Phytotaxa 138 (1): 1–14 (2013)
www.mapress.com/phytotaxa/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

http://dx.doi.org/10.11646/phytotaxa.138.1.1

Revision of *Oxalis* section *Palmatifoliae* DC. (Oxalidaceae)

ALICIA LÓPEZ[1], ANDREA F. PANSERI[2] & ESTRELLA URTUBEY[1]

[1] *Instituto de Botánica Darwinion (CONICET – ANCEFN), Labardén 200, CC 22, B1642HYD, San Isidro, Buenos Aires, Argentina; e-mail: alopez@darwin.edu.ar; eurtubey@darwin.edu.ar.*

[2] *Instituto de Botánica del Nordeste (UNNE – CONICET), Sargento Cabral 2131, CC 209, 3400, Corrientes, Argentina; e-mail: panseriandrea@gmail.com*

Abstract

A taxonomic revision of *Oxalis* section *Palmatifoliae* is presented, together with cluster analyses to clarify the limits of the species. This monophyletic section includes five species endemic from Southern Argentina and Chile. A key for the species, descriptions, illustrations, synonymy, and geographical distribution for each species are also provided. Five lectotypifications and two new synonymies are proposed.

Key words: Patagonia, South America, Systematic, Taxonomy

Introduction

Oxalis Linnaeus (1753: 433) is a cosmopolitan genus that comprises approximately 500 species distributed in three main centres of species richness. The most important one is found in South America, with ca. half the species and the highest morphological variation, including variation in life-form, ranging from herbs to shrubs, acaulescent herbs to cushion shrubs, and adaptations to almost every environment (Knuth 1930, Macbride 1949, Lourteig 1994). The second centre of diversification is in South Africa where more than 200 bulbous species are concentrated in the Cape Region (Dreyer & Makgakga 2003). In North America, there are ca. 50 species, most of which are perennial and distributed in the south-western region (Eiten 1963, Denton 1973, Lourteig 1975, 1979, 1980, Nesom 2009). In addition, several cosmopolitan species and other few endemic species grow in Europe, Asia, and Oceania (Knuth 1930, Lourteig 1994).

The most comprehensive taxonomic treatment of the genus *Oxalis* was written by Lourteig (2000). Lourteig considered the genus divided into four subgenera, based mainly on characters of the leaf: *Oxalis*, *Monoxalis* (Small 1903: 665) Lourteig (1980: 451), *Trifidus* Lourteig (1995: 389), and *Thamnoxys* (Endlicher 1840: 1172) Reiche (1894: 275) emend. Lourteig (1994: 1). According to Lourteig (1994) the subgenus *Oxalis* is characterized by the presence of leaves with 3-multi leaflets subsessile, and it is divided into 19 sections.

Section *Palmatifoliae* de Candolle (1824: 702), endemic to South America, was named in allusion to the palmate leaves and grouped species by the following characters states: acaulescent or naked short-stem habit, leaves palmate, peltate-nerved and petiolate, with 5–13 leaflets, without glands and 1-flowered plants. De Candolle included nine species: *O. commersonii* de Candolle (1824: 702), *O. enneaphylla* Cavanilles (1799: 411), *O. flabellifolia* Jacquin (1794: 94), *O. flava* Linnaeus (1753: 433), *O. laciniata* Cavanilles (1799: 412), *O. lupinifolia* Jacquin (1794: 92), *O. mallobolba* Cavanilles (1797: 64), *O. pectinata* Jacquin (1794: 95), and *O. tomentosa* Thunberg (1781: 24).

Endlicher (1840) created the name *Palamoxys* but make use of the description of sect. *Palmatifoliae* by de Candolle, and included under this name the species *O. mallobolba*, *O. enneaphylla*, *O. laciniata*, *O. lupinifolia*, *O. Pectinata*, and *O. tomentosa*.

Accepted by Manuel Belgrano: 11 Sept. 2013; published: 18 Oct. 2013

Reiche (1894) introduced the non formal level of Divisio I, *Palmatifoliae*, retaining *O. enneaphylla* and *O. laciniata* from de Candolle's classification and adding *O. adenophylla* Gillies ex Hooker & Arnott (1832: 165), *O. bustillosii* Philippi (1856: 614), and *O. squamoso-radicosa* Steudel (1856: 443).

Knuth (1930) considered sect. *Palmatifoliae* as a "natural unit", and a transition between sections constituted only by rhizome-bearing plants (26 sections), and bulb-bearing plants (8 sections), due to the presence of both structures and intermediates within sect. *Palmatifoliae.* Knuth conserved from de Candolle's schema *O. enneaphylla*, *O. laciniata*, and *O. mallobolba*, and from Reiche's *O. adenophylla* and *O. squamoso-radicosa*. Additionally, Knuth incorporated in the section the species *O. pumila* D´Urville (1826: 616) (formerly placed in Division Trifoliatae, Uniflorae, in Reiche 1894), *O. cunninghamii* Knuth (1919: 308), *O. fueguensis* Knuth (1913: 36), *O. loricata* Dusén (1901: 247), *O. patagonica* Spegazzini (1897: 500), *O. prichardii* Rendle (1904: 334), that were described after Reiche's classification. Knuth (1930) excluded from sect. *Palmatifoliae* the species *O. commersonii, O. flebellifolia, O. flava*, *O. lupinifolia, O. pectinata,* and *O. tomentosa* and also proposed the synonymy of *O. bustillosii* under *O. adenophylla*.

Lourteig (2000), following Reiche, included five species and one subspecies in sect. *Palmatifoliae*: *O. adenophylla*, *O. enneaphylla* (= *O. pumila*), *O. enneaphylla* subsp. *ibari* (Philippi, 1879: 25) Lourteig (1988: 9) (= *O. patagonica*), *O. laciniata* (= *O. prichardii*), *O. loricata*, and *O. squamoso-radicosa*.

Recently, the species *O. morronei* López & Múlgura (2011: 41) was described and placed in sect. *Palmatifoliae*, increasing the number of species to six.

Section *Palmatifoliae* was recently recognized as monophyletic from partial molecular phylogenies of *Oxalis* (Heibl & Renner 2012). Even though Heibl & Renner`s manuscript focuses on the adaptive radiation of Chilean *Oxalis*, the study includes a representative number of the species belonging to sect. *Palmatifoliae,* which grouped into a strongly supported clade.

The main goal of this work is to contribute to the delimitation of the species of *Oxalis* sect. *Palmatifoliae* based on morphological studies and Cluster Analyses. Additionally, to provide morphological descriptions, geographical distribution, habitat, phenology, illustrations, and other relevant notes for each taxa, together with a key to the species, synonymy, and typification.

Materials & Methods

Morphological Study

Herbarium and type specimens from BAB, LIL, and SI were examined, together with high resolution images of type specimens housed at BM, C, CORD, E, G, GOET, K, LIL, LP, M, MA, P, S, SGO, UPS, and US acceded at http://plants.jstor.org/. Morphological observations were conducted using a Leica ocular lens. Phenological, geographical, and ecological data was obtained from specimen's labels and literature, and field work.

Some considerations are needed to a better understanding of the morphological descriptions provided in this manuscript, and are as follows: (1) Lourteig (1975, and posterior works) uses the term "*calli*" instead of "*calloso-maculata*" used by Knuth (1930). We decided to keep "*calli*" to describe the presence of orange-red spots in the margins of the leaflets and sepals. (2) Lourteig (2000) applies the term *"celulosa"* (=cellulose) instead of *"lacunoso"* (=lacunose) to describe the surface of the leaflets; we prefer the latter one, lacunose, due to its accurate definition, which alludes to a surface covered with depressions, pitted with shallow holes larger than those described as alveolate (Stearn 1983). (3) We also decided to keep the term "scale", in the sense of any foliaceous organ with form and consistency similar to the scales of fish and other animals (Font Quer 1993), to describe the structures that conform and surround the rhizome, including stipules that are adnate to the base of the petiole after the dehiscence of the leaves (Lourteig 2000: 204). (4) A distinction between two kinds of scales is made: "nutritious" scales to designate the ones with defined growing, elliptical, fleshy or leathery, and "protective" scales to designate the ones constituted by the persistent stipules, linear, membranous.

Cluster Analyses

Twelve qualitative characters (8 vegetative and 4 reproductive) and 13 quantitative characters (8 vegetative and 5 reproductive) (Table 1) were scored with no missing values for 79 specimens. Qualitative characters were coded. The specimens employed in the analysis are cited for each species in the taxonomic treatment below. The variability of the characters within each species was analyzed by a multivariate analysis of variance (MANOVA). Cluster analyses were carried out on the basis of similarity matrices obtained with the simple matching coefficient and using the UPMGA clustering algorithm. These analyses were performed using the program InfoStat (Di Rienzo et al. 2009).

TABLE 1. Morphological attributes. Quantitative characters resumed for each species. Qualitative characters represented by the minimum and maximum measured values (expressed in mm). Results of MANOVA are shown in the last rows; different letters indicate significant differences (Hotelling post-hoc test for multiple comparisons of means).

Qualitative Characters.	*O. adenophylla*	*O. enneaphylla*	*O. laciniata*	*O. loricata*	*O. morronei*
1. Subterranean structure: Pseudo-Bulb (0), Rhizome (1)	0	1	1	1	1
2. Nutritious Scales: absent (0), present (1)	0	1	1	1	1
3. Nutritious Scales, macula: absent (0), present (1)	0	0	1	0/1	1
4. Protective Scales: absent (0), present (1)	1	1	0	0	0
5. Petiole: Glabrous (0), pubescent (1)	0	1	0/1	0	1
6. Leaflets, shape: obcordate (0), linear (1), square (2)	0	0	1	0	2
7. Leaflets, margins: smooth (0), wavy (1)	0	0	0/1	0	1
8. Leaflets, pubescence: glabrous (0), in both surfaces (1), in the margin (2)	0	0/1/2	0/1/2	0	0/1/2
9. Inflorescence cymes: uni-flowered: (0), bi-flowered (1)	0/1	0	0	0	0
10. Peduncle: glabrous (0), pubescent (1)	0	1	0/1	0	1
11. Sepal: glabrous (0), pubescent (1)	0/1	1	0/1	1	1
12. *Calli*: absent (0), present (1)	0/1	0/1	0/1	0/1	0
Quantitative Characters.					
1. Nutritious Scales: length	-	2,5-6	2-5	3-5,5	2-3
2. Nutritious Scales: width	-	1-3	1-3	2,5-5	1,5-2
3. Protective Scales: length	5-20	2,5-30	-	-	-
4. Protective Scales: width	1-2	1-2	-	-	-
5. Petiole: length	10-150	8-150	30-160	35-190	20-35
6. Leaflets: number	6-13	8-13	7-19	7-11	7-8
7. Leaflets: length	2-8	2-15	4,5-23	3,5-22	2-2,5
8. Leaflets: width	3-12	4-12	1,2-4	3,5-22	2-2,5
9. Bracts: length	3-10	2-10	1-5	3-5	1-1,5
10. Bracts: width	1-3	1-2	1,5-3	1,5-2,5	1
11. Sepals: length	4-8	5-10	5-10	5-12	4-5
12. Sepals: width	2-5	1,5-4	1,2-4	2,5-5	1,5-2
13. Petals: length	10-22	13-25	15-27	10-27	8-10
MANOVA: λ= 0.003; F = 17,79	A	B	C	D	E

Results

Morphological study

After the morphological study of the type specimens and additional material, five species are recognized for *Oxalis* sect. *Palmatifoliae*: *O. adenophylla*, *O. enneaphylla*, *O. laciniata*, *O. loricata* and *O. morronei*.

Cluster Analyses

Quantitative characters are summarized in Table 1. The maximum and minimum observed values for all species (expressed in mm) are, for the nutritious scales: 2–5 × 1–5; protective scales: 2.5–30 × 1–2; petiole length (which also defines the plant height): 8–190; number of leaflets: 6–19; leaflets: 2–23, 1.2 × 22; bracts: 1–10 × 1–2.5; sepals: 4–12 × 1.2–5; and diameter of the corolla: 16–54. MANOVA showed that the means of all the variables differ significantly within the five considered taxa ($\lambda = 0.003$; $F = 17.79$; $p < 0.0001$) (Table 1).

The UPGMA phenogram based on morphological similarities of the populations is shown in Figure 1. The cophenetic correlation was 0.889. Four clusters (groups) of individuals were formed; the forth cluster is divided at a distance of cut of 0.59 into two groups.

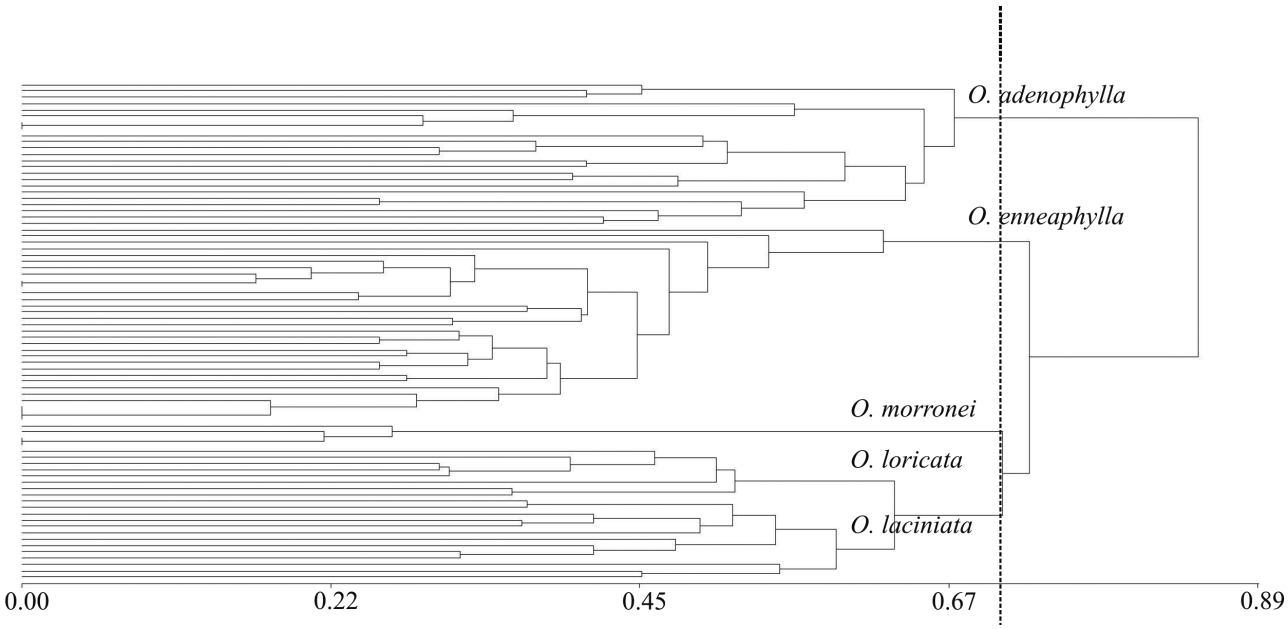

FIGURE 1. Phenogram of unweighted-pair group method (UPGMA) derived from average taxonomic distance. Cophenetic correlation coefficient = 0.889.

Taxonomic Treatment

Oxalis sect. ***Palmatifoliae*** de Candolle (1824: 702) pro parte (*O. enneaphylla* Cav. *et O. Laciniata* Cav.). *Oxalis* sect. *Palamoxys* Endlicher (1840: 1172) pro parte (*O. enneaphylla* Cav. *et O. laciniata* Cav.). Type species: *Oxalis laciniata* Cav., designated by Lourteig (2000: 521).

Perennial herbs, acaulescent, with rhizome or pseudobulb covered with scales; stipules adnate to the petiole; leaves palmated, stalked, peltate-nerved; leaflets 5 to 20, petiolulate, glaucous, with lacunose surface. Inflorescences cymes 1-2-flowered; sepals with *calli* sometimes present; petals pink to violet coloured. Tristyly present. Fruit a globose capsule.

Oxalis sect. *Palmatifoliae* comprises five species endemic of Southern Argentina and Chile (Fig. 2), growing in the Subantartic and Patagonian phytogeographical provinces (Cabrera 1971) (Fig. 3A), ranging from sea level up to 2600 m elevation.

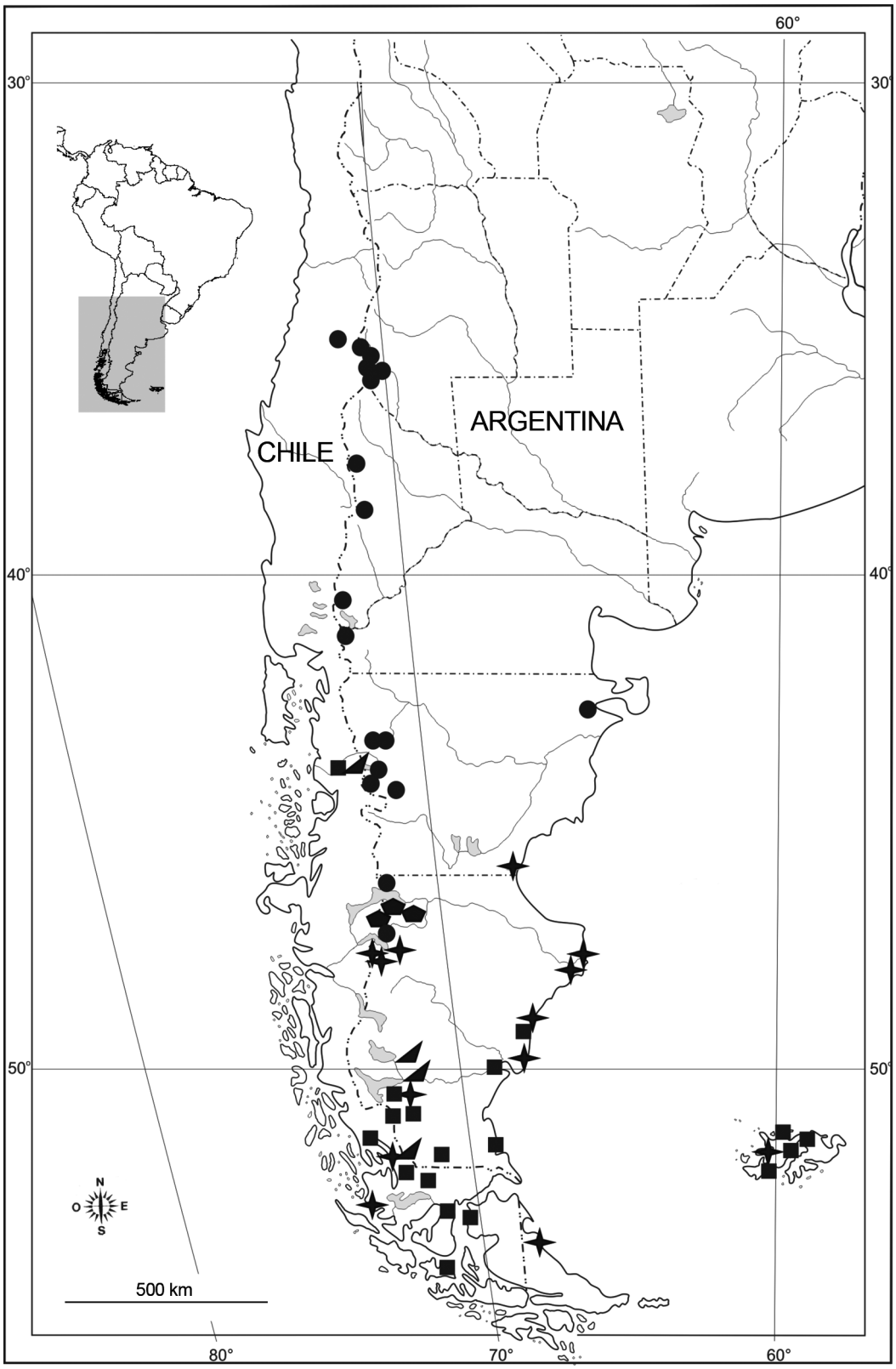

FIGURE 2. Distribution Map of the species of *Oxalis* sect. *Palmatifoliae*: *O. adenophylla* (circles), *O. enneaphylla* (squares), *O. laciniata* (stars), *O. loricata* (triangles), *O. morronei* (pentagons).

Key to the species of *Oxalis* sect. *Palmatifoliae*

1. Rhizome vertical, hollow, covered exclusively by protective scales ("pseudobulb"). Cymes 1- or sometimes 2-flowered ..... *O. adenophylla*
- Rhizome horizontal, solid, covered by nutritious scales, sometimes also by protective scales. Cymes 1-flowered ... 2
2 . Protective scales densely or loosely covering the rhizomes ..... *O. enneaphylla*
- Protective scales absent 3
3 . Leaflets linear ..... *O. laciniata*
- Leaflets not linear 4
4 . Leaflets obcordate, with smooth margin. Plants glabrescent ..... *O. loricata*
- Leaflets square-shaped with wavy margins. Plants pubescent ..... *O. morronei*

1. ***Oxalis adenophylla*** Gillies ex Hooker & Arnott (1832: 165). *Acetosella adenophylla* (Gillies ex Hook. & Arn.) Kuntze (1891: 91). Lectoype (designated here):— CHILE. Cerro de la Pulcura, *J. Gillies 19* (E 322285!). (Figs 3B, 4A-B)

Oxalis bustillosii Philippi (1856: 614). *Acetosella bustillosii* (Phil.) Kuntze (1891: 92). Lectotype (designated here):— CHILE. Cordillera de la Compañia, February 1854, *P. Germain s.n.* (SGO-51021, barcode no. 291!)

Herbs, 4–15 cm high. *Roots* one or more, obtriangular, up to 7 × 3 cm, with fibrous ramifications. Pseudobulb constituted by a vertical rhizome, up to 20 × 5 mm, hollow, covered with protective scales, linear, 10–35 × 1–3.5 mm, reddish-brown, membranous, apex acute, margin densely ciliated, waving cilia up to 5 mm. *Stipules* 3–7 × 1–2 mm, fully adnate to the petiole, narrowed towards the apex, reddish, hyaline, glabrous to pubescent on both surfaces. *Petiole* 4–15 cm, glabrous (or sparsely glandular pubescent). *Leaflets* 8–12, obcordated, up to 8 × 8 mm, incised 1/6–2/3, lobes divergent, unequal, oblong, glabrous (or with few fine and wavy trichomes) *calli* sometimes present. *Inflorescence* 1(-2)-flowered, peduncle up to 15 cm, glabrous; bracts 3–9 × 0.3–2.5 mm; pedicel 4–10 mm; bracteoles up to 5 × 1 mm; sepals broadly ovate, 4–8 × 2.5–5 mm, moderately unequal, long acuminate or acute, rarely obtuse, apex ciliate, cilia wavy, sometimes with *calli*. *Flowers* up to 45 mm diam.; petals obovate or spatulate, pink to violet, white at base, veins and throat purple, base unguiculate, margin finely ciliate at the appex. Short, mid, and long styled morphs present. *Fruit* globose capsule, 6–7 mm diam.; glabrous or with short, simple, glandular trichomes; carpels pubescent inside, 1-2-seeded. Seeds elipsoideo-asymmetric, ± 2 × 1 mm, ochre.

Phenology:—Flowering and fruiting in spring and summer.

Distribution and habitat:—Endemic of the Subantartic forests and Patagonic steppe, from the south of Mendoza to Santa Cruz provinces (Argentina) and Central Chile. Found in humid soils, next to lakes and rivers, also in steppes dominated by *Mulinum spinosum* (Cav.) Persoon ("neneo"); from sea level up to 2600 m elevation (Fig. 2).

Notes:—Lourteig (2000: 530) implicitly lectotypified *Oxalis adenophylla* with a material at Kew (K) by stating "*Tipo: Argentina, Mendoza, Alto de las Rabonas, Gillies 196 18... K*". This lectotyfication is not valid since the mentioned specimen is in conflict with the protologue (ICN Art. 9.19, Mc Neill et al., 2012). The mentioned collection site does not correspond to the one indicated in the protologue ("Cerro de la Polcura" in Chile) and *Gillies 196* was not found at K. The specimen located at E, with barcode number 322285, collected by *Gillies* at the type locality, which also has a second label with number *19*, is designated here as lectotype.

Lourteig (2000: 530) designated the specimen *Germain s.n.* from Cordilleras del Maule (Chile) as lectotype of *Oxalis bustillosii*. This specimen is also in conflict because its collection site does not correspond with the protologue (ICN Art. 9.19). Two syntypes are indicated in the protologue: *V. Bustillos s.n.*, from San Fernando, and *Germain s.n.*, from illa de la Compañia. The specimen housed at SGO (catalogue number 51021 and barcode number 291), collected by Germain in Cordillera de la Compañia is designated here as lectotype of *O. bustillosii*.

The fleshy edible turnip-shaped root is present in fresh material but usually absent in herbarium specimens, remaining only the pseudobulb.

FIGURE 3. A. Habitat of *Oxalis adenophylla* and *O. morronei*: Road from Los Antiguos to Paso Río Roballos, Santa Cruz Province, Argentina. **B**. *O. adenophylla*. **C**. *O. enneaphylla*. **D**. *O. laciniata*. **E**. *O. loricata* . **F**. *O. morronei*. (A, B, F by A. López; C by C. Guerrido; D by A. Sérsic; E by M. L. Ilibarren).

Additional specimens examined:—ARGENTINA. Chubut: Dpto. Futaleufú, Cerro Cuche, 28 January 1947, *A. Soriano 2513* (SI); entre Tecka y Corcovado, 22 October 2005, *A. Cocucci et al. 3496* (SI); Dpto. Languñeo, Tecka, Estancia Quichaura, 7 January 1948, *A. Soriano 2850* (SI); Dpto. Rawson, RP 41, 46º 52'

7,6” S 71º 52’ 39,8” W, 1 December 2002, *M. Bonifacino & M. Donato 752* (SI); Dpto. Río Senger, Aldea Beleiro, Estancia La Media Luna, 3 December 1981, *C.B. Villamil et al. 2197* (SI); Pampa de Chaila, Estancia La Media Luna, 3 December 1981, *C.B. Villamil et al. 2225* (SI); Dpto. Tehuelches, camino lago Los Niños-lago Vintter, campo de G. Alemán, puesto Chenkit, 23 January 1992, *E.G. Nicora 9637* (SI); RP 19, a 1 km de Río Pico al lago Vintter, caserío a orillas del Arroyo Jaramillo, en el corral después del caserío, pasando el bosquecillo de *Nothofagus*, 7 January 2011, *L.M. Zavala Gallo et al. 160* (SI); Estancia El Cherque, al E de Río Pico, 29 November 1946, *A. Soriano 2183* (SI). Mendoza: Dpto. Malargüe, Paso Pehuenche, límite con Chile, 8 March 2007, *E. Méndez 10410* (SI); Paso Pehuenche, límite con Chile, 24 November 2010, *F.O. Zuloaga et al. 12442* (SI). Neuquén: Dpto. Aluminé, entre Pino Hachado y Villa Pehuenia, RP 23, 29 November 2010, *F.O. Zuloaga et al. 12624* (SI); 19 January 2003, *A. Cocucci & A.N. Sérsic 2367* (SI); Dpto. Lácar, Cerro Chapelco, del refugio Graef hacia arriba, 3 January 1983, *C.B. Villamil et al. 2763* (SI); Dpto. Minas, confluencia de los ríos Pichi-Neuquén y Neuquén, Cerro De las Yeguas, 23 January 1970, *O. Boelcke et al. 13762* (SI); paso del Macho, bajada a laguna deshielo, 26 January 1970, *O. Boelcke et al. 13913* (SI); Cordillera del Viento, cruzada de Tricao Malal al cajón del Butaló, ladera W próximo a Portezuelo, 3 November 1964, *O. Boelcke et al. 11592* (SI); camino geométrico al S de Aguas Calientes, río Covunco, comienzo de la picada S al Domuyo, 27 January 2001, *C. Ezcurra 3107* (SI). Río Negro: Dpto. Bariloche, Cerro Catedral, 7 February 2012, *E. Urtubey & K. Tremetsberger 730* (SI). Santa Cruz: Dpto. Lago Buenos Aires, camino fronterizo, al N del Paso R. Roballos, rumbo a los Antiguos, 24 January 2003, *M.J. Belgrano et al. 85* (SI); RP 41, camino de Los Antiguos a Paso Río Roballos, 9 January 2011, *L.M. Zavala Gallo et al. 201* (SI); RP 45, de Perito Moreno a El Portezuelo, vega ancha a 15 km del Portezuelo, 1 December 2009, *F. Biganzoli et al. 2298* (SI); camino a Los Antiguos, 15,6 –21 Km N Paso Roballos, 19 January 2007, *C. Zanotti 125* (SI). CHILE. Región VII: Prov. Maule, ruta J–55, 2–3 km from the Argentina border and Paso Vergara, 12 December 2010, *L.A. Johnson & L.M. Zavala Gallo 10–163* (SI).

2. ***Oxalis enneaphylla*** Cavanilles (1799: 411). *Acetosella enneaphylla* (Cav.) Kuntze (1891: 92). Lectotype (here designated):—ARGENTINA. Islas Malvinas: prope Portum Egmont; *L. Née s.n.* (MA-476046!; isolectotype MA-475679!) (Figs. 3C, 4C–G).

Oxalis ibarii Philippi (1879: 25). *Oxalis enneaphylla* subsp. *ibari* (Phil.) Lourteig (1988: 9). Neotype (designated by Lourteig 2000: 528):—ARGENTINA. Santa Cruz: Río Gallegos, Cerro Norte, al pie, 80 m, 27 November 1950, *H.O. Sleumer 836* (neotype US-2055729!, isoneotypes LIL-356086!, S). *Syn. nov.*

Oxalis patagonica Spegazzini (1897: 501). *Oxalis enneaphylla* var. *patagonica* (Speg.) Skottsberg (1916: 253). Lectotype (here designated):—ARGENTINA. Santa Cruz: in monticulis arenosis circa piscinas salzas prope Río Santa Cruz, 1882, *C.L. Spegazzini s.n.* (LP-4446!; isolectotype LP-4444!).

Oxalis cunninghamii Knuth (1919: 308). Lectotype (designated by Lourteig 2000: 529):—CHILE. Magallanes: Cape Negro, 29 November 1867, *R.O. Cunningham s.n.* (K 531729!; isolectotypes C!, S). *Syn nov.*

Oxalis frigida Knuth (1919: 309). Lectotype (designated by Lourteig 2000: 529):—CHILE. Ad fretum magellanicum, Cap. Negro, November 1855 *W. Lechler 1123* (P; isolectotypes G, GOET 8534!, K 531728!, M 0172273!, P, S).

Oxalis pumila d’Urville (1825: 50). *Oxalis enneaphylla* var. *pumila* (D’Urv.) Hooker (1842: 494). Type:—ARGENTINA. Illes Malouines *d’Urville* (not located).

Herbs, 1–15 cm high. *Roots* adventitious, fibrous; rhizome horizontal, thin; nutritious scales elliptical, 6 × 3 mm, spirally imbricated, reddish-brown, leathery, thick, apex acute, section sub-plane-convex, margins smooth; macula absent; protective scales, linear, 25 × 1.5–2 mm, reddish, membranous, apex acute, totally glabrous to ± sericeous-pubescent, margin with long wavy cilia intertwined with the upcoming stipules. *Stipules* 3–7 × 1–3 mm, fully adnate to the petiole, narrowed towards the apex, reddish, hyaline, glabrous to pubescent on both surfaces. *Petiole* 1–15 cm, pubescent. *Leaflets* 7–13, obtuse, 1.5–8 × 4–12 mm, green or glaucous, triangular cuneate, incised 1/3–2/3, lobes asymmetric divergent, glabrous to densely pubescent, sometimes with *calli* in the margins. *Inflorescence* 1-flowered; peduncle 1–15 cm, glabrous or pubescent; bracts oval or triangular-acute 10 × 2 mm, whitish or reddish, hyaline, amplexicaul, glabrous or ciliate towards the apex; pedicel 2–10 mm; sepals elliptic or ovate, 10 × 4 mm, acute or subacute, reddish or

yellowish, surface glabrous, apex and margin sericea. *Flowers* up to 60 mm diam.; petals obovate or spatulate, base unguiculate, upper margin finely ciliate, white, pink or violet, veins purple. Short, mid, and long styled morphs present. *Fruit*, globose capsule, 6–7 mm diam.; glabrous or with short, simple, glandular trichomes; carpels pubescent inside, 1–2-seeded. Seeds elipsoideo-asymmetric, ± 2 × 1 mm, ochre. 2n=28 (de Azkue 2000)

Phenology:—Flowering and fruiting in spring and summer.

Distribution and habitat:—Found at the Southern end of Patagonia, Magellan region and along the Andes to Tierra del Fuego and Islas Malvinas; from sea level up to 2600 m. (Fig. 2).

Notes:—At the Herbarium of Madrid (MA) two sheets of *Oxalis enneaphylla* collected by *L. Née* (without any collection number) are housed. Both are probably syntypes and belong to the same original collection. The specimen MA 476046 is designated here as lectotype because it has a remarkable similarity with the illustration that accompanies the protologue.

At LP two specimens of *O. patagonica* collected by C. L. Spegazzini are housed; both specimens match the protologue. The specimen LP 4446 bears a label on Spegazzini's hand-writing and is selected here as lectotype.

Regarding the typification of *O. pumila*, a lectotype should be selected from the specimens collected by A. d'Urville and C. Gaudichaud housed at P, which are not available at the time of this work.

Additional specimens examined:—ARGENTINA. Santa Cruz (without locallity) *C. Burmeister 98* (SI); *C. Burmeister 84* (SI); Dpto. Güer Aike, Estancia Las Vizcachas, Cerro Pto. La Piedra, faldeos SE, W Arroyo Bueno, 50º43´S, 72º8´W, 26 January 1977, *T.B.P.A. 2520* (SI); Estancia Stag River, W de Punta Gruesa, Meseta Latorre, ladera superior, 51º32´S 72º9´W, 18 February 1978, *T.B.P.A. 3329* (SI); Estancia Guaken-Aike, camino al puesto La Carlina, 9 November 1977, *T.B.P.A. 2399* (SI); RN 40, camino de Río Gallegos a Río Turbio, 116 km SE de Río Turbio, 17 January 2003, *M.J. Belgrano 21* (SI); Dpto. Lago Argentino, Sierra Buenos Aires, 5 March 1914, *C.M. Hicken & L. Hauman, Iter Patagonicum 644* (SI); 1914, *C.M. Hicken & L. Hauman, Iter Patagonicum 645* (SI); El Calafate, cima del Cerro Huyliche, Estancia "Huyliche", 12 November 2011, *L.M. Zavala Gallo et al. 231* (SI); Calafate, Estancia Anita, Cerro Huyliche, Los Laberintos, 10 January 2001, *C. Guerrido et al. 350* (SI); 1914, *C.M. Hicken & L. Hauman, Iter Patagonicum 640* (SI); verano 1958–1959, *P. James 89* (SI); January 1904, *C. Burmeister 54* (SI); 1909, *E. Molina Massey 6* (SI 19679); Dpto. Lago Buenos Aires, Río Santa Cruz, December 1903, *C. Burmeister 61* (SI); Dpto. Magallanes, San Julián, 10 December 1944, *J. Blake 376* (SI). Tierra del Fuego e Islas del Atlántico Sur: Río Lashifashaj valley, W side, mountain opposite Cerro Cornú, 54º48´S, 67º26´W, 1 March 1968, *D.M. Moore 2088* (SI); Estancia Río Hondo, dunes at mouth of Río Marazzi, 53º27'S, 69º19'W, 10 November 1971, *D.M. Moore 2399* (SI); Bahía Inútil, 5 November 1930, *A. Donat 342* (SI); Misión de Río Grande, 8 March 1921, *F. Pastore s.n.* (SI 26643); Seal Rockery, *M.J. Dimitri 232* (SI). CHILE. Region XII: Prov. Magallanes, 5 January 1931, *A. Donat 440* (SI); Punta Arenas, *C.M. Hicken 214* (SI); Club Hípico, 1 December 1910, *A. Benove 202* (SI); Porvenir, frente a Punta Arenas, 16 January 1904, *C.M. Hicken 221* (SI); Prov. Última Esperanza, Morro Chico, 1 March 1917, *G. Bonarelli s.n.* (SI 19806).

3. ***Oxalis laciniata*** Cavanilles (1799: 7). *Acetosella laciniata* (Cav.) Kuntze (1891: 92). Type:—ARGENTINA. Santa Cruz: Deseado, "Porto Deseado, *L. Née s.n.*" (MA 655396!). (Fig. 3D, 4H-L).

Oxalis squamoso-radicosa Steudel (1856: 443). Lectotype (designated by Lourteig 2000: 524):— CHILE. Magallanes: ad sinum Peckett Harbour. *W. Lechler 1122* (P; isolectotypes G 359280!, G 359281!, GOET 8546!, K 531727!, P, UPS V–140225!).

Oxalis prichardii Rendle (1904: 334). Type:—ARGENTINA. Santa Cruz: Lago Argentino, "South Patagonia: bare sandy ground, Burmeister Peninsula, Lake Argentino 1900–1901, *H. H. Prichard s.n.*" (BM 797279!).

Oxalis squamoso-radicosa var. *pubescens* Skottsberg (1916: 254). *O. laciniata* Cav. var. *pubescens* (Skottsb.) J.M.H. Shaw (2011: 33). Type:—ARGENTINA. Santa Cruz: Río Chico, Lago Pueyrredon-Posadas, vid Río Tarde, 1050 m, 21 December 1908; *C.J.F. Skottsberg s.n.* (UPS V–140229!; isotype K). *Syn. nov.*

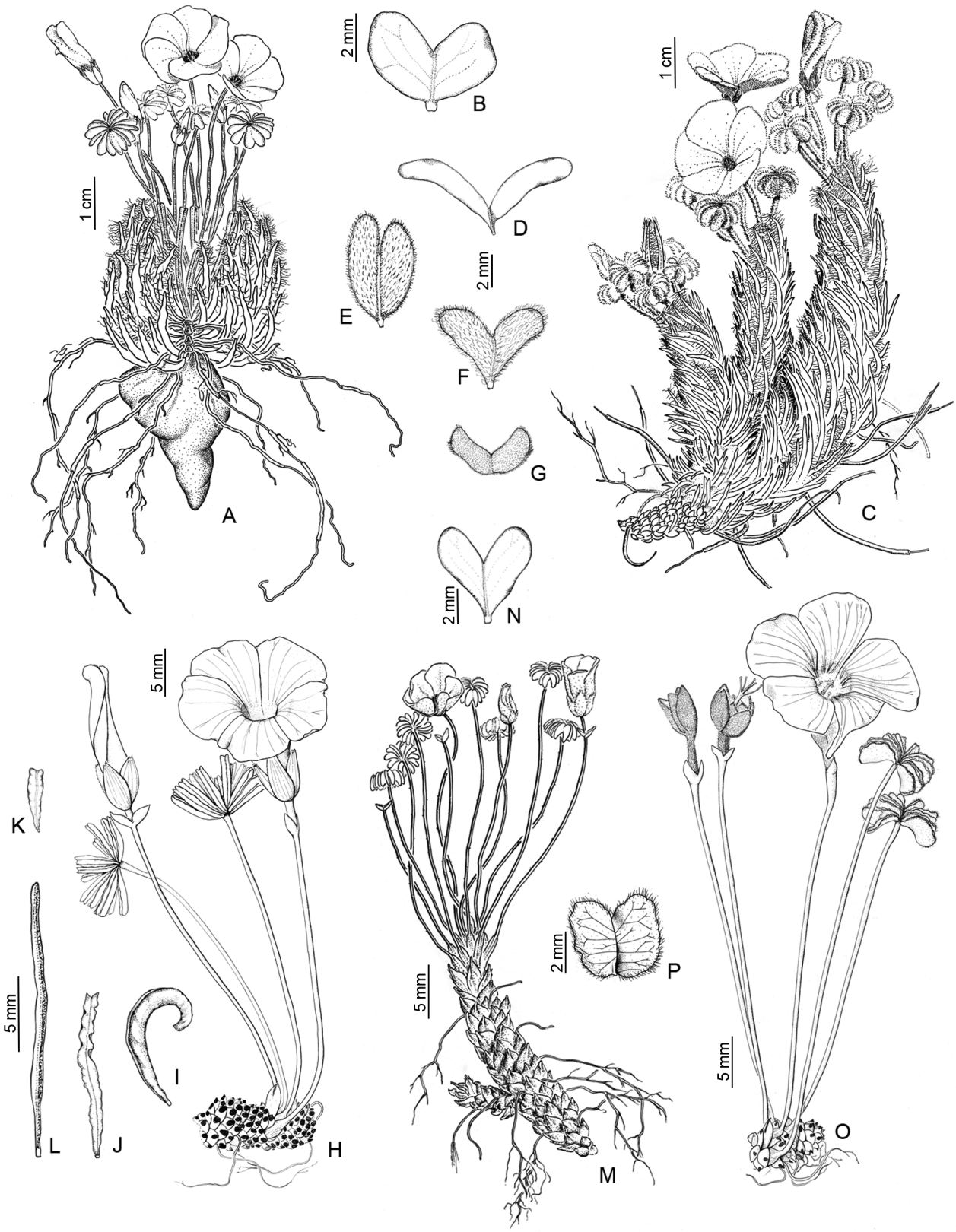

FIGURE 4. *Oxalis adenophylla*. A. Plant. B. Leaflet. *O. enneaphylla.* C. Plant. D.-G. Leaflets. *O. laciniata.* H. Plant. I-L. Leaflets. *O. loricata.* M. Plant. N. Leaflet. *O. morronei.* O. Plant. P. Leaflet. A-B from *Zuloaga et al. 12442* (SI); C from *Guerrido 425* (SI); D from *Kreibohn 535* (SI); E. from *Dimitri 332* (SI); F from *Hicken 214* (SI); G from *Zavala-Gallo 231* (SI); H from *Guerrido 355* (SI); I from *Kiesling 9954* (SI); J, L from *Cocucci 3710* (SI); K from *Suárez 813* (SI); M-N from *Roig 413* (SI); O-P from *Zavala-Gallo 204* (SI). A, M drawn by M. Moreno; B, D-G, I-L, N by A. López; H, O-P by J. Castello.

Herbs 3–16 cm high. *Roots* adventitious, fibrous; rhizome horizontal, cylindrical, thin, with thinning every 1–2 cm; nutritious scales triangular or rhombic, up to 5 × 3 mm, spirally imbricate, whitish to brownish-red, thick, fleshy, macula always present, intense orange at the apex, section subplane-convex, margin smooth. *Stipules* ± 7 × 3 mm, narrowed towards the apex, fully adnate to the petiole, reddish, hyaline, glabrous to pubescent on both surfaces. *Petiole* filiform, 3–16 cm, glabrous to densely pubescent, without glandular trichomes. *Leaflets* 8–12, linear, 5–23 × 1–4 mm, emarginate, glaucous. *Inflorescence* 1-flowered; peduncle 3–16 cm, glabrous or pubescent; bracts 2, broadly ovate, 2.5–6 × 2–3.5 mm, opposite, adnate, amplexicaul, hyaline, unequal; pedicels 2–12 mm, glabrous or pubescent; sepals elliptic, obtuse or broadly acute, 10 × 4 mm; *calli* usually present. *Flowers* up to 60 mm diam., petals broadly obovate, pink to violet, with darker veins, spathulate, base unguiculate, upper margin finely ciliate. Mid and long styled morphs observed. *Fruit*, globose capsule, 6–7 mm diam., glabrous or with short, simple, glandular trichomes; carpels pubescent inside, 1–2-seeded. Seeds elipsoideo-asymmetric, ± 2 × 1 mm, ochre.

Phenology:—Flowering and fruiting in spring and summer.

Distribution and habitat:—Endemic of Southern Argentina (from Chubut to Santa Cruz provinces) and Chile (XII Region); from sea level up to 2600 m. (Fig. 2).

Notes:—This is a very polymorphic species considering leaflets margins which can vary from crenate and undulate to entire and flat depending on the habitat (Shaw, 2011). This was the main characteristic formerly used to differentiate *O. laciniata* from *O. squamoso-radicosa.*

The material cited by Shaw (2011) under *O. laciniata* var. *pubescens* belongs to *O. morronei*.

After the study of over a hundred herbarium specimens, individuals with and without trichomes were observed. However, considering that the trichomes could be present in some of the organs and the variation is gradual from glabrous to pubescent, we conclude that the presence of trichomes is insufficient to support *O. laciniata* var. *pubescens*.

Additional specimens examined:—ARGENTINA. Chubut: Dpto. Escalante, Comodoro Rivadavia, Begoña, 3 November 1946, *A. Soriano 2028* (SI); Valle de la Laguna Blanca, 71º15´S, 45º52´W, 10 October 1901, *J. Koslowsky 133* (SI). Santa Cruz: (without locallity) 1 October 1913, *A. Benove 204* (SI); Dpto. Corpen Aike, desde San Julián hacia Piedra Buena, 2 November 2001, *R. Kiesling 9954* (SI); 22 km al sur de Comandante Piedra Buena, cárcava al W de la RN 3, 6 November 2005, *A. Cocucci et al. 3710* (SI); Dpto. Lago Argentino, El Calafate, Campo Calafate, camino a CEJL, 13 November 1999, *C. Guerrido et al. 136* (SI); Punta Hualychu a Punta Bonita, 27 October 2002, *C. Guerrido et al. 548* (SI); El Calafate, Cerro Huyliche Excursión 4x4 Laberinto 1 de regreso a Calafate, 11 January 2001, *C. Guerrido et al. 355* (SI); Estancia Anita, faldeo Cerro Huyliche, November 2002, *C. Guerrido et al. 541* (SI); Dpto. Lago Buenos Aires, Perito Moreno, November 1973, *C. Suárez 813* (SI); Dpto. Magallanes, San Julián, 5 November 1955, *J. Blake 447* (SI); 26 October 1944, *J. Blake 410* (SI); Dpto. Río Chico, 50 km N de Bajo Caracoles, 6 November 2001, *R. Kiesling 9971* (SI). Tierra del Fuego e Islas del Atlántico Sur: Dpto. Río Grande, cabo Domingo, 18 November 1971, *D.M. Moore 2512* (SI). CHILE. Región XII. Magallanes: Puerto Prat, 4 February 1904, *C.M. Hicken 219* (SI).

4. ***Oxalis loricata*** Dusén (1901: 247). Lectotype (designated here):—CHILE. Patagonia Australis: Cerro Toro, supra terminum silvae 18–19 March 1899. *O. Borge 194* (S R–9782!, isolectotypes CORD 2983!, S 10–21873!). (Fig. 3E, 4M-N).

Herbs, 3.5–19 mm high. *Roots* adventitious, fibrous; horizontal rhizome, cylindrical, thin, with thinning every 1–2 cm; nutritious scales triangular or rhombiform, up to 5.5 × 5 mm, spirally imbricate, reddish-brown, thick, fleshy; macula sometimes present, intense orange at the apex, section subplane-convex, margin smooth. *Stipules* 5 × 2.25 mm, fully adnate to the petiole, glabrous or with very short, simple, glandular trichomes. *Petiole* filiform, 3.5–19 cm, glabrous; leaflets 5–12, obovate-cuneate or obcordate, 22–3.5 × 22–3.5 mm, green-glaucous, sometimes with reddish margins, incised 1/6–1/4, unequal, glabrous or laxly ciliate.

Inflorescence 1-flowered, peduncle longer than or equal to the foliage, glabrous; bracts 2 (rare 3), ovate, 5 × 2.5 mm, opposite, hyaline, acute, amplexicaul; pedicel 10–20 mm, glabrous; sepals acute or subacute, 12 × 5 mm, green or reddish, glabrous to entirely pubescent; *calli* sometimes present. *Flowers* up to 60 mm diam., petals broadly obovate or spatulate, pink to violet streaked darker base unguiculate, upper margin finely ciliate. Short and mid styled morphs observed. *Fruit* globose capsule, 6–7 mm diam., glabrous or with short, simple, glandular trichomes; carpels pubescent inside, 1–2-seeded. Seeds elipsoideo-asymmetric, ± 2 × 1 mm, ochre.

Phenology:—Flowering and fruiting in spring and summer.

Distribution and habitat:—Endemic of Southern Argentinean-Chilean Patagonia; from sea level up to 2600 m elevation. (Fig. 2).

Notes:—Three duplicates of *O. Borge 194* were located: Two of them at S, where most of Dusen's types are deposited; S R-9782 is selected here as lectotype of *Oxalis loricata* due to its excellent state of conservation.

Additonal specimens examined:—ARGENTINA. Santa Cruz: Dpto. Güer Aike, Estancia Stag River, meseta Latorre, 24 January 1978, *F.A. Roig et al. 413, T.B.P.A.* (SI); Cerro Punta Gruesa, 24 January 1978, *F.A. Roig et al. 302, T.B.P.A.* (SI); Dpto. Lago Argentino, Sierra Buenos Aires, 5 March 1914, *C.M. Hicken & L. Hauman, Iter Patagonicum 371* (SI); verano 1958–1959, *P. James 101* (SI), Lago Viedma, January 1916, *L. Witte 49* (SI). CHILE. Región XII. Prov. Magallanes: (without locallity) 5 January 1931, *A. Donat 439* (SI); Prov. Tierra del Fuego, 15 km N of Porvenir, Lag. de los Cygnes, 6 November 1971, *D.M. Moore 2333* (SI); Porvenir, Cerro Pirámide, 28 January 1939, *I. von Rentzell 6107* (SI); Prov. Última Esperanza, Cerro Dorotea, 8 January 1939, *W.J. Eyerdam 24193* (SI).

5. ***Oxalis morronei*** A. López & Múlgura (2011: 41). Type:—ARGENTINA. Santa Cruz: Dpto. Lago Buenos Aires, RP 41, camino de Los Antiguos a Paso Río Roballos, 9 January 2011, *L.M. Zavala Gallo et al. 204* (SI!). (Fig. 3F, 4O-P).

Herbs 4–5 cm high. *Roots* adventitious, fibrous; horizontal rhizomes, thin, 4–5 mm diam. with sparse ramifications; nutritious scales conical, 4 × 2 mm, spirally imbricate, whitish, macula always present, intense orange at the apex. *Stipules* 2.0–2.5 mm, narrowed toward the apex, fully adnate to the petiole, hyaline. *Petioles* 4–5 cm; leaflets 10–12, square, 3.5–4.0 × 4.5–5.0 mm, apex deeply emarginate, slightly cordate at base, margin wavy, ciliate, glabrous. *Inflorescence*1-flowered; peduncle 4–5 cm, glabrous; bracteoles ovate, acute, up to 2 mm, hyaline, sheathing, adnate at the base, glabrous; pedicel ca. 3 mm, pubescent; sepals 5.0–5.5 × 2.0–2.5 mm, externally pubescent, glabrous internally. *Flowers* up to 40 mm diam.; petals obovate or spatulate, pink to violet, veins purple, base unguiculate, upper margin finely ciliate. Short, mid, and long styled morphs present. *Fruit* not seen.

Phenology:—Flowering and fruiting in spring and summer.

Distribution and habitat:—Endemic of Santa Cruz province (Argentina), it grows in rocky slopes (shelter of rocks) and on sandy soils; from sea level up to 2600 m elevation (Fig. 2).

Additonal specimens examined:—ARGENTINA: Santa Cruz: Mesetas Altas, 4 November 1930, *A. Donat 7620* (LIL); Dpto. Lago Buenos Aires, meseta del lago, 42 km NW del casco Estancia La Vizcaina, 10 December 1986, *M.I. Sánchez et al. 574* (BAB); meseta del lago, 35 km NW del casco Estancia La Vizcaína, 10 December 1986, *M.I. Sánchez et al. 567* (BAB).

Discussion

The five accepted species: *O. adenophylla*, *O. enneaphylla*, *O. laciniata*, *O. loricata,* and *O. morronei* were clearly distinguishable by both, traditionally morphological observations, and multivariate methods based on

vegetative and reproductive characters. UPGMA analysis showed that the cophenetic correlation was indicative of a good fit between the cophenetic value matrix and the mean taxonomic distance matrix. At the chosen level of similarity, five groups of individuals were formed. The most differentiated cluster is constituted by the individuals of *O. adenophylla*, separated by the presence of a pseudo-bulb, the absence of nutritious scales, and the presence of bi-flowered cymes. *Oxalis enneaphylla* also comprises a well differentiated group in the analysis, sharing with *O. adenophylla* the presence of protective scales. *Oxalis enneaphylla, O. laciniata, O. loricata*, and *O. morronei* share a subterranean rhizome with nutritious scales. The individuals of *O. morronei* can be differentiated by the square-shaped leaflets. The individuals of *O. loricata* and *O. laciniata* are closely related, but the ones belonging to *O. laciniata* are differentiated by having linear leaflets (*vs*. obcordate leaflets in *O. loricata*).

Acknowledgements

We express thanks to M.E. Múlgura for valuable comments and critical reading; the curators of BA, BAB, CTES, LIL, and SI for loans or permission to consult herbarium material; J. Castello, M. Moreno, and A. Toscani for illustrations and images of the species; Consejo Nacional de Investigaciones Científicas y Técnicas for financial support, and the Editors of Phytotaxa for allowing the reproduction of a figure.

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