Systematic Botany (2015), 40(3): pp. 922–928

DOI 10.1600/036364415X689348
Date of publication September 22, 2015

A New Species of *Valeriana* from the Andean Region of Northwestern Argentina Based on Morphological and Molecular Data

Juan M. Acosta,[1,2] Luciana U. Salomón,[1] Christian A. Zanotti,[1] and Raúl E. Pozner[1]

[1]Instituto de Botánica Darwinion, Labardén 200, C. C. 22, B1642HYD San Isidro, Buenos Aires, Argentina.
[2]Author for correspondence (jacosta@darwin.edu.ar)

Communicating Editor: Ricarda Riina

Abstract*—*Valeriana serratifolia, a new species from the Andean region of northwestern Argentina, is described and illustrated. It can be distinguished from its closest morphological taxon, *V. macrorhiza*, by its entire, spathulate leaves with serrulate margin, and falcate fruits, 2–2.5 mm long, crowned by the reduced annular calyx shifted toward the ventral face. A phylogenetic analysis based on DNA sequences of plastid markers *trnL–F* and *trnK* intron supported *V. macrorhiza* as its closest related species. We also provide a key to differentiate ***V. serratifolia*** from the epappose species of *Valeriana* from Argentina.

Keywords—Taxonomy, trnL–F, trnK intron, Valeriana macrorhiza, Valeriana serratifolia, Valerianaceae.

Valeriana L. includes ca. 300 species distributed worldwide, with the exception of Australia and New Zealand. Most *Valeriana* species grow in temperate regions of the Northern Hemisphere, and particularly in the South American Andes. The high Andes species range from paramo habitats in the north to the Patagonia region in the south, which is an important center of secondary diversification (Kutschker 2008a, 2011). The Argentinian flora includes 48 species of *Valeriana*, mainly distributed along the Andes and central mountains (Borsini 1944, 1960, 1962b; Xifreda 1999; Kutschker 2008b; Méndez 2010; Kutschker 2011; Zanotti et al. 2014).

During a floristic study of the vegetation from northwestern Argentina, we found an epappose taxon of *Valeriana* not assignable to any other recorded species from that area and the rest of South America. Based on the morphological and molecular study of this material, revision of herbarium specimens and images of types, we propose a new species. We discuss its morphological relatives and phylogenetic relationships. In addition, we include a key to the epappose *Valeriana* species from Argentina.

Materials and Methods

***Morphological Study*—**The morphological study was based on collections of *Valeriana* from Argentina, Bolivia, Brazil, Chile, and Peru at SI; types images from B, BC, BM, BR, C, F, G, GH, GOET, HAL, K, LIL, LINN, M, MA, MO, NY, P, PH, S, and US (herbarium acronyms follow Thiers 2014) at the website of JSTOR (http://plants.jstor.org), original descriptions and regional floras of Argentina (Borsini 1942, 1944, 1946; Cabrera 1993; Borsini 1999; Novara 2008), Brazil (Borsini 1962a), Chile (Borsini 1966), and Peru (Killip 1937).

To complete morphological characterization of the plant materials by counting the number of locules per anther and locules per fruit, three flowers and three fruits of the holotype were rehydrated at 60°C, fixed with FAA, dehydrated with ethanol, and embedded in Histowax (Ruzin 1999). Microtomical 12 μm sections were stained with safranina–fast green (Ruzin 1999), and permanently mounted with Histomount. Digital images of the anatomical sections were taken with NIS–elements. Anatomical slides are deposited with the holotype at SI.

To create the key to the Argentinian species of *Valeriana* with epappose fruits we borrowed from the key of *Valeriana* of Borsini (1944) and Kutschker (2008a, 2011). Additionally, we consulted original descriptions and regional floras of Argentina (Borsini 1942, 1946; Cabrera 1993; Borsini 1999; Novara 2008; Méndez 2010), and reviewed herbarium specimens, some of wich are cited in Appendix 1.

For the type locality of plant materials studied herein (Abra Fundición, Santa Victoria Department in the Province of Salta, Argentina), temperature and precipitation variables were extracted from BioClim (Hijmans et al. 2005) using a spatial resolution of 2.5 arc–minutes.

***Molecular Sampling*—**Plant materials studied herein as well as *Valeriana macrorhiza* DC., were analyzed to assess their phylogenetic placement. The new sequences generated in our work were included in the matrix published by Bell et al. (2012). Eighty–three accessions of Valerianaceae were included in the final analyses. Some species were represented by more than one accession. Taxa sampled, voucher information, and GenBank accessions are listed in Appendix 2. Other species from Argentina (*V. dinorrhiza* (Griseb.) Höck, *V. munozii* Borsini, and *V. ruizlealii* Borsini), Bolivia, and Perú (*Valeriana parvula* Killip), were not included in the phylogeny since it was not possible to obtain leaf material for DNA extraction.

***DNA Extraction, PCR Amplification, Sequencing and Alignment*—**Total DNA was isolated from leaves of exemplars collected in northern Andean region (Argentina) and the closest morphologically related species *V. macrorhiza* (collected in the field and dried in silica gel) using a modified CTAB protocol by Doyle and Doyle (1987). Two plastid loci, *trnL–F* intergenic spacer and *trnK* intron, were chosen to reconstruct the phylogeny of *Valeriana*. These two chloroplast markers were selected because they have the highest number of parsimony informative characters from nine markers previously utilized in Valerianaceae (Bell et al. 2012). The information about primers for the *trnL–F* region and *trnK* intron, and details about PCR amplification can be found in Bell (2007). Sequencing reactions were performed by Macrogen using the ABI PRISM BigDye terminator cycle sequencing kits with AmpliTaq DNA polymerase (Applied Biosystems, Seoul, Korea) following the protocols supplied by the manufacturer. Sequences were assembled and edited using the program Chromas Pro v.1.41 (Technelysium Pty, South Brisbane, Australia), which was also used for checking the presence of single peaks in the chromatograms. The new sequences obtained were aligned manually by eye to a published data matrix for Valerianaceae (Bell et al. 2012) using the program Bioedit v.7.0.9.0 (Hall 1999). The aligned data matrix is available from TreeBASE (study number S16628).

***Phylogenetic Analyses*—**We used maximum parsimony (MP) and maximum likelihood (ML) analyses to infer phylogeny. In these analyses gaps were treated as missing data.

Maximum parsimony analyses were conducted using TNT ver. 1.1 (Goloboff et al. 2008) on the concatenated dataset. All characters were equally weighted and treated as unordered. Prior to heuristic searches, all uninformative characters were deactivated. The searches used 1,000 replicates, each of which generated ten Wagner trees using a random addition sequence of taxa from the data matrix, swapping the initial tree with TBR (tree bisection and reconnection) and retaining a maximum of one tree in each replicate. Subsequently, all optimal trees were swapped using TBR, holding a maximum of 20,000 trees. Branches with ambiguous length of zero or one were collapsed. A strict consensus tree was generated from the MP trees. To evaluate the relative support for individual clades, bootstrap analysis (Felsenstein 1985) was performed using 1,000 replicates with heuristics search settings identical to those of the original search.

For the ML analyses, the best–fit substitution model for both chloroplast marker was the general time reversible with a gamma–shape parameter and a proportion of invariant sites (GTR + G + I), selected by

the Akaike information criterion (AIC) as implemented in jModelTest 2.1.1 (Darriba et al. 2012). We performed the ML analysis in RAxML ver. 7.0.4 (Stamatakis 2006) on the concatenated dataset. RAxML was used to conduct nonparametric bootstrap (BS) analysis and searches for the best–scoring ML tree in a single run (Stamatakis et al. 2008). We executed 1,000 rapid bootstrap inferences and, thereafter, a thorough ML search under the GTR + G + I model.

Results

Morphology—Plants of *Valeriana serratifolia* are low, perennial herbs with a thickened rootstock (Fig. 1A). All leaves are basal, rosulate, spathulate with serrulate margin on the distal half (Fig. 1A–B). The inflorescences are glomeruliform

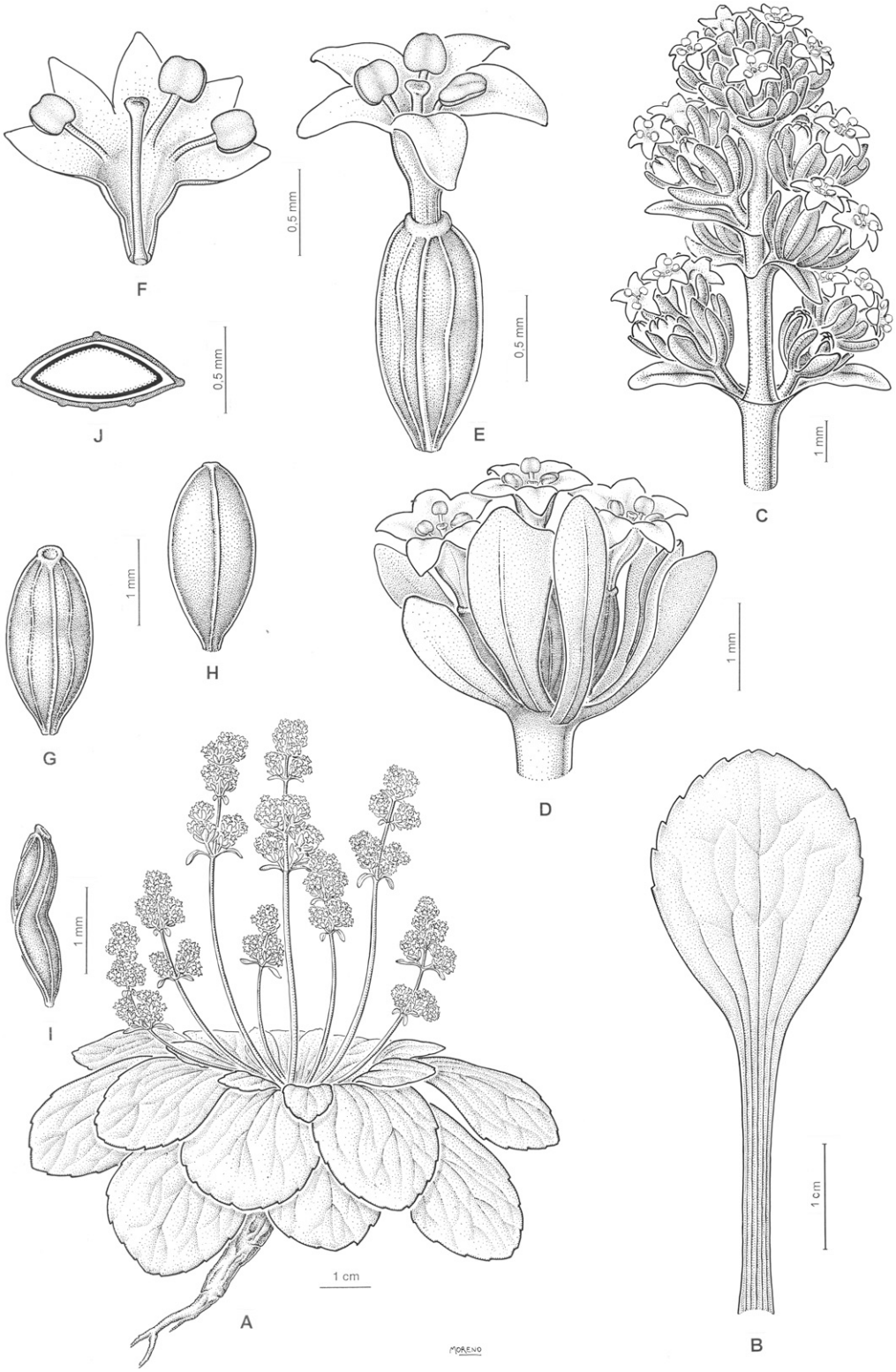

Fig. 1. *Valeriana serratifolia* A. Habit. B. Leaf. C. Inflorescence. D. Cyme. E. Floret. F. Corolla. G-H. Achene ventral and dorsal views. I. Achene lateral view. J. Achene transverse section. (All based on *Zuloaga et al. 13173*, holotype: SI).

(Fig. 1C–D). The flowers are perfect with a funnel–shaped corolla, 5–lobed, white (Fig. 1E), with three stamens, alternipetalous, attached to the middle portion of the tube, anthers exserted (Fig. 1F) and bisporangiate (Fig. 2A). The achene is ellipsoid, glabrous (Fig. 1G–H), falcate (Fig. 1I), crowned by the reduced annular calyx, slightly shifted toward the ventral face (Fig. 1G, I), not triquetrous in transverse section (Fig. 1J and Fig. 2B), 1–locular (Fig. 2B).

Molecular Phylogenetics—The aligned combined matrix of the *trnL-F* and *trnK* intron regions resulted in 1,624 characters, of which 471 were parsimony informative. The heuristic search found 1,130 most parsimonious trees with a length of 1,094 steps, consistency index (excluding uninformative characters) = 0.61 and retention index = 0.81. The ML tree was highly congruent with the MP strict consensus tree, hence only the ML tree is presented with branch support values obtained from both analyses (Fig. 3).

Phylogenetic analyses using either MP and ML inference placed *Valeriana serratifolia* sister to *V. macrorhiza* (BS ML = 88; BS MP = 86; Fig. 3). All four vouchers of *V. macrorhiza* from different localities formed a strongly supported monophyletic group (BS ML = 100; BS MP = 100; Fig. 3).

Discussion

In our molecular phylogenetic study, *Valeriana serratifolia* appears most closely related to *V. macrorhiza*. The clade *Valeriana serratifolia* + *V. macrorhiza* is highly supported, but its position within *Valeriana* phylogeny is still unsolved. Although extensive phylogenetic work has been done on South American Valerianaceae (Hidago et al. 2004; Bell and Donoghue 2005; Bell 2007; Bell et al. 2012), to date no northwestern Argentinean species has been included in any molecular phylogenetic analysis. To resolve the phylogenetic position of *V. serratifolia* + *V. macrorhiza* clade, a thorough investigation of the group of species with epappose fruits from the Andean region of northwestern Argentina, traditionally considered into *Valeriana* subgen. *Phyllactis* Borsini (Borsini 1944), is needed.

Valeriana serratifolia can be differentiated from the rest of *Valeriana* with epappose fruits mainly by its spathulate leaves with serrulate margins on the distal half. Morphologically, the new species is closely related to *V. macrorhiza*, a species from the southern Andes of Argentina and Chile (Kutschker and Morrone 2012). Both species have a woody rootstock, a basal rosette of entire leaves, and ellipsoidal, 1–locular, glabrous, epappose fruits. However, they can be distinguished from each other because *V. macrorhiza* has oblanceolate leaves with entire margins and straight fruits, with accrescent, cup–shaped, unevenly toothed calyces, versus spathulate leaves with serrulate margins on the distal half, and falcate fruits crowned by a reduced annular calyces, slightly shifted toward the ventral face, in *V. serratifolia*.

The Andean region of northwestern Argentina was considered an area of endemism for *Valeriana* species by Kutschker and Morrone (2012). This region was defined by species endemic to Argentina (*V. descolei* Borsini, *V. dinorrhiza, V. munozii* and *V. ruizlealii*), all of which have a fruit without a pappus and a reduced dispersal capability (Kutschker and Morrone 2012) such as *V. serratifolia*. It is noteworthy that *V. dinorrhiza, V. munozii,* and *V. ruizlealii* resemble *V. serratifolia*. *Valeriana munozii* has capituliform inflorescences, and peduncles with bracts divided at the base (vs. glomeruliform inflorescences and scapiform peduncles without bracts in *V. serratifolia*). *Valeriana ruizlealii* differs from *V. serratifolia* by having an elongated stem up to more than 1 m high with leaves divided at the base, stigmas with three thread–like branches and hairy fruits (vs. shorter stems, 4–10 cm high, without an elongated distal portion, flowers with a trilobed stigma, and glabrous fruits in *V. serratifolia*). *Valeriana dinorrhiza* can be differentiated because it has narrowly oblanceolate leaves, stigmas with three thread–like branches, and ovoid straight fruits (vs. spathulate leaves, trilobed stigmas and ellipsoidal falcate fruits in *V. serratifolia*).

Additionally, *Valeriana parvula*, a species from southern Peru (Killip 1937) and also cited for northern Bolivia (Weberling 2007) resembles *V. serratifolia*. Both species are low, perennial herbs, have woody rootstocks with eppapose fruits, but they can be distinguished because *V. parvula* has orbicular (or abruptly narrowed at the base) leaves with entire margins, and ovoid, straight fruits with accrescent calyces which form a short cylinder versus spathulate leaves with serrulate margins and ellipsoidal falcate fruits with a reduced, unnoticeable calyces of *V. serratifolia*.

As summarized in Table 1, *Valeriana serratifolia* has a unique combination of morphological characters not found

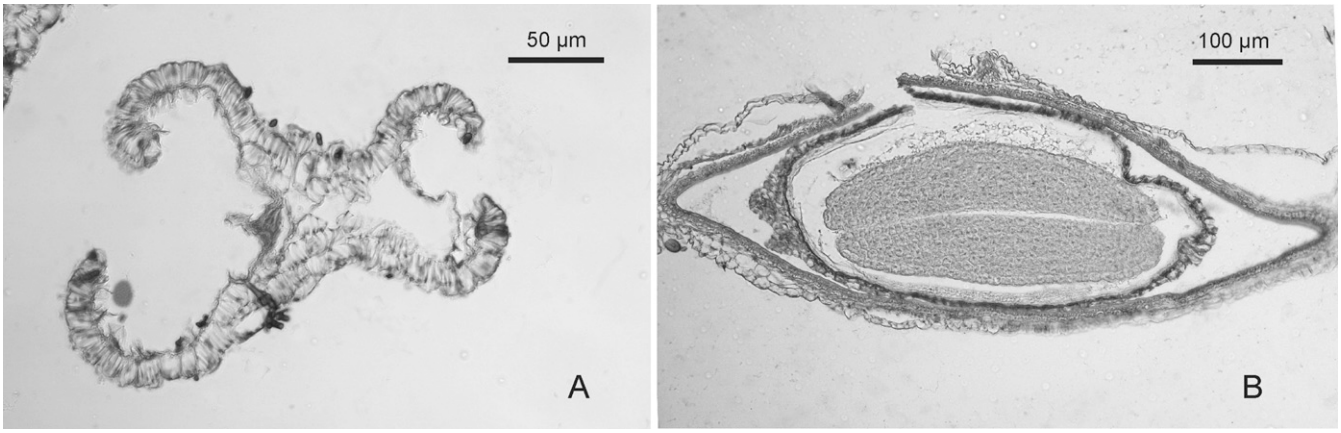

Fig. 2. *Valeriana serratifolia*. A. Transverse section of a dehiscent anther with tapetal remains still inside each locule. B. Transverse section of a fruit and seed. (All based on *Zuloaga et al. 13173,* holotype: SI).

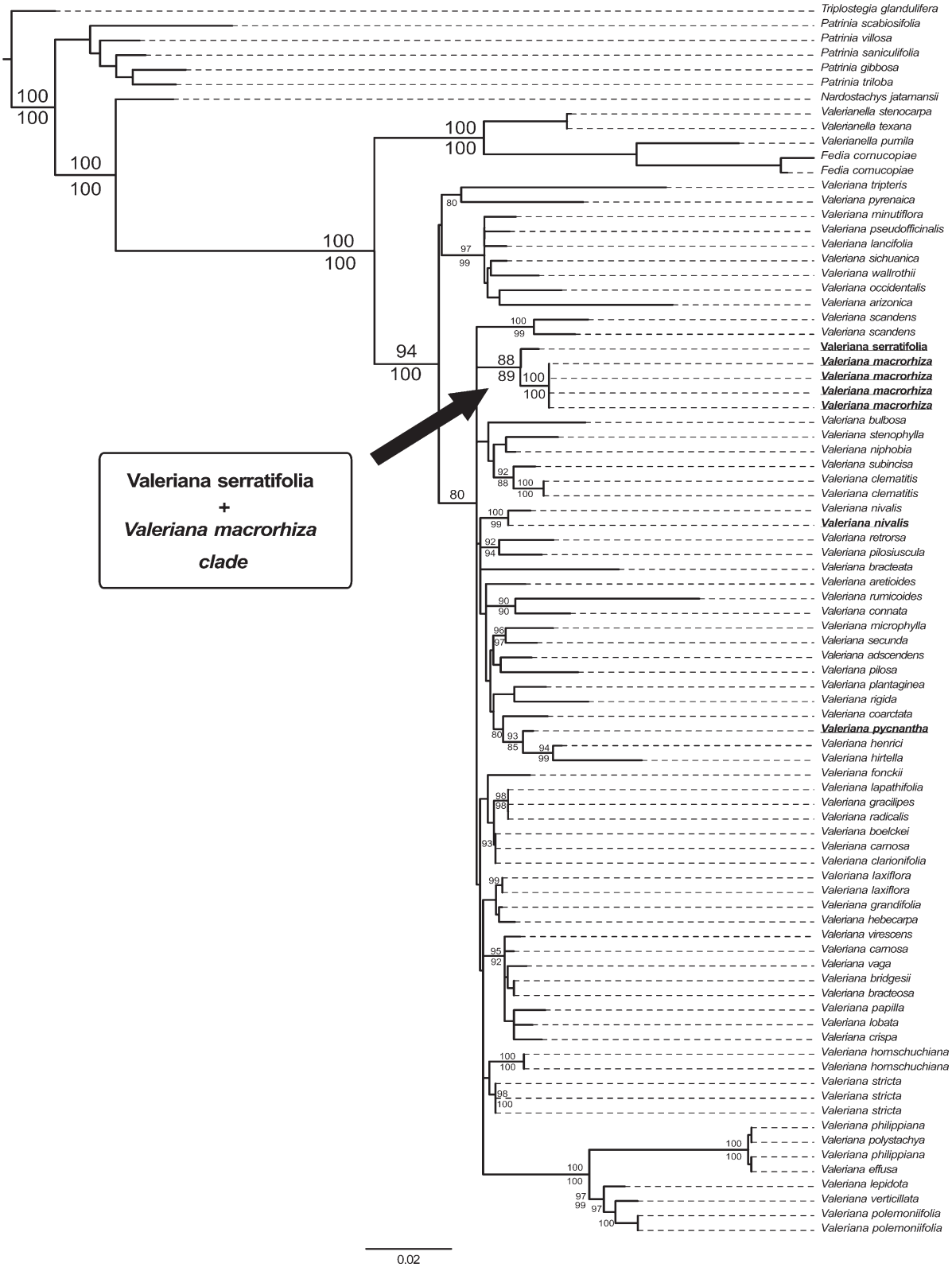

FIG. 3. Maximum likelihood (ML) tree inferred with RAxML using a concatenated dataset (*trnL-F* and *trnK* intron). Numbers above and below branches represent bootstrap values greater than 80% for ML and maximum parsimony, respectively. Newly sequenced accessions are in bold and underlined.

in other species of *Valeriana*. The detailed morphological comparison and the molecular phylogeny presented herein support the recognition of the plant material described below as a new species.

TAXONOMIC TREATMENT

Valeriana serratifolia J. M. Acosta, L. Salomón & C. A. Zanotti, sp. nov.—TYPE: ARGENTINA. Salta: Depto.

TABLE 1. Principal morphological differences and geographic distribution of *Valeriana serratifolia* and related species (NW = northwestern; SA = southern Andes).

Characters	*Valeriana dinorrhiza*	*Valeriana macrorhiza*	*Valeriana munozii*	*Valeriana parvula*	*Valeriana ruizlealii*	*Valeriana serratifolia*
Leaf Margin	Entire	Entire	Entire	Entire	Entire	Serrulate
Stigma	Triphid	Trilobed	Trilobed	Trilobed	Triphid	Trilobed
Calyx	Absent	Cup-shaped/unevenly toothed	Absent	Cup-shaped	Absent	Absent
Fruit shape	Ovoid	Ellipsoid	Claviform	Ellipsoid	Pyriform	Ellipsoid
Fruit pilosity	Glabrous	Glabrous	Glabrous	Glabrous	Pubescent	Glabrous
Fruit size (mm)	1.5–2.5	3.5–4	4–4.5	1.5–2	2–2.5	1.5–2
Geographic distribution	NW Argentina	SA Argentina- Chile	NW Argentina	Peru- Bolivia	NW Argentina	NW Argentina

Santa Victoria, Abra Fundición, camino a Nazareno, 22°26′14″S, 65°10′08″W, 4,570 m, 21 Jan 2011, *Zuloaga, F. O., Aagesen, L., Salariato, D. L. & Zanotti, C. A. 13173* (holotype: SI!-158033[barcode # 055122]).

Perennial rosulate herbs 4–10 cm tall, glabrous. Stem simple, erect, short, thick, with visible leaf scars. Leaves simple, spathulate, 2.5–5.5 × 1.2–2.5 cm, amplexicaul; blade fleshy, entire, attenuate to a flat pseudopetiole 0.2–0.5 cm wide; apex obtuse, the margin serrulate on the distal half. Inflorescences arising from lateral buds. Peduncle scapiform, 2.5–7.5 cm long, without reduced cauline leaves. Inflorescences glomeruliform with 1–3 lateral pairs of cymes, the lowest pair often distant from the upper ones; bracts of the lateral branches 0.4–0.5 × 0.1 cm, opposite, sessile, oblanceolate–spathulate, amplexicaul, the margin entire. Cymes 0.5–0.7 cm diam, 5–20(–25) flowered, shortly pedunculate; floral bracts 1.5–2 × 0.5–1 mm, oblanceolate–spathulate or spathulate, slightly emarginate, margin entire; florets perfect; calyx reduced to a rim; corolla 1–1.5 mm long, funnel–shaped, 5–lobed, white; stamens 3, alternipetalous, attached to the middle portion of the tube, anthers exserted, bisporangiate; style exserted, stigmatic surface trilobed. Achene ca. 2 × 1 mm, ellipsoid, falcate, glabrous, 1–nerved on the dorsal face, slightly 3–nerved on the ventral face, 1–locular, crowned by the reduced annular calyx, slightly shifted toward the ventral face.

Etymology—The species name refers to its leaves with serrulate margins.

Distribution, Ecology, and Conservation Status—*Valeriana serratifolia* is only known for Abra Fundición, Santa Victoria Department in the Province of Salta, Argentina (Fig. 4). This locality corresponds to the high Andes biogeographical province of Cabrera and Willink (1973) and has annual maximum, mean, and minimum temperatures of 14°C, 4.3°C, and –5.4°C, respectively; and annual mean precipitation of 247 mm (Hijmans et al. 2005). Its populations grow at nearly 4,500 m on open, rocky soils. Among the most frequent species of the surrounding vegetation are: *Perezia atacamensis* (Phil.) Reiche, *Senecio candollei* Wedd., *Gentianella pseudocrassula* (Gilg) Fabris, *Bromus modestus* Renvoize, *Valeriana nivalis* Wedd., *Draba macleanii* Hook., and *Brayopsis monimocalyx* O. E. Schulz. This novelty has been collected only from the type locality, an area less than 1 km^2. According to the IUCN red list categories and criteria (IUCN 2001), and until new localities are found, *Valeriana serratifolia* can be referred to as a critically endangered species (CR).

Phenology—Plants were found with flowers and fruits in January.

KEY TO THE ARGENTINIAN SPECIES OF *VALERIANA* WITH EPAPPOSE FRUITS

1. Fruits glabrous . . . 2
   2. Leaves arranged in a basal rosette . . . 3
      3. Leaves pinnatifid to lobulate . . . *V. hunzikeri* Borsini
      3. Leaves entire . . . 4
         4. Leaf margin serrulate on the distal half, falcate fruits crowned by a reduced annular calyx, slightly shifted toward the ventral face . . . *V. serratifolia*
         4. Leaf margin entire . . . 5
            5. Calyx accrescent, cup-shaped and unevenly toothed . . . *V. macrorhiza*
            5. Calyx not accrescent, reduced to a rim or unnoticeable . . . 6
               6. Inflorescences capituliform . . . *V. muñozii*
               6. Inflorescences glomeruliform . . . *V. dinorrhiza*
   2. Leaves not arranged in a basal rosette (if the internodes are short, these are always visible as in *V. polystachya* Sm.) . . . 7
      7. Leaves entire . . . 8
         8. Inflorescences paniculiform . . . *V. salicariifolia* Vahl
         8. Inflorescences glomeruliform . . . 9
            9. Perennial herbs. Fruits falcate . . . *V. corymbulosa* (Wedd.) Cabrera
            9. Annual herbs. Fruits triquetrous . . . *V. samolifolia* (DC.) Colla
      7. Leaves pinnatisect, sometimes also with entire basal leaves (*V. polystachya*) . . . 10
         10. Fruits suborbicular with an urceolate calyx . . . *V. ferax* (Griseb.) Höck
         10. Fruits oblong, cup-shaped, with a reduced or saucer-shaped calyx . . . *V. polystachya*
1. Fruits pubescent, at least sparingly pilosulous on one face or at the base . . . 11
   11. Leaves arranged in a basal rosette . . . 12
      12. Leaves entire . . . 13
         13. Inflorescences capituliform. Fruits cup-shaped, straight, papillose at base . . . *V. descolei* Borsini
         13. Inflorescences glomeruliform. Fruits pyriform, oblong, ovoid, falcate, non papillose at base . . . *V. ruizlealii*
      12. Leaves pinnatifid to pinnatisect . . . 14
         14. Inflorescences glomeruliform. Fruits not papillose at base . . . *V. stuckertii* Briq.
         14. Inflorescences capituliform. Fruits papillose at base . . . 15

15. Plants pubescent, leaves pinnatisect. Fruits entirely pilose. Flowers white ..... *V. corynodes* Borsini
15. Plants glabrous with pinnatifid or pinnately divided leaves. Fruits pilose on the lower half. Flowers yellow ..... *V. tunuyanense* E. Méndez
11. Leaves dispersed along the stem 16
16. Calyx completely reduced in fruit ..... *V. kurtziana* Borsini
16. Calyx urceolate/cup-shaped in fruit 17
17. Folioles with a serrate margin. Fruits suborbicular with a cup-shaped calyx and winged awns ..... *V. tucumana* Borsini
17. Folioles with an entire to unevenly toothed margin. Fruits ellipsoid with a urceolate calyx without winged awns ..... *V. polybotrya* (Griseb.) Höck

Acknowledgments The authors thank Fernando O. Zuloaga (SI) and anonymous referees for reviewing the manuscript and for their useful comments and corrections that enriched and clarified the manuscript significantly. We especially thanks Charles Bell for molecular data and for supplying two vouchers of *Valeriana macrorhiza*. Thanks to the collection manager of PH, Alina Freire Fierro, who allowed us to obtain type material of *Valeriana parvula.* Thanks to the curator of SI for allowing the review of specimens. We also thank to Marcelo Moreno (SI) for the illustration of the new species. This research was supported by the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina.

Literature Cited

Bell, C. D. 2007. Phylogenetic placement and biogeography of the North American species of *Valerianella* (Valerianaceae: Dipsacales) based on chloroplast and nuclear DNA. *Molecular Phylogenetics and Evolution* 44: 929–941.

Bell, C. D. and M. J. Donoghue. 2005. Phylogeny and biogeography of Valerianaceae (Dipsacales) with special reference to the South American valerians. *Organisms, Diversity & Evolution* 5: 147–159.

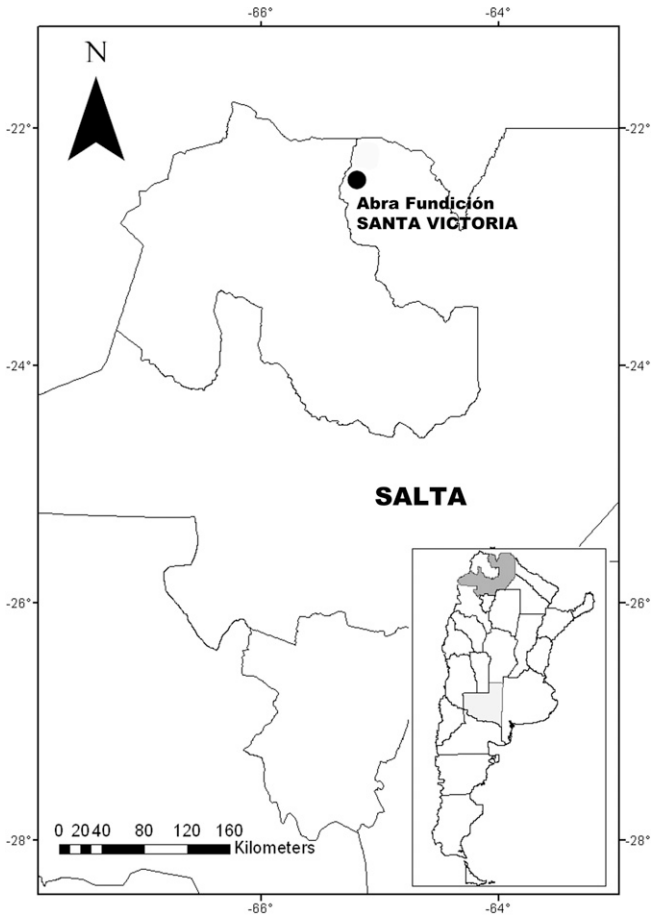

Fig. 4. Map indicating the only known locality of *V. serratifolia* in Salta province, Argentina.

Bell, C. D., A. Kutschker, and M. T. K. Arroyo. 2012. Phylogeny and diversification of Valerianaceae (Dipsacales) in the southern Andes. *Molecular Phylogenetics and Evolution* 63: 724–737.

Borsini, O. E. 1942. Valerianáceas de Tucumán. *Lilloa* 8: 353–377.

Borsini, O. E. 1944. Valerianaceae. Pp 275–372 in *Genera et species olantarum Argentinarum II*, vol 2, ed. H. Descole. Tucumán: Fundación Miguel Lillo.

Borsini, O. E. 1946. Addenda a las Valerianáceas argentinas II. Nuevos materiales consultados. *Lilloa* 12: 67–85.

Borsini, O. E. 1960. Una nueva *Valeriana* Argentina: *Valeriana hunzikeri. Lilloa* 30: 361–363.

Borsini, O. E. 1962a. Revisión de las Valerianáceas de Brasil. *Lilloa* 31: 149–170.

Borsini, O. E. 1962b. *Valeriana kurtziana* nov. sp. *Lilloa* 31: 145–147.

Borsini, O. E. 1966. Valerianáceas de Chile. *Lilloa* 32: 375–476.

Borsini, O. E. 1999. Valerianaceae. Pp 448–471 in *Flora Patagónica*, vol 8. ed. M. N. Correa. Buenos Aires: Colección Cientifica del Instituto Nacional de Tecnología Agropecuaria.

Cabrera, A. L. 1993. Valerianaceae. Pp 443–469, in *Flora de la Provincia de Jujuy,* vol 13, ed. A. L. Cabrera. Buenos Aires: Colección Científica del Instituto Nacional de Tecnología Agropecuaria.

Cabrera, A. L. and A. Willink. 1973. Biogeografía de América Latina. Organización de los Estados Americanos, Serie Biológica, Monografía 13. Washington, D. C.: Organización de los Estados Americanos.

Darriba, D., G. L. Taboada, R. Doallo, and D. Posada. 2012. jModelTest 2: More models, new heuristics and parallel computing. *Nature Methods* 9: 772–772.

Doyle, J. J. and J. L. Doyle. 1987. A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochemical Bulletin* 19: 11–15.

Felsenstein, J. 1985. Confidence limits on phylogenies: An approach using the bootstrap. *Evolution* 39: 783–791.

Goloboff, P. A., J. S. Farris, and K. C. Nixon. 2008. TNT, a free program for phylogenetic analysis. *Cladistics* 24: 774–786.

Hall, T. A. 1999. BioEdit: A user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series* 41: 95–98.

Hidago, O., T. Garntje, A. Susanna, and J. Mathez. 2004. Phylogeny of Valerianaceae based on *matK* and ITS markers, with reference to *matK* individual polymorphism. *Annals of Botany* 93: 283–293.

Hijmans, R. J., S. E. Cameron, J. L. Parra, P. G. Jones, and A. Jarvis. 2005. Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology* 25: 1965–1978.

IUCN. 2001. IUCN red list categories and criteria: version 3.1. IUCN Species Survival Commission. Gland, Switzerland and Cambridge, U. K.: IUCN.

Killip, E. P. 1937. Valerianaceae. Pp 287–321 in *Flora of Peru* Part VI, vol 13, ed. E. P. Macbride. Chicago: Field Museum Press.

Kutschker, A. M. 2008a. Morfología del fruto en especies de *Valeriana* (Valerianaceae) de los Andes australes. *Darwiniana* 46: 17–35.

Kutschker, A. M. 2008b. Valerianaceae. Pp 3091–3101 in *Catálogo de las Plantas Vasculares del Cono Sur*, vol 3, eds F. O. Zuloaga, O. Morrone, and M. J. Belgrano. St. Louis: Missouri Botanical Garden.

Kutschker, A. M. 2011. Revisión del género *Valeriana* (Valerianaceae) en Sudamérica austral. *Gayana Botánica* 68: 244–296.

Kutschker, A. M. and J. J. Morrone. 2012. Distributional patterns of the species of *Valeriana* (Valerianaceae) in southern South America. *Plant Systematics and Evolution* 298: 535–547.

Méndez, E. 2010. Una nueva especie de *Valeriana* (Valerianaceae) para la Argentina. *Darwiniana* 48: 201–203.

Novara, L. J. 2008. Valerianaceae. *Aportes Botánicos de Salta-Serie Flora* 8: 1–22.

Ruzin, S. 1999. Plant microtechnique and microscopy. New York: Oxford University Press.

Stamatakis, A. 2006. RAxML-VI-HPC: Maximum likelihood-based phylogenetic analyses with thousands of taxa and mixed models. *Bioinformatics* 22: 2688–2690.

Stamatakis, A., P. Hoover, and J. Rougemont. 2008. A rapid bootstrap algorithm for the RAxML web servers. *Systematic Biology* 57: 758–771.

Thiers, B. 2014. Index herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/. Accessed June 14, 2014.

Weberling, F. 2007. Notes on South American Valerianaceae IV. *Feddes Repertorium* 118: 327-351.

Xifreda, C. C. 1999. Valerianaceae. Pp 1131–1136 in *Catálogo de las plantas vasculares de la República Argentina* II, vol 74, eds F. O. Zuloaga and O. Morrone. St. Louis: Missouri Botanical Garden.

Zanotti, C. A., M. A. Suescún, and J. M. Acosta. 2014. Confirmation of *Valeriana nivalis* (Valerianaceae) to the Argentinian flora. *Phytotaxa* 167: 295–300.

Appendix 1. Selected material examined of other species of Valeriana

Valeriana dinorrhiza (Griseb.) Höck. ARGENTINA. **Catamarca:** Departamento Andalgalá, Cerro Yutuyaco, 3,700 m, 9 February 1916, *P. Jörgensen 1182* (SI). **Salta:** Departamento Cafayate, Cerro del Cajón, 4,280 m, 15 February 1914, *D. Rodríguez 1370* (SI). **Tucumán:** Departamento Tafí, Cumbres Calchaquíes, Cerro Bayo, 4,200 m, 15 March 1984, *E. V. Gómez Sosa & M. E. Múlgura 201* (SI); Departamento Tafí, Sierras Calchaquies, Peñas Azules, 3,400 m, 29 January 1933, *A. Burkart 5302* (SI); Departamento Tafí, Quebrada del Baroico, km 82 camino a Tucumán, Tafí del Valle-Santa María, 26 February 1959, *L. Diers 272* (SI); Departamento Chicligasta, Estancia Las Pavas, Puerto El Bayo, 3,200 m, 12 March 1924, *S. Venturi 3098* (SI).

Valeriana macrorhiza DC. ARGENTINA. **Neuquén:** Departamento Minas, Valle superior del Arroyo Atreuco, 02 February 1964, *O. Boelcke 11526* (SI-059850); Departamento Minas, Confluencia de los ríos Pichi-Neuquén y Neuquén, Cerro de las Yeguas, 23 March 1970, *O. Boelcke 13789* (SI; BAA; BAB); Departamento Minas, Valle superior del A° Atreuco, 2,010–2,050 m, 02 March 1964, *O. Boelcke 11509* (SI-052128; BAA; BAB); Departamento Minas, Parque Nacional Nahuel Huapi, Lago Espejo Chico, alrededores de la cumbre del Cerro La Mona, pedrero, 1,700–1,970 m, 13 February 2002, *C. Ezcurra 3352* (SI-059854); Departamento Ñorquin, Copahue, 2,000 m, 23 January 1980, *C. Ezcurra 160* (SI); Departamento Ñorquin, alrededores del pueblo, mallín, 2,000 m, 22 January 2002, *C. Ezcurra 3172* (SI-052349; MU); Departamento Los Lagos, subida al cerro Ventana, 1,600 m, 19 February 1940, *J. Diem 855* (SI-052122); Departamento Los Lagos, Copahue, 2,016 m, 14 February 2007, *J. Chiapella 1824* (CORD; SI-059831; CTES). **Mendoza:** Departamento Malargüe, Del Mirador de Valle Hermoso a Las Leñas, 2,860 m, 22 November 2010, *F. O. Zuloaga 12367* (SI); Departamento Malargüe, Paso Pehuenche, límite con Chile, 2,570 m, 24 November 2010, *F. O. Zuloaga et al. 12441* (SI).

Valeriana munozii Borsini. ARGENTINA. Mendoza**:** Tres Esquinas, 2,200 m, December 1921, *E. Carette 395* (holotype, SI 000537). Mendoza: Loncoche, November 1911, *C. Hicken s. n.* (SI).

Valeriana parvula Killip. PERÚ. Department of Cusco: Cerro de Colquipata, Open grassypuna, 4,000–4,200 m, *F. W. Pennell 13756* (holotype, PH 00028718; isotype, SI, fragments).

Valeriana ruizlealii Borsini. ARGENTINA. **Salta:** Cerro El Cajón, 4,100 m, 30 January 1914, *D. Rodríguez 1377* (SI). **San Juan:** Departamento Angaco, Sierra de Pié de Palo; camino a Mogote de los Corralitos, El Balcón de la Virgen, 3,000 m, 19 January 1981, *R. Kiesling 3129* (SI); Sierra de Pie de Palo, Mogote de los Corralitos, Cerca de la antena, 3,150 m, 15 February 1984, *R. Kiesling 4438* (SI); Pie de Palo, camino a Mogote de los Corralitos, 2,600 m, 06 February 2000, *R. Kiesling 9361* (SI); Departamento Calingasta, Quebrada de las Burras, Vega del Mal Paso, 2,900 m, 13 February 1990, *R. Kiesling et al. 7450* (SI); Departamento Iglesia, Quebrada de Chita, 7 km al oeste pasando el puerto de Don Nelson, margen norte de la huella, 3,600 m, 29 December 2004, *C. Meglioli 200* (SI). **Mendoza:** Departamento Luján de Cuyo, vallecitos cerca del refugio Edelweiss, 2,826 m, 11 January 2003, *A. A. Cocucci 2188* (CORD; SI; CTES); Departamento Tunuyán, Puesto Gerdamería Alférez Portinari, Arroyo de la Cascada Vieja, 2,570 m, 20 January 1963, *O. Boelcke 10133* (SI).

Appendix 2. Taxon names, voucher material and GenBank accession numbers for trnL-F and trnK intron sequences, respectively, used in the molecular study. New sequences generated for this paper are in bold and underlined

Fedia cornucopiae (L.) Gaertn., *Eriksson 806*, AF447013, AY794226. ***Fedia conucopiae*** (L.) Gaertn., Africa, JF269260, 269460. ***Nardostachys jatamansi*** DC., *Boufford et al. #28099*, AF447010, AY794315. ***Patrinia gibbosa*** Maxim., *Mast #19885022*, AY792886, AY794317. ***Patrinia saniculifolia*** Hemsl., *Chase 19250*, JF269261, JF269969. ***Patrinia scabiosifolia*** Link, *Bell #104*, AY792887, AY794318. ***Patrinia triloba*** Miq., *Eriksson 807*, AF447011, AY794316. ***Patrinia villosa*** Juss., *Mast #19910230*, AY792888, AY794319. ***Triplostegia glandulifera*** Wall. ex DC., *Boufford et al. #28440*, AF447009, AY794323. ***Valeriana adscendens*** Turcz., *Bell #EC006*, AY792892, AY794325. ***Valeriana aretioides*** Kunth, *Sklenar & Laegaard #7224*, AY792895, AY794329. ***Valeriana arizonica*** A. Gray, *Barrie et al. #272*, AY792896, AY794330. ***Valeriana boelckei*** Rossow, *ALV 122*, JF269262, JF269970. ***Valeriana bracteata*** Benth, *Bell # EC018*, AY792898, AY794332. ***Valeriana bracteosa*** Phil., JF269263, JF269971. ***Valeriana bridgesii*** Hook. & Arn., *Arroyo et al. #993921*, JF269264, JF269972. ***Valeriana bulbosa*** Wedd, *Eriksen & Molau #540*, AY792900, AY794334. ***Valeriana carnosa*** Sm., *Kutschker 801*, JF269266, JF269974**.** ***Valeriana clarionifolia*** Phil., *Kutschker 802*, JF269268, JF269976. ***Valeriana clematitis*** Kunth, *Ahumada & Ahumada 8282*, JF269269, JF269977. ***Valeriana clematitis*** Kunth, *Madrinan #2111*, AY792903, AY794340. ***Valeriana coarctata*** Ruiz & Pav., *Davis et al. #1571*, AY792904, AY794341. ***Valeriana connata*** Ruiz & Pav., *Molau & Eriksen #3464*, AY792905, AY794342. ***Valeriana crispa*** Ruiz & Pav., *Arroyo et al. #207074*, JF269270, JF269978. ***Valeriana effusa*** Griseb., *Biurrum et al. 4664*, JF269271, JF269979. ***Valeriana fonckii*** Phil., *Kutschker 803*, JF269272, JF269980. ***Valeriana graciliceps*** Clos, *Arroyo & Humaña 991851*, JF269273, JF269981. ***Valeriana grandifolia*** Phil., *Matthei 679*, JF269274, JF269982. ***Valeriana hebecarpa*** DC., *Mihoc 3163*, JF269275, JF269983. ***Valeriana henrici*** (Graebn.) B. Eriksen, *Molau & Eriksen #3497*, AY360128, AY794349. ***Valeriana hirtella*** Kunth, *Cotton et al. #1548*, AY360134, AY794350. ***Valeriana hornschuchiana*** Walp., *Arroyo & Humaña 980630*, JF269276, JF269984. ***Valeriana hornschuchiana*** Walp., *Arroyo et al. 210625*, JF269277, JF269985. ***Valeriana lancifolia*** Hand.-Mazz., *Boufford et al*. 38699, JF269278, JF269986. ***Valeriana lapathifolia*** Vahl., *Kutschker 812*, JF269279, JF269987. ***Valeriana laxiflora*** DC., JF269280, JF269989. ***Valeriana laxiflora*** DC., *Kutschker 806*, JF269281, JF269988. ***Valeriana lepidota*** Clos, *Arroyo & Becerra 209668*, JF269282, JF269990. ***Valeriana lobata*** Phil., *Arroyo & Humaña 992267*, JF269284, JF269992. ***Valeriana macrorhiza*** Poepp. ex DC., Argentina, Chubut, *Kutschker 901*, **KP828762**, **KP828767**. ***Valeriana macrorhiza*** Poepp. ex DC., Chile, Region VI, *Arroyo 201107*, **KP828763**, **KP828768**. ***Valeriana macrorhiza*** Poepp. ex DC., Argentina, Mendoza, *Zuloaga 12367*, **KP828764**, **KP828769**. ***Valeriana macrorhiza*** Poepp. ex DC., Argentina, Mendoza, *Zuloaga 12441* **KP828765**, **KP828770**. ***Valeriana microphylla*** Kunth, *Bell #EC006*, AY360122, AY794355. ***Valeriana minutiflora*** Hand.-Mazz., *Boufford et al. #28646*, AF447012, AY794356. ***Valeriana niphobia*** Briq., *Kutschker 804*, AY360129, AY794359. ***Valeriana nivalis*** Wedd., *Molau 4830*, AY792914, AY794360. ***Valeriana nivalis*** Wedd., Argentina, Salta, *Zuloaga 13176*, KJ756528, **KP828771**. ***Valeriana occidentalis*** A. Heller, *Schenk #477*, AY792915, AY794361. ***Valeriana papilla*** Bertero ex DC., *Arroyo et al. #205909*, JF269287, JF269995. ***Valeriana philippiana*** Briq., *Kutschker 809*, JF269288, JF269996. ***Valeriana philippiana*** Briq., *Weigend et al. 6859*, JF269289, JF269997. ***Valeriana pilosa*** Ruiz & Pav., AY360131, AY794365. ***Valeriana pilosiuscula*** M. Martens & Galeotti, *Ramamoorthy & Esquival 900*, JF269290, JF269998. ***Valeriana plantaginea*** Kunth, *Bell #EC001*, AY792918, AY794367. ***Valeriana polemoniifolia*** Phil., *Puntieri s.n.*, JF269292, JF270000. ***Valeriana polemoniifolia*** Phil., *Arroyo et al. #992939*, JF269291, JF269999. ***Valeriana polystachya*** Sm., *Hurrel et al. 5336*, JF269293, JF270001. ***Valeriana pseudofficinalis*** C. Y. Cheng & H. B. Chen, *Boufford et al. #30689*, JF269294, JF270002. ***Valeriana pycnantha*** A. Gray, Argentina, Jujuy, *Zuloaga 13432*, KJ756525, **KP828772**. ***Valeriana pyrenaica*** L., *Mast #23659628*, AY360132, AY794372. ***Valeriana radicalis*** Clos, *Arroyo et al. 201442*, JF269295, JF270003. ***Valeriana retrorsa*** Fern., *Berrie et al. 395*, JF269296, JF270004. ***Valeriana rigida*** Ruiz & Pav., *Bell #EC016*, AY360130, AY794373. ***Valeriana rumicoides*** Wedd, *Molau et al. #2579*, AY792924, AY794375. ***Valeriana scandens*** Loefl. ex L. var. ***scandens***, *Slanis et al. 67*, JF269297, JF270005. ***Valeriana scandens*** Loefl. ex L., *Barrie & Nixon #1293*, AY792926, AY794377. ***Valeriana secunda*** B. Eriksen, *Bell #EC015*, AY79298, AY794379. ***Valeriana serratifolia*** Acosta, Salomón & Zanotti, Argentina, Salta, *Zuloaga 13173*, **KP828766**, **KP828773.** ***Valeriana sichuanica*** D. Y. Hong, *Boufford et al. 36803*, JF269298, JF270006. ***Valeriana stenophylla*** Killip, *Zapata #67*, AY792930, AY794384. ***Valeriana stricta*** Clos, *Teillier & Delaunoy 5583*, JF269299, JF270007. ***Valeriana stricta*** Clos, *Arroyo et al. #980654*, JF269300, JF270008. ***Valeriana stricta*** Clos, *Arroyo et al. #991483*, JF269301, JF270009. ***Valeriana subincisa*** Benth., *Berrie 935*, JF269302, JF270010. ***Valeriana tripteris*** L., *Bell #SWITZ005*, AY792937, AY794391. ***Valeriana vaga*** Clos, *Arroyo et al. #994006*, JF269303, JF270011. ***Valeriana verticillata*** Clos, *Arroyo et al. #209817*, JF269304, JF270012. ***Valeriana virescens*** Clos, *Kutschker 807*, JF269305, JF270013. ***Valeriana wallrothii*** Kreyer, *Billiet V782*, AY792940, AY794394. ***Valerianella pumila*** DC., *Bell #108*, AY792945, AY794399. ***Valerianella stenocarpa*** Krok, *Carr 11647*, DQ354211, DQ354191. ***Valerianella texana*** Dyal, *Carr 11052*, DQ354209, DQ354193.