



Revisions in the South American *Calandrinia caespitosa* complex (Montiaceae)

ARVE ELVEBAKK^{1*}, ANA ROSA FLORES² & JOHN MICHAEL WATSON²

¹University of Tromsø – Arctic University of Norway, Tromsø University Museum, N-9037 Tromsø, Norway;

e-mail: arve.elvebakk@uit.no

²Casilla 161, Los Andes, Chile; e-mail: john.anita.watson@gmail.com

* author for correspondence

Abstract

Calandrinia caespitosa is one of seven species currently recognized in *Calandrinia* sect. *Acaules*. It has been interpreted by all recent studies to represent a single species with variable flower colours. It is here shown that, on the contrary, this entity is a complex which includes four distinct species. *C. caespitosa* inhabits depressions at elevations between 2500 and 4000 m in the Andes mountains between 29° S and 36° S. It is morphologically characterized in having 6–8 ellipsoid, flamboyant red petaloids, yellowish-green towards the base. Its typification is discussed, while the synonyms *C. diffusa* and *C. densiflora* are neotypified on specimens preserved at K. *C. skottsbergii* grows in dry, gravelly mountains in central Patagonia from ca. 38–47° S. It has 6–12 petaloids which are truncate and longer and broader than those of *C. caespitosa*, orange or rarely yellow, and capsules much larger than those of *C. caespitosa*. A deviating species pair occurs in southern Patagonia: *C. fuegiana* with white or pinkish petaloids and *C. ranunculina* with yellow petaloids. The latter species is described in this study as new to science. Both *C. fuegiana* and *C. ranunculina* share a rather small, weakly zygomorphic perianth with 2+4 petaloids which open for a short period, and then close to allow for self-pollination when the anthers move towards the stigma. This is interpreted here as an adaptation to the very strong winds prevailing in their habitats. *C. fuegiana* grows in screes and snow beds in the high mountains from 47° S to near 52° S, in addition to an isolated distribution area further south in the mountains near Lago Fagnano in Tierra del Fuego at c. 54° 30' S. Its capsules are large and similar to those of *C. skottsbergii*, except that they curve distinctly when mature. *C. ranunculina*, on the other hand, has adapted to the lowland steppes of southern Patagonia (49° to 54° S), and has very distinct, short and urn-shaped capsules with strongly recurving valves. No hybrids between these species have been detected where any of them meet. A distribution map and a table including comparison of 30 characters between the species are also presented, as well as SEM images of seeds, which also differ morphologically between the species.

Key words: Argentina, Chile, distribution, new species, pollination, self-pollination, taxonomy

Introduction

The genus *Calandrinia* Kunth (in Humboldt *et al.* 1823: 77) has traditionally been placed within Portulacaceae Juss. (e.g., Barnéoud 1846, Pax & Hoffmann 1934, Añón 1984). A recent revision by Nyffeler & Egli (2010) has shown, however, that some genera, including *Calandrinia*, have to be transferred to the family Montiaceae Raf.

From the nomenclatural point of view, *Calandrinia* has been conserved at genus level, with *C. caulescens* Kunth (in Humboldt *et al.* 1823: 78) treated as generitype, vs. the predating genus *Baitaria* Ruíz & Pavón (1794: 63) with its subsequently described species *B. acaulis* Ruíz & Pavón (1798: 111).

Calandrinia was originally described including two species: *C. caulescens* Kunth and *C. acaulis* Kunth (in Humboldt *et al.* 1823: 78). Subsequently, additional taxa were described or new combination were proposed (e.g., Candolle 1828, Arnott 1831, Barnéoud 1846, Philippi 1856). Barnéoud (1846) listed 51 species from Chile. Pax & Hoffman (1934), indicated c. 150 species, and its inclusion in *Claytonia* Linnaeus (1753: 204) as proposed meanwhile by Kuntze (1891: 56) had been rejected. From the 1980s, *Calandrinia* was still considered to be a large and diverse genus, with its species number referred to as “ca. 150” (Añón 1984), “above 100” (Hershkovitz 1991) or “125” (Judd *et al.* 2002).

A revision process was initiated by Carolin (1987), who highlighted the high heterogeneity of *Calandrinia*. On the basis of the evaluation of many morphological and anatomical characters and a cladistic analysis, he proposed to split

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References

- Ackermann, M. & Weigend, M. (2006) Nectar, floral morphology and pollination syndrome in Loasaceae subfam. Loasoideae (Cornales). *Annals of Botany* 98: 503–514.
<http://dx.doi.org/10.1093/aob/mcl136>
- Añón S. de C., D. (1953) Las especies argentinas del género *Calandrinia*. *Boletín de la Sociedad Argentina de Botánica* 5: 1–29.
- Añón S. de C., D. (1984) Portulacaceae. In: Correa, M.N. (Ed.) *Flora Patagónica* 4a. *Dicotyledones dialipétalas (Salicaceae a Cruciferae)*. Colección Científica del Instituto Nacional de Tecnología Agropecuaria (INTA), VII (IV a). INTA, Buenos Aires, pp. 167–195.
- Añón S. de C., D. & Peralta, I.E. (1994) Portulacaceae. Portulacáceas. Familia de las portulacas. In: Kiesling, R. (Ed.) *Flora de San Juan, Republica Argentina. Pteridofitas, Gimnospermas, Dicotiledoneas Dialipetalas (Salicaceas a Leguminosas)* 1. Vazquez Mazzini Editores, Buenos Aires, pp. 144–171.
- Arnott, G.A.W. (1831) On some new species of Portulacaceae. *Edinburgh Journal of Natural and Geographical Science, New Series* 3: 354–356.
- Arroyo, M.T.K., Primack, R. & Armesto, J. (1982) Community studies in pollination ecology in the high temperate Andes of Central Chile. I. Pollination mechanisms and altitudinal variation. *American Journal of Botany* 69: 82–97.
<http://dx.doi.org/10.2307/2442833>
- Arroyo, M.T.K., Marticorena, C., Miranda, P., Matthei, O., Landero, A. & Squeo, F. (1989) Contribution to the high elevation flora of the Chilean Patagonia: a checklist of species on mountains on an east-west transect in the Sierra de los Baguales, latitude 50° S. *Gayana Botánica* 46: 121–151.
- Barnéoud, F.M. (1846) Portulacaceae. In: Gay, C. (Ed.) *Historia física y política de Chile* 2. Fain & Thunot, Paris & Museo de Historia Natural de Santiago, pp. 466–515.
- Bird, J. (1938) Antiquity and migrations of the early inhabitants of Patagonia. *The Geographical Review* 28: 250–275.
<http://dx.doi.org/10.2307/210474>
- Boelcke, O., Correa, M.N., Moore, D.M. & Roig, F.A. (1985) Catálogo de las plantas vasculares. In: Boelcke, O., Moore, D.M. & Roig, F.A. (Eds.) *Transecta botánica de la Patagonia austral*. Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina), Instituto de la Patagonia (Chile) and Royal Society (Great Britain), Buenos Aires, pp. 129–255.
- Candolle, F.A. de (1828) *Prodromus systematis naturalis regni vegetabilis sive enumeratio contracta ordinum generum specierumque plantarum huc usque cognitarum, juxta methodi naturalis normas digesti* 3. Parisiis, Treuttel et Würtz, Paris, 494 pp.
- Carolin, R.C. (1987) A review of the family Portulacaceae. *Australian Journal of Botany* 35: 383–412.
<http://dx.doi.org/10.1071/BT9870383>
- Carolin, R.C. (1993) Portulacaceae. In: Kubitzki, K., Rohwer, J.G. & Bittrich, V. (Eds.) *The families and genera of vascular plants. Flowering plants, dicotyledons. Magnoliid, Hamamelid and Caryophyllid families* 2. Springer-Verlag, Berlin, Heidelberg, New York, pp. 544–555.
- Erskine, P. (1994) With the AGS in the Andes. *Bulletin of the Alpine Garden Society* 62: 255–292.
- Ferreya, M., Ezcurra, C. & Clayton, S. (2005) *Flores de alta montaña de los Andes patagónicos*. Editorial Literature of Latin America (LOLA), Buenos Aires, 239 pp.
- Fjeldså, J. & Krabbe, N. (1990) *Birds of the High Andes*. Zoological Museum, University of Copenhagen & Apollo Books, Svendborg, Denmark, 881 pp

- Ford, D.I. (1993) New combinations in *Montiopsis* Kuntze (Portulacaceae). *Phytologia* 74: 273–278.
- Gandoger, M.M. (1912) Manipulas plantarum novarum praecipue Americae australioris. *Bulletin de la Société Botanique de France* 59: 704–710.
<http://dx.doi.org/10.1080/00378941.1912.10832498>
- Henríquez, J.M., Pisano, E. & Marticorena, C. (1995) Catálogo de la flora vascular de Magallanes (XII Región, Chile). *Anales del Instituto de la Patagonia, Series Ciencias Naturales* 23: 5–30.
- Hershkovitz, M.A. (1991a) Phylogenetic assessment and revised circumscription of *Cistanthe* Spach (Portulacaceae). *Annals of the Missouri Botanical Garden* 78: 1009–1021.
<http://dx.doi.org/10.2307/2399741>
- Hershkovitz, M.A. (1991b) Taxonomic notes on *Cistanthe*, *Calandrinia* and *Talinum*. *Phytologia* 70: 209–225.
- Hershkovitz, M.A. (1993) Revised circumscriptions and subgeneric taxonomies of *Calandrinia* and *Montiopsis* (Portulacaceae) with notes on phylogeny of the portulacaceous alliance. *Annals of the Missouri Botanical Garden* 80: 333–365.
<http://dx.doi.org/10.2307/2399789>
- Hershkovitz, M.A. (1999) *Parakeelya*: a new genus segregated from *Calandrinia*. *Phytologia* 84: 98–106.
- Hershkovitz, M.A. (2006) Ribosomal and chloroplast DNA evidence for diversification of western American Portulacaceae in the Andean Region. *Gayana Botánica* 63: 13–74.
<http://dx.doi.org/10.4067/S0717-66432006000100002>
- Hershkovitz, M.A. & Ford, D.I. (1993) *Calandrinia carolinii*: new name for *Baitaria acaulis* Ruiz & Pavón. *Phytologia* 74: 279–283.
- Hershkovitz, M.A. & Zimmer, E.A. (2000) Ribosomal DNA evidence and disjunctions of western American Portulacaceae. *Molecular Phylogenetics and Evolution* 15: 419–439.
<http://dx.doi.org/10.1006/mpev.1999.0720>
- Hoffmann, A., Arroyo, M.K., Liberona, F., Muñoz, M. & Watson, J. (1998) *Plantas altoandinas en la flora silvestre de Chile*. Ediciones Fundación Claudio Gay, Santiago de Chile, 281 pp.
- Hood, M.E., Mena-Ali, J.I., Gibson, A.K., Oxelman, B., Giraud, T., Yockteng, R., Arroyo, M.T.K., Conti, F., Pedersen, A.B., Gladieux, P. & Antonovics, J. (2010) Distribution of the anther-smut pathogen *Microbotryum* on species of the Caryophyllaceae. *New Phytologist* 187: 217–229.
<http://dx.doi.org/10.1111/j.1469-8137.2010.03268.x>
- Humboldt, F.W.H.A., Bonpland, A.J.A. & Kunth, K.S. (1823) *Nova genera et species plantarum* 6. Librairie Graeco-Latino-Germanica, Paris, 600 pp.
- IUCN. (2012) *IUCN Red list categories and criteria: version 3.1*. Second edition. Gland, Switzerland and Cambridge, UK: IUCN. iv + 32 pp. Available from: http://jr.iucnredlist.org/documents/redlist_cats_crit_en.pdf.
- IUCN (2014) *The IUCN red list of threatened species: version 2014.2*. IUCN Red List Unit, Cambridge, U.K. Available from: <http://www.iucnredlist.org/> (accessed 5 November 2014).
- Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. & Donoghue, M.J. (2002) *Plant systematics, a phylogenetic approach*. Second edition. Sinauer Ass., Inc., Sunderland, Massachusetts, USA, 576 pp.
- Linnaeus, C. (1753) *Species plantarum* 1, Holmiae, Impensis Laurentii Salvii, 560 pp.
- Kuntze, C.E.O. (1891) *Revisio generum plantarum vascularium omnium atque cellularium multarum secundum leges nomenclaturae internationales cum enumeratione plantarum exoticarum in itinere mundi collectarum* 1. A. Felix, Leipzig, I–CLV, 374 pp.
- Kuntze, C.E.O. (1898) *Revisio generum plantarum vascularium omnium atque cellularium multarum secundum leges nomenclaturae internationales cum enumeratione plantarum exoticarum in itinere mundi collectarum* 3. A. Felix, Leipzig, CLVI–CDXX, 576 pp.
- Marticorena, C. & Quezada, M. (1985) Catálogo de la flora vascular de Chile. *Gayana Botánica* 42: 1–157.
- Martínez, D. & González, G. (2005) *Las aves de Chile: nueva guía de campo*. Ediciones del Naturalista, Santiago de Chile, 620 pp.
- McNeill, J., Barrie, F.R., Buck, W.R., Demoulin, V., Greuter, W., Hawksworth, D.L., Heredeen, P.S., Knapp, S., Marhold, K., Prado, J., Prud'Homme van Reine, W.F., Smith, G.F., Wiersema, J.H. & Turland, N.J. (Eds.) (2012) International code of nomenclature for algae, fungi & plants: Adopted by the Eighteenth International Botanical Congress, Melbourne, Australia, July 2011. *Regnum Vegetabile* 154: 1–274.
- Moore, D.M. (1975) The alpine flora of Tierra del Fuego. *Anales del Instituto Botánico A. J. Cavanilles* 32: 419–443.
- Moore, D.M. (1983a) *Flora of Tierra del Fuego*. Anthony Nelson & Missouri Botanical Garden, Oswestry, England & Missouri, 396 pp.
- Moore, D.M. (1983b) The flora of the Fuego-Patagonian cordilleras: its origins and affinities. *Revista Chilena de Historia Natural* 56: 123–136.
- Nyffeler, R. & Eggli, U. (2010) Disintegrating Portulacaceae: a new familial classification of the suborder Portulacineae (Caryophyllales) based on molecular and morphological data. *Taxon* 59: 227–240.
- Obbens, F.J. (2011) Five new species of *Calandrinia* (Portulacaceae) from Western Australia with additional information on morphological observations. *Nyutsia* 21: 1–23.

- Pande, P.C. (2001) *Calandrinia ciliata* (Ruiz & Pavón) DC: a new record for India. *Journal of Economic and Taxonomic Botany* 25: 269–270.
- Pax, F.A. & Hoffman, K. (1934) Portulacaceae. In: Engler, A. & Harms, H. (Eds.) *Die natürlichen Pflanzenfamilien nebst ihren Gattungen und wichtigeren Arten, insbesondere den Nutzpflanzen* 20(16c). Engelmann, Berlin, pp. 234–262.
- Peralta, I.E. (1988) Sinopsis de las especies de *Calandrinia* (Portulacaceae) de los Andes Mendocinos. *Boletín de la Sociedad Argentina de Botánica* 25: 514–537.
- Peralta, I.E. (1990) Portulacaceae. In: Zuloaga, F.O. & Morriconi, O. (Eds.) *Catálogo de las plantas vasculares de la República Argentina II. Fabaceae – Zygophyllaceae (Dicotyledoneae). Monographs in Systematic Botany from the Missouri Botanical Garden* 74: 948–951.
- Peralta, I.E. (1996) Valor taxonómico de los caracteres de las semillas en *Calandrinia sensu lato*. (Portulacaceae). *Multequina* 5: 91–110.
- Peralta, I.E. & Ford-Wentz, D.I. (2008) Portulacaceae. In: Zuloaga, F.O., Morrone, O., Belgrano, M.J., Marticorena, C. & Marchesi, E. (Eds.) *Catálogo de las Plantas Vasculares del Cono Sur (Argentina, Sur de Brasil, Chile, Paraguay y Uruguay). Dicotyledoneae: Fabaceae (Senna-Zygia) – Zygophyllaceae* 3. *Monographs in Systematic Botany from the Missouri Botanical Garden* 107: 2796–2817.
- Pérez, F., Arroyo, M.T.K., Medel, R. & Hershkovitz, M.A. (2006) Ancestral reconstruction of flower morphology and pollination systems in *Schizanthus* (Solanaceae). *American Journal of Botany* 93: 1029–1038.
<http://dx.doi.org/10.3732/ajb.93.7.1029>
- Philippi, R.A. (1856) Plantarum novarum chilensium. *Linnaea* 28: 609–655, 661–752.
- Philippi, R.A. (1893) Plantas nuevas chilenas de las familias Rosáceas, Onagráceas i demás familias del tomo II de Gay (continuación): Portuláceas. *Anales de la Universidad de Chile* 85: 167–195.
- Riedemann, P., Aldunate, G. & Teillier, S. (2008) *Flora nativa de valor ornamental, identificación y propagación. Chile: Zona Cordillera de los Andes*. Corporación Jardín Chagual, Santiago de Chile, 674 pp.
- Reiche, K. (1897) Zur Systematik der chilenischen Arten der Gattung *Calandrinia*. *Berichte der deutschen botanischen Gesellschaft* 15: 493–503.
- Reiche, K. (1898) Familia Portulacáceas. In: Reiche, K. (Ed.) *Estudios criticos de la Flora de Chile, Tomo Segundo*. Cervantes, Santiago de Chile, pp. 323–361.
- Rochette, H.E. & Wenborne, H.G. (2003) *Secretas de la Cordillera de Santiago*. Travesía Ediciones, Santiago de Chile, 190 pp.
- Rolfé, R. (1989) *Calandrinia rupestris* Barn. *Quarterly Bulletin of the Alpine Garden Society* 57: 200–202.
- Ruiz, H. & Pavón, J. (1794) *Florae peruvianaee et chilensis prodromus, sive novorum generum plantarum, et chilensium descriptiones et icones*. I–XII. Gabriel de Sancha, Madrid, 154 pp.
- Ruiz, H. & Pavón, J. (1798) *Systema vegetabilium florae peruvianaee et chilensis, characteres prodromi genericos differentiales, specium omnium differentias, durantionem, loca natalia, tempus florendi, nomina vernacula, vires et usus nonnullis illustrationibus interspersis complectens*. I–VI. Gabriel de Sancha, Madrid, 456 pp.
- Sheader, M., Brickell, C., Erskine, P., Little, H., Little, A. & Sheader, A.-L. (2013) *Flowers of the Patagonian Mountains*. Alpine Garden Society, Pershore, Worcs., England, 320 pp.
- Shrestha, M., Dyer, A.G., Boyd-Gerny, S., Wong, B.B.M. & Burd, M. (2013) Shades of red: bird-pollinated flowers target the specific colour discrimination abilities of avian vision. *New Phytologist* 198: 301–310.
<http://dx.doi.org/10.1111/nph.12135>
- Skottsberg, C. (1916) Botanische Ergebnisse der schwedischen Expedition nach Patagonien und dem Feuerlande 1907–1909. V. Die Vegetationsverhältnisse längs der Cordillera de los Andes s. von 41° s. Br. Ein Beitrag zur Kenntnis der Vegetation in Chiloé, dem andinen Patagonien und Feuerland. *Kungliga Svenska Vetenskapsakademiens Handlingar* 56(5): 1–366; pl. 23.
- Spach, É. (1836) *Histoire Naturelle des Végétaux, Phanerogames* 5. Librairie encyclopédique de Roret. Paris, 534 pp.
- Tahir, S.S. & Carolin, R.C. (2011) A new species of *Calandrinia* (Portulacaceae) from Northern Territory, Australia. *Proceedings of the Linnean Society of New South Wales* 133: 111–14.
- Teillier, S., Marticorena, A. & Niemeyer, H.M. (2011) *Flora andina de Santiago*. Universidad de Chile, Santiago de Chile, 478 pp.
- Thiers, B. (2011) *Index herbariorum, a global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium. Available from: <http://sweetgum.nybg.org/ih/> (accessed March 2014).
- Thomson, J.D. & Wilson, P. (2008) Explaining evolutionary shifts between bee and hummingbird pollination: convergence, divergence, and directionality. *International Journal of Plant Science* 169: 23–38.
<http://dx.doi.org/10.1086/523361>
- Ulbrich, O.E. (1934) Chenopodiaceae. In: Engler, A. & Prantl, K.A.E. (Eds.) *Die natürlichen Pflanzenfamilien nebst ihren Gattungen und wichtigeren Arten, insbesondere den Nutzpflanzen* 20(16c). Engelmann, Berlin, pp. 379–584.
- Vánky, K. (1998) The genus *Microbotryum* (Smut Fungi). *Mycotaxon* 67: 33–60.

- Watson, J.M. (1976) Andes, 1971 and 1972 Part 9. *Quarterly Bulletin of the Alpine Garden Society* 44: 98–108.
- Watson, J.M. (1993) *Calandrinia*. In: Beckett, K. (Ed.) *Alpine Garden Society Encyclopaedia of Alpines* 1. AGS Publications Ltd., Pershore, Worcs., England, pp. 163, 197–202.
- West, J.G. & Chinnock, R.J. (2013) *Calandrinia mirabilis* (Portulacaceae), a spectacular new species from Western Australia with notes on its ecology, seed germination and horticultural potential. *Journal of the Adelaide Botanic Gardens* 26: 97–102.
- Wingenroth, M. & Suárez, J. (1984) *Flores de los Andes. Alta montaña de Mendoza*. Instituto Argentino de Nivología y Glaciología (IANIGLA), Mendoza, 144 pp.