz, Bot. Chron. 3: 17. 1983, Typus: “Italia: Insula Elba, marina di Campo, 12.4.1980, W. Lang w.n. (B)”; *P. perligularis* H. Scholz, Willdenowia 16: 404. 1987, non *Poa perligulata* Pilger, Notizbl. Bot. Gart. Berlin-Dahlem 11: 779. 1933; *P. bulbosa* f. *variegata* Font Quer, nom. nud., in sched. (MA 11272), **syn. nov.**; *P. bulbosa* f. *minor* H. Villar, nom. nud., in sched. (MA 156764, MA 156765), **syn. nov.**], is distributed throughout the range of the species and comprises plants in which the spikelets produce normal flowers; this variety is found mostly in provinces covered by *Flora iberica* [**Port.:** Ag AAI BAI BA BB BL DL E Mi R TM. **Spa.:** A Al Ab Av (B) Ba (Bi) Bu C Ca Cc (Cs) CR Co Cu Ge Gr Gu H Hu J L Le Lo Lu M Ma (Na) Or O P PM[(Ib) Mll (Me)] Po S Sa Sg Se So (SS) T Te To V Va Vi Z Za], where it ranges from sea level to 2895 m and generally thrives in exposed places.

Bulbs appear to have arisen in *Poa* at least twice and possibly as many as four times (Cabi et al. 2016). Taxa having bulbs are distributed in four clades: (1) *P. supersect. Poa*

(*P. densa* Troitsky and *P. diversifolia* (Boiss. & Balansa) Hack. ex Boiss; (2) in or near *P. supersect. Homalopoa* (*P. pseudobulbosa* Bor); (3) N-clade (*P. pelasgis* H. Scholz); and (4) *P. subgen. Ochlopoa* sect. *Arenariae* (type: *P. bulbosa*) mixed with species of *P. sect. Alpinæ* (type: *P. alpina*).

In Sierra de Mariola (Alicante), a population has been detected (MA 752991) in which the ligule of the upper leaves in some individuals is very short (1–1.5 mm), subtruncate and irregularly dentate or not.

## 16. *Poa ligulata* Boiss., Voy. Bot. Espagne 2: 659. 1842

*Poa concinna* var. *membranacea* Boiss., Elench. Pl. Nov. 89. 1838, nom. subst. (Burdet et al. 1981 stated that they had not seen material corresponding to this taxon in herbarium G; however, they forgot that this name has been replaced by *P. ligulata* and, therefore, the type material is the same).

*Poa djurdjurae* Trab. in Batt. & Trab., Fl. Alger 207. 1884. [Type: “Col de Tirourda (juin 1883)”).

*Poa paui* Font Quer, Iter Marocc. n. 34. 1928, nom. in sched. [Type: “Hab. in glareosis calc. montis Tisuka (Gomara), 2100 m. / alt.; 13 junii.” (lectotype designated here: “Dr. Font Quer. – Iter Maroccanum, 1928 / 34. Poa paui F. Q., sp. nov. / Hab. in glareosis calc. montis Tisuka (Gomara), 2100 m. / alt.; 13 junii. / Descr.: Poa ligulata affinis, sed folia subquadruplo lon-/ giora, ligulis subduplo elongatis et angustioribus; panicula laxa, / glumis virescentibus, spiculis majoribus.” (label printed): BC 70616, lower central specimen; isolectotypes designated here: BC 70616a, b, and c; MA 11378; GDA 31039)].

*Poa ligulata* var. *paui* (Font Quer) Maire, Bull. Soc. Sci. Nat. Maroc 11: 113. 1931.

*Poa ligulata* var. *djurdjurae* (Trab.) Maire, Bull. Soc. Hist. Nat. Afrique N. 22: 323. 1931.

*Poa membranacea* (Boiss.) C. Vicioso, Anales Jard. Bot. Madrid 2: 192. 1942, nom. illeg.; Anales Jard. Bot. Madrid, 6(2): 13. 1946.

*Poa ligulata* var. *eu-ligulata* Maire & Weiller in Maire, Fl. Afrique N. 3: 87. 1955, nom. inval.

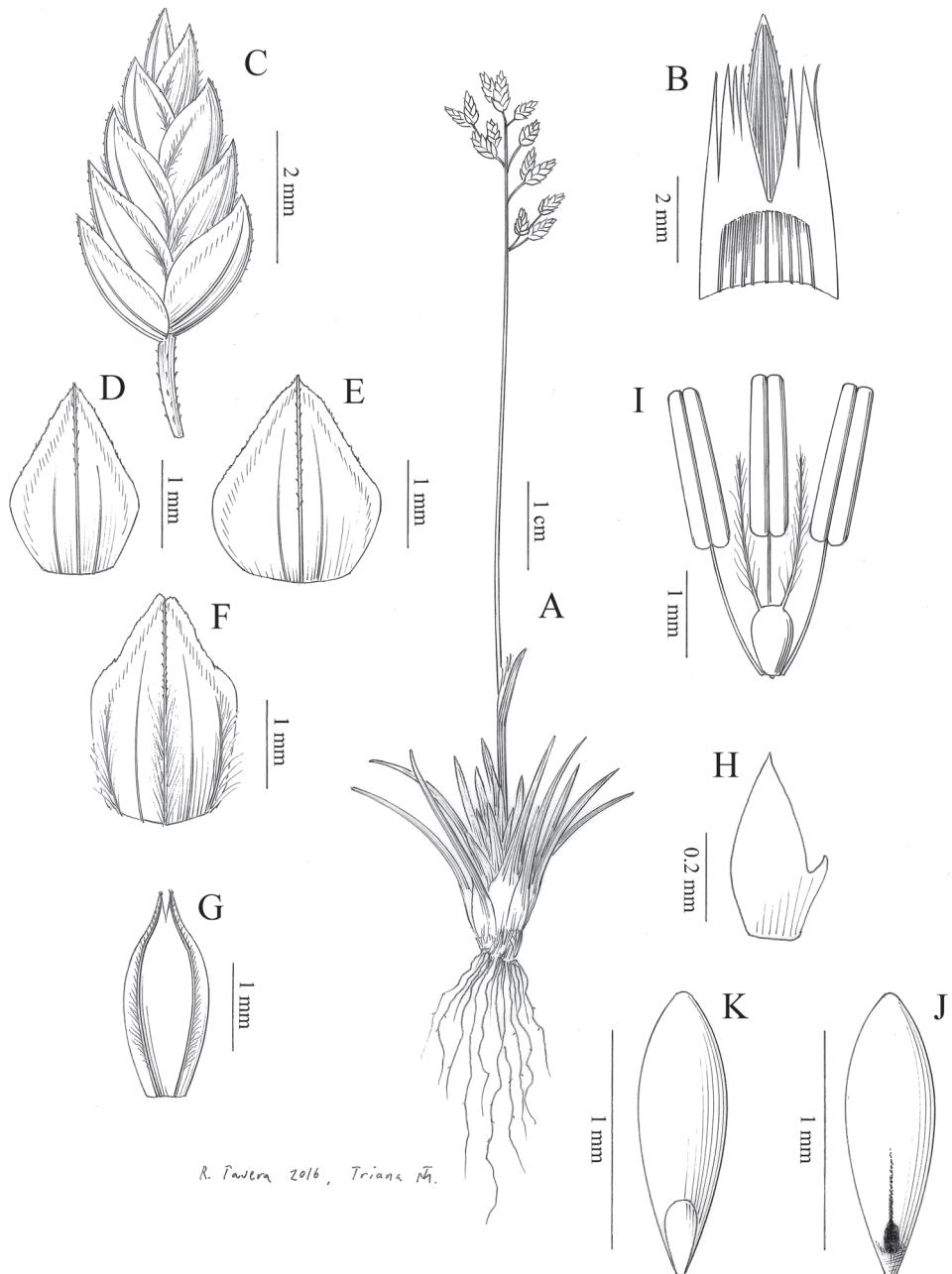
*Poa ligulata* var. *mauretanica* Maire, Fl. Afrique N. 3: 88. 1955. [Type: “M. Beni Snassen au Ras Foughal! (E.); Moyen Atlas ! (M., J., E.) ; Rif (F.-Q., M.)”].

III. Bolòs and Vigo (2001: 378), Devesa (1987: 265), Fig. 4.

**Type.** [Loc. ind. “Hab. in glareosis frigidis in sumâ Sierra Tejeda et in Sierra Nevada loco Corral dicto”] (lectotype designated by Hernández Cardona 1978, pg. 267, 358: top specimen on the right, G 00418689!, Herb.-Boiss.; isolectotypes: G 00418689a, b, c!, Herb.-Boiss.; ex herbier Reuter-Barbey, G 00418691!, 00418691a!; ex herbier De Candolle, G00418690!; vide Burdet et al. 1981, pg. 578).

**Flowering.** (April) May to July.

**Ecology.** Rocky places, pastures in protosols and stony places, on limestone and dolomite, less frequently on schist or gypsum; (700) 740–3200 m a.s.l.



**Figure 4.** *Poa ligulata* Boiss. **A** Habit **B** Detail of the apex of the sheath and ligule, in adaxial view (upper leaf) **C** Spikelet **D** Lower glume, in abaxial view **E** Upper glume, in abaxial view **F** Lemma, in abaxial view **G** Palea, in abaxial view **H** Lodicule **I** Sexual verticils **J** Caryopsis, in adaxial view **K** Caryopsis, in abaxial view. Drawn from MA 414266 and MA 423181.

**Distribution.** Iberian Peninsula and NW Africa. E half of Spain, rarer towards the W. **Spa.:** (A) (Ab) Al Bu Ca Cc Cs CR Cu Gr Gu J Le Lo M Ma Mu Na (Or) P S Sg Se So Te To V Z. For a representative list of studied materials, see Suppl. material 1.

**Notes.** This species is unmistakable because of its large ligules, which are very exerted, decurrent on the leaf sheath—especially those of the base and shoots—and pearly white, which makes its white-green tufts very striking. Its presence is indicated for the first time in the region of Extremadura (Spain).

### 17. *Poa alpina* L., Sp. Pl. 67. 1753 subsp. *alpina*

**III.** Soreng and Peterson (2012: 11, fig. I, A–E), Pignatti (1981: 473).

**Type.** “Habitat in alpibus Lapponicis, Helveticis” (lectotype designated by Soreng 2000, pg. 254: Herb. Linn. No. 87.2!).

**Flowering.** June to August (September).

**Ecology.** Pastures in pine forests, fir woods, beeches and bushes, ruderalised hills and rocky plains, on limestone, schist, granite and slate; 1200–3150 m a.s.l.

**Distribution.** Circumboreal: Europe, Asia, N America, locally at low elevations in NW Africa (Morocco). N Spain, Cantabrian Mountains, Pyrenees and the Iberian System. **And. Esp.:** (Av) B Bi Ge Hu L Le Lo Na O P S (Sa) So Te Vi. For a representative list of studied materials, see Suppl. material 1.

**Notes.** A characteristic of this species is the size and shape difference of the ligule on the basal leaves and shoots—especially the oldest ones—compared with that of the upper leaves. In the first case, the ligule is tiny, with a more or less complete margin; in the second case, the ligule is noticeably larger, often with an irregular margin and sometimes even split into two or more parts.

This is a very polymorphic taxon, with four recognised, sometimes intergrading varieties in the territory encompassed by our revision. Plant size, leaf stiffness and panicle contraction can vary extensively depending on altitude, exposure and soil type. The first of these varieties is *Poa alpina* var. *alpina* [*Poa frigida* Gaudin, Alpina 3: 33. 1808, type: “au-dessous du glacier de Plan-nové; dans la vallée de Bagnes etc.”; *P. alpina* var. *frigida* (Gaudin) Salisb., Flora 16(2): 473. 1833; *P. alpina* var. *genuina* Godr. in Gren. & Godr., Fl. France 3: 543. 1855, nom. inval.; *P. alpina* var. *involuta* Lange, Pugill. Pl. Hispan. 47. 1860, **syn. nov.**, type: “In regione alpina Pyren. Hisp. ad Port de Benasque (9 Aug. c. fl.)!”, lectotype designated here: “Herb. Joh. Lange (printed) / Poa alpina var. involucrata nob. / ligulio foliorum omnium truncatis, ver. / -illegible- infer. folio -illegible- tetta / Port de Benasque reg. alp. 9 Aug. 1851. (manuscr.)”: C 10022547, specimen on the left), Fig. 5; *P. nuriensis* *alpina* Sennen, Bull. Soc. Bot. France 73: 677. 1926, nom. nud., **syn. nov.**; *P. alpina* subsp. *digitata* Beauverd, Bull. Soc. Bot. Genève, sér. 2, 26: 122, fig. 2a–g. 1936, type: “Hab. in locis apricis calidisque valleculae dictae “du Grand Tabuc” ad locum dic-



**Figure 5.** Lectotype of *Poa alpina* var. *involucrata* Lange (C 10022547). Reproduced with permission of the Natural History Museum of Denmark.

tum “les Grangettes”, ca. 1800 m alt., supra thermis “Le Monétier de Briançon”, 15 Julii 1933, leg. J. Vergnet et G. Beauverd”; *P. badensis* subsp. *multiflora* sensu Rivas Mart., Itinera Geobot. 15: 705. 2002, non *P. alpina* var. *multiflora* Gaudin, Fl. Helv. 1: 245. 1828; *P. nuriensis* Sennen, Pl. Espagne n. 4063. 1916, nom. nud., in sched. (BC 70515; MA 11298), **syn. nov.**]. This circumboreal taxon includes large plants having large, generally delicate, non-rigid leaves with non-thickened margins—or thickened less than 0.05 mm—and developed inflorescences that are only slightly condensed. This variety is typically found in sheltered, less-exposed locations and is widespread throughout the range of the species [**And. Spa.:** (Av) B Bi Ge Hu L Le Lo Na O P S (Sa) So Te Vi].

Under more adverse conditions, the plants are usually small and possess short, stiff leaves with non-thickened, or up to 0.05 mm thick, margins and very contracted panicles. These plants have been designated as *Poa alpina* var. *brevifolia* (Gaudin) Godr. in Gren. & Godr., Fl. France 3: 543. 1855 [*Poa alpina* subsp. *brevifolia* Gaudin, Fl. Helv. 1: 245. 1828, basion., type: “in M. Sempronio ad pylas vallis Ganter”], a variety distributed in mountains of C Europe and extended through the central and eastern Pyrenees [**And. Spa.:** B Hu L]. This pattern of variation is probably clinal and needs to be checked experimentally. The third recognised variety, *Poa alpina* var. *molinerii* (Balb.) Endl., Cat. Horti Vindob. 46. 1842 [*Poa molinerii* Balb., Elenco 85. 1801, basion., type: “Locis saxosis, et siccis prope Tenda reperta est, ac in hortum Taurinensem adlata ab eximio Ignatio MOLINERI, cuius triviale nomen imposui, utpote ejus stirpis inventore”], comprises plants having leaves with whitish, cartilaginous, thickened (0.1–0.15 mm) margins that, together with the middle underside vein, form a clear, visible contrast to the green leaf blade, the latter mostly flat or conduplicate and rigid. This taxon, is distributed in mountains of S and C Europe and, to date, only two populations of *P. alpina* var. *molinerii* have been detected for *Flora iberica*, one in **Andorra** (Coll de Ordino, on the way to Casamanya, 2100 m; MA 514862) and the other in **Spain** (Lérida, Clot del Munyidor, 2215 m; BC 877255).

Finally, *Poa alpina* var. *vivipara* L., Sp. Pl. 67. 1753. [Type: “An haec α. β. sequentis tantum varietas; Lectotype designated by Soreng 2000, pg. 254: three left-hand culms, LINN-87.4; *Poa vivipara* (L.) Willd., Enum. Pl. 103. 1809; *P. alpina* subsp. *vivipara* (L.) Arcang., Comp. Fl. Ital. 785. 1882; *P. alpina* f. *vivipara* (L.) B. Boivin, Naturaliste Canad. 94: 628. 1967], includes plants with pseudoviviparous spikelets. This variety, distributed mainly in N and C Europe, Greenland, Iceland and N America, has only been detected in a population in the territory covered by *Flora iberica* (**Spain:** Na), namely, it was collected in the valley of Roncal at 1600 m a.s.l (SEV 97164). The inflorescences of these plants conserved on this sheet show a great contrast of colours: glumes and lemmas of light green and straight or curved, dark green proliferations.

Another taxon described for the flora of Morocco is *Poa alpina* subsp. *stenobotrya* Maire (Bull. Soc. Hist. Nat. Afrique N. 33: 95. 1942), which is distinguished by its linear-lanceolate panicle and the presence of hairs at the base of the lemmas.

## Conclusions

In the territory covered by *Flora iberica*, the genus *Poa* is represented by 24 taxa (17 species, 1 subspecies and 8 varieties), mostly perennial. The majority of these taxa have broad global and/or European distributions, whereas two (*P. legionensis* and *P. minor* subsp. *nevadensis*) are Spanish endemics and two have restricted distributions (*P. ligulata*, Iberian–North African; *P. flaccidula*, Iberian–North African and the Balearic Islands, extending to Provence, France). The most widely distributed species are *P. bulbosa* and *P. annua*, reflecting their worldwide range. The provinces with the greatest representation of *Poa* are Huesca, Santander, Lérida and Andorra, all located in the N Iberian Peninsula, which are traversed by mountain systems and subjected to a temperate climate.

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## References

- Bolòs O, Vigo J (2001) Flora dels Països Catalans, vol. 4. Editorial Barcino, Barcelona, 1–750.
- Burdet HM, Charpin A, Jacquemoud F (1981) Types nomenclaturaux des taxa ibériques décrits par Boissier ou Reuter. I. Gymnospermes à Graminées. Candollea 36: 543–584. [http://bibdigital.rjb.csic.es/PDF/Burdet\\_Types\\_I\\_Gymnospermae-Gramineae.pdf](http://bibdigital.rjb.csic.es/PDF/Burdet_Types_I_Gymnospermae-Gramineae.pdf)
- Cabi E, Soreng RJ, Gillespie L, Amiri N (2016) *Poa densa* (Poaceae), an overlooked Turkish steppe grass, and the evolution of bulbs in *Poa*. Willdenowia 46(2): 201–211. <https://doi.org/10.3372/wi.46.46201>
- Devesa JA (1987) *Poa* L. In: Valdés B, Talavera S, Galiano EF (Eds) Flora de Andalucía Occidental, vol. 3. Editorial Ketres, Barcelona, 260–265.
- Edmonson JR (1980) *Poa* L. In: Tutin TG, Heywood VH, Burges NA, Moore NA, Valentine DH, Walters SM (Eds) Flora Europaea, vol. 5. Cambridge University Press, Cambridge, 159–167.

- Fernández Casas J, Gamarra R (1993) Herbarium Lagascanum. *Fontqueria* 36: 67–108. <http://bibdigital.rjb.csic.es/spa/Volumenes.php?Libro=2699>
- Flora iberica (2018) <http://www.floraiberica.es/> [accessed 22.03.2018]
- Franco JA, Rocha ML (1998) Nova Flora de Portugal (continente e Açores), vol. 3. Escolar editor, Lisboa, 1–283.
- Gillespie LJ, Soreng RJ, Bull RD, Jacobs SWL, Refulio-Rodriguez NF (2008) Phylogenetics relationships in subtribe Poinae (Poaceae, Poeae) based on nuclear ITS and plastid *trnT-trnL-trnF* sequences. *Botany* 86: 938–967. <https://doi.org/10.1139/B08-076>
- Giussani LM, Gillespie LJ, Scataglini MA, Negritto MA, Anton AM, Soreng RJ (2016) Breeding system diversification and evolution in American *Poa* supersect. *Homalopoa* (Poaceae: Poeae: Poinae). *Annals of Botany* 118(2): 281–303. <https://doi.org/10.1093/aob/mcw108>
- Hernández Cardona AM (1976) Notas sobre el género *Poa* en la Península Ibérica. *Acta Botanica Malacitana* 2: 31–38. <http://www.biolog.uma.es/abm/abm.html>
- Hernández Cardona AM (1978) Estudio monográfico de los géneros *Poa* y *Bellardiochloa* en la Península Ibérica e islas Baleares. *Dissertationes Botanicae* 46: 1–365.
- Kerguélen M (1975) Les gramineae (Poaceae) de la Flore Française. Essai de mise au point taxonomique et nomenclaturale. *Lejeunia* 75: 1–343.
- Kirschner J, Kirschnerová L, Štěpánek J (2007) Generally accepted plant names based on material from the Czech Republic and published in 1753–1820. *Preslia* 79: 323–365.
- Maire R (1955) *Poa* L. Flore de l'Afrique du Nord, vol. 3. P. Lechevalier, Paris, 76–101.
- Mao Q, Huff R (2012) The evolutionary origin of *Poa annua*. *Crop Science* 52(4): 1910–1922. <https://doi.org/10.2135/cropsci2012.01.0016>
- Meikle RD (1985) Flora of Cyprus, vol. 2. The Bentham-Moxon Trust, Royal Botanic Gardens, Kew, 1741–1746.
- Nannfeldt JA (1937) The chromosome numbers of *Poa* sect. *Ochlopoa* A. & Gr. and their taxonomical significance. *Botaniska Notiser* 1937: 238–254.
- Ofir M, Kigel J (2014) Temporal and intraclonal variation of flowering and pseudovivipary in *Poa bulbosa*. *Annals of Botany* 113(7): 1249–1256. <https://doi.org/10.1093/aob/mcu037>
- PAF (2018) Panarctic Flora. Annotated checklist of the Panarctic Flora. Vascular plants. <https://nhm2.uio.no/paf/>
- Pignatti S (1982) Flora d'Italia, vol. 3. Edagricoltore, Bolonia, 1–780.
- Portal R (2005) *Poa* de France, Belgique et Suisse. Ed. Vals près, R. Portal, Baltimore, Md., 1–303.
- Rosselló JA, Sáez LI (2000) Index Balearicum: an annotated check-list of the vascular plants described from the Balearic Islands. *Collectanea Botanica* (Barcelona) 25(1): 3–203. <http://collectaneabotanica.revistas.csic.es/index.php/collectaneabotanica/article/viewArticle/42>
- Ruiz T (1991) *Poa* L. In: Devesa JA (Ed) Las gramíneas de Extremadura. Servicio de Publicaciones de la Universidad de Extremadura, Badajoz, 23–33. <http://bibdigital.rjb.csic.es/spa/Libro.php?Libro=5767>
- Soreng RJ (2000) *Poa*. In Cafferty S, Jarvis CE, Turland NJ (Eds) Typification of Linnaean plant names in the Poaceae (Gramineae). *Taxon* 49(2): 239–260.
- Soreng RJ, Barrie FR (1999) Proposal to conserve the name *Poa pratensis* (Gramineae) with a conserved type. *Taxon* 48(1): 157–159. <https://doi.org/10.2307/1224640>

- Soreng RJ, Bull RD, Gillespie LJ (2010) Phylogeny and reticulation in *Poa* based on plastid *trnTLF* and nrITS sequences with attention to diploids. In: Seberg O, Petersen G, Barfod AS, Davis JI (Eds) Diversity, phylogeny, and evolution in the Monocotyledons. Aarhus University Press, Aarhus, 619–644.
- Soreng RJ, Gillespie LJ, Consaul LL (2017) Taxonomy of the *Poa laxa* group, including two new taxa from Arctic Canada and Greenland, and Oregon, and a re-examination of *P.* sect. *Oreinos* (Poaceae). Nordic Journal of Botany 35(5): 513–538. <https://doi.org/10.1111/njb.01507>
- Soreng RJ, Peterson PM (2012) Revision of *Poa* L. (Poaceae, Pooideae, Poeae, Poinae) in Mexico: New records, re-evaluation of *P. ruprechtii*, and two new species, *P. palmeri* and *P. wendtii*. PhytoKeys 15(0): 1–104. <https://doi.org/10.3897/phytokeys.15.3084>
- Soreng RJ, Peterson PM, Romaschenko K, Davidse G, Zuloaga FO, Judziewicz EJ, Filgueiras TS, Davis JI, Morrone O (2015) A worldwide phylogenetic classification of the Poaceae (Gramineae). Journal of Systematics and Evolution 53(2): 117–137. <https://doi.org/10.1111/jse.12150>
- Soreng RJ, Peterson PM, Romaschenko K, Davidse G, Teisher JK, Clark LG, Barberá P, Gillespie LJ, Zuloaga FO (2017) A worldwide phylogenetic classification of the Poaceae (Gramineae) II: An update and comparison of two 2015 classifications. Journal of Systematics and Evolution 55(4): 259–290. <https://doi.org/10.1111/jse.12262>
- Stoneberg Holt SD, Horová L, Bureš P (2004) Indel patterns of the plastid DNA *trnL-trnF* region within the genus *Poa* (Poaceae). Journal of Plant Research 117(5): 393–407. <https://doi.org/10.1007/s10265-004-0172-4>
- Thiers B [continuously updated] Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/science/ih/> [accessed 20.03.2018]
- Watson L, Dallwitz MJ (1992) The Grass genera of the World. Cab International, Wallingford, 718–719.
- Willkomm M (1870) *Poa* L. In: Willkomm M, Lange J (Eds) Prodromus Flora Hispanicae, vol. 1. Stuttgartiae, 80–83.
- Willkomm M (1893) Supplementum Prodromi Flora Hispanicae. Stuttgartiae, 1–370.

## Supplementary material I

### List of representative sheets for each province and taxon, excluding type material

Authors: Ana Ortega-Olivencia, Juan A. Devesa

Data type: species data

Explanation note: The total number of studied sheets is also indicated for each taxon.

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Link: <https://doi.org/10.3897/phytokeys.103.26029.suppl1>

## Checklist of gypsophilous vascular flora in Italy

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\* These authors contributed equally to the writing of this paper, the project and the first list of plants, coordinating the group, elaborating the data and editing the text. The other authors contributed by completing and evaluating the plant list.

## Abstract

Our understanding of the richness and uniqueness of the flora growing on gypsum substrates in Italy has grown significantly since the 19<sup>th</sup> century and, even today, new plant species are still being discovered. However, the plants and plant communities, growing on gypsum substrates in Italy, are still a relatively unknown subject.

The main aim of this paper was to elaborate a checklist of the Italian gypsophilous flora, to increase knowledge about this peculiar flora and for which conservation efforts need to be addressed.

Through a structured group communication process of experts (application of the Delphi technique), a remarkable number of experienced Italian botanists have joined together to select focal plant species linked to gypsum substrates. From the results obtained, 31 plant species behave as absolute or preferent taxa (gypsophytes and gypsoclines) and form the ‘core’ Italian gypsophilous flora. The most abundant life forms were chamaephytes and hemicryptophytes, belonging to Poaceae and Brassicaceae; as for chorotypes, the most represented are Mediterranean and narrow endemics. By improving on previously available information about the flora with a clear preference for gypsum in Italy, this undertaking represents an important contribution to the knowledge of a habitat which is today considered a priority for conservation.

## Keywords

Edaphism, Gypsophyte, Habitats Directive, Plant preservation

## Introduction

The relationship between local bedrock types and vegetation cover has long been highlighted. Andrea Cesalpino, in *De plantis libri XVI* (1583), had already documented the existence of endemic plant species on the Italian serpentines. The term ‘edaphism’ – interpreted as a ‘geobotanical phenomenon giving rise to particular floras on certain substrates’ (Font Quer 1977) or ‘those physical and chemical effects induced on living beings by the soil’ (Sarmiento 2001) – has been used extensively in Europe since the 19<sup>th</sup> century (Parsons 1976, Kruckeberg 2002). The species and the plant assemblages growing on gypsum provide a clear example of the strict relationship between soil and vegetation, as many plant species grow exclusively or preferentially on such peculiar substrates. This geobotanical pattern occurs in more than 70 countries worldwide (Pérez-García et al. 2017). Nevertheless, the gypsicolous substrates represent a largely underrated or ignored habitat, with serious consequences for both flora and fauna conservation. These habitats host sparse and scattered vegetation, since the gypsum outcrops often represent geological islands interrupting the uniformity of other surrounding landscapes. Local evolutionary processes have probably been facilitated by the geographical isolation of outcrops, so that the appearance of several plant species with a narrow distribution have been favoured (Moore et al. 2014). This kind of geographic speciation could have been complemented by some selective pressure that might have favoured the survival of certain plant lineages on nutrient-unbalanced, water-limited soils which are unfavourable to the establishment of most plants (Merlo et al. 1998, 2001, Bolukbasi et al. 2016).

There is an abundance of accurate information concerning gypsophilous plant communities in Spain (Mota et al. 2011), but not for those other European countries where such substrata also occur. In Cyprus, for instance, it is only the outcrop located at Rizoeelia National Park that are known, but unfortunately it seems that both local flora and vegetation are degraded due to several impact factors (EIONET 2008). The first scholar to study the gypsophilous flora of Italy was Macchiati (1888). There have been some studies in mainland Italy and Sicily which have increased our knowledge about this flora, e.g. Gallo (2014). Such previous studies on both the rate of endemism and risk of extinction amongst these plant communities pointed out that 'Mediterranean gypsum vegetation' should be considered a Priority Habitat (\*1520) for conservation according to the 92/43 EU Directive (Anonymous 1992). Since no specific national law has yet been enacted in Italy (Fenu et al. 2017, Rossi et al. 2016), this directive theoretically represents the major instrument for plant conservation. Several Italian gypsum outcrops have been identified as SCI (Sites of Community Importance) and SCZ (Special Conservation Zones) e.g. Piano di Gestione Complessi Gessosi M. Conca, SIC ITA050006 (IUCN UNEP-WCMC 2014, Mento 2008). However, information about gypsum vegetation in Italy is still deficient: in fact, neither its current area, nor the recent trends in term of quantity and quality (last 50 years) are known (Loidi 2016). An accurate checklist of Italian gypsophilous flora has not yet been produced; hence, only published investigations concerning these flora and vegetation could be used as a reference guide. When taking into account that conservation policies at any level must be based on scientific assessments about habitats, species conservation status and existing threats (IUCN 2001; Joppa et al. 2013), the exhaustive knowledge about the flora typical of gypsum outcrops in Italy would be a crucial step towards the application of any sort of conservation measure (Mota et al. 2004, 2011, Martínez-Hernández et al. 2011, 2015).

Therefore, the aims of this research were (i) to elaborate a checklist of Italian gypsophilous vascular flora through a structured group communication process of experts; (ii) to expand the knowledge of this flora type to which conservation efforts need to be addressed; (iii) to examine the spectrum of taxonomical groups, life forms and chorotypes of this flora. Through this approach, the comparison between the gypsophilous flora of Italy and that of other countries was carried out in order to detect common phylogenetic, functional and biogeographic patterns that allow a better understanding of the gypsophily phenomenon at European and global levels.

## Methods

Several approaches have been proposed to elucidate which plant species can be considered as best linked to gypsum substrates (Mota et al. 2016). However, coping with an extremely species-rich flora over a wide territory such as Italy, using the Delphi technique (Hasson et al. 2000) resulted in being the most effective way to build a checklist of gypsophilous flora by using the so-called 'expert criterion' (Mota et al. 2008, 2009).

### The Delphi technique

The Delphi technique is a structured, anonymous and iterative survey undertaken by a panel of ‘experts’, which enables a group of individuals to collectively address a complex problem through a structured group communication process. This method has been applied in ecology to fill in data gaps (Eycott et al. 2011), through the experience of the participants (Ochoa-Gaona et al. 2010). The technique can be classified into four categories relevant to ecology and conservation (Hasson and Keeney 2011). One of these categories is Decision Delphi, which is used to identify focal species for conservation.

Our scheme comprised two rounds of semi-structured questionnaires, each followed by an aggregation of responses and anonymous feedback from the experts. The number of rounds was limited and adapted according to the time available. An increased number of rounds would make the process more time-consuming.

### Preparation of the first round of the questionnaire

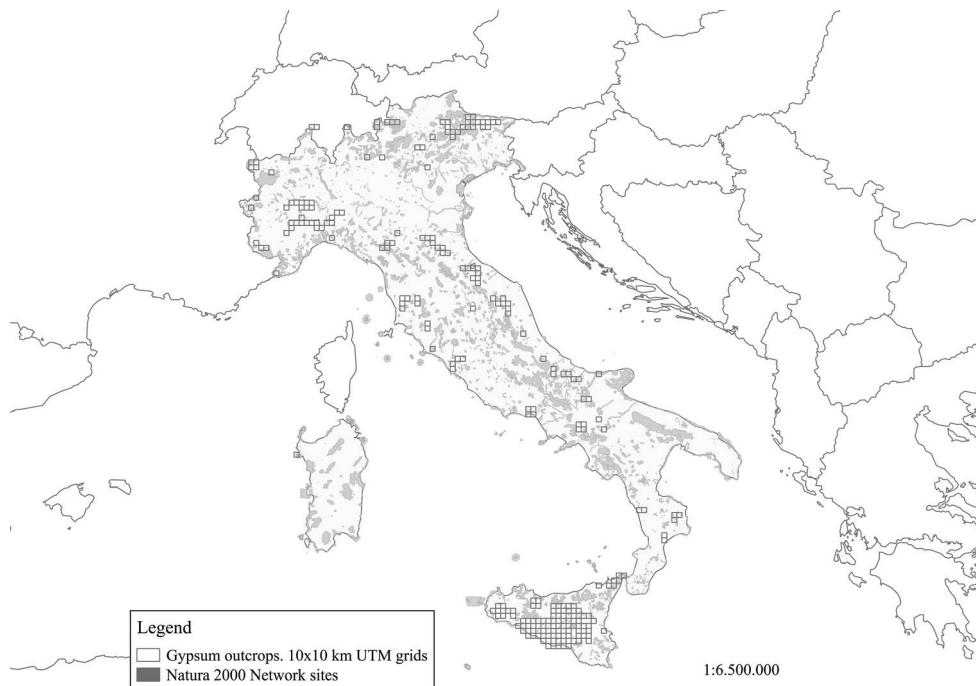
A semi-structured survey, drawing from evidence based on published literature, was designed. The initial listing of taxa included species issuing from bibliographical references, which recorded the presence of these taxa on gypsum substrates (See Appendix 1: Methodology References for detailed information).

### Selection and invitation of a panel of experts

Participants from a great diversity of backgrounds were included (e.g. teachers, scientists, conservationists, non-governmental organisations, policy-makers, environmental managers and technicians) in order to obtain a wide range of perspectives and minimise bias arising from self-interest or information preferences. The participants included the co-authors of this article, i.e. experts situated in the Italian peninsula and Sardinia – hereinafter Italy (9) – and in Sicily (11). The reason why the number of Sicilian botanists involved is greater than those from mainland Italy is due to the considerable extension and importance that gypsum outcrops have in Sicily (Fig. 1).

### Collection and analysis of the completed questionnaire for the first round

Once the preliminary plant catalogue was elaborated, the complete list was submitted to the group of experts (Musarella et al. 2016). The experts were clearly asked to base their gypsophily assessment for each plant species only on their personal field experience in order to avoid any judgement based on bibliographical references or other sources of information. In addition, the peers were provided with a series of hierarchical criteria according to the Likert (1932) scale, a method where participants were asked to rank their responses on a scale of ‘one to five’ (Table 1) where ‘one’ indicated



**Figure 1.** Italian gypsum outcrop presences in 10×10 km UTM grids.

**Table 1.** Likert scale ranking for the gypsophilous character of the taxa.

5	Strictly gypsophile species; that is, species that do not live outside gypsum substrates (except accidentally). <b>ALWAYS GROW ON GYPSUM</b>	<b>Strict gypsophyte</b>
4	Species with great preference for gypsum and which are found very rarely outside this substrate. <b>ALMOST ALWAYS GROW ON GYPSUM</b>	<b>Preferential gypsophyte</b>
3	Species that live on gypsum, but which can also live on other substrates. If they live on many other different types of soil, they will not fit into this category. For example, if they live on limestone, marls and gypsum they could fall into this category. At least, it is as abundant (or almost) on gypsum as it is on other types of substrates. <b>GYPSUM AND OTHER HIGHLY RELATED SUBSTRATES ARE THEIR PREFERRED HABITATS</b>	<b>Subgypsophyte</b>
2	Species that may be abundant on gypsum, although they could be even more frequent on other types of substrates. <b>CLEARLY MORE COMMON OUTSIDE OF GYPSUM</b>	<b>Gypsovag</b>
1	Very rare species on gypsum or absent on this type of soil. <b>NEVER (OR ONLY ACCIDENTALLY) ON GYPSUM</b>	<b>Accidental</b>

an ‘absolute absence on gypsum outcrops (plants that avoid gypsum or, at most, may eventually occur on this substrate)’, while ‘five’ indicated ‘absolute preference (the considered plant species only grows on gypsum)’.

## Preparation and analysis of second round questionnaire

The collated responses from the first round were used to prepare a second questionnaire. The experts were requested to add new taxa candidates to be subsequently evaluated by the panel (Spampinato et al. 2016). The second round questionnaire was administered only to respondents who participated to the first round. The responses were collated and analysed using quantitative measures. Statistical summaries were generated for the responses, central tendencies (mean, median) and the levels of dispersion (standard deviation and interquartile ranges) of each taxon. The results were compiled into a report, which was used in the next step as feedback and described quantitative details to the participants.

## Plant species data

Information about plant species included in the checklist was collected: (i) taxonomic rank (Bartolucci et al. 2018); (ii) family (Peruzzi 2010); (iii) chorology and (iv) life form (Pignatti 1982); (v) conservation status (Rossi et al. 2014); and (vi) functional groups (narrow gypsophiles, wide gypsophiles or gypsovags) according to Bolukbasi et al. (2016) and Palacio et al. (2007). See Suppl. material 1 for complete information.

## Checklist data analysis

Considering that the plant species assessment was made with a quantitative but discontinuous scale, median values could be useful criteria for selecting the gypsophilous species (Mota et al. 2011). According to the proposed Likert scale, species like gypso-clines (subgypsophytes or preferential gypsophytes) with median values 3 and 4 could be considered; and those with median values >4, such as gypsophytes.

Several statistical t-student and ANOVA tests were performed (SPSS ver. 22.0.0.0. IBM SPSS Statistics). Only taxa with gypsophily median values  $\geq 2$  were assessed in order to exclude ‘casual occurring taxa’. This analysis examined statistical differences between gypsum affinity (gypsophily), functional groups (narrow gypsophile, wide gypsophile and gypsovag) and distribution (Endemic, Mediterranean s.l., European, Eurasiac/Widespread).

## Results

### Decision Delphi technique

The first round of the questionnaire comprised 115 plant taxa. However, experts included more than 69% of other taxa growing on Italian gypsum substrates. This fact

implied that, during the second round questionnaire, the panel of experts made assessments of 380 taxa (Suppl. material 1). All these taxa were assessed by at least one of the experts. The set of 380 taxa received on average 8.95 valuations out of 20 (i.e. almost half of the specialists, 44.60%, gave an assessment). The average number of evaluations from the mainland Italian botanists was 2.29, compared to 6.65 from the Sicilian botanists.

The species in this catalogue belong to 59 different families. As far as the taxonomic spectrum of the 380 taxa is concerned, the most represented families were Asteraceae (14%), Poaceae (9.5%), Fabaceae (8.4%), Lamiaceae (6.3%) and Orchidaceae (6.1%). Moreover, the percentages of life forms on this preliminary list were as follows: therophytes (28.7%), hemicryptophytes (24%), geophytes (17.1%), chamaephytes (16.3%), nanophanerophytes (7.9%) and phanerophytes (6.1%). According to their distribution, two groups were clearly highlighted. The first one is composed of species with Mediterranean distribution (49.5%); the second included Italian endemic species (16.8%). The rest of the species were grouped (in smaller percentages) under Eurimediterranean, Submediterranean, European and Euroasiatic/Widespread species. Considering the conservation status of the species in the preliminary list, only seven taxa had IUCN extinction risk assessments and five of them were considered to be threatened according to IUCN categories: CR [*Aizoanthemopsis hispanicum* (L.) Klak., *Limonium calcarae* (Tod. ex Janka) Pignatti and *Astragalus raphaelis* Ferro]; EN [*Allosorus persicus* (Bory) Christenh.]; VU [*Tripolium sorrentinoi* (Tod.) Raimondo & Greuter].

### Checklist of Italian gypsophilous flora

The consensus, established amongst the responses of the panel of experts, produced the first checklist of Italian gypsophilous flora. A tiny group of 31 species out of the 380 preliminary taxa (8.16%) obtained median values over 3 from the experts' assessments, so that they can be considered as gypsophiles or gypsoclines (Table 2).

The 31 Italian gypsophilous taxa, on average, received 11 evaluations by experts (i.e. more than 55% of specialists evaluated this group): a result which increased the average number of assessments that the 380 taxa considered as the preliminary list received by more than 10%. Specifically, only the 9 species group composed of *Chaenorhinum rupestre* (Guss.) Speta, *Sedum gypsicola* Boiss. & Reut. subsp. *trinacriae* Afferni, *Brassica villosa* Biv. subsp. *tineoi* (Lojac.) Raimondo & Mazzola, *Diplotaxis harra* (Forssk.) Boiss. subsp. *crassifolia* (Rafin.) DC., *Erysimum metlesicsii* Polatschek, *Astragalus caprinus* L. subsp. *huetii* (Bunge) Podlech, *Capparis sicula* Veill., *Gypsophila arrostii* Guss. subsp. *arrostii* and *Matthiola fruticulosa* (L.) Maire subsp. *fruticulosa*, was evaluated by 11 or more specialists.

Within the evaluation of the Italian Checklist of gypsophilous flora, 8 taxa obtained arithmetic-mean values higher than 4, whilst 8 taxa values were greater than or equal to 3. In the case of the median calculation, 5 species showed values equal to 5, 8 taxa reached values equal to or greater than 4 and 18 were equal to or above the median value 3.

**Table 2.** Checklist of Italian gypsophilous flora. Species are listed in decreasing order of Median. Life-form: Therophyte (T), Chamaephyte (Ch), Hemicyclophtye (H), Nanophanerophyte (NP), Geophyte (G). Distribution: Endemic (Endem.), Mediterranean (Medit.), Sub-Mediterranean (S-Medit.), European (Europ.), Widespread (Wide.). IUCN category: Endangered (EN), Least Concern (LC) species. Number of assessment (NA). Median (Median) and average (Mean) values of experts assessments. Standard deviation (SD). Median values from mainland Italy and Sicilian experts separately (Mainland Med/Sicily Med).

Species	Synonym	Family	Life form	Chorology	IUCN	NA	Score	Median	Mean	SD	Mainland	Sicily
								Median	Mean	SD	Median	Median
<i>Chaenorhinum rupestre</i> (Guss.) Speta	<i>Chaenorhinum exile</i> (Coss. & Krailk) Lange	Plantaginaceae	T	S-Medit.	-	11	55	5.00	5.00	0.00	-	5.00
<i>Festuca gypsophila</i> Hack.	<i>Cenopis gypsophila</i> (Hack.) Panero	Poaceae	T	Medit.	-	1	5	5.00	5.00	0.00	-	5.00
<i>Sedum gypsicola</i> Boiss. & Reuter subsp. <i>trinacriae</i> Affermi		Crassulaceae	Ch	Medit.	-	11	51	5.00	4.64	0.67	-	5.00
<i>Petroedum ochroleucum</i> (Chaix) Nieden subsp. <i>mediterraneum</i> (L.Gallo) Nieden		Crassulaceae	Ch	Endem.	-	9	38	5.00	4.22	1.30	-	5.00
<i>Alliorus persicus</i> (Bory) Christenh.	<i>Cheilanthes persica</i> (Bory) Mett. ex Kuhn, <i>Notholaena persica</i> Bory	Peridaceae	H	Medit.	EN	5	21	5.00	4.20	1.10	5.00	3.00
<i>Artemisia pedemontana</i> Ball.		Asteraceae	Ch	Europ.	-	2	9	4.50	4.50	0.71	5.00	4.00
<i>Seipa austriotitica</i> Martinovský subsp. <i>freniana</i> Moraldo & Ricceri		Poaceae	H	Endem.	LC	5	21	4.00	4.20	0.84	4.50	4.00
<i>Diplotaxis harriz</i> (Forsk.) Boiss. subsp. <i>crassifolia</i> (Raf.) Maire	<i>Diplotaxis crassifolia</i> (Raf.) DC.	Brassicaceae	Ch	S-Medit.	-	11	45	4.00	4.09	0.94	-	4.00
<i>Brassica villosa</i> Biv. subsp. <i>tineoi</i> (Lojac.) Raimondo & Mazzola		Brassicaceae	Ch	Endem.	-	11	43	4.00	3.91	1.30	-	4.00
<i>Erysimum mediterraneum</i> Poladschek		Brassicaceae	H	Endem.	-	11	40	4.00	3.64	0.92	-	4.00
<i>Limonium catanzaroi</i> Brullo		Plumbaginaceae	H	Endem.	-	5	18	4.00	3.60	1.67	-	4.00
<i>Limonium optimae</i> Raimondo		Plumbaginaceae	H	Endem.	-	5	18	4.00	3.60	1.67	-	4.00
<i>Reaumuria verniculata</i> L.		Tamaricaceae	NP	S-Medit.	-	4	13	4.00	3.25	1.50	-	4.00
<i>Gypsophila arrostii</i> Guss. subsp. <i>arrostii</i>		Caryophyllaceae	Ch	Endem.	-	11	36	3.00	3.27	0.90	-	3.00

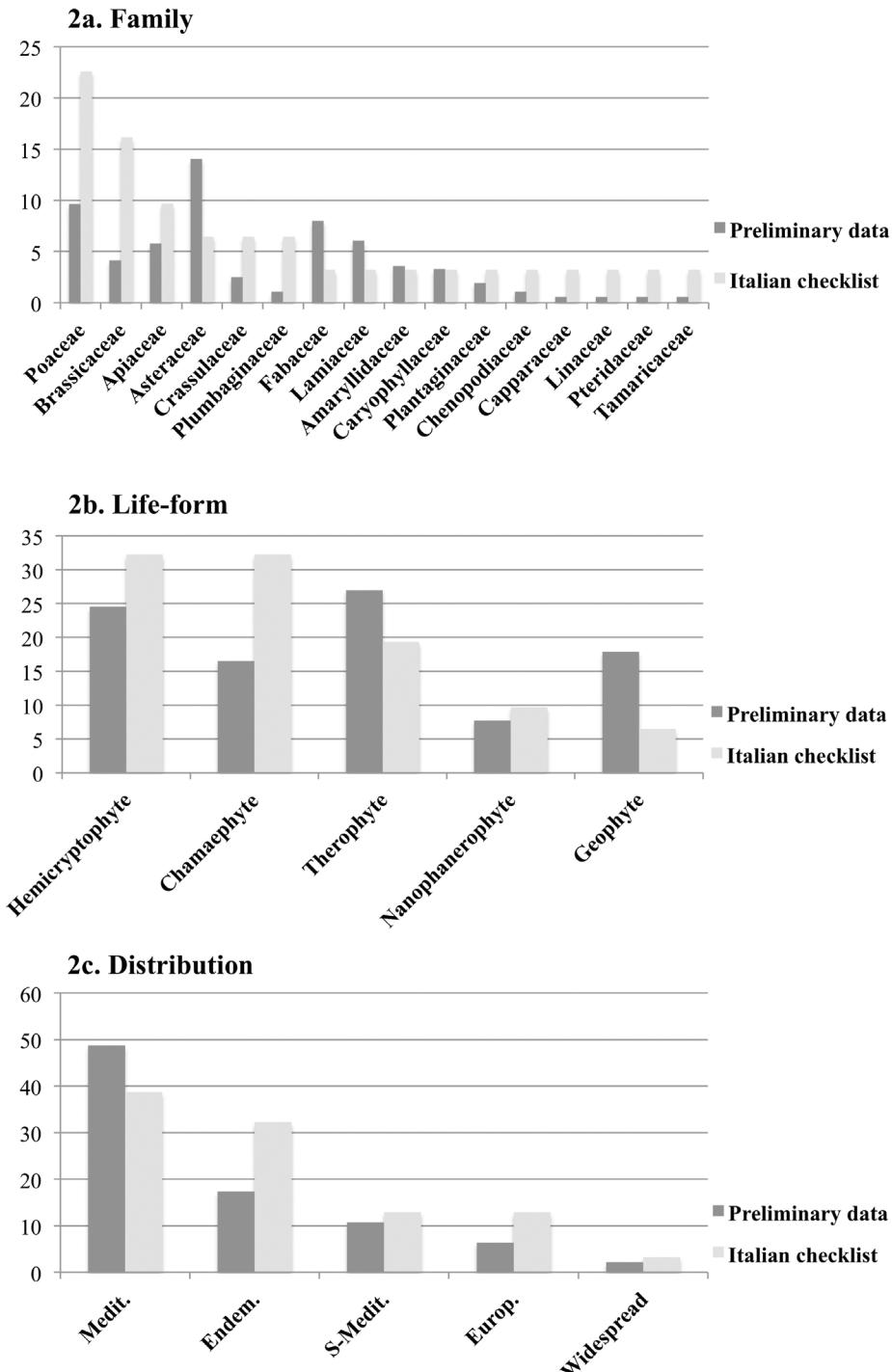
Species	Synonymy	Family	Life form	Chorology	IUCN	NA	Score	Median	Mean	SD	Mainland Median	Sicily Median
<i>Matthiola fruticulosa</i> (L.)												
Maire subsp. <i>coronopifolia</i> (Sm.) Giardina & Raimondo		Brassicaceae	Ch	Endem.	-	1	3	3.00	3.00	-	-	3.00
<i>Allium moschatum</i> L.		Amaryllidaceae	G	Europ.	-	1	3	3.00	3.00	-	3.00	-
<i>Elymus elongatus</i> (Host) Runemark subsp. <i>elongatus</i>	<i>Elymus obtusifolius</i> (DC.) Conert	Poaceae	G	Europ.	-	1	3	3.00	3.00	-	-	3.00
<i>Thapsia meoides</i> (Desf.) Guss.		Apiaceae	H	Medit.	-	4	11	3.00	2.75	0.50	-	3.00
<i>Matthiola fruticulosa</i> (L.)	<i>Matthiola tristis</i> (L.) R.Br.	Brassicaceae	Ch	Europ.	-	11	30	3.00	2.73	0.90	2.00	3.00
Maire subsp. <i>fruticulosa</i>	<i>Ammi crinitum</i> Guss.	Apiaceae	T	Endem.	-	5	13	3.00	2.60	0.89	-	3.00
<i>Stipa barbata</i> Desf. subsp. <i>barbata</i>		Poaceae	H	Medit.	-	7	18	3.00	2.57	0.79	-	3.00
<i>Linum decumbens</i> Desf.		Linaceae	T	Medit.	-	9	23	3.00	2.56	0.53	-	3.00
<i>Phagnalon rupestre</i> (L.) DC.		Asteraceae	Ch	Medit.	-	9	23	3.00	2.56	0.88	3.00	2.50
subsp. <i>illyricum</i> (H.Lindb.) Ginzb.		Fabaceae	H	Endem.	-	11	28	3.00	2.55	1.13	-	3.00
<i>Astragalus caprinus</i> L.		Capparaceae	NP	Medit.	-	11	28	3.00	2.55	0.82	1.00	3.00
subsp. <i>hueiti</i> (Bunge) Podlech	<i>Capparis spinosa</i> L. subsp. <i>spinosa</i> var. <i>canticens</i> Coss.	Lamiaceae	Ch	Medit.	-	7	16	3.00	2.29	0.95	-	3.00
<i>Teucrium luteum</i> (Mill.) Degen	<i>Teucrium polium</i> L. subsp. <i>atticum</i> (Schreb.) Arcang.	Poaceae	H	S-Medit.	-	9	20	3.00	2.22	0.97	3.00	2.50
<i>Ligustrum spartum</i> L.		Apiaceae	H	Medit.	-	5	11	3.00	2.20	1.10	-	3.00
<i>Cachrys sicula</i> L.	<i>Hippomarathrum siculum</i> (L.) Hoffm. & Link	Poaceae	T	Medit.	-	5	11	3.00	2.20	1.10	1.00	3.00
<i>Panapholis strigosa</i> (Dumont)												
C.E.Hubb.												
<i>Suaeda vera</i> J.F.Gmel.	<i>Suaeda fruticosa</i> (L.) Forsk. (auct. Fl. Ital.)	Amaranthaceae	NP	Wide.	-	5	11	3.00	2.20	1.10	1.00	3.00
<i>Panapholis incurva</i> (L.) C.E.Hubb.	<i>Lepidium incurvum</i> (L.) Druce	Poaceae	T	Medit.	-	7	15	3.00	2.14	1.07	1.00	3.00

The plant species on the Italian Checklist are present in 16 families (Figure 2 and Table 3), amongst which the most abundant are Poaceae (22.6%), Brassicaceae (16.1%), Apiaceae (9.7%), Asteraceae, Crassulaceae and Plumbaginaceae (6.5%). Interestingly, these 6 families alone represented almost 70% of the total gypsophilous species. As regards life forms, the spectrum is as follows: chamaephytes (32.26%), hemicryptophytes (32.26%), therophytes (19.35%), nanophanerophytes (9.67%) and geophytes (6.45%). In terms of the distribution analysis, the Italian Checklist highlights exactly the same two groups of the initial list, with those species with Mediterranean distribution predominating (38.7%), followed by the group composed of Italian endemic species. In the case of this last group, the species percentage was double that in the same analysis on the preliminary list (32.3%) (Figure 2).

When the evaluations of the Sicilian experts are compared with those of experts from the peninsula (Table 2), the latter consider 23 species with gypsophily values higher than 3, although only 6 of them were included in the final checklist (19.4%). These species are *Artemisia pedemontana* Balb., *Allosorus persicus* (Bory) Christenh., *Stipa austroitalica* Martinovský subsp. *frentana* Moraldo & Ricceri, *Allium moschatum* L., *Lygeum spartum* L. and *Phagnalon rupestre* (L.) DC. subsp. *illyricum* (H.Lindb.) Ginzb.

**Table 3.** Percentage of gypsophile taxa grouping by taxonomic families and a comparison between Italian and Spanish Checklists (Mota et al. 2011).

Family	Italian Checklist	Spanish Checklist
Amaryllidaceae	3.23	1.41
Apiaceae	9.68	1.41
Asteraceae	6.45	14.08
Brassicaceae	16.13	12.68
Campanulaceae	—	1.41
Capparaceae	3.23	—
Caryophyllaceae	3.23	8.45
Amaranthaceae	3.23	—
Cistaceae	—	4.23
Crassulaceae	6.45	1.41
Euphorbiaceae	—	1.41
Fabaceae	3.23	9.86
Frankeniaciae	—	1.41
Gentianaceae	—	1.41
Lamiaceae	3.23	11.27
Linaceae	3.23	—
Orobanchaceae	—	1.41
Plantaginaceae	3.23	5.63
Plumbaginaceae	6.45	12.68
Poaceae	22.58	4.23
Primulaceae	—	1.41
Pteridaceae	3.23	—
Resedaceae	—	4.23
Tamaricaceae	3.23	—



**Figure 2.** Percentage of taxa grouping by taxonomic families, life-forms and distribution and comparison between gypsophilous flora and preliminary data.

The Sicilian experts considered 32 taxa with gypsophily values equal to or greater than 3 and 28 of these species are present in the final checklist (90.3%).

Finally, in the case of Sardinia, where few gypsum outcrops are located in the northwest and in southeast of the island, local experts have highlighted the presence of three taxa (*Euphorbia pithyusa* L. subsp. *pithyusa*, *Helichrysum italicum* (Roth) G.Don subsp. *tyrrhenicum* (Bacch., Brullo & Giusso) Herrando, J.M.Blanco, L.Sáez & Galbany and *Teucrium marum* L. subsp. *occidentale* Mus, Mayol & Rossellò) which reached gypsophily values between 1.86 and 2.33 in the experts' assessments.

### Statistical analysis

Statistical tests (t-student) showed significant differences between the groups of Italian endemic plants versus species with a wider distribution; the Italian endemics obtained a higher average value of gypsophily (Table 4). However, when comparing the gypsophily values and groups of taxonomic family or life form, no significant difference was found.

In addition, when considering the clustering performed by distribution, the ANOVA analysis showed the existence of significant differences in gypsophily values between the Italian endemics and those showing both Mediterranean and European distribution. This is not so for species with a wider distribution range, such as Eurasian and widespread taxa. However, this result could be an artefact due to the small size of this sample, since its average gypsophily value is the one that most differed from the endemic species group (Table 5a).

Finally, according to the grouping variables narrow gypsophile, wide gypsophile and gypsovag, the species considered as narrow gypsophile, showed on average the highest gypsophily values and reached maximum values. Both species regarded as narrow gypsophile and wide gypsophile showed statistically significant results with higher gypsophily values than those considered as gypsovags. Nevertheless, there were no significant differences between the groups of narrow gypsophile and wide gypsophile, so that this separation was not supported (Table 5b).

For further information about the statistical analyses performed see Suppl. material 2.

### Discussion

*Ad hoc* investigations on gypsophily have been performed in only 12 countries and only five of these studies approached a functional perspective (Mota et al. 2016). However, documented gypsophilous flora can be found in at least 75 countries (Pérez-García et al. 2017, 2018).

This work provides the first Checklist of Italian gypsophytes, including 31 taxa showing a great affinity for this substrate, 12 of which can be unequivocally considered as strictly gypsophytes. In addition, a number of further species often found on these substrates is detailed. As mentioned before, although the studies on gypsophilous flora

**Table 4.** *t*-student analyses by gypsophily level, taxa grouping by endemic and non-endemic species. Number of species (N). Average (AV). Standard deviation (SD). Standard error (SE).

	N	AV	SD	SE	<i>p</i> -value	95% confidence interval	
						Min	Max
Endemism	46	2.4000	0.7731	0.1153	<b>0.0030</b>	2.1680	2.6320
Rest	293	2.1460	0.4744	0.0285		2.0900	2.2020
Total	339	2.1810	0.5321	0.0296		2.1230	2.2390

\* *p*-value < 0.05**Table 5.** ANOVA analysis by gypsophily level. Average (AV). Standard deviation (SD). 5a) Grouping by distribution: Italian endemic, Mediterranean, European and Wide distribution. 5b) Grouping by functional group: narrow gypsophile, wide gypsophile and gypsovag.

a) Chorotype		AV	SD	<i>p</i> -value	95% confidence interval	
					Min	Max
Endemic	Mediterranean	<b>0.2358</b>	0.0868	<b>0.0350</b>	0.0120	0.4600
	European	<b>0.2917</b>	0.1038	<b>0.0270</b>	0.0240	0.5600
	Eurasiat/Widespread	0.3412	0.1498	0.1060	-0.0460	0.7280
Mediterranean	Endemic	<b>-0.2358</b>	0.0868	<b>0.0350</b>	-0.4600	-0.0120
	European	0.0558	0.0774	0.8890	-0.1440	0.2560
	Eurasiat/Widespread	0.1054	0.1329	0.8580	-0.2380	0.4490
European	Endemic	<b>-0.2917</b>	0.1038	<b>0.0270</b>	-0.5600	-0.0240
	Mediterranean	-0.0558	0.0774	0.8890	-0.2560	0.1440
	Eurasiat/Widespread	0.0495	0.1446	0.9860	-0.3240	0.4230
Eurasiat/Widespread	Endemic	-0.3412	0.1498	0.1060	-0.7280	0.0460
	Mediterranean	-0.1054	0.1329	0.8580	-0.4490	0.2380
	European	-0.0495	0.1446	0.9860	-0.4230	0.3240
b) Functional group		AV	SD	<i>p</i> -value	95% confidence interval	
					Min	Max
Narrow gypsophile	Wide gypsophile	0.1524	0.1014	0.2910	-0.0860	0.3910
	Gypsovag	<b>1.6692</b>	0.0848	<b>0.0000</b>	1.4690	1.8690
Wide gypsophile	Narrow gypsophile	-0.1524	0.1014	0.2910	-0.3910	0.0860
	Gypsovag	<b>1.5168</b>	0.0596	<b>0.0000</b>	1.3760	1.6570
Gypsovag	Narrow gypsophile	<b>-1.6692</b>	0.0848	<b>0.0000</b>	-1.8690	-1.4690
	Wide gypsophile	<b>-1.5168</b>	0.0596	<b>0.0000</b>	-1.6570	-1.3760

\* *p*-value < 0.05

in Italy date as far back as the 19<sup>th</sup> century (Macchiati 1888), there is no knowledge of the existence of detailed ecological, functional or phylogeographic studies. After this first analysis of Italian flora, it would not be possible to discard a second evaluation based on the information presented in this work and any new information generated in the future (e.g. Montanari et al. 2016). A new revision should not only take into

account the vascular flora, but also the plant assemblages associated with these outcrops. It must be noted that Italy presents a complex natural scenario, with a strong North-South environmental gradient conditioning the composition and dynamics of plant communities. In the case of vegetation associated with gypsum outcrops, this gradient is remarkable and it is impossible to overlook the far greater aridity of the southernmost regions, which exaggerates the gypsophily phenomenon (Merlo et al. 1998, 2001). This probably explains why the largest contingent of gypsophytes in the Italian territory is concentrated in Sicily.

This research reinforces the idea that, provided there is no definitive criterion for establishing whether a species is a gypsophyte or not, the inductive approach based on 'expert criterion' is not only plausible, but perhaps the only one possible to establish the groundwork for future research on gypsophily. To further complicate this scenario, the same species may have different affinity levels for gypsum substrates in isolated territories: e.g. *Sedum gypsicola* subsp. *trinacriae* shows gypsophily median value of 5 in Italy, but in Spain, the nominal subspecies (*S. gypsicola* subsp. *gypsicola*) reached a median value of 4 in a previous study (Mota et al. 2011).

Both the taxonomical and life form spectra concerning the 31 gypsophytes on the Italian Checklist are largely in agreement with the data recorded in other areas of the Mediterranean Basin for this type of substrates (EIONET 2008, Bolukbasi et al. 2016). As far as the most represented families are concerned, the taxonomic spectrum of the strictly gypsophilous flora in Italy is similar. Brassicaceae and Poaceae are amongst the families with a higher number of species, although the latter is slightly over-represented in Italy. Poaceae occur frequently in very stressful environments (Baskin and Baskin 2000) and, consequently, it is easy to understand why there is a high number of them, which can be considered as peculiar to gypsum substrates. Other conspicuous families in the taxonomic spectrum of the Italian gypsophytes are Apiaceae, Asteraceae, Plumbaginaceae and Crassulaceae. All of them are found in arid Mediterranean environments and, therefore, it is not surprising to find them so well represented in Italy.

Although there were variations in the abundance percentages, the most common families with the greatest match with the grouping occurred for the Spanish gypsophilous flora (Mota et al. 2011), where Asteraceae (14.1%), Brassicaceae and Plumbaginaceae (12.68%) correspond to the larger families. Nevertheless, Poaceae and Apiaceae obtained greater representation in the Italian gypsophilous flora. On the contrary, Lamiaceae, Fabaceae and Caryophyllaceae families appear to be less common on Italian gypsum outcrops with respect to other countries (Table 3).

Plant formations linked to gypsum substrates are usually dominated by small plant species such as chamaephytes or hemicryptophytes, similarly to those which occur in other Mediterranean areas, although there are exceptions of woody plant formations growing on gypsum (Pérez-García et al. 2017). The intense exposure to sunshine for these environments, the shortage of water and nutrient imbalance are probably responsible for this scenery. In addition, the abundance of therophytes may be explained by water shortage. Thus, some annual plants can be favoured on gypsum by drought (Merlo et al. 2001).

## Conclusions

Efforts to ensure the conservation of Mediterranean gypsophilous vegetation, considered as a Priority Habitat, should be focused on endangered, rare or endemic species, according to the premises established by the EU. All these efforts cannot be easily undertaken unless it is previously determined which species, out of many hundreds, are to be given top priority. The approach adopted in this work may help both to focus on certain species and to detect research and conservation priorities. The high proportion of Italian endemic species and the geographic rarity component of the flora associated with Italian gypsum outcrops is an aspect that makes these outcrops very interesting habitats. However, the degree of threat to the gypsophilous flora in Italy could have been insufficiently assessed. This fact is confirmed since less than 7% of the gypsophytes of the Italian Checklist have been evaluated under IUCN protocol. As there has been a prior effort to establish a network of sites for the conservation of nature (Natura 2000 Network), it would be worthwhile to extend this initiative to areas supporting Italian gypsum outcrops that have biodiversity values worthy of consideration. In order to achieve this purpose, an in-depth review of the conservation status for both the gypsophilous flora and the natural areas where these substrata occur in Italy is crucial. Data generated by experts in conservation, for which threat categories of red-listed species are based, should be incorporated into nature protection Acts (Mendoza-Fernández and Mota 2016) to ensure the preservation of these sites in Italy.

There are numerous SCI and SCZ including gypsum outcrops and their associated flora. The question that remains to be clarified is whether they are sufficient to ensure the conservation of this flora as well as the vegetation linked to this peculiar substrate. In this examination of gaps in conservation, fauna and other plant groups, such as lichens and bryophytes, should be integrated (Mota et al. 2011).

At this moment, the existence of endemic and rare flora with remarkable eco-morphological adaptations and the description of new taxa growing on gypsum outcrops fully justifies the conservation of these outcrops (Gallo 2014). Some Italian gypsum outcrops are currently under protection, but other areas have not yet been included in the network of nature reserves. As Panuccio et al. (2017) and Spampinato et al. (2018) pointed out for Calabria (South-Italy) and Mendoza-Fernández et al. (2014) for Andalusia (southern Spain), arid or semi-arid territories are often under-represented in protected area networks. This is the case for most Italian gypsum sites. Furthermore, the checklist of Italian gypsophytes should contribute to a better understanding of the autoecology and synecology of rare and endemic species and, therefore, to better conservation of the biodiversity associated with gypsum areas in Italy. For example, scrub communities, typical of Italian gypsum substrates, represent one of the major gaps in conservation habitats in the European Union. In order to fill this gap, the peculiar Italian gypsum habitats could be considered by modifying the meaning that habitat 1520\* currently has in the manual of habitat interpretation and through the addition of Italian gypsophytes in order to include the gypsum habitat in Italy, amongst those of European interest.

Data provided in this paper denote an important advance in this sense, because only five plant species in Italy have been recognised as characteristic taxa for this habitat on the European Red List of Habitats (Loidi 2016). These are: *Brassica villosa* subsp. *tineoi*, *Chaenorhinum rupestre*, *Festuca gypsophila* (*Ctenopsis gypsophila*), *Erysimum metlesicsii* and *Sedum gypsicola* subsp. *trinacriae*. However, according to the information provided in this paper, at least twelve species, more than double, could be indicative plants for this Priority Habitat. Thus, the following should be added to those already mentioned: *Petrosedum ochroleucum* subsp. *mediterraneum*, *Allosorus persicus*, *Artemisia pedemontana*, *Diplotaxis harra* subsp. *crassifolia* and *Stipa austroitalica* subsp. *frentana*. In addition, some species typically related to saline soils belonging to the “Serie gessoso-solfifera” of Sicily, such as *Reaumuria vermiculata*, *Limonium catanzaroi* and *Limonium optimae*, may also occur.

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## References

- Anonymous (1992) Council Directive 92/43/CEE on the conservation of natural habitats and of wild fauna and flora. European Commission, Brussels, Belgium. DOCE, 206/1992 l: 7–50.
- Bartolucci F, Peruzzi L, Galasso G, Albano A, Alessandrini A, Ardenghi NMG, Astuti G, Bacchetta G, Conti F (2018) An updated checklist of the vascular flora native to Italy. Plant Biosystems 152(2): 179–303. <https://doi.org/10.1080/11263504.2017.1419996>
- Baskin JM, Baskin CC (2000) Vegetation of limestone and dolomite glades in the Ozarks and Midwest Regions of the United States. Annals of the Missouri Botanical Garden 87(2): 286–294. <https://doi.org/10.2307/2666165>
- Bolukbasi A, Kurt L, Palacio S (2016) Unravelling the mechanisms for plant survival on gypsum soils: An analysis of the chemical composition of gypsum plants from Turkey. Plant Biology 18(2): 271–279. <https://doi.org/10.1111/plb.12401>

- Cesalpino A (1583) *De plantis libri XVI*. Florentiae: Apud Georgium Marescottonum.
- EIONET (2008) Report on the main results of the surveillance under article 11 for annex I habitat types Annex D. European Environment Agency. Available on [cdr.eionet.europa.eu/cy/eu/art17/envruly\\_3a/habitattype-1520.xml/manage\\_document](http://cdr.eionet.europa.eu/cy/eu/art17/envruly_3a/habitattype-1520.xml/manage_document)
- Eycott AE, Marzano M, Watts K (2011) Filling evidence gaps with expert opinion: The use of Delphi analysis in least-cost modelling of functional connectivity. *Landscape and Urban Planning* 103(3-4): 400–409. <https://doi.org/10.1016/j.landurbplan.2011.08.014>
- Fenu G, Bacchetta G, Giacanelli V, Gargano D, Montagnani C, Orsenigo S, Cogoni D, Rossi G, Ercole S (2017) Conserving plant diversity in Europe: Outcomes, criticisms and perspectives of the Habitats Directive application in Italy. *Biodiversity and Conservation* 62(2): 309–328. <https://doi.org/10.1007/s10531-016-1244-1>
- Font Quer P (1977) *Diccionario de Botánica* (6 edn). Labor, Barcelona, Spain.
- Gallo L (2014) *Sedum ochroleucum* subsp. *mediterraneum* (Crassulaceae), a new Italian endemic. *Willdenowia* 44(1): 27–33. <https://doi.org/10.3372/wi.44.44104>
- Hasson F, Keeney S (2011) Enhancing rigour in the Delphi technique research. *Technological Forecasting and Social Change* 78(9): 1695–1704. <https://doi.org/10.1016/j.techfore.2011.04.005>
- Hasson F, Keeney S, McKenna H (2000) Research guidelines for the Delphi survey technique. *Journal of Advanced Nursing* 32: 8. <https://doi.org/10.1046/j.1365-2648.2000.t01-1-01567.x>
- IUCN (2001) IUCN Red List categories Ver. 3.1. Prepared by the IUCN Species Survival Commission. World Conservation Union, Gland, Suiza & Cambridge, UK.
- IUCN UNEP-WCMC (2014) The World Database on Protected Areas WDPA. Cambridge, UK.
- Joppa LN, Visconti P, Jenkins CN, Pimm SL (2013) Achieving the Convention on Biological Diversity's Goals for Plant Conservation. *Science* 341(6150): 1100–1103. <https://doi.org/10.1126/science.1241706>
- Kruckeberg AR (2002) *Geology and Plant Life*. University of Washington Press, USA.
- Likert R (1932) A technique for the measurement of attitudes. *Archives de Psychologie* 140: 1–55.
- Loidi J (2016) F6.7 Mediterranean gypsum scrub. In: Janssen JAM, Rodwell JS, García Criado M, Gubbay S, Haynes T, Nieto A, et al. (Eds) *European Red List of Habitats. Part 2. Terrestrial and freshwater habitats*. European Commission.
- Macchiati L (1888) Contribuzione alla flora del gesso. *Nuovo Giornale Botanico Italiano* 20: 418–422.
- Martínez-Hernández F, Pérez-García FJ, Garrido-Becerra JA, Mendoza-Fernández AJ, Medina-Cazorla JM, Martínez-Nieto MI, Merlo Calvente ME, Mota Poveda JF (2011) The distribution of Iberian gypsophile flora as a criterion for conservation policy. *Biodiversity and Conservation* 20(6): 1353–1364. <https://doi.org/10.1007/s10531-011-0031-2>
- Martínez-Hernández F, Mendoza-Fernández AJ, Pérez-García FJ, Martínez-Nieto MI, Garrido-Becerra JA, Salmerón-Sánchez E, Merlo ME, Gil C, Mota JF (2015) Areas of endemism as a conservation criterion for Iberian gypsophile flora: A multi-scale test using the NDM/VNDM program. *Plant Biosystems* 149(3): 483–493. <https://doi.org/10.1080/11263504.2015.1040481>
- Mendoza-Fernández A, Pérez-García FJ, Martínez-Hernández F, Medina-Cazorla JM, Garrido-Becerra JA, Merlo Calvente ME, Guirado Romero JS, Mota JF (2014) Threatened plants

- of arid ecosystems in the Mediterranean Basin: A case study of the south-eastern Iberian Peninsula. *Oryx* 48(4): 548–554. <https://doi.org/10.1017/S0030605313000495>
- Mendoza-Fernández AJ, Mota JF (2016) Red Lists versus nature protection Acts: New analytical and numerical method to test threat trends. *Biodiversity and Conservation* 25(2): 239–260. <https://doi.org/10.1007/s10531-015-1040-3>
- Mento G (Coord.) (2008) Piano di Gestione Complessi Gessosi M. Conca, SCI ITA050006. Club Alpino Italiano Sicilia, Italia.
- Merlo ME, Mota JF, Cabello J, Alemán MM (1998) La gipsofilia en plantas: Un apasionante edafismo. *Investigación y Gestión* 3: 103–112.
- Merlo ME, Rodríguez-Tamayo ML, Jiménez ML, Mota JF (2001) Recapitulación sobre el comportamiento biogeográfico de algunos gipsófitos y halófitos ibéricos. *Monografías de Flora y Vegetación Bética* 12: 77–95.
- Montanari S, Bagli L, Sirotti M, Faggi G, Alessandrini A (2016) Flora dei gessi e solfi della Romagna Orientale. *Memorie dell’Istituto Italiano di Speleologia* 31: 181–219.
- Moore MJ, Mota JF, Douglas NA, Flores-Olvera H, Ochoterena H (2014) The ecology, assembly, and evolution of gypsophile floras. In: Rajakaruna N, Boyd R, Harris T (Eds) *Plant Ecology and Evolution in Harsh Environments*. Hauppauge Nova Science Publishers, NY, 97–128.
- Mota JF, Sola AJ, Jiménez-Sánchez ML, Pérez-García F, Merlo ME (2004) Gypsicolous flora, conservation and restoration of quarries in the southeast of the Iberian Peninsula. *Biodiversity and Conservation* 13(10): 1797–1808. <https://doi.org/10.1023/B:BIOC.0000035866.59091.e5>
- Mota JF, Medina-Cazorla JM, Navarro FB, Pérez-García FJ, Pérez-Latorre A, Sánchez-Gómez P, Torres JA, Benavente A, Blanca G, Gil C, Lorite J, Merlo ME (2008) Dolomite flora of the Baetic Ranges glades South Spain: A review. *Flora* 203(5): 359–375. <https://doi.org/10.1016/j.flora.2007.06.006>
- Mota JF, Sánchez-Gómez P, Merlo ME, Catalán P, Laguna E, de la Cruz Rot M, Navarro Reyes FB, Marchal Gallardo F, Bartolomé Esteban C, Martínez Labarga JM, Sainz Ollero H, Valle Tendero F, Serra Laliga L, Martínez Hernández F, Garrido Becerra JA, Pérez García FJ (2009) Aproximación a la checklist de los gipsófitos ibéricos. *Anales de Biología* 31: 71–80. ISSN 1989-2128
- Mota JF, Sánchez-Gómez P, Guirado Romero JS (Eds) (2011) Diversidad vegetal de las yeseras ibéricas. ADIF-Mediterráneo Asesores Consultores, Almería, España.
- Mota JF, Garrido-Becerra JA, Pérez-García FJ, Salmerón-Sánchez E, Sánchez-Gómez P, Merlo E (2016) Conceptual baseline for a global checklist of gypsophytes. *Lazaroa* 37: 7–30. <https://doi.org/10.5209/LAZA.54044>
- Musarella CM, Spampinato G, Mendoza-Fernández AJ, Mota JF, Alessandrini A, Brullo S, Caldarella O, Ciaschetti G, Conti F, Spampinato G (2016) Preliminary checklist of the Italian gypsophilous flora. In: Bacchetta G (Ed.) *Conservation studies on Mediterranean threatened flora and vegetation. Book of Abstracts of the X International Meeting Biodiversity Conservation and Management, Sardinia 13–18 June*. University of Cagliari, (Cagliari, Italy), 53.
- Ochoa-Gaona S, Kampichler C, de Jong BHJ, Hernández S, Geissen V, Huerta E (2010) A multi-criterion index for the evaluation of local tropical forest conditions in Mexico. *Forest Ecology and Management* 260(5): 618–627. <https://doi.org/10.1016/j.foreco.2010.05.018>

- Palacio S, Escudero A, Montserrat-Martí G, Maestro-Martínez M, Milla R, Albert MJ (2007) Plants living in gypsum: Beyond the specialist model. *Annals of Botany* 99(2): 333–343. <https://doi.org/10.1093/aob/mcl263>
- Panuccio MR, Fazio A, Musarella CM, Mendoza-Fernández AJ, Mota JF, Spampinato G (2017) Seed germination and antioxidant pattern in *Lavandula multifida* (Lamiaceae): A comparison between core and peripheral populations. *Plant Biosystems* 152(3): 398–406. <https://doi.org/10.1080/11263504.2017.1297333>
- Parsons RF (1976) Gypsophily in plants: A review. *The American Midland Naturalist Journal* 96(1): 1–20. <https://doi.org/10.2307/2424564>
- Pérez-García FJ, Akhani H, Parsons PF, Jennifer L, Silcock, Latif Kurt, Özdeniz E, Spampinato G, Musarella CM, Salmerón-Sánchez E, Sola F, Merlo ME, Martínez-Hernández F, Mendoza-Fernández AJ, Garrido-Becerra JA, Mota JF (2018) A first inventory of gypsum flora in the Palearctic and Australia. *Mediterranean Botany* 39(1): 35–49. <https://doi.org/10.5209/MBOT.59040>
- Pérez-García FJ, Martínez-Hernández F, Mendoza-Fernández AJ, Merlo ME, Sola F, Salmerón-Sánchez E, Garrido-Becerra JA, Mota JF (2017) Towards a global checklist of the world gypsophytes: A qualitative approach. *Plant Sociology* 54(2): 61–76. <https://doi.org/10.7338/pls2017542S1/06>
- Peruzzi L (2010) Checklist dei generi e delle famiglie della flora vascolare italiana. *Informatore Botanico Italiano* 421: 151–170.
- Pignatti S (1982) Flora d'Italia. Edagricole, Bologna.
- Rossi G, Montagnani C, Abeli T, Gargano D, Peruzzi L, Fenu G, Magrini S, Orsenigo S (2014) Are Red Lists really useful for plant conservation? The New Red List of the Italian Flora in the perspective of national conservation policies. *Plant Biosystems* 148(2): 187–190. <https://doi.org/10.1080/11263504.2013.868375>
- Rossi G, Orsenigo S, Montagnani C, Fenu G, Gargano D, Peruzzi L, Abeli T (2016) Is legal protection sufficient to ensure plant conservation? The Italian Red List of policy species as a case study. *Oryx* 50(3): 431–436. <https://doi.org/10.1017/S003060531500006X>
- Sarmiento FO (2001) Diccionario de ecología: paisajes, conservación y desarrollo sustentable para Latinoamérica. Ediciones Abya-Yala, Quito, Ecuador, 1–226.
- Spampinato G, Musarella CM, Mendoza-Fernández AJ, Mota JF, Alessandrini A, Brullo S, Troia A (2016) Towards a checklist of the Italian gypsophilous vascular flora. In: Book of abstract of III International Plant Science Conference of Società Botanica Italiana, Rome (Italy), 21–23 september 2016. Università Tor Vergata, Rome, Italy, 53.
- Spampinato G, Musarella CM, Cano-Ortiz A, Signorino G (2018) Habitat, occurrence and conservation status of Saharo-Macaronesico-South-Mediterranean element *Fagonia cretica* L. Zygophyllaceae. *Journal of Arid Land* 10(1): 140–151. <https://doi.org/10.1007/s40333-017-0076-5>

## Appendix I

### References appendix

- Aleffi, M., Pellis, G. & Puglisi, M. (2014). The bryophyte flora of six gypsum outcrops in the Northern Apennines Nature 2000 Network, Emilia Romagna Region, Italy. *Plant Biosystems*, 1484, 825–836.
- Antolini, P. (1984). Rassegna dei principali affioramenti di gesso in Italia. *Atti della Accademia roveretana degli Agiati*, 24, 83–117.
- Bazan, G., Ilardi, V., Minissale, P. & Sciandrello, S. (2006). La biodiversità vegetale di Monte Gibliscemi Mazzarino Sicilia. *Quaderni di Botanica ambientale e applicata*, 172, 121–140.
- Biondi, E., Blasi, C., Allegrezza, M., Anzellotti, I., Azzella, M.M., Carli, E. et al. (2014). Plant communities of Italy: The Vegetation Prodrome. *Plant Biosystems*, 1484, 728–814.
- Brullo, S., Marcenò, C., Minissale, P. & Spampinato, G. (1989). Su una nuova associazione del *Sedo-Ctenopson gypsophilae* rinvenuta in Sicilia. *Archivio Botanico e Biogeografico Italiano*, 651(2), 100–108.
- Cobau, R. (1932). Su la flora dei “gessi” bolognesi. *Nuovo Giornale Botanico Italiano*, 392, 313–345.
- Conti, F. (1998). An annotated checklist of the flora of the Abruzzo. *Bocconeia*, 10.
- Conti, F. & Pirone, G. (1988). Segnalazioni Floristiche Italiane. *Informatore Botanico Italiano*, 20, 654–656.
- Corbetta, F. (1964). Alcuni aspetti della vegetazione dei gessi Bolognesi. *Natura e Montagna*, 24, 30–37.
- Di Falco, G., Manzi, A. & Manzi, G. (2003). *I gessi di Gessopalena e della valle dell'Aventino*. Un museo nel territorio. Editrice Ianieri, Pescara.
- Di Martino, A., Marcenò, C. & Raimondo, F.M. (1976). Nota preliminare sulla vegetazione gipsofila della Sicilia centro-meridionale. *Giornale Botanico Italiano*, 111, 369–370.
- Ferrari, C. (1974). La vegetazione delle rupi gessose di Miserrazzano e della Croara, Bologna. *Notes de Fitosociologia*, 8, 65–74.
- Ferro, G., Coniglione, P. & Oliveri, S. (1979). I praticelli effimeri su gesso nel territorio di Caltanissetta, Sicilia. *Atti dell'Accademia Gioenia di Scienze Naturali in Catania*, 64, 137–141.
- Gallo, L. (2014). *Sedum ochroleucum* subsp. *mediterraneum* Crassulaceae, a new Italian endemic. *Willdenowia*, 44, 27–33.
- Gianguzzi, L., D'Amico, A., Caldarella, O. & Romano, S. (2010). Note distributive ed ecologiche su alcune rare entità della flora vascolare siciliana. *Il Naturalista Siciliano*, 342, 227–244.
- Gianguzzi, L., D'Amico, A., Caldarella, O. & Romano, S. (2011). La flora vascolare delle Rocche di Entella entroterra della Sicilia occidentale. *Il Naturalista Siciliano*, 353(4), 363–405.

- Giardina, G., Raimondo, F.M. & Spadaro, V. (2007). A catalogue of plants growing in Sicily. *Bocconeia*, 20, 5–582.
- Giusso del Galdo, G., Marcenò, C., Musarella, C.M. & Sciandrello, S. (2008). La vegetazione costiera R.N.O. ‘Torre Salsa’ Siculiana-AG. *Informatore Botanico Italiano*, 401, 73–89.
- Macchiati, L. (1888). Contribuzione alla flora del gesso. *Nuovo Giornale Botanico Italiano*, 20, 418–422.
- Macchiati, L. (1891). Seconda contribuzione alla flora del gesso. *Nuovo Giornale Botanico Italiano*, 23, 171–175.
- Macchiati, L. (1892). Terza contribuzione alla flora del gesso. *Bullettino della Società Botanica Italiana*, 120–122.
- Manzi, A. (1993). Note floristiche per le regioni Abruzzo e Marche. *Archivio Botanico*, 68, 13–180.
- Marcenò, C., Falci, A. & Pasta, S. (2011). Su alcuni lembi di vegetazione pre-forestale e forestale della provincia di Enna Sicilia centrale. *Naturalista Siciliano*, 352, 295–312.
- Marcenò, C. & Gristina, A.S. (2010). Su *Chaenorhinum rubrifolium* Dc. Fourr. *Scrophulariaceae*, specie nuova per la flora siciliana e sull’ecologia e distribuzione del genere *Chaenorhinum* DC. Reichenb. in Sicilia. *Naturalista Siciliano*, 343(4), 477–485.
- Montanari, S., Bagli, L., Sirotti, M., Faggi, G. & Alessandrini, A. (2016). Flora dei gessi e solfi della Romagna Orientale. *Memorie dell’Istituto Italiano di Speleologia*, 31, 181–219.
- Pasquini, D. (1944). La vegetazione dei gessi reggiani. *Atti della Società dei naturalisti e matematici di Modena*, 75, 264–282.
- Pasta, S. (2001). Lineamenti della flora e della vegetazione del Lago Sfondato. *Naturalista Siciliano*, 4, 401–421.
- Pasta, S. & La Mantia, T. (2001). Lineamenti della flora e della vegetazione dell’area della Riserva Naturale “Grotta di Santa Ninfa”. *Naturalista Siciliano*, 4, 271–297.
- Privitera, M. (1989). La vegetazione muscinale dei gessi dell’Agrigentino, Sicilia occidentale. *Bullettino della Accademia Gioenia di Scienze Naturali*, 22, 105–113.
- Raimondo, F.M., Domina, G. & Spadaro, V. (2010). Checklist of the vascular flora of Sicily. *Quaderni di Botanica Ambientale e Applicata*, 21, 189–252.
- Troia, A., Pasta, S., Campo, G. & Romano, S. (1998). Indagini tassonomiche e corologiche sul genere *Sedum* L. serie Rupestris Berger Crassulaceae in Sicilia. *Naturalista Siciliano*, 4(221-2), 73–85.
- Troia, A. (2002). *La flora gipsicola. Aspetti biologici ed ecologici delle piante che vivono sul gesso*. Palermo: Assessorato Territorio e Ambiente Regione Siciliana & Club Alpino Italiano.

## Supplementary material I

### Plant species data

Authors: Carmelo Maria Musarella, Antonio Jesús Mendoza-Fernández, Juan Francisco Mota, Alessandro Alessandrini, Gianluigi Bacchetta, Salvatore Brullo, Orazio Caldarella, Giampiero Ciaschetti, Fabio Conti, Luciano Di Martino, Amedeo Falci, Lorenzo Gianguzzi, Riccardo Guarino, Aurelio Manzi, Pietro Minissale, Sergio Montanari, Salvatore Pasta, Lorenzo Peruzzi, Lina Podda, Saverio Sciandrello, Leonardo Scuderi, Angelo Troia, Giovanni Spampinato

Data type: species data

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Link: <https://doi.org/10.3897/phytokeys.103.25690.suppl1>

## Supplementary material 2

### ANOVA analysis by gypsophily level

Authors: Carmelo Maria Musarella, Antonio Jesús Mendoza-Fernández, Juan Francisco Mota, Alessandro Alessandrini, Gianluigi Bacchetta, Salvatore Brullo, Orazio Caldarella, Giampiero Ciaschetti, Fabio Conti, Luciano Di Martino, Amedeo Falci, Lorenzo Gianguzzi, Riccardo Guarino, Aurelio Manzi, Pietro Minissale, Sergio Montanari, Salvatore Pasta, Lorenzo Peruzzi, Lina Podda, Saverio Sciandrello, Leonardo Scuderi, Angelo Troia, Giovanni Spampinato

Data type: statistical data

Explanation note: ANOVA analysis by gypsophily level.

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Link: <https://doi.org/10.3897/phytokeys.103.25690.suppl2>

# Phylogeny of *Muhlenbergia* subg. *Pseudosporobolus*, including *M. spatha* (Poaceae, Chloridoideae, Cynodonteae, Muhlenbergiinae) now found in Zacatecas, Mexico

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## Abstract

*Muhlenbergia spatha*, previously known only from near the type locality in San Luis Potosí, is reported from two localities in Zacatecas, Mexico. Historically, botanists have overlooked this diminutive annual. To clarify affinities of *M. spatha*, we present a molecular phylogeny emphasising species in *M.* subg. *Pseudosporobolus* using sequence data from two plastid markers (*rpl32-trnL* and *rps16* intron) and nrDNA ITS. In addition, we include an updated description, illustration and discussion of the habitat of *M. spatha*.

## Resumen

*Muhlenbergia spatha*, anteriormente conocida solo cerca de la localidad tipo en San Luis Potosí, se reporta en dos localidades en Zacatecas, México. Históricamente, los botánicos han pasado por alto esta diminuta anual. Para aclarar las afinidades de *M. spatha*, presentamos una filogenia molecular que enfatiza especies en *M.* subg. *Pseudosporobolus* usando datos de secuencia de dos marcadores plástidos (*rpl32-trnL* e *rps16* intron) y nrADN EIT. Además, incluimos una descripción actualizada, ilustración y discusión del hábitat de *M. spatha*.

## Keywords

grasses, ITS, Mexico, *Muhlenbergia*, plastid DNA sequences, *Schaffnerella gracilis*, systematics, taxonomy

## Introduction

*Muhlenbergia spatha* Columbus is a small (usually less than 20 cm tall) annual first collected in the mountains of San Miguelito, in the valley of San Luis Potosí by J.G. Schaffner in 1876 (Bentham 1882). There are few collections of this species (only two known numbers collected by Schaffner with at least 14 duplicates) and it was thought to be extirpated until it was rediscovered near the type locality by J.T. Columbus along the Río Potosino in the Sierra de San Miguelito in 2001 (Columbus et al. 2001). *Muhlenbergia spatha* can be separated from other species in the genus by its possessing small, few-branched condensed panicles that are partially included in a spatheolate sheath with each branch containing 1–5 sessile spikelets.

Bentham (1882) thought *Schaffnerella gracilis* (Benth.) Nash ( $\equiv$  *Schaffnera gracilis* Benth.  $\equiv$  *Muhlenbergia spatha*) was related to other members of the Zoysieae (e.g. *Zoysia* Willd. and *Aegopogon* P. Beauv = *Muhlenbergia* Schreb.), but he also suggested the inflorescences were nearer to members of the Andropogoneae or Pappophoreae. Beal (1896), Nash (1912), and Conzatti (1988) followed Bentham and included the monotypic *Schaffnerella* Nash in the Zoysieae. There are no modern treatments of *Schaffnerella* in Mexico, although a fairly complete genus and species description is given in Nash (1912) and, later, much abbreviated in Conzatti (1988). Pilger (1956) placed *Schaffnerella* in the tribe Lappagineae Link, again near *Zoysia* and *Aegopogon*. Clayton and Renvoize (1986) indicated *Schaffnerella* was “an isolated genus apparently related to *Opizid*” J. Presl (= *Bouteloua* Lag.; Peterson et al. 2015) and placed it in the tribe Cynodonteae. Currently, the Cynodonteae includes 25 subtribes, 95 genera and 859 species (Peterson et al. 2010a, 2016, 2017; Soreng et al. 2017). Molecular DNA sequence studies support placement of *Schaffnerella* in the Cynodonteae, aligning the genus within the monogeneric subtribe Muhlenbergiinae Pilg. in *Muhlenbergia* Schreb. subg. *Pseudosporobolus* (Parodi) P.M. Peterson (Columbus et al. 2010; Peterson et al. 2010a, 2010b). There are at least 27 species of *Muhlenbergia* that align within *M.* subg. *Pseudosporobolus*.

In this paper, we report two new collections of *Muhlenbergia spatha* in Zacatecas, include a complete updated description and illustration and present a molecular phylogeny of species in *M.* subg. *Pseudosporobolus* using sequence data from two plastid markers (*rpl32-trnL* and *rps16* intron) and a single nuclear marker (ITS). Our new molecular phylogeny of *M.* subg. *Pseudosporobolus* was included to characterise evolutionary relationships of *M. spatha*, since earlier analyses for this species were based on few markers (Columbus et al. 2010; Peterson et al. 2010b). Based on a single sequence (*rpl32-trnL*), *M. spatha* paired with *M. alopecuroides* (Griseb.) P.M. Peterson & Columbus in a plastid tree and it paired with *M. wrightii* Vasey ex J.M. Coulter. in a combined (plastid and ITS) tree (Peterson et al. 2010b).

## Materials and methods

**Phylogenetic analyses.** Detailed methods for DNA extraction, amplification, sequencing and phylogenetic analysis are given in Peterson et al. (2010a, 2010b, 2014, 2015, 2016). In brief, we estimated the phylogeny amongst members of *Muhlenbergia* based on the analysis of three molecular markers (nuclear ribosomal ITS 1&2; plastid *rpl32-trnL* and *rps16* intron DNA sequences). For this study we included a sampling of species within the five subgenera of *Muhlenbergia*, *M. ramulosa* (Kunth) Swallen and the outgroups *Distichlis scoparia* (Nees ex Kunth) Arechav. (Cynodonteae, Monanthochloinae), *Sporobolus indicus* (L.) R. Br. (Zoysieae, Sporobolinae) and *Willkommia sarmentosa* Hack. (Cynodonteae, Traginae) [Peterson et al. 2010b, 2016]. Voucher information and GenBank numbers for all 41 samples used in the analysis are given in Table 1.

## Results and discussion

**Phylogeny.** A total of 16 new sequences from *Muhlenbergia phleoides* (Kunth) Columbus, *M. pungens* Thurb. ex A. Gray, *M. seatonii* Scribn., *M. spatha*, *M. tenuissima* (J. Presl) Kunth and *M. utilis* (Torr.) Hitchc. are reported in GenBank (Table 1). Total aligned characters for individual regions and other parameters are noted in Table 2. In Figure 1, we combined the plastid–ITS sequences in our analysis since there was little incongruence between these data sets.

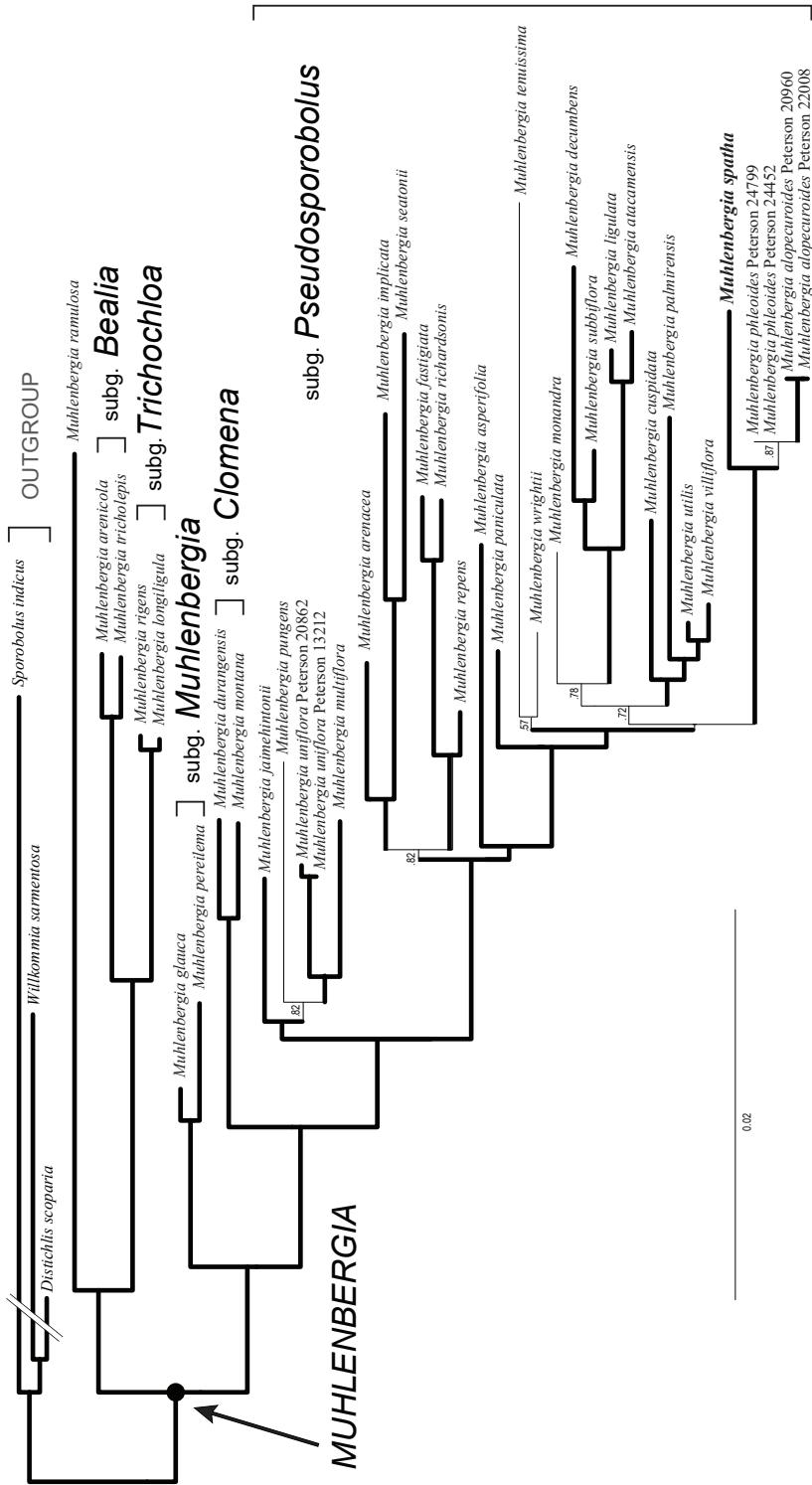
The maximum-likelihood tree from the combined analysis of ITS and two plastid regions (*rpl32-trnL* and *rps16* intron) is well resolved, with strong support for the monophyly of *Muhlenbergia*, including *M. ramulosa* and five subgenera, *Bealia*, *Clomena*, *Muhlenbergia*, *Pseudosporobolus* and *Trichochloa* [Fig. 1; posterior probability (PP) = 1 for thick branches]. Within *Muhlenbergia* subg. *Pseudosporobolus*, *M. spatha* is strongly supported (PP = 1) as sister to *M. phleoides* and *M. alopecuroides*. *Muhlenbergia decumbens* Swallen, *M. monandra* Alegría & Rúgolo, *M. pungens*, *M. seatonii* and *M. tenuissima* are newly reported as occurring in *M. subg. Pseudosporobolus*, bringing the total to 27 species for this subgenus.

It is interesting but not surprising that *Muhlenbergia phleoides*, a close relative of *M. spatha*, was found as an associated species at both collection sites in Zacatecas (Rosales 3490 & Herrera Arrieta; Peterson 25544 & Herrera Arrieta). *Muhlenbergia spatha*, *M. alopecuroides*, *M. phleoides* and *M. phalaroides* Kunth (a presumed member of this clade, not yet sampled and not included in our tree) all have plumbeous-mottled spikelets that disarticulate as a unit (below the glumes) leaving a small cuplike tip and glumes with 2–5 recurved awns (Reeder 2003; Peterson et al. in prep.). Plumbeous-mottled spikelets and well-developed sclerenchyma girders in the primary vascular bundles are additional traits shared by members of *M. subg. Pseudosporobolus* (Watson and Dallwitz 1992; Peterson and Herrera Arrieta 2001; Peterson et al. 2010b).

**Table 1.** Taxon voucher (collector, number and where the specimen is housed), country of origin and GenBank accession for DNA sequences of rps16 intron, rpl32-trnL and ITS regions (**bold** indicates new accession); a dash (–) indicates missing data.

N	TAXON	VOUCHER	Country	rps16 intron	rpl32-trnL	ITS
<b>OUTGROUP</b>						
1	<i>Distichlis scoparia</i> var. <i>erinacea</i> (Nees ex Kunth) Arechav.	Peterson 17475, Soreng & Refulio-Rodriguez (US)	Argentina, Neuquen	GU360477	GU359803	GU359334
2	<i>Sporobolus indicus</i> (L.) R. Br.	Peterson 22025 & Saarela (US)	Mexico, Chihuahua	GU360355	GU359913	GU359209
3	<i>Willkommia sarmentosa</i> Hack.	Schweickerdt 2181 (US)	South Africa,	GU360343	GU359924	GU359194
<b>MUHLENBERGIA</b>						
4	<i>Muhlenbergia ramosa</i> (Kunth) Swallen	Peterson 22447 & Saarela (US)	Mexico, Durango	GU360406	GU359953	GU359115
<b>subg. Bealia</b>						
5	<i>Muhlenbergia arenicola</i> Buckley	Peterson 19947 & Lara-Contreras (US)	Mexico, Coahuila	GU360413	GU359960	GU359166
6	<i>Muhlenbergia tricholepis</i> (Torr.) Columbus	Peterson 22099 & Saarela (US)	Mexico, Chihuahua	GU360305	GU359853	GU359278
<b>subg. Clomena</b>						
7	<i>Muhlenbergia durangensis</i> Y. Herrera	Peterson 13644, Knowles, Dietrich, Braxton & Gonzalez-Elizondo (US)	Mexico, Durango	HM143552	HM143162	HM143060
8	<i>Muhlenbergia montana</i> (Nutt.) Hitchc.	Peterson 22234 & Saarela (US)	Mexico, Sinaloa	GU360417	GU359964	GU359162
<b>subg. Muhlenbergia</b>						
9	<i>Muhlenbergia glauca</i> (Nees) B.D. Jacks.	Peterson 21023, Saarela, Lara Contreras & Reyna Alvarez (US)	Mexico, Coahuila	HM143563	HM143173	HM143072
10	<i>Muhlenbergia pereilema</i> P.M. Peterson	Peterson 22191 & Saarela (US)	Mexico, Sinaloa	GU360282	GU359993	GU359131
<b>subg. Pseudosporobolus</b>						
11	<i>Muhlenbergia alopecuroides</i> (Griseb.) P.M. Peterson & Columbus	Peterson 20960, Saarela, Lara Contreras & Reyna Alvarez (US)	Mexico,	GU360426	GU359976	GU359152
12	<i>Muhlenbergia alopecuroides</i> (Griseb.) P.M. Peterson & Columbus	Peterson 22008 & Saarela (US)	Mexico, Chihuahua	GU360425	GU359975	GU359153
13	<i>Muhlenbergia arenacea</i> (Buckley) Hitchc.	Peterson 10624 & Annable (US)	Mexico, Coahuila	GU360414	GU359961	GU359165
14	<i>Muhlenbergia asperifolia</i> (Nees & Meyen ex Trin.) Parodi	Peterson 15452, Soreng, Finot & Judziewicz (US)	Chile, Region III (Atacama)	HM143539	HM143149	HM143048
15	<i>Muhlenbergia atacamensis</i> Parodi	Peterson 19626, Soreng, Salariato, & Panizza, (US)	Argentina, Jujuy	GU360489	GU359879	GU359344
16	<i>Muhlenbergia cuspidata</i> (Torr. ex Hook.) Rydb.	Hill 35331 (US)	USA	HM143546	HM143156	HM143055
17	<i>Muhlenbergia decumbens</i> Swallen	Columbus 3653 (RSA)	Mexico	—	—	EF153029
18	<i>Muhlenbergia fastigiata</i> (J. Presl) Henrard	Peterson 21512, Soreng, LaTorre & Rojas Fox (US)	Peru, Ancash	HM143556	HM143166	HM143064
19	<i>Muhlenbergia implicata</i> (Kunth) Trin.	Peterson 22266, Saarela (US)	Mexico, Oaxaca	HM143568	HM143179	HM143077

N	TAXON	VOUCHER	Country	rps16 intron	rpl32-trnL	ITS
20	<i>Muhlenbergia jaime-hintonii</i> P.M. Peterson & Valdés-Reyna	Peterson 15841 & Valdés-Reyna (US)	Mexico, Nuevo León	HM143569	HM143181	HM143079
21	<i>Muhlenbergia ligulata</i> (E. Fourn.) Scribn. & Merr.	Peterson 22416 & Saarela (US)	Mexico, Durango	GU360440	GU359863	GU359273
22	<i>Muhlenbergia monandra</i> Alegria & Rúgolo	Peterson 17990 & Refulio-Rodriguez (US)	Peru, Lima	—	—	GQ397891
23	<i>Muhlenbergia multiflora</i> Columbus	Peterson 7845 & Annable (US)	USA, Colorado	GU360289	GU359985	GU359138
24	<i>Muhlenbergia palmirensis</i> Grignon & Lægaard	Peterson 9317 & Judziewicz (US)	Ecuador, Chimbo- razo	HM143586	HM143200	HM143098
25	<i>Muhlenbergia paniculata</i> (Nutt.) Columbus	Peterson 12070 & Annable (US)	USA, Colorado	GU360375	GU359936	GU359201
26	<i>Muhlenbergia phleoides</i> (Kunth) Columbus	Peterson 24452, Romaschenko & Valdés-Reyna (US)	Mexico, Nuevo León	—	<b>MH400231</b>	<b>MH400228</b>
27	<i>Muhlenbergia phleoides</i> (Kunth) Columbus	Peterson 24799, Romaschenko, Rodriguez Avalos, Herrera-Simoni, & Garcia Rodriguez (US)	Mexico, Aguascalientes	—	<b>MH400232</b>	<b>MH400229</b>
28	<i>Muhlenbergia pungens</i> Thurb. ex A. Gray	Ricketson 4642 (MO)	USA, Arizona	<b>MH508106</b>	<b>MH508102</b>	<b>MH508098</b>
29	<i>Muhlenbergia repens</i> (J. Presl) Hitchc.	Peterson 7900 & Annable (US)	USA, New Mexico	<b>HM143596</b>	<b>HM143212</b>	<b>HM143110</b>
30	<i>Muhlenbergia richardsonis</i> (Trin.) Rydb.	Peterson 7832 & Annable (US)	USA, Colorado.	HM143598	HM143214	HM143112
31	<i>Muhlenbergia seatonii</i> Scribn.	Peterson 9946	Mexico, Puebla	<b>MH508107</b>	<b>MH508103</b>	<b>MH508099</b>
32	<i>Muhlenbergia spatha</i> Columbus	Schaffner 134 (US)	Mexico,	—	GU359981	<b>MH400230</b>
33	<i>Muhlenbergia subbiflora</i> Hitchc.	Peterson 21158, Saarela, Rosen & Reid (US)	Mexico, Durango	GU360439	GU359877	GU359318
34	<i>Muhlenbergia tenuissima</i> (J. Presl) Kunth	Peterson 4751 & Annable	Mexico, Jalisco	<b>MH508108</b>	<b>MH508104</b>	<b>MH508100</b>
35	<i>Muhlenbergia uniflora</i> (Muhl.) Fernald	Peterson 13212, Annable, Pizzolato, Gordon, Frett, Frick, Morrone & Griner (US)	USA, New Jersey	HM143616	HM143232	HM143130
36	<i>Muhlenbergia uniflora</i> (Muhl.) Fernald	Peterson 20862 & Saarela (US)	USA, New York	GU360275	GU359994	GU359119
37	<i>Muhlenbergia utilis</i> (Torr.) Hitchc.	Peterson 24869 & Romaschenko (US)	Mexico, San Luis Potosí	—	<b>MH508105</b>	<b>MH508101</b>
38	<i>Muhlenbergia villosa</i> Hitchc.	Peterson 15811 & Valdés-Reyna (US)	Mexico, Nuevo León	HM143620	HM143236	HM143133
39	<i>Muhlenbergia wrightii</i> Vasey ex J.M. Coulter.	Peterson 20964, Saarela, Lara Contreras & Reyna Alvarez (US)	Mexico, Coahuila	HM143623	HM143240	HM143137
<b>subg. <i>Trichochloa</i></b>						
40	<i>Muhlenbergia rigens</i> (Benth.) Hitchc.	Peterson 22129 & Saarela (US)	Mexico, Chihuahua	GU360357	GU359951	GU359117
41	<i>Muhlenbergia longiligula</i> Hitchc.	Peterson 15224 & Cayouette (US)	USA, Arizona	HM143574	HM143187	HM143085



**Figure 1** Maximum-likelihood tree inferred from combined plastid (*yp/32-trnL, rps16* intron) and ITS sequences. Thick branches indicate posterior probabilities of 1; numbers above branches are posterior probabilities less than 1 but greater than 0.50; Scale bar: 2%.

**Table 2.** Characteristics of the three regions, *rPL32-trnL*, *rps16* intron and ITS and parameters used in Bayesian analyses indicated by Akaike Information Criterion (AIC).

	<i>rPL32-trnL</i>	<i>rps16</i> intron	<i>Combined plastid data</i>	ITS	Overall
Total aligned characters	996	1088	2084	761	2845
Likelihood score (-lnL)	4758.44	3429.94		9569.67	
Number of substitution types	6	6	-	6	-
Model for amongst-site rate variation	gamma	gamma	-	gamma	-
Substitution rates					
rAC	1.1071	1.2315		1.5168	
rAG	1.8768	1.2968		2.8806	
rAT	0.4688	0.4669		1.9244	
rCG	1.2702	1.0243		0.7054	
rCT	1.4748	2.4545		5.3115	
rGT	1.0000	1.0000		1.0000	
Character state frequencies					
fA	0.3827	0.3860		0.2585	
fC	0.1189	0.1105		0.1967	
fG	0.1241	0.1772		0.2539	
fT	0.3740	0.3261		0.2907	
Proportion of invariable sites	0.1608	0.3844	-	0.3790	-
Substitution model	TVM+G	TVM+G	-	GTR+I+G	-
Gamma shape parameter ( $\alpha$ )	0.9290	0.9303	-	0.7988	-

## Taxonomy

*Muhlenbergia spatha* Columbus, Aliso 28: 66. 2010, non *Muhlenbergia gracilis* (Kunth) Trin. (1824).

Fig. 2A–D

*Schaffnera gracilis* Benth., Hooker's Icon. Pl. 14: 59, t. 1378. 1882. *Schaffnerella gracilis* (Benth.) Nash, N. Amer. Fl. 17(2): 141. 1912, non *Schaffneria* Fée ex T. Moore (1857). *Muhlenbergia columbi* P.M. Peterson, Amer. J. Bot. 97(9): 1543. 2010, nom. illeg. superfl. Type: Mexico, San Luis Potosí, mountains of San Miguelita, Aug 1876, J.G. Schaffner 1070 (holotype: K-000309066 [image!]; isotypes PH-00022592 [image!], US-397116!, YU-063983 [image!]).

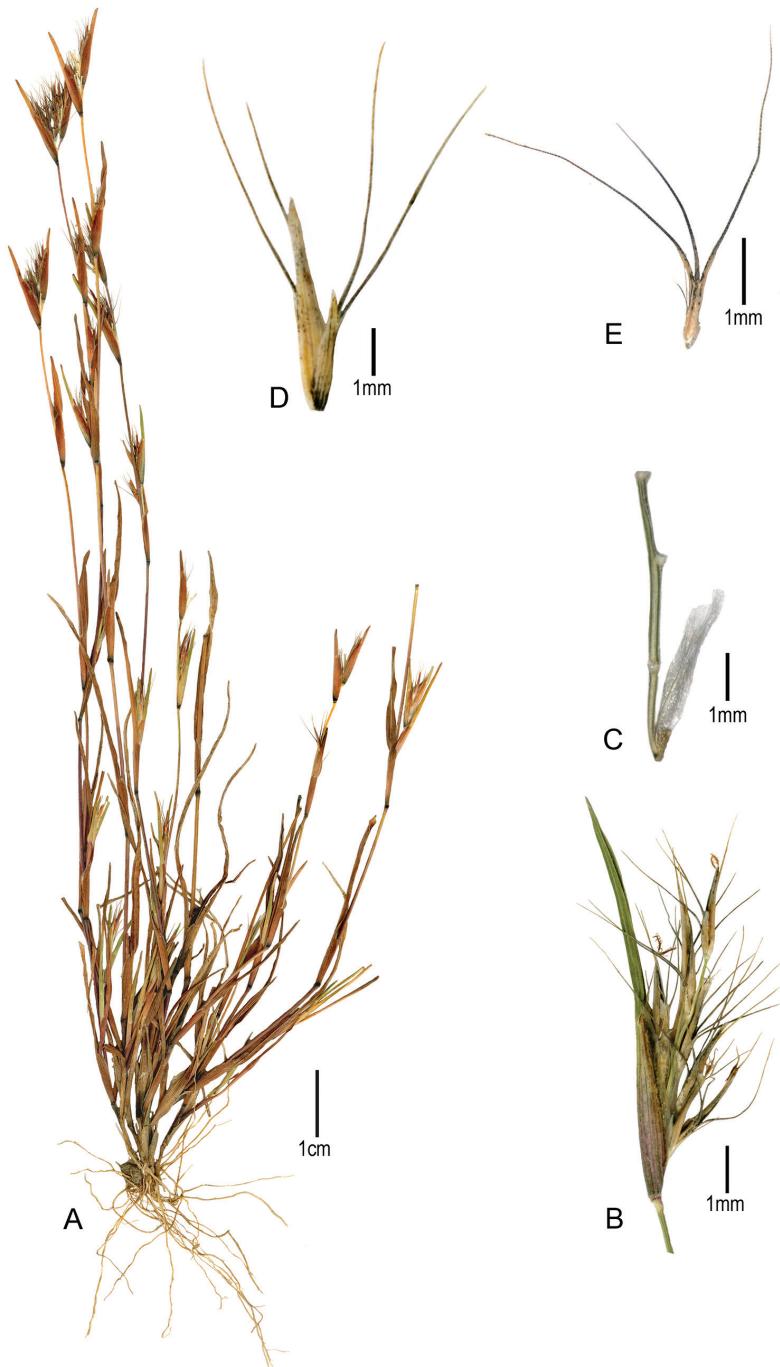
**Description.** Delicate **annuals**, loosely caespitose. **Culms** 5–20(–30) cm tall, erect, geniculate below; **nodes** scaberulous, branching at lower and middle nodes; **internodes** 2.0–4.5(–8.0) cm long, strongly 4–6 ribbed. **Leaves** caulescent and basal; **ligules** 0.8–1.8 mm long, membranous, decurrent, apex obtuse, minutely erose; **sheaths** 0.8–1.5 cm long, much shorter than the internodes, oblong, open, chartaceous, strongly ribbed with 7–9 veins, sometimes keeled, margins hyaline; **blades** 0.5–4 cm long, 0.5–1.5 mm wide, flat or folded, adaxially scattered pubescent near base, the hairs antrorse leaning,

apex obtuse. **Inflorescences** compound, fasciculate, composed of terminal and axillary condensed **panicles**, these branched near the base, the basal-most branch usually with a sterile floret at the base consisting of two scales, the entire panicle partially included in a spatheolate sheath; **sterile florets** 2–4 mm long, 0.8–1 mm wide, linear-apiculate, flat, hyaline, 1-veined; **racemose branches** each bearing 1–5 fertile sessile spikelets, the spikelets separated by 1–4 mm on each branch; **rachis** angular, 3 or 4-ribbed. **Spikelets** 4.4–6 mm long, lanceolate, laterally compressed, solitary, composed of one fertile floret, plumbeous-mottled; **rachilla** not extended; **callus** short, blunt, pubescent, located just below the glumes where disarticulation occurs leaving a small cuplike tip; **glumes** dimorphic; **lower glumes** absent or obscure; **upper glumes** 3.5–5(–6) mm long, about as long as the lemma, oblong, chartaceous, firmer than fertile lemma (excluding the awns), 7–9-veined, lateral veins ribbed, pubescent along the veins on lower ½, apex deeply bifid and 3(5)-awned, the awns 5–7 mm long, scabrous, recurved, arising between the bifid apex; **lemmas** (4–)4.8–6 mm long, lanceolate, membranous, 3-veined, keeled, midvein scaberulous, lateral veins ribbed, apex acute to acuminate, minutely bifid, 1-awned, the awn 3–5 mm long arising from between the teeth; **paleas** 3.7–5.5 mm long, shorter than the lemmas, oblong, hyaline to membranous, tightly involute, 2-veined, apex obtuse, unawned; **stamens** 3; **anthers** 2–2.5 mm long, yellowish; **ovary** glabrous; **caryopses** 1.8–2 mm long, 0.5 mm wide, narrowly fusiform, straw coloured.

**Distribution.** The species is known only from the type locality in San Luis Potosí and Municipio Villanueva, Zacatecas.

**Ecology.** *Muhlenbergia spatha* was found by the authors growing on flat table rock in open areas near arroyos associated with *Bouteloua hirsuta* Lag., *B. curtipendula* (Michx.) Torr., *Schizachyrium sanguineum* (Retz.) Alston, *Quercus*, *Juniperus*, *Muhlenbergia implicata* (Kunth) Trin., *M. phleoides*, *M. rigida* (Kunth) Kunth, *Chloris submutica* Kunth, *Digitaria ternata* (A. Rich.) Stapf, *Microchloa kunthii* Desv., *Aristida adscensionis* L., *A. divaricata* Humb. & Bonpl. ex Willd., *Enneapogon desvauxii* P. Beauvois, *Piptochaetium fimbriatum* (Kunth) Hitchc., *Eragrostis intermedia* Hitchc., *E. pectinacea* (Michx.) Nees and *Eleusine multiflora* Hochst. ex A. Rich.

**Habitat.** At the southern edge of the Sierra Madre Occidental Range in the Sierra Fría de Aguascalientes, we recently found *Muhlenbergia spatha* in two localities south of the city of Zacatecas in a corridor located east of Villanueva: 1) 17.4 km east of Villanueva on flat table rock just above Arroyo “El Muerto” in open areas and 2) about 1 km northeast of the small village Palomas Viejas along Arroyo Juan Manuel on natural grasslands near cultivated fields. These two sites are approximately 204 km W (air distance) from the type locality southwest of San Luis Potosí in the Sierra de San Miguelito along the Río Potosino (Columbus et al. 2001). According to Instituto Nacional de Estadística, Geografía e Informática [INEGI] (2003, 2005), the Sierra San Miguelito is placed in the Mesa del Centro Province in the Sierra Madre Oriental. Near Villanueva, Zacatecas, the soils are Haplic Phaeozem (forming sodium carbonate,  $\text{Na}_2\text{CO}_3$ ) over extrusive igneous rock (acidic) in a semi-dry climate with an annual mean temperature of 16°C and an annual mean precipitation of 60 cm (INEGI 2008a, 2008b). In the Sierra de San Miguelito along the Rio Potosino, the soils are Calcic



**Figure 2.** *Muhlenbergia spatha*: **A** Habit **B** Panicle partially enclosed by the leaf sheath **C** Basal panicle branch with a lower sterile floret and small cuplike structures (callus remains) where the fertile spikelets were inserted **D** Spikelet, side view **E** Upper glume showing three recurved awns, dorsal view. (*Peterson 25544 & Herrera Arrieta, CIIDIR*).

Regosol (forming calcium carbonate,  $\text{CaCO}_3$ ) of medium texture over extrusive igneous rock (acidic) in a semi-dry climate with an annual mean temperature of 16 °C and an annual mean precipitation of 40 cm (INEGI 2008a, 2008b). Without field verification, it is uncertain whether the soil differences among these sites are significant, but we are reasonably certain that all are alkaline with an elevated pH.

**Conservation status.** The species is rare in Mexico and is known from only three recent collections. Since it is a diminutive, short-lived annual, the species is easily overlooked and the main concern seems to be loss of habitat via human impact, i.e. agriculture, dam and road construction.

**Specimens examined.** Mexico. **San Luis Potosí:** 1876, *J.G. Schaffner* 134 (GOET-006918 [image!], US-825687); Sierra de San Miguelito, Río Potosino, 22°04'55"N, 101°03'51"W, 1980 m, 2 Oct 2001, *J.T. Columbus* 4040 (RSA [image! in Columbus et al. 2001]). **Zacatecas:** Mpio. Villanueva, Arroyo Juan Manuel ± 1 km NE of Palomas Viejas near Villanueva, 22°24'36"N, 102°43'01"W, 2112 m, 22 Oct 2006, *O. Rosales* 3490 ♂ & *Y. Herrera Arrieta* (CIIDIR); Mpio Villanueva, 10.8 mi [17.4 km] E of Villanueva, just above arroyo “El Muerto”, 22°22'47.1"N, 102°43'31.5"W, 2083 m, 2 Oct 2015, *P.M. Peterson* 25544 ♂ & *Y. Herrera Arrieta* (CIIDIR, US).

**Comments.** The hand written script (verified by J. Rzedowski, per. comm., also see Rzedowski 1959) on the label of the holotype (K) says: “*Muehlenbergia gracilis* mihi,” indicating that Jose Guillermo Schaffner thought he had collected a new species of *Muhlenbergia*. Bentham (1882) agreed with Schaffner that it was a new species but thought it had enough unique morphological features (spatheolate sheathed panicles, sessile spikelets and 3(5)-awned upper glumes) to warrant description of a new genus.

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## References

- Beal WJ (1896) Grasses of North America, Vol. II. Henry Holt and Company, New York, 1–706.  
Bentham G (1882) Plate 1378. *Schaffnera gracilis*, Benth. Gramineae, Tribe Zoysieae? Hooker’s Icones Plantarum 14: 59.

- Clayton WD, Renvoize SA (1986) Genera graminum. Grasses of the world. Kew Bulletin, Additional Series 13: 1–389.
- Columbus JT, Bell HL, Cerros-Tlatilpa R, Griffith MP, Porter JM (2001) *Schaffnerella* re-discovered! (Gramineae, Chloridoideae). Aviso 20: 45–90. <https://doi.org/10.5642/ali-so.20012001.08>
- Columbus JT, Peterson PM, Refulio Rodríguez NF, Cerros-Tlatilpa R, Kinney MS (2010) Phylogenetics of Muhlenbergiinae (Poaceae: Chloridoideae, Cynodonteae) based on ITS and *trnL*-*F*DNA sequences. Aarhus University Press, Aarhus, 477–496.
- Conzatti C (1988) Flora taxonomica Mexicana, Vol. I. Consejo Nacional de Ciencia Y Tecnología, Mexico D.F., 1064 pp.
- INEGI (2003) Cartas de Uso del Suelo y Vegetación. Conjunto de datos vectoriales de la carta de Uso del suelo y vegetación. Escala 1:1 000000. Serie II (Continuo Nacional). <http://www.inegi.org.mx/>
- INEGI (2005) Geología. Conjunto de datos vectoriales. Escala 1:1 000000. <http://www.inegi.org.mx/>
- INEGI (2008a) Cartas climatológicas. Conjunto de datos vectoriales. Escala 1:1 000000. <http://www.inegi.org.mx/>
- INEGI (2008b) Perfiles de Suelos, Estados Unidos Mexicanos. Conjunto de datos vectoriales. Escala 1:1000000. <http://www.inegi.org.mx/>
- Nash GV (1912) 36. *Schaffnerella* Nash. In: Britton NL, Murrill WA, Barnhart JH (Eds) North American flora 17(2). New York Botanical Garden, New York, 141.
- Peterson PM, Herrera Arrieta Y (2001) A leaf blade anatomical survey of *Muhlenbergia* (Poaceae: Muhlenbergiinae). *Sida* 19: 469–506.
- Peterson PM, Romaschenko K, Herrera Arrieta Y (2015) Phylogeny and subgeneric classification of *Bouteloua* with a new species, *B. herrera-arrietae* (Poaceae: Chloridoideae: Cynodonteae: Boutelouinae). *Journal of Systematics and Evolution* 53(4): 351–366. <https://onlinelibrary.wiley.com/doi/10.1111/jse.12159>. <https://doi.org/10.1111/jse.12159>
- Peterson PM, Romaschenko K, Herrera Arrieta Y (2016) A molecular phylogeny and classification of the Cynodonteae (Poaceae: Chloridoideae) with four new genera: *Orthacanthus*, *Triplasiella*, *Tripogonella*, and *Zaqiqah*; three new subtribes: Dactylocteniinae, Orininae, and Zaqqahinae; and a subgeneric classification of *Distichlis*. *Taxon* 65(6): 1263–1287. <https://doi.org/10.12705/656.4>
- Peterson PM, Romaschenko K, Herrera Arrieta Y (2017) Four new subtribes: Allolepiinae, Jouveinae, Kaliniinae, and Sohnsiinae in the Cynodonteae (Poaceae: Chloridoideae). *Phytoneuron* 2017–44: 1–9. <http://www.phytoneuron.net/2017Phytoneuron/44PhytoN-ChloridoidSubtribes.pdf>
- Peterson PM, Romaschenko K, Johnson G (2010a) A classification of the Chloridoideae (Poaceae) based on multi-gene phylogenetic trees. *Molecular Phylogenetics and Evolution* 55(2): 580–598. <https://doi.org/10.1016/j.ympev.2010.01.018> PubMed
- Peterson PM, Romaschenko K, Johnson G (2010b) A phylogeny and classification of the Muhlenbergiinae (Poaceae: Chloridoideae: Cynodonteae) based on plastid and nuclear DNA sequences. *American Journal of Botany* 97(9): 1532–1554. <https://doi.org/10.3732/ajb.0900359> PubMed

- Peterson PM, Romaschenko K, Soreng RJ (2014) A laboratory guide for generating DNA bar-codes in grasses: a case study of *Leptochloa* s.l. (Poaceae: Chloridoideae). *Webbia* 69(1): 1–12. <https://doi.org/10.1080/00837792.2014.927555>
- Pilger R (1956) Gramineae II. Duncker & Humblot, Berlin, 1–168.
- Reeder CG (2003) 17.34 *Lycurus* Kunth. In: Barkworth ME, Capels KM, Long S, Piep MB (Eds) Magnoliophyta: Commelinidae (in part): Poaceae, part 2 Flora of North America North of Mexico, Vol 25. Oxford University Press, New York, 200–203.
- Rzedowski J (1959) Las colecciones botánicas de Wilhelm (Jose Guillermo) Schaffner en San Luis Potosí. I. Acta Científica Potosina 3: 99–121.
- Soreng RJ, Peterson PM, Romaschenko K, Davidse G, Teisher JK, Clark LG, Barberá P, Gillespie LJ, Zuloaga FO (2017) A worldwide phylogenetic classification of the Poaceae (Gramineae) II: An update and a comparison of two 2015 classifications. *Journal of Systematics and Evolution* 55(4): 259–290. [http://onlinelibrary.wiley.com/doi/10.1111/jse.12262](http://onlinelibrary.wiley.com/doi/10.1111/jse.12262/full) <https://doi.org/10.1111/jse.12262>
- Watson L, Dallwitz M (1992) The Grass Genera of the World. CAB International, Wallingford, 1038 pp.