The genus *Solidago* L. (Astereae, Asteraceae) in South America and related taxa in North America

by

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Author’s declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

The goldenrod genus *Solidago* L. is one of the larger genera in the flowering plant family Asteraceae. The genus is primarily North American and was recently revised in Flora of North America. In contrast, *Solidago* in South America is not well understood and has been thought to be represented by one group in one subsection the S. *chilensis* complex with only two species. However, among specimens borrowed to analyze the *Solidago chilensis* complex were a small number of collections of two additional species, *S. missouriensis* Nutt. and *S. virgaurea* [synonym: *S. patagonica*], from two different subsections not previously reported from South America. Using multivariate morphometric analyses on a matrix of 50 traits of 160 specimens (stepwise discriminant, classificatory and canonical analyses), the distinctiveness of the *Solidago chilensis* complex was tested and found to be statistically different from three morphologically similar North America species. Using just the 104 specimens of the *Solidago chilensis* complex, the previously published classification dividing the complex into two species was tested and found to be supported statistically but with many misclassifications *a posteriori*. Alternative ways of dividing the complex into species and varieties were explored in order to create a statistically strongly supported revised classification of the *Solidago chilensis* complex with two species, *S. chilensis* and *S. microglossa*.

Acknowledgements

I would like to thank Dr. J. C. Semple for all his support. I would like to thank Leo, who helped me through this in many ways. Thanks to Gisela Sancho (La Plata) for her assistance with the collections from my field trip in South America, and the National Park Administration from Argentina that allow me to collect (when possible) within the protected areas. Finally, I would like to thank Joan Venn for her help in the herbarium. This research was supported by Natural Sciences and Engineering Research Council of Canada Discovery Grants to J.C. Semple and University of Waterloo International Masters Student Awards to the author.

Muchisimas gracias a mi papá, mamá y a Maria del Carmen, quienes ademas de prestarme todo al alcance de sus manos para que mi campaña sea un éxito, me acompañaron y apoyaron durante todo el viaje. Sin su apoyo mi viaje no hubiese sido lo que fue.

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Chapter 1: Introduction

1.1 An overview of the genus *Solidago* and its position within the Asteraceae

The family Asteraceae is the largest family of flowering plants. It is a well defined group consisting of over 1500 genera and 23000 species (Angiosperm Phylogeny Group II, 2003; Judd *et al.*, 2008). This family has a global distribution, except in Antarctica. It is well represented in most climates (Bremer, 1994), being found especially in temperate and/or tropical montane regions and in open and/or dry habitats (Judd et al, 2008). The general characteristics of this family (Fig. 1) are the flowers arranged in heads (capitula) and often grouped into larger secondary and sometimes tertiary inflorescences. The florets are surrounded by an involucre of usually green bracts (phyllaries) with a midvein, and the florets are arranged upon a common receptacle. They are epigynous, usually 5-merous. The calyx is modified to pappus. The corolla consists of united petals. Members of the genus *Solidago* usually have yellow ray and disc florets, although two species have white rays. The five stamens are epipetalous with short filaments and introrsely dehiscent anthers that are fused. The ovary is inferior, bicarpellate, unilocular, and has one ovule with basal placentation. The style branches have two stigmas along the margins and often end in a papillate appendage evolved to push pollen out of the anther tube. The fruit is a cypsela (Flora North America Editorial Committee, 2006).

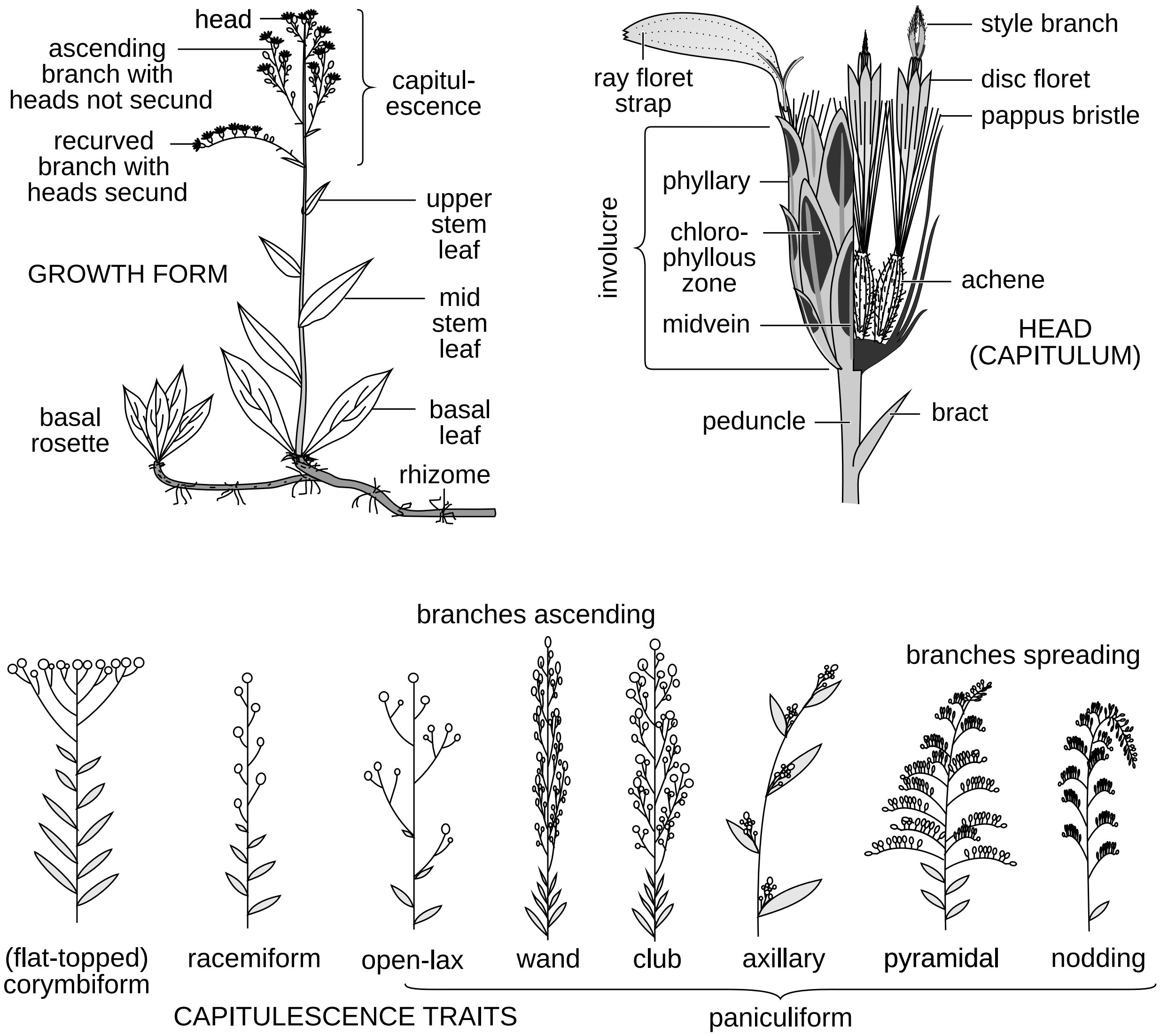


Figure 1. General morphology of Solidago. (Modified with permission from Semple et al. 1999).

The Asteraceae (Compositae) has been divided into various different tribes, which may or may not represent natural groupings (Cronquist, 1981). Several treatments of the family have been presented, with the first comprehensive one done by Bentham (1873) in which he divided the group into 13 tribes, one of which being the Astereae. Bentham's taxonomic treatment has been expanded and revised by many authors including Cronquist (1955, 1977, 1980), Zhang and Bremer (1993) and Bremer (1994). On recent molecular phylogenetic data, the Angiosperm Phylogeny Group (APGII, 2003; Judd *et al.*, 2008) has suggested that Asteraceae is treated as part of a more widely defined Asterales within the Asterids II informal clade. Funk *et al.* (2005a, b) presented a supertree phylogeny of the family which was found to include 36 clades. These clades are accepted in the soon to be published major review of the family (Funk *et al.*, 2009, in press).

The genus *Solidago* is a member of the tribe Astereae and the subtribe Solidagininae (Nesom, 2000). *Solidago* is among the taxonomically most difficult genera of the Asteraceae (Fernald, 1950; Semple and Cook 2006).

Studies on the phylogeny of the tribe Astereae have done much to resolve relationships of the goldenrods to each other and to other genera within the tribe (Beck *et al.* 2004, Brouillet *et al.* 2009, in press). Earlier efforts had been less conclusive, e.g., Lane *et al.* (1996) included several species of *Solidago* in their chloroplast DNA restriction fragment length polymorphisms (cpDNA RFLP) study of North American members of the tribe.

The species of the genus are phenotypically plastic that is reflected in great variation on its morphology in differents environments (Jakobs *et al.*, 2004), at the same time presents usually few sharp morphological discontinuities.

Genetic barriers among species are poorly developed (Kress *et al.*, 2005). For this reason, resolution of the phylogeny within *Solidago* has been difficult to obtain. In the first phylogenetic analysis of the genus, Zhang (1996) studied cpDNA RFLP in species of *Solidago* and related genera. He helped clarify the generic limits of *Solidago* and provided the first real guide to relationships among groups of species within the genus (Semple *et al.*, 1999), but many taxa were not included. However, within the genus there was no resolution beyond grouping of a few closely related species.

Initial efforts to barcode species in the genus have met with no real success (J.C. Semple, pers. comm. 2009; based on collaboration with the University of Guelph BarCoding Group). A comprehensive DNA sequence based phylogeny of the genus is still needed. The internal transcribed spacer (ITS) region is the most commonly sequenced for plant molecular systematic investigations. This region has shown broad utility across photosynthetic eukaryotes (with exception of ferns) and it has been suggested as a possible plant barcode locus (Stoeckle 2003). Brouillet *et al.* (2009) were successful resolving the phylogeny of tribe Astereae using ITS. However, Schilling *et al.* (2008) reported on a lack of resolution in the phylogeny of *Solidago* based on sequence data due to very low levels of variation in ITS and ETS. Similarly, Kress *et al.* (2005) had included *Solidago* as part of their attempt to use DNA barcodes to identify flowering plants species in eight genera, but they had little or no sequence divergence for the seven plastids regions (*trnH*-psbA, *rpl36*-rps8, *trnK*-rps16, *trnV*-atpE, trnC-*ycf6*, *ycf6*-*psbM*, *trnL*) sampled in *Solidago*.

Although the phylogeny in the North American Clade has been recently resolved and a detailed treatment of the genus as it occurs in Canada and the United States was included in The Flora North America (Semple and Cook 2006); the genus *Solidago* in South America has been only dealt with in floristic treatments. Cabrera (1971) and Sancho and Espinar (2003) presented floristic keys based on the density of the panicle (inflorescence) and consequently distinguished two species: *Solidago chilensis* Meyen and *Solidago patagonica* Phil. Sancho and Espinar (2003) went even further and separated *Solidago chilensis* in two varieties on the basis of pubescence traits: *S. chilensis var. chilensis* and *S.*

chilensis var. megapotamica (DC.) Cabrera.

The uncertainty of the taxonomy of the genus *Solidago* in South America is reflected in the extended nomenclature based on South American collections. The following tentative nomenclature was provided by John Semple (pers. comm., 2007) and lists all the names that have been proposed:

***Solidago chilensis* Meyen, Reise 1:311. 1834. TYPE (Holotype: B, destroyed)**

Solidago linearifolia DC., Prodr. 5:341. 1836. *S. microglossa* DC. var. *linearifolia* (DC.) Bak. In Mart., Fl. Bras. 6(3): 10. 1882. TYPE: “in campus Chilensibus,” *Nee* (T: G-DC)

Solidago linearifolia DC. var. *poeppigii* DC., Prodr. 5: 341. 1836. TYPE: South America, without definite locality. *Poeppig ccxxvii* (T: not seen)

Solidago odora Hook. & Arn, Comp. Bot. Mag. 2: 45. 1836. non Aiton (1789). TYPE: (T: not seen)

Solidago coquimbana Phil., Linnaea 33: 138. 1864-65. TYPE: CHILE. Cordera. Cordillera de Thapel, Jan 1860, *Volikmann s.n.* (T: SGO, photo!)

Solidago laxiflora Phil., Anal. Univ. Chile 87: 429. 1894. TYPE: CHILE. S. Francisco del Monte, 1880, Martio s.n. (HT ?: SGO, photo!, annot. as "typus" by R. Acevedo de V. 1957)

Solidago floribunda Phil., Anal. Univ. Chile 87: 430. 1894. non *S. floribundus* Wall. (date?), nec Bush (1918). TYPE: CHILE. Ooalle??? Lautaro??, Jan 1880, Navarro?? (T: SGO, photo! annot. cotypus)

Solidago araucana hil., Anal. Univ. Chile 87: 431. 1894. TYPE: CHILE. (T: not seen)

Solidago valdiviana Phil., Anal. Univ. Chile 87: 431. 1894. TYPE: CHILE. Prov. Valdivi, San Juan, aestati1 887, *Philippi s.n.* (T: SGO, photo!, annot "typus", C. Muñez P., 1944)

Solidago recta Phil., Anal. Univ. Chile 87: 431. 1894. TYPE: CHILE. (T: not seen)

Solidago micrantha Phil., Anal. Univ. Chile 87: 432. 1894. TYPE: CHILE. (T: not seen)

Solidago parviflora Phil., Anal. Univ. Chile 87: 432. 1894. non Raf. (1820). TYPE: CHILE. Pirihuaico, Feb 1887, *Otto s.n.* (T: SGO, photo!) annot. as "typus" by R. Acevedo de V. 1957)

?*Aster sagei* Phil. Anal. Univ. Chile 87: 405. 1894. TYPE: CHILE. "Ex Araucania attulit orn, Carlos Sage". (T: not seen)

Solidago linearifolia DC. var. *brachypoda* Sprg. Revist. Agron. La Plata, 3: 610. 1897. TYPE: ARGENTINA. (T: not seen)

***S. microglossa* DC., Prodr. 5: 332. 1836. *Aster polyglossus* var. *microglossus* (DC.) O. Ktze., Rev. Gen. 1: 318. 1891. TYPE: Brazil. *Bacle s.n.* (T: G-DC photo!; photo in MO ex Krukoff)**

Solidago microglossa DC. var. *megapotamica* DC., Prodr. 5: 332. 1836. *Solidago chilensis* Meyen var. *megapotamica* (DC.) Cabrera, Darwinia 16: 409. 1970. TYPE: BRAZIL. Prov. RIO GRANDE. in h. Mus. reg. Par. à Mus. imp. Bras. miss. sub n. 846, 854, et 857 (HT: G-DC, photo!; *Gaudichaud 854*, P photo in MO ex Krukoff!)

Solidago marginella DC., Prodr. 5: 332. 1836. TYPE: BRAZIL. Bacle (T: G-DC, photo!)

Solidago marginella DC. var. *sublanceolata* DC., Prodr. 5: 332. 1836. TYPE: BRAZIL. in h. Mus. reg. Par. à Mus. imp. Bras. sub n. 860 missa. (not seen)

Solidago polyglossa DC., Prodr. 5: 332. 1836. *Aster polyglossa* (DC.) O. Ktze., Rev. Gen. 1: 318. 1891. TYPE: BRAZIL. RIO GRANDE. v.s. in h. Mus. reg. Par. à Mus. imp. Bras. sub n. 860 missa. *Gaudichard 860* (T: G-DC, photo!, fragments; P photo in MO! ex Krukoff).

Solidago odora Hook. & Arn. var. *glabra* Hook. & Arn., Comp. Bot. Mag. 2: 45. 1836. TYPE: ARGENTINA. Mendoza. (T: not seen).

Solidago odora Hook. & Arn. var. *scabra* Hook. & Arn., Comp. Bot. Mag. 2: 45. 1836. TYPE: URUGUAY.(T: not seen)

Solidago odora Hook. & Arn. [var.] *glabriuscula* Hook. & Arn., Comp. Bot. Mag. 2: 45. 1836. TYPE: ARGENTINA. Buenos Aires & Mendoza. (T: not seen)

?*Solidago nitidula* Mart. ex Baker in Mart., Fl. Bras. 6(3): 10. 1882. TYPE: "Mss. inherb. proprio" (T: not seen)

?*Solidago repens* D. Don ex Baker in Mart., Fl. Bras. 6(3): 11. 1882. TYPE: Herb. Lambert (T: not seen)

?*Solidago vulneraria* Mart., Syst. Mat. Med. Bras. 9. nomen.

Solidago bonariensis D. Don ex Baker in Mart., Fl. Bras. 6(3): 11. 1882. non Larranaga (1923). TYPE: (T: not seen)

Solidago microglossa DC. var. *macrophylla* Niederl., Bol. Mens. Mus. Prodr. Argent. 3, no. 29: 186. 1890. nom. nud. TYPE: ARGENTINA. (T: not seen)

Solidago microglossa DC. var. *ramosa* Arech., Anal. Mus. Nac. Montevideo, 6: 197. 1907. Arech. Fl. Uruguay, 3: 197. 1907. TYPE: URUGUAY. (T: not seen)

Solidago bonaerensis Larranaga, Escritos D. A. Larranaga 2: 255 [Pub. Inst. Hist. Geog. Uruguay] 1923. Nomen nudum. TYPE: URUGUAY. (T: not seen)

The genus *Solidago* is native to North America with about 90 species native to Canada, the United States and Mexico (Semple and Cook 2006), with an additional approximately one dozen Eurasian and South American species all derived from North American taxa. Nesom (1993) mentioned one species autochthonous in South America, *S. microglossa* DC. as belonging in the *S.* sect. *Unilaterales*. *Solidago* in South America includes a species complex that has not been explored in detail (*Solidago chilensis* complex). Semple *et al.* (1999) described this complex as part of the *S. linearifolia* DC., *S. microglossa* DC., and *S. patagonica* Phil. group of taxa. He recently treated the South American species as part of the *S. chilensis* complex and included it in *S.* subsect. *Triplinervae* (Torrey & A. Gray) G.L. Nesom (http://www.jcsemple.uwaterloo.ca/goldenrod_figs.htm; Semple (2007). Semple (personal communication) indicated that the South American *S. chilensis* complex is most similar morphologically to *S. juliae, S. leavenworthii* and *S. tortifolia,* each native to different areas in the southern United States from Florida to the Hill County of western Texas and adjacent Mexico. In accordance, the morphological description of *S. chilensis* by Cabrera (1974) is closest to that of *S. tortifolia* from the North American group in Semple and Cook (2006).

It is known that *Solidago* is a common genus in Argentina, particularly an invasive one along riversides and in humid fields (Cabrera, 1974). However, there is little knowledge of the complex in South America, few studies had been made in this genus and consequently there is lack of accuracy in the information coming from incomplete information from collections and missing type specimens. Cabrera (1971) mentioned different provinces where it was found and in a later work (Cabrera, 1974) he mentioned some specific counties when he referred to *S. chilensis* var. *chilensis* and *S. chilensis* var. *megapotamica*. While most species from North America flower between late summer (August) and mid fall (September and October), South American *S. chilensis* flowers two times in the year, during the summer (December-March) and in late fall (June). In contrast with a lot of studies on North American *Solidago* phylogeny, there is a blank when it comes to the South American phylogeny. In order to clarify the phylogeny, firstly it is necessary to clarify the nomenclature and taxonomy of the genus in that area.

In a similar way, there has been a scarce research on cytology on the genus in South America comparing with the thousands of counts published for the genus in North America. Chromosome numbers have been widely used in systematic investigations in Asteraceae and they vary greatly from $2n = 4$ to $2n = 432$ in the family (Semple and Watanabe 2009). The genus *Solidago* has a base chromosome number of $x = 9$ ($2n = 18$) with polyploidy series within many species (Semple *et al.*, 1999; Semple & Cook, 2006). Polyploidy is common in many genera, including *Solidago*, being a conspicuous feature of chromosomal evolution in higher plants (Stebbins, 1971). The size and number of some plant structures (particularly involucre height and number of ray and disc florets) are affected by ploidy levels (Semple *et al.*, 1990). Consequently, chromosome number as a diagnostic trait introduces potential information about possible differences between allopatric races increasing the differences in morphological traits.

Chromosome counts have been reported six times for members of the of the *S. chilensis* complex; all counts were diploid, 2*n* = 9II or 2*n* = 18. Covas and Schnack (1946;1947) reported a count for *S. chilensis* as did Hunziker *et al.* (1989); both cited in Cabrera (1974). Turner *et al.* (1979) reported counts for *S. chilensis* (2*n*=18) from Salta Province, Argentina and *S. microglossa* (2*n*= 18) from Santa Fe Province, Argentina. The recent chromosome count of 2n = 18 reported by Dematteis *et al.* (2007) for *S. chilensis var. megapotamica* was from Paraguay. Polyploidy has not been reported for any *Solidago* from South America.

The study area (South America) is divided into the non-Andean east and the mountain chain in the Andean west. The non-Andean east includes the Pampas region (grassland), dry in the winter but with a permanently humid subtropical; the Gran Chaco with rainfall in the southern summer in the form of violent storms; and the eastern Patagonia with less than 250 mm of rain per year and the rainy season mainly during the winter. The mountain chain in the Andean west (subdivided into the northern, central, and southern Andes) acts as a climatic divisor line between the west and east of South America. It differs all along in the types of soil and plant-life as a phenomenon caused by differences between the tropical and non-tropical climates of the 8000 km-long mountain range (Junk, 1969).

In Summary, the North American genus *Solidago* has been studied in detail (Semple and Cook, 2006) and the nomenclature, morphology, and natural history of a many of the species are well known compared to the lack of information on South American species. The main goal of this research is to contribute a more accurate understanding of *Solidago* in South America (Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay). In order to acomplish this the thesis focuses on the *S. chilensis* complex (Semple, 2007) includes morphological variation, nomenclature, biogeography, and cytogeography. It would be informative to apply molecular techniques to clarify the phylogeny of the group. However, such work in *Solidago* has proven of very limited value to date due to a lack of variation in molecular markers mentioned above (Kress *et al.*, 2005; Schilling *et al.*, 2008). Therefore, molecular work will not be included in this Masters thesis.

1.2 Objectives

1. Quantitatively determine the differences in the morphological traits among putative taxa using a multivariate morphometric method.

Difficulties on *Solidago* classification have been revealed by the preliminary observations of *Solidago chilensis* complex herbarium specimens. Technical morphological and floral traits have done much in accurately show differences among different taxa of the genus when used in multivariate morphometric studies in North America. In the case of *Solidago* in South America there is no record of the use of this analysis to assess the differences among taxa.

2. Determine the number of taxa and rank them.

The use of multivariate morphometric analyses has been sussccessful in the determination of taxa within *Solidago* in North America. In the same way I will assess a possible existence of putative taxa in South America.

3. Present a distribution map of the *Solidago* in South America.

There has not been published before a distribution map of *Solidago* in South America. For this reason, and with the revision of as many herbarium collections as well as my own collection in the field, I will plot a dot distribution map and draw a possible geographical distribution range of the genus in South America.

4. Initiate a cytogeographic study of the *Solidago chilensis* complex.

Although this study is not the first one to report chromosome numbers in South American *Solidago*, it will be be the first to present cytogeographic map.

5. Develop a more accurate and useful key to identify taxa of *Solidago* in South America.

The published key that has been presented for the first time in 1974 (Cabrera), and updated in 2003 (Sancho and Espinar) has not been successful in the preliminary specimens identification of the taxa into two groups and this could be a consequence of the diagnostic character that has been suggested to be affect by environmental changes. A more accurate and improved key to identify all the taxa of *Solidago* in South America is necessary.

Chapter 2: Materials and Methods

2.1 Fieldwork

Fieldwork was undertaken in April 2008 to collect specimens of *Solidago*. Samples were collected in 22 provinces in Argentina: Misiones, Corrientes, Formosa, Chaco, Santa Fe, Cordoba, Jujuy, Salta, Santiago del Estero, Tucuman, Entre Rios, Buenos Aires, La Rioja, San Juan, San Luis, Catamarca, Mendoza, Neuquen, La Pampa, Rio Negro, Chubut, Santa Cruz, and at one population in Region XI in Chile (Fig.2). Plants were collected from along roadsides, mainly in wet areas or close to rivers and ponds. When it was possible, we collected in protected areas with permission. The collections were made with a minimum interval of 100 km between two consecutive groups of plants. When collecting, we selected plants in flower (when possible). They were uprooted using a small shovel obtaining as much rhizome and roots as possible. Cypselae were also collected from plants that were past bloom from closest plants. The plant was placed in a plastic bag with a collection number. Collection information including collector, date, latitude, longitude, altitude, habitat and any other relevant information was recorded using Firestone Atlas de Rutas 2008 and a Colorado 300-GPS (Garmin). All specimens collected on a day were placed in a larger bag at the time of collection to prevent damage and desiccation. At the end of the day, the plants were labeled and pressed in a 25 x 38 cm plant press between pieces of newspaper labeled with the collection number. They were then dried for the night, or until dry, using a heater that optimized the airflow between the specimens. The plants were deposited as voucher specimens at the University of Waterloo herbarium and a duplicate of each collection will be deposited at the Museo de la Plata, Buenos Aires, Argentina.

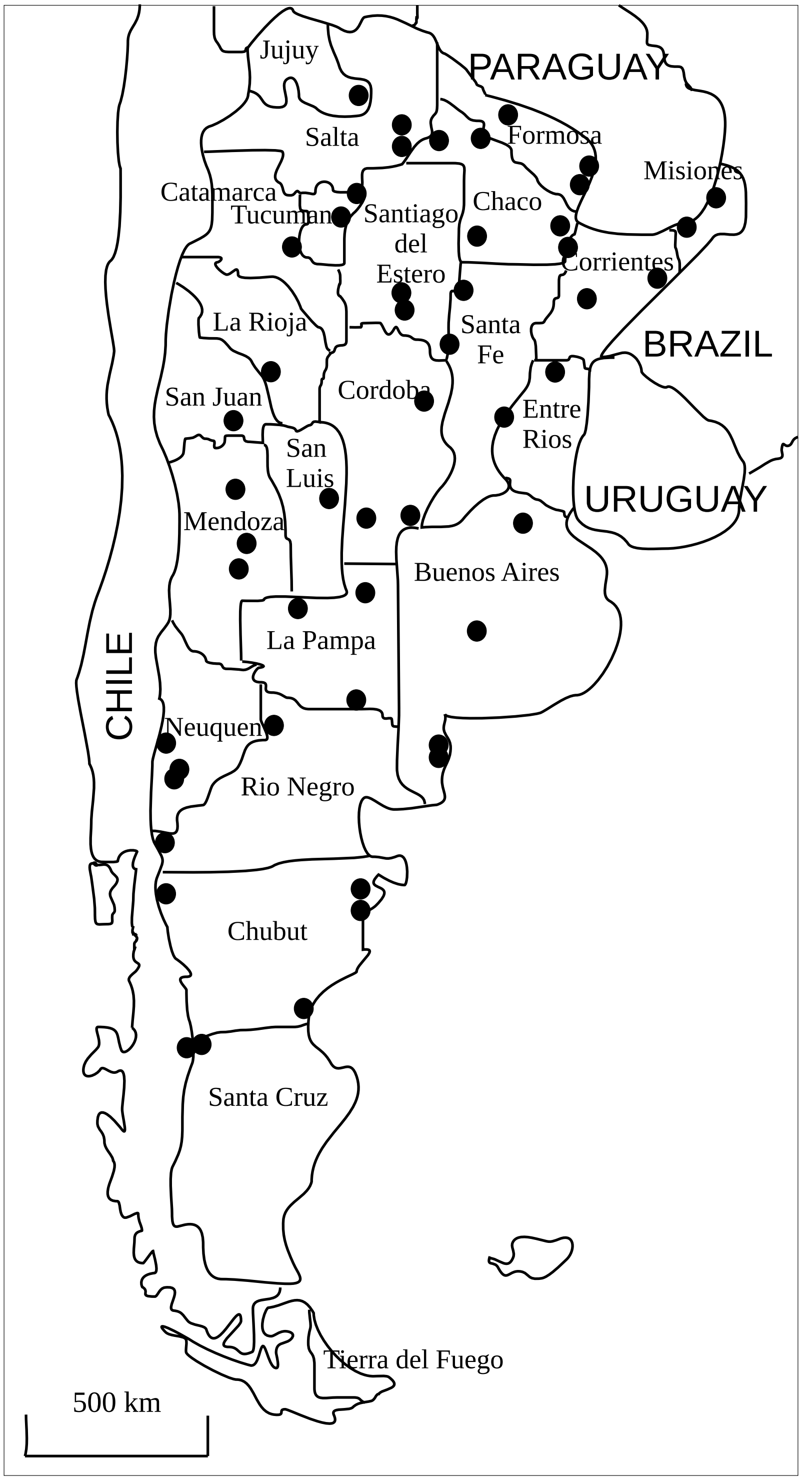


Figure 2. Argentina map with provinces. Black dots indicate the 54 places sampled during the field trip.

2.2 Herbarium collections

Specimens from WAT were examined, and additional specimens were borrowed and examined from other herbaria in the United States, Argentina, and Madeira (MADM, MO, LP, TX, LL: Holmgren *et al.*, 1981). In total 313 sheets were examined to determine the ranges of distribution, the most probable flowering dates, and to assess the most critical areas in need of further sampling prior to undertaking fieldwork.

2.3 Green House work and Chromosome counts

Fieldwork to collect cypselae of plants of the *S. chilensis* complex in Argentina and Chile provided specimens from which chromosome counts were obtained. These data were also used to map the distribution of the taxa.

The cypselae of plants collected during the field season were planted at the University of Waterloo Department of Biology greenhouse. Thirty-four plants of *Solidago* out of fifty-four collections were grown. Once the plants reached sufficient maturity, root tips samples were taken to use in chromosome counting. Plants were taken out of the pot, removing the excess of soil to obtain as much root tips as possible. Collection time was around noon on sunny days in the fall of 2008, as maximal levels of root tips cells undergoing mitosis were found at these times. Approximately 5-10 healthy looking, white root tips were collected from each plant and placed in a saturated paradichlorobenzene (PDB) aquious solution for ca. 3 h under refrigeration. Root tips were then fixed in acetic acid:alcohol fixative (3:1, ETOH-glacial acetic acid) and placed in a freezer. When the chromosomes were to be counted, root tips were removed from the freezer and the acetic alcohol fixative was pipetted off. The cells were then hydrolyzed in 2 mls of 1 mol/L HCl for 25 min at 60◦C. The HCl was pipetted off and was replaced with deionized water. The root tips then were subsequently placed in an open Petri dish where they were stained with 1% acetic orcein for a few seconds. A root tip was chosen under 10x magnification and was placed on a glass slide where the mitotic portion of the root was removed using a scalpel blade. Several drops of 1% acetic orcein where then added to the slide followed by a glass coverslip. By squashing the root tip under a glass coverslip covered with sheet of blotting paper and by pounding the slide with the eraser end of a pencil, the cells were then separated and flattened. Counts of chromosomes were made under the 1000x using phase contrast compound microscope (Owen *et al.* 2006).

2.4 Multivariate morphometric analyses

In order to determine the appropriate classification of members of the *S. chilensis* complex compared with separate taxon from North America and to establish the most suitable rank for statistically distinct groups within the South American complex, a sufficiently large sample of plants was chosen to include representatives of all morphological variants in the complex. A total of 313 specimens were examined, from which 160 plants were selected and scored for inclusion in the statistical analyses.

Using descriptions of North American taxa found in the literature (Semple *et al.*, 1999; Cook, 2002) and personal observations, a list of the distinguishing traits was created. These were chosen because of the great success they had been in previous North American *Solidago* studies. Additional characters were implemented based on observations of South American specimens, e.g., presence/absence of the three-nerved phyllaries, length of stem hairs. In total, 50 floral and vegetative traits were scored (Table 1). When possible, five measurements for each trait were made on, and the average was included in the statistical analyses. An additional specimen from Madeira was added to the analyses because of its morphological similarity to the members of *S. chilensis* complex. For consistency, plants in a similar developmental stage (anthesis) were measured. Sometimes, floral traits could not be measured because of the lack of sufficient florets. Basal and lower stem leaves were often missing or withering, resulting in a lack of data for such leaves. A matrix of 160 plants by 50 floral and morphological traits was constructed. All univariate and multivariate analyses were performed using Excel 2003 (Microsoft Inc.)

and SYSTAT 10 for Windows (SPSS Inc. 2000).

Box plots were produced (SYSTAT 10 for Windows) to identify outliers as a result of a data entry error, and to individually examine each trait. Such errors were corrected and the analysis of the data proceeded.

Prior to carrying out discriminant analyses, a Pearson's Correlation was performed to identify pairs of characters with a high degree of correlation ($|r| > 0.7$) and, where observed, one member of each pair was then excluded from further statistical analyses (Appendix A). Characters that were used to determine *a priori* group membership were excluded from discriminant analyses to avoid circular logic. For the same reason, some characters used in *a priori* group assignment were categorical rather than quantitative.

Table 1. Traits characterized and measured for the *S. chilensis* complex and related taxa from North America (*S. tortifolia*, *S. leavenworthii*, *S.juliae*). Traits with an * were not included in discriminant analyses because they correlated strongly (correlation coefficient of |r| > 0.7) with another trait or there were not enough measurements to be considered representative. Traits marked with # were also excluded as they were used to identify *a priori* groups in some analyses.

Character Code	Character Description
STEMHT*	Stem height (cm)
ISTPUBD	Stem hairs-number of hairs counted on 1 mm on the inflorescence stem
USTPUBD*	Stem hairs-number of hairs counted on 1mm on the upper stem
MSTPUBD*	Stem hairs-number of hairs counted on 1mm on the mid stem
BSTPUBD	Stem hairs-number of hairs counted on 1mm on the basal stem
ISTHLN	Hair length (mm)-measured in the inflorescence stem
USTHLN*	Hair length (mm)-measured in the upper stem
MSTHLN*	Hair length (mm)-measured in the mid stem
BSTHLN*	Hair length (mm)-measured in the basal stem
BLLENG*	Basal leaf length (cm)-measured from the leaf base to tip
BLWID*	Basal leaf width (cm)-measured at the widest point
BLWTOE*	Basal leaf measured from the widest point to tip
BLSERAT*	Basal leaf dentation-number of serrations on one half of the leaf margin
MLLENG	Mid stem leaf length (cm)-measured from the leaf base to tip
MLWID	Mid stem leaf width (cm)-measured at the widest point to the tip
MLWTOE*	Mid stem leaf measured from the widest point to the tip (cm)
MLSERAT#	Mid stem leaf dentation-number of serrations on one half of the margin
ULLENG	Upper stem leaf length (cm)-measured from the leaf base to tip
ULWID	Upper stem leaf width (cm)-measured at the widest point
ULWTOE*	Upper stem leaf measured from the widest point to tip (cm)
ULSERAT#	Upper stem leaf dentation-number of serrations on one half of the leaf margin
ILLENG	Inflorescence leaf length (cm)-measured from the leaf base to tip
ILWID	Inflorescence leaf width (cm)- measured at the widest point
ILWTOE*	Inflorescence leaf measured from the widest point to tip
ILSERAT#	Inflorescence leaf dentation-number of serrations on one half of the leaf margin
CAPBRANG	Angle formed between the main stem and the branch measured from the inflorescence
CAPW	Width of the inflorescence-measured at the widest point (cm)
CAPL	Length of the inflorescence-measured from the base to tip (cm)
LONGBR	Length of the longest branch in the inflorescence (cm)
HEADHT*	Head height (cm)
OPHYLL	Outer phyllary length (cm)-measured from the phyllary base to tip
OPHYLW	Outer phyllary width (cm)-measured at the widest point
OPHYLWTOE*	Outer phyllary measured from the widest point to tip (cm)
OPHYLV	Outer phyllary number of veins
IPHYLL	Inner phyllary length (cm)-measured from the phyllary base to tip
IPHYLW	Inner phyllary width (cm)-measured at the widest point
IPHYLWTOE*	Inner phyllary measured from the widest to tip (cm)

IPHYLV	Inner phyllary number of veins
RFLOR	Number of ray florets per head
RSTRAPL	Ray strap length (mm)-measured from the top of the corolla tube to the tip of the strap
RSTRAPWD*	Ray strap width (mm)-measured at widest point
RACHL*	Ray achene length (mm)-at the anthesis stage
RPAPL	Ray pappus length (mm)
DFLOR	Number of disc florets per head
DCORL	Disc corolla tube length (mm)-measured from the base to the tip of the corolla tube
DACHL	Disc achene length (mm)-at the anthesis stage
DCORLIMB*	Disc corolla limb length (mm)-measured from the tip of the corolla tube to the end of the corolla
DLOBL	Disc corolla lobe length (mm)
DPAPL	Disc pappus length (mm)
BRANCHD*#	Distance between the first to branches in the base of the inflorescence

2.4.1 *Solidago chilensis* and related taxa in North America

The *a priori* assignment of the specimens to the four putative species level groups was based on characters used in the literature (Semple & Cook, 2006; Cabrera, 1971) and on geographical location. The number of specimens representing each taxon is shown in parenthesis: *S. tortifolia* (14; Fig. 3), *S. juliae* (8; Fig. 4), *S. leavenworthii* (15, Fig. 5), and *S. chilensis* (104). The *a priori* classification of specimens as belonging to *S. juliae* was based mainly on geographical distribution specifically present on the Edwards Plateau and in Trans-Pecos Texas and adjacent to Mexico. Following Semple and Cook (2006), the number of serrations in mid stem leaves was a used to identify *S. leavenworthii*. Specimens placed *a priori* in *S. tortifolia* came from outer coastal plain, from North Carolina to Texas, and have between 2-8 ray florets. Identification of specimens *a priori* as being *S. chilensis* was based on their geographical distribution; all were from South America except the one introduced sample from Madeira Island in the eastern Atlantic Ocean.

Stepwise discriminant analysis was used to select a subset of characters that yielded the best separation of *a priori* groups in N-dimension hyperspace. In each analysis, N-1 traits were used where N equaled the sample size of the *a priori* group with the fewest samples. Discriminant statistical analyses were performed on the data matrix using the traits identified by the stepwise analysis. The equality of group centroids was tested using three different tests: Wilk's lambda, Pillai's Trace and Hotelling-Lawley Trace. The Geisser assignment probabilities were calculated in order to determine the reliability of the *a posteriori* classification of the specimens relative to the *a priori* groupings and the strengths of alternative classification of specimens. The objective of the analyses was to determine the statistical support for each *a priori* group and the results were then used to determine the suitable rank for each statistically different group.

Multivariate Studi
Solidago chilens
S
R.Lopez Laphitz & J.C. S
WAT 2008 Uni

PARK: Oscar Scherer State Park - SARASOTA

FAMILY: ASTERACEAE
SCIENTIFIC NAME: Solidago tortifolia Ell.
COMMON NAME(S): Twist-leaf goldenrod

COMMENTS: Erect composite to 1.5m hght - Unco
Flower - yellowish, in near-termina
Fruit - achene

LOCATION: Township 38 South, Range 18 East, S
Along south side of Park Drive
HABITAT: Scrubby flatwoods COLLECTOR: J. W
DATE: 10-15-92 NUMBER: 0S0110

Figure 3. Morphology of *Solidago tortifolia* Elliott. **A.** Shoot. **B.** Upper mid stem. **C.** Wilted and twisted lower stem leaves. **D.** Upper mid stem leaves. **E.** Head. A-B, *Weber 0S0110* (USF); C & E, *Godfrey 67409* (MO); D, *Semple & Wunderlin 4561* (WAT).

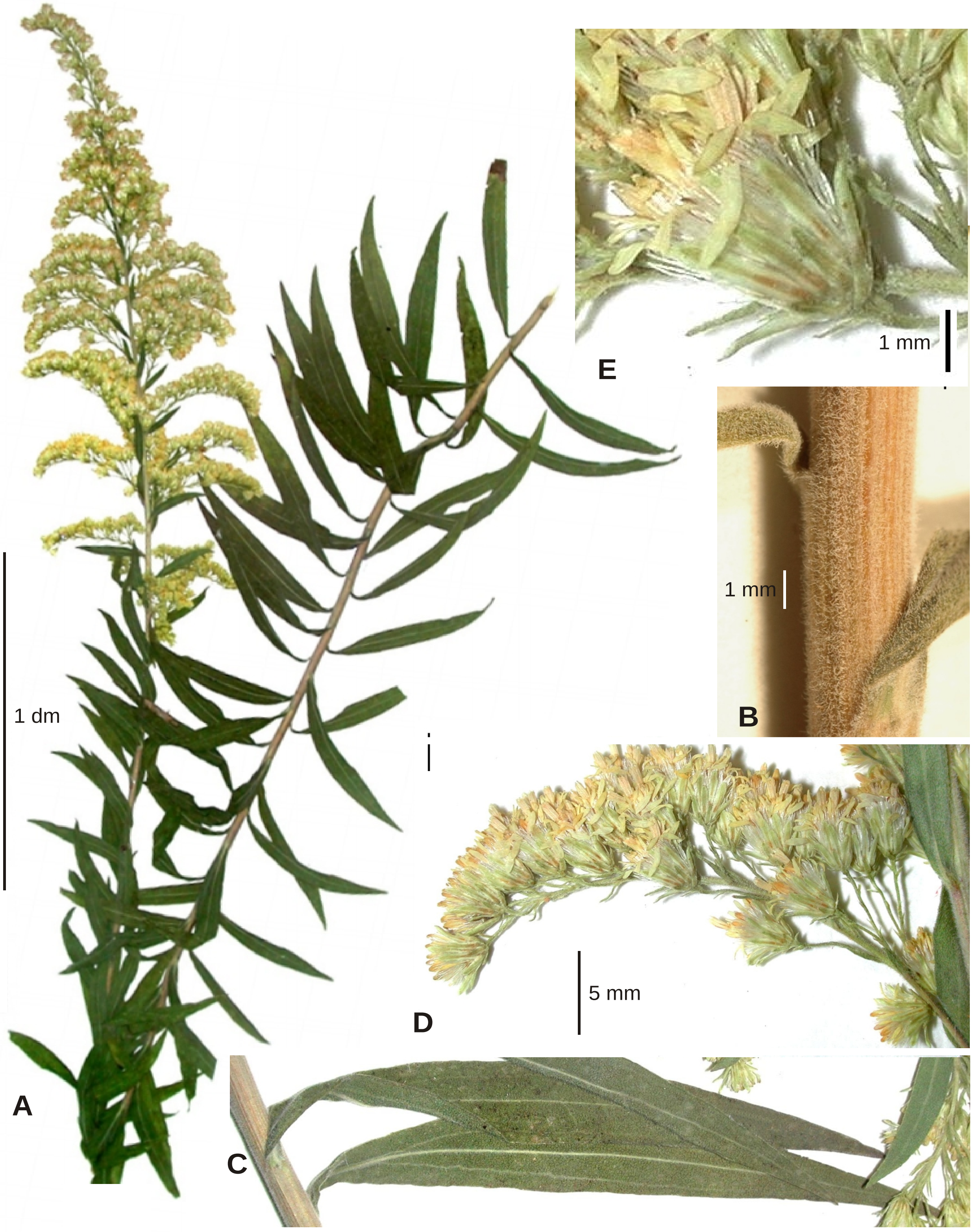


Figure 4. Morphology of *Solidago juliae* GL Nesom. **A.** Mid-size shoot, (WAT). **B.** Stems. **C.** Mid stem leaves. **D.** Inflorescence. **E.** Heads. Isotype *Nesom and Nesom 7212* (WAT)

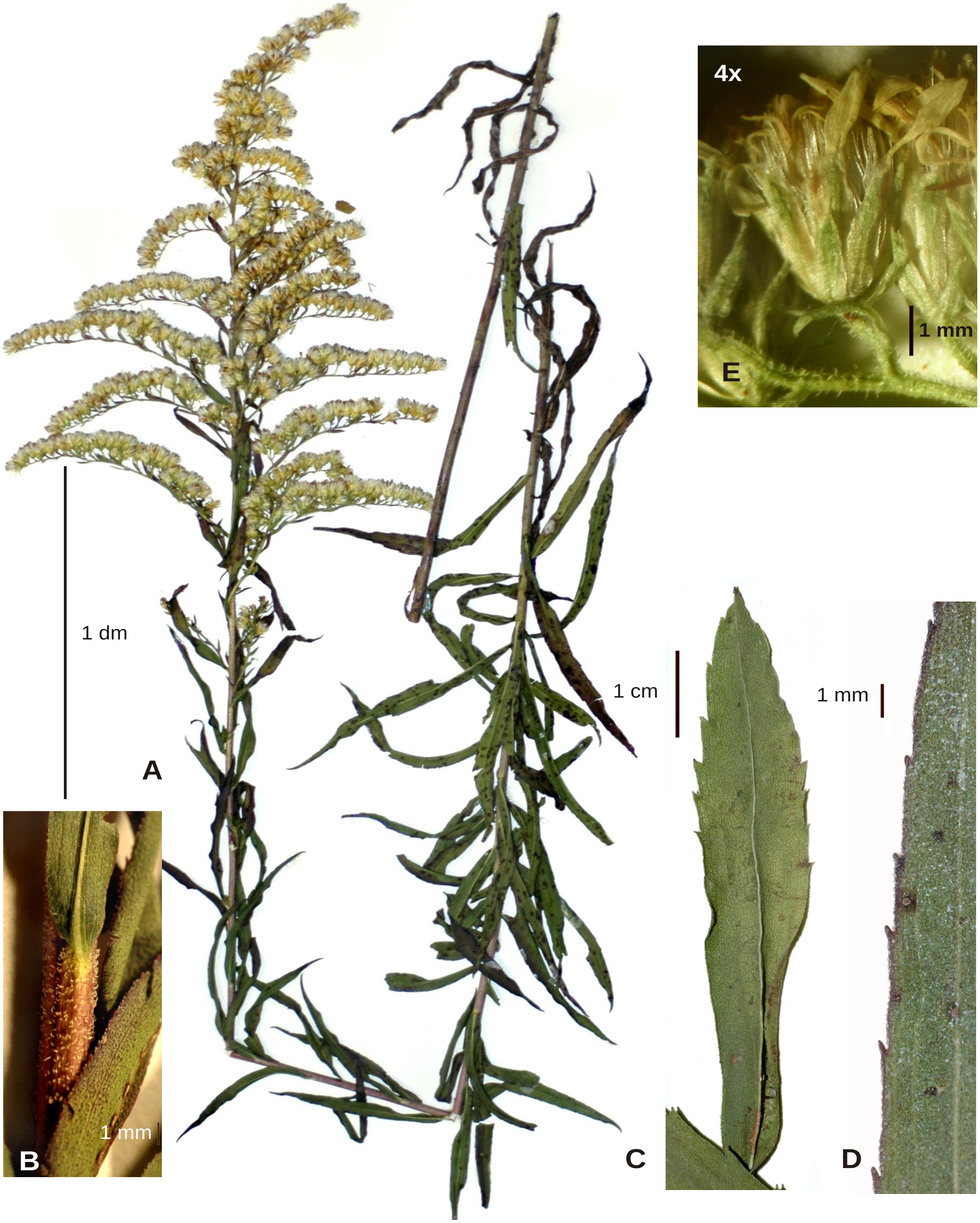


Figure 5 . Morphology of *Solidago leavenworthii* Torr. & A. Gray. **A.** Shoot. **B.** Upper stem. **C.** Lower mid stem leaf, robust plant. **D.** Leaf margin detail. **E.** Heads. A-B, D, *Semple 11703* (WAT); C and E, *Semple 11733* (WAT).

2.4.2 *Solidago chilensis complex in South America*

The discriminant analyses were repeated as above excluding North American taxa. First, specimens were assigned *a priori* to two groups: *S. chilensis* with dense inflorescence and *S. "patagonica"* with lax inflorescence. These two putative groups were proposed to assess the existence of two species following the published floristic key in Sancho and Espinar (2003). Specimens were assigned to *S. chilensis* with dense inflorescence when the average distance between the two first branches of the inflorescence was less than 2.5 cm (measured between the first and subsequent branch from the base of the inflorescence). Similarly, specimens were assigned to "*S. patagonica"* with lax inflorescence when the average distance between the two first branches was equal or more than to 2.5 cm. The number of specimens representing each *a priori* group is shown in parenthesis: *S. chilensis* with dense inflorescence (80) and *S. patagonica* with lax inflorescence (36).

A second *a priori* assignment of two putative groups in South America was based on mid-stem hair length. In this way, all plants that had longest hair length equal or longer than 0.5 mm were assigned *a priori* to *S. microglossa* with long hairs. Similarly, the group of plants with the longest hair length shorter than 0.5 mm was assigned *a priori* to *S. chilensis* with short hairs. The number of specimens representing each *a priori* group is shown in parenthesis: *S. microglossa* with long hairs (30) and *S. chilensis* with short hairs (88).

In a third *a priori* classification, hair density of the mid stem of the plant (measured as the number of hairs in 1 mm length of the stem) was used to define *a priori* groups. Plants observed with hair density of 5 or less hairs were identified *a priori* as not hairy-*S. chilensis s.l.*, and plants with hair density over 5 were identified *a priori* as hairy-*S. chilensis s.l.* The number of specimens representing each *a priori* group is shown in parenthesis: densely hairy-*S. chilensis s.l.* (53) and sparsely hairy-*S. chilensis s.l* .(66).

Stepwise discriminant analysis was used to select a subset of characters that produced the best separation between *a priori* groups. Other discriminant statistical analyses were performed on the data matrix including the traits identified in the stepwise analysis (N-1 rule followed). The equality of group centroids was tested using three different tests: Wilk's lambda, Pillai's Trace and Hotelling-Lawley Trace. The Geisser assignment probabilities were calculated in order to determine the reliability of the *a posteriori* classification of the specimens relative to the *a priori* groupings and the strengths of alternative classification of specimens.

Chapter 3: Results

3.1 Geographical distribution in South America of two species of *Solidago* not in *S.* subsect. *Triplinervae*

Two species of *Solidago* were found in South America that belong in subsections of the genus different from the *S. chilensis* complex. They are, or are similar to, *S. missourensis* Nutt. and *S. virgaurea* DC. (or possibly the separate species *S. patagonica* Phil.) which are members of *Solidago* subsect., *Junceae* and *Solidago* subsect. *Solidago*, respectively. A distribution map was plotted including the two species (Fig. 6). The map was based on all herbaria specimens observed. Thirteen specimens of *S. missourensis* and one of *S. virgaurea* [=*S. patagonica*] were examined in this study. The small sample sizes restricted analysis to just the phytogeography. *Solidago missourensis* was restricted to the provinces of Mendoza, Neuquen, Rio Negro, and Chubut in Argentina. *Solidago virgaurea* [=*S. patagonica*] from the same general area of South America was found in Aysen (Chile).

Figure 6. Dot distribution of *Solidago virgaurea* [=*S. patagonica*] subsect. *Solidago* and *Solidago missouriensis* subsect. *Junceae*

3.2 Univariate Analyses of members of *Solidago* subsect. *Triplinervae*

3.2.1 Box plots

Univariate characteristics were plotted for five putative taxa. These were *S. juliae*, *S. tortifolia*, *S. leavenworthii*, and the two *a priori* taxa of the *S. chilensis* complex: *S. microglossa* with long hairs and *S. chilensis* with short hairs. Several univariate characteristics showed differences among taxa. Figure 7 shows box plots of the number of hairs per mm along the stem of both the inflorescence stem and basal stem respectively for each putative taxon. *Solidago juliae* had the highest pubescence density on inflorescence stems among the five taxa, while *S. chilensis* was often almost glabrous. For basal stem pubescence, *S. chilensis* and *S. leavenworthii* were almost glabrous and the other taxa had high variability in hair density. Box plots in Figure 8 how the ranges of mid stem leaf length and upper stem leaf length. *Solidago chilensis, S. microglossa* and *S. leavenworthii* had the longest mid stem leaves, while *S. tortifolia* had the shortest. The pattern was similar for upper stem leaf length, but the overlap in ranges for all taxa was greater and the mean length was less than for mid stem leaves. Figure 9 shows that *S. leavenworthii* had more leaf serrations on both mid and upper stem leaf margins compared to the other taxa and that the upper stem leaf margins of the three North American taxa were more serrate generally than the two South American taxa. Figure 10 shows the widths of the inflorescence for each of the taxa. *Solidago juliae* had on average the widest inflorescence. Figures 11 and 12 show box plots of four different involucre and phyllary traits. *Solidago juliae* and *S. tortifolia* tended to have shorter and narrower phyllaries than the other taxa. Box plots showing number of ray and disc florets per head (Fig. 13) reveal that *S. tortifolia* had the lowest number of both florets compared to the other four taxa. Figure 14 shows that the pappus is noticeably shorter in *S. juliae* and *S. tortifolia* than in the other taxa. Box plots show of the disc floret achene length (Figure 15) reveal that *S. tortifolia* had the smallest achenes among the five taxa.

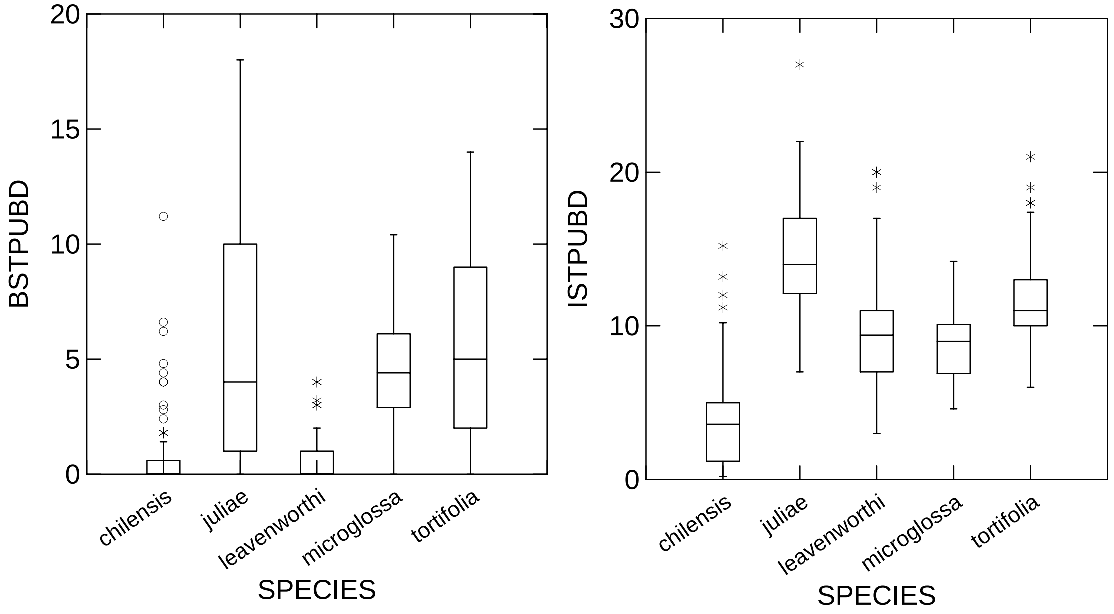


Figure 7. Box plots of the number of hairs on the stem: in the inflorescence (ISTPUB) on the right and on the basal stem (BSTPUB) on the left.

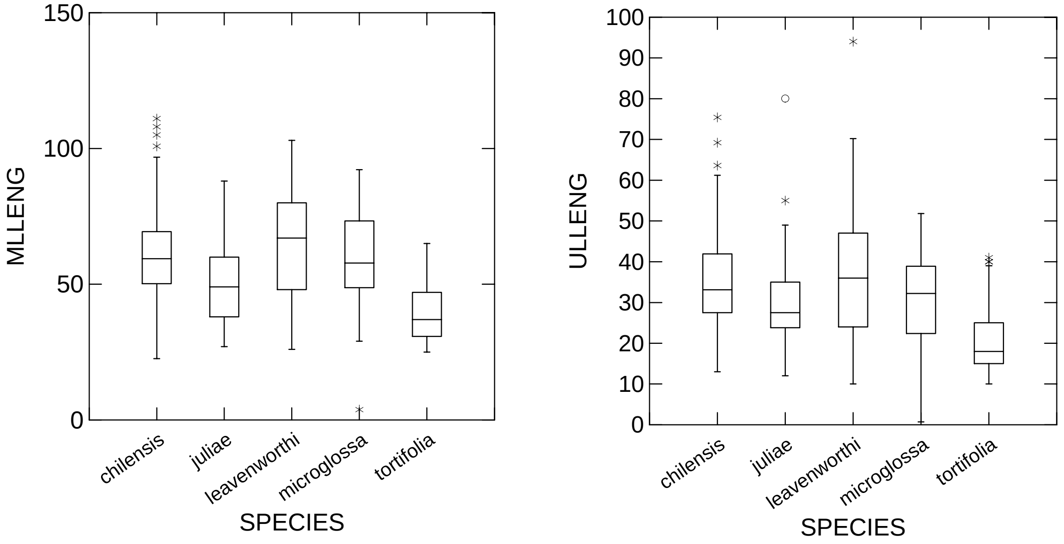


Figure 8. Box plots of the mid stem leaf length (MLLENG) on the left and upper stem leaf length (ULLENG) on the right.

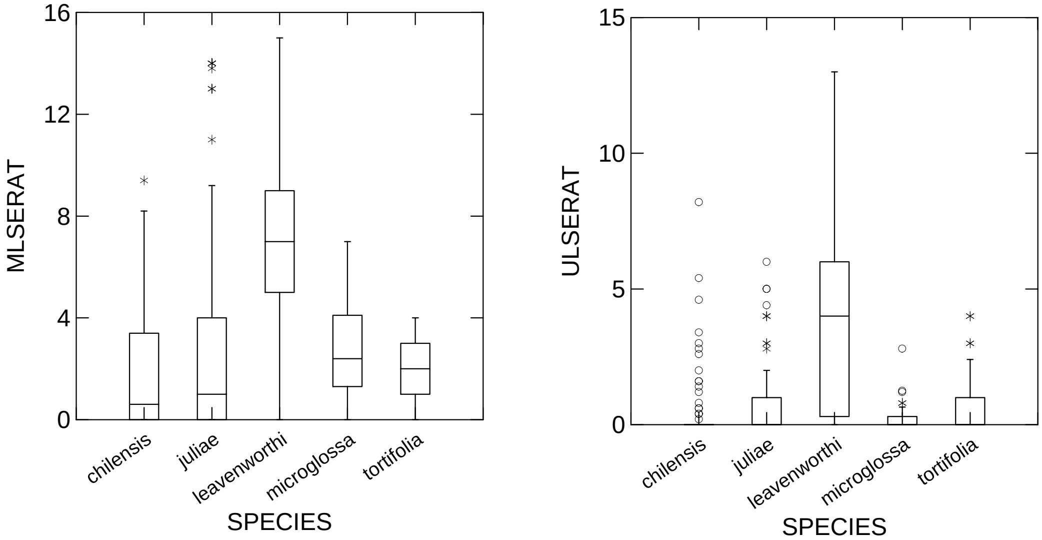


Figure 9. Box plots of the mid stem serrations leaf (MLSERAT) on the left and upper stem serrations leaf (ULSERAT) on the right.

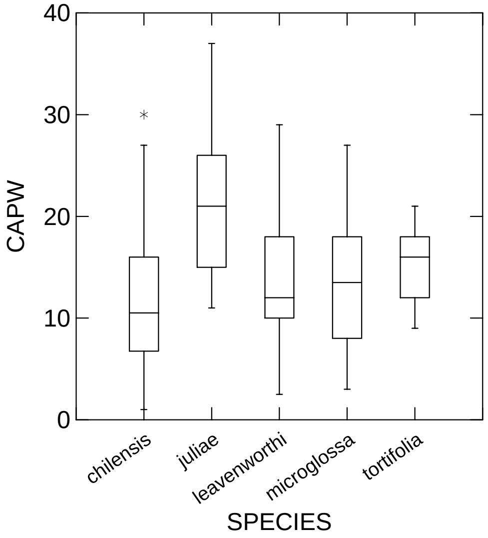


Figure 10. Box plots of the inflorescence width (CAPWID).

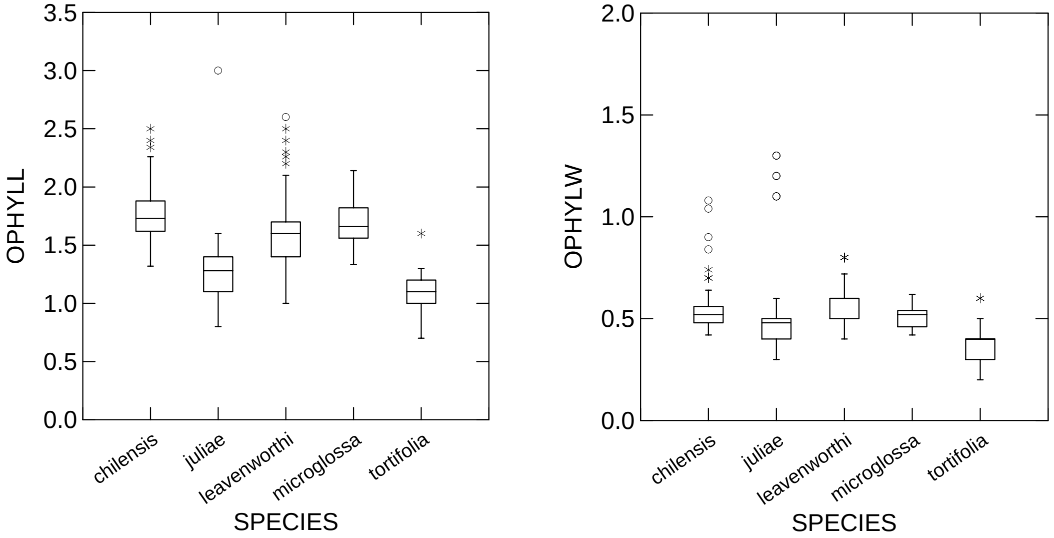


Figure 11. Box plots of the outer phyllary length (OPHYLL) on the left and the outer phyllary width (OPHYLW) on the right.

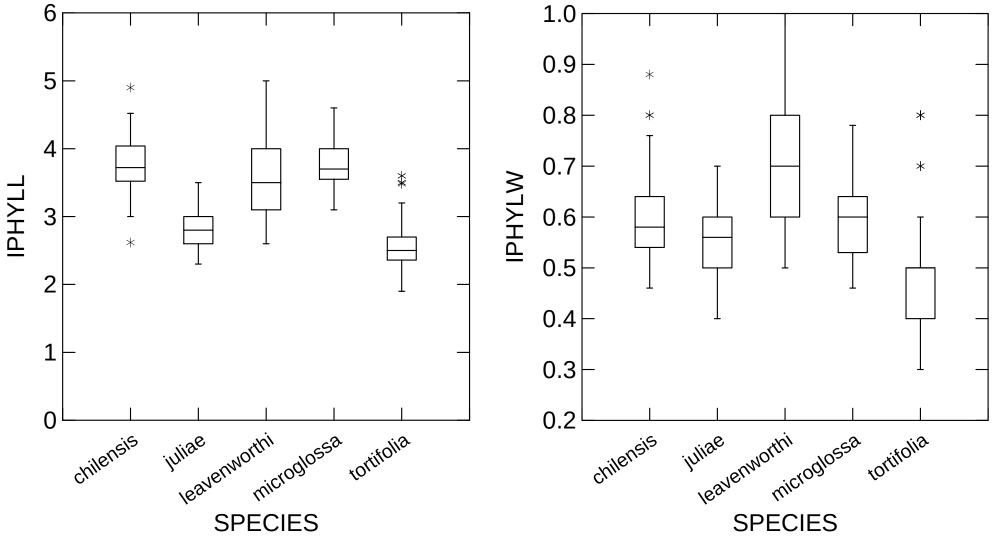


Figure 12. Box plots of the inner phyllary length (IPHYLL) on the left and the inner phyllary width (IPHYLW) on the right.

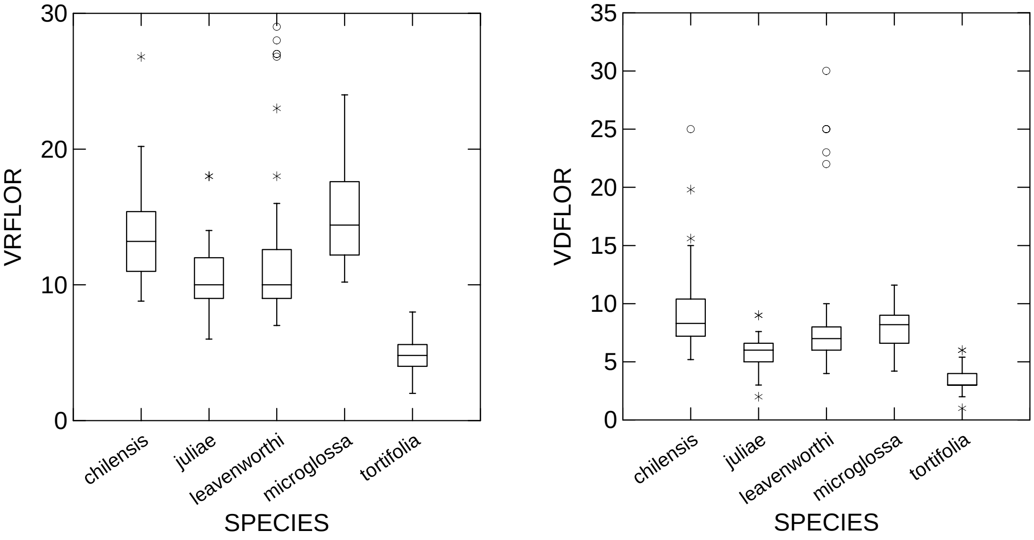


Figure 13. Box plots of the number of disc florets per head (DFLOR) on the left and the number of ray florets per head (RFLOR) on the right

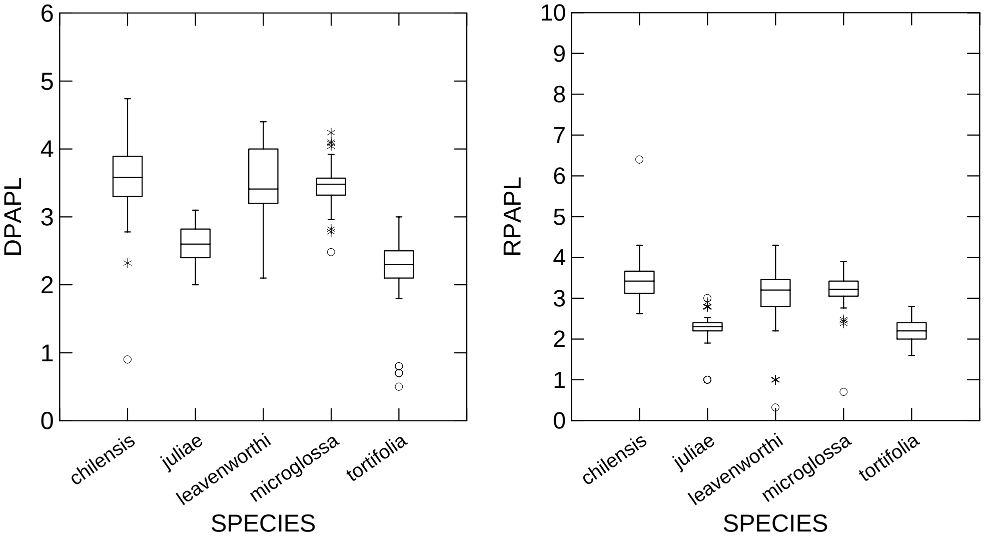


Figure 14. Box plots of the disc floret pappus length (DPAPL) on the left and the ray floret pappus length (RPAPL) on the right.

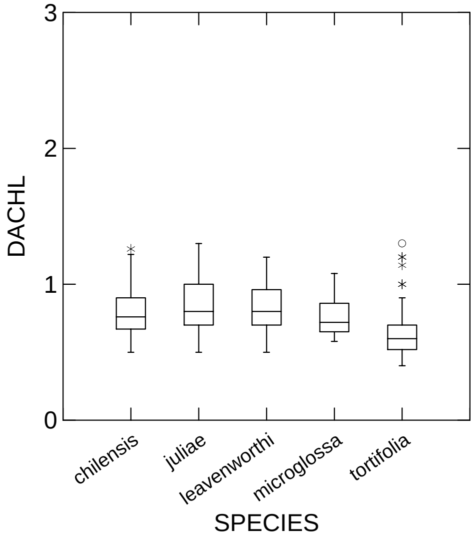


Figure 15. Box plots of the disc floret achene length (DACHL).

3.2.2 Scatterplot

Hair density and hair length were plotted for the *S. chilensis* and *S. microglossa* (Figure 16). While there was considerable variation in hair density in both species, the two species differed in hair length. *Solidago chilensis* had hairs of 0.425 mm long or less, while *S. microglossa* had hairs of 0.45 to 1.3 mm long. This scatter plot shows two well defined groups based on hair length, while the number of hairs in both groups overlapped in the range of 3-14 hairs per mm along the stem.

Means, standard deviations and ranges of all traits included in the stepwise discriminant analyses for *S. chilensis*, *S. microglossa*, *S. juliae*, *S. tortifolia* and *S. leavenworthii* are presented in Table 2.

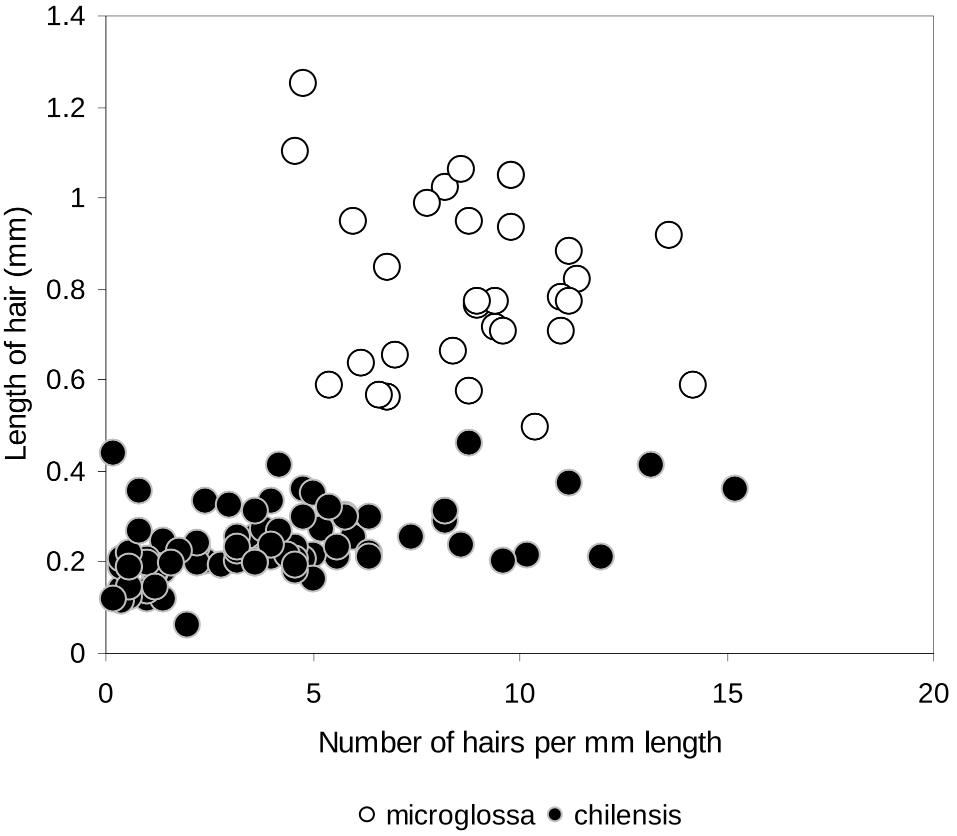


Figure 16. Scatterplot between length of hair (mm) and the number of hairs measured per mm.

Table 2. Mean ± standard deviation and range (minimum-maximum) by species level *a priori* group for the 54 traits included in the stepwise discriminant analysis of 160 specimens of *Solid ago* subsect. *Triplinervae*: see table 1 for trait descriptions.

Taxa	***chilensis***	***microglossa***	***juliae***	***tortifolia***	***leavenworthii***
Trait	N= 88	N= 31	N=11	N=15	N=15
STEMHT	64.8 ± 32.7	81 ± 28.3	95.2 ± 38.2	83.3 ± 35.2	84.1 ± 29.2
(cm)	7-170	36-167	60-180	30-140	47-165
ISTPUBD	3.8 ± 3.1	8.9±2.3	14.8 ± 2.9	11.5 ± 2.25	9.31 ±3.2
	2-16	2-22	11-27	6-21	3-20
USTPUBD	2.8 ± 2.65	8 ± 2.7	14.5 ± 2.7	11 ± 2.5	5.3 ± 3
	0-0	1-17	8-22	5-18	0-13
MSTPUBD	1.8 ± 2.2	6.7 ± 2.4	12.15 ± 4	10.6 ± 2.5	3.05 ± 3
	0-0	0-13	0-20	6-18	0-12
BSTPUBD	0.8 ± 1.8	4.6 ± 2.3	5.4 ± 5.4	5.5 ± 4	0.4 ± 0.8
	0-0	0-13	0-12	0-14	0-4
ISTHLN	0.2 ± 0.1	0.8 ± 0.2	0.5 ± 0.1	0.3 ± 0.1	0.3 ± 0.1
(mm)	0.06-0.75	0.21-1.5	0.19-0.75	0.19-0.67	0.21-0.5
USTHLN	0.2 ± 0.1	0.9 ± 0.15	0.5 ± 0.1	0.3 ± 0.1	0.25 ± 0
(mm)	0.06-1.25	0.21-1.67	0.21-0.94	0.19-0.67	0-0.37
MSTHLN	0.2 ± 0.1	0.9 ± 0.3	0.4 ± 0.2	0.2 ± 0.1	0.2 ± 0.1
(mm)	0.06-0.5	1.75-0.5	0.21-0.75	0.12-0.56	0-0.44
BSTHLN	0.1± 0.1	0.6 ± 0.3	0.3 ± 0.1	0.2 ± 0	0.2 ± 0.1
(mm)	0.06-0.75	0.21-1.25	0.12-0.5	0.12-0.44	0.06-0.5
MLLENG	61 ± 18	58.5 ± 18.2	50 ± 11.4	40 ± 9.1	65.35 ± 19.8
(cm)	3-130	22-105	27-88	25-65	26-103
MWID	6.6 ± 2.3	8.7 ± 3	7.2 ± 2.2	5 ± 1.4	8 ± 1.9
(mm)	0-32	4-19	4-17	2-8	4-13
MLWTOE	27.2 ± 9.1	27.1 ± 8.8	23.2 ± 5.5	18.8 ± 4.5	31.7 ± 9.25
(cm)	0-60	12-50	9-35	10-30	10-50
MSERAT	1.9 ± 2.4	2.7 ± 2	3.1 ± 4.5	1.93± 0.8	7.2 ± 3.55
	0-12	0-8	0-14	0-4	0-15
ULLENG	36.5 ± 12.3	30.4 ± 11	31± 10.5	20.9 ± 8	37 ± 16.6
(cm)	0.5-80	11-55	12-80	10-41	10-94
ULWID	3.95 ± 2.3	4.7 ± 1.7	4.6 ± 0.9	3.1 ± 0.7	4.6 ± 1.7
(cm)	0-27	1.5-10	2.5-9	1.5-5	2-10
ULWTOE	17.5 ±6.3	15.6 ± 5.8	14.1 ± 3.5	10.3 ±3.95	18 ± 7.6
(cm)	0-40	6-35	6-28	5-20	5-42
ULSERAT	0.5 ± 1.3	0.3 ± 0.6	0.9 ± 1.45	0.7 ± 0.86	3.7 ± 2.8
	0-10	0-5	0-6	0-4	0-13
ILLENG	18.65 ±6.5	17.3 ± 5.5	18.05 ±7.3	12.2 ± 4.5	22.4 ± 8.5
(cm)	4.4-45	6-40	8-40	4-30	5-43
ILWID	2.2 ± 1.5	2.8 ± 1	2.9 ± 1.2	1.95 ± 0.5	3 ± 1.1
(cm)	0.5-2.21	1-15	1-7	1-4	1-6
ILWTOE	8.95 ± 3.45	8.7 ± 3.3	8.6 ± 3.6	6.1 ± 2.3	11.2 ± 4.5
(cm)	1-25	3-27	4-20	2.5-14	2-29
ILSERAT	0.05 ± 0.3	0.01 ± 0.07	0.3 ± 0.8	0.15 ± 0.4	1.15 ± 1.3
	0-5	0-1	0-4	0-2	0-7
CAPBRANG	27.9 ± 9.85	29.8 ± 14.5	34.5 ± 5.3	38.2 ± 6.1	27.9 ±7.9
	1-60	15-90	30-40	30-50	9-40

CAPW	12.0 ± 6.5	13.7 ± 6.5	21.7 ± 8.4	15.4 ± 3.4	13.3 ± 6.7
(cm)	1-30	3-27	11-37	9-21	29-2.5
CAPL	8.7 ± 6.6	8.8 ± 4.8	8.3 ± 1.7	9.4 ± 3.6	6.8 ± 5.0
(cm)	2-35	2-18	5.5-1	3-15	1.5-20
LONGBR	5.5 ± 4.5	5.1 ± 3	7.3 ± 3.4	6 ± 2.25	6.3 ± 6.2
(cm)	2-35	1-12	3.5-12	2-10	1.5-20
HEADHT	4.4 ± 0.5	4.4 ± 0.4	3.4 ± 0.25	3.1 ± 0.2	4.3 ± 0.6
(cm)	3-7	3-6	4.1-2.6	2.6-4	2.9-6
OPHYLL	1.8 ± 0.2	1.7 ± 0.2	2.6 ± 4.1	1.1 ± 0.1	1.6 ± 0.3
(cm)	1.1-2.7	0.17-2.6	0.8-3	0.7-1.6	1-2.6
OPHYLW	0.55 ± 0.1	0.5 ± 0.05	0.5 ± 0.2	0.3 ± 0	0.6 ± 0.1
(cm)	0.3-1.6	0.3-0.7	0.3-1.3	0.2-0.6	0.4-0.8
OPHYLWTOE	1.3 ± 0.2	1.3 ± 0.15	1 ± 0.2	0.7 ± 0.2	1.2 ± 0.3
(cm)	0.5-2.2	0.8-1.8	0.4-1.3	0.3-1.3	0.6-2.1
OPHYLV	1.1 ± 0.2	1.05 ± 0.2	1 ± 0	0 ± 1	1±0
	1-3	1-3	1-1	1-1	1-1
IPHYLL	3.8 ±0.4	3.8 ± 0.35	2.8 ± 0.2	2.6 ± 0.3	3.5 ± 0.5
(cm)	2.4-5.1	0.29-4.8	2.3-3.5	1.9-3.6	2.6-5
IPHYLW	0.6 ± 0.1	0.6 ± 0.1	0.55 ± 0.05	0.49 ± 0.1	0.7 ± 0.1
(cm)	0.3-1	0.3-0.8	0.4-0.7	0.3-0.8	0.5-1
IPHYLWTOE	1.9 ± 0.2	1.8 ± 0.2	1.4 ± 0.1	1.3 ± 0.2	1.7 ± 0.3
(cm)	0.9-2.6	1-2.4	0.8-1.7	0.9-2	0.1-2.9
IPHYLV	1.9 ± 0.7	2.3 ± 0.7	1.7 ± 0.6	1.25 ± 0.4	1.7 ± 0.8
	1-7	1-3	1-3	1-3	1-3
#RFLOR	13.5 ± 3.1	15.1 ± 3.6	10.4 ± 1.8	4.75 ± 1.2	11.7 ± 4.5
	7- 29	4-28	6-18	2-8	7-29
RSTRAPL	2.9 ± 7.8	1.9 ± 0.3	1.3 ± 0.25	1.35 ± 0.35	1.9 ± 0.4
(mm)	0.4-3.1	1-2.9	0.7-1.8	0.7-4	1-3
RSTRAPWD	0.5 ± 0.7	0.4 ± 0.1	0.3 ± 0.1	0.3 ± 0.1	0.4 ± 0.1
(mm)	0.1-0.9	0.1-0.7	0.1-0.6	0.1-1.5	0.2-0.8
RACHBL	1.1 ± 3.7	0.8 ± 0.6	0.8 ± 0.2	0.6 ± 0.2	0.8 ± 0.2
(mm)	0.3-3.3	0.4-4	0.5-1.3	0.4-1.2	0-1.5
RPAPL	3.4 ± 0.5	3.1 ± 0.6	2.2 ± 0.45	2.2 ± 0.2	2.95 ± 0.9
(mm)	2.3-4.5	0.37-4.3	1-3	1.6-2.8	0.32-4.3
#DFLOR	9.2 ± 3.2	8 ± 1.85	5.8 ± 1	3.6 ± 0.9	8.05 ± 5
	2-25	2-30	2-7	1-6	4-30
DCORL	3.7 ± 0.4	3.6 ± 0.3	3.2 ± 0.2	2.8 ± 0.3	3.8 ± 0.4
(mm)	2.4-4.9	2.7-4.6	2.5-4	0.3-3.8	2.6-4.7
DACHBL	0.8± 0.2	0.8 ± 0.1	0.85 ± 0.2	0.6 ± 0.2	0.8 ± 0.2
(mm)	0.1-2.6	0.5-1.2	0.5-1.3	0.4-1.3	0.5-1.2
DCORLIMB	2.6 ± 0.4	2.5 ± 0.3	2 ± 0.15	1.9 ± 0.2	2.5 ± 0.3
(mm)	1.5-4.6	1.4-3.5	1.5-2.5	1.3-2.5	1.7-3.5
DLOBL	2 ± 0.3	1.05 ± 0.2	1.1 ± 0.3	0.8 ± 0.3	1 ± 0.1
(mm)	0.12-3.9	0.6-2.3	0.4-2.7	0.4-1.9	0.7-1.5
DPAPL	3.6 ± 0.5	3.4 ± 0.4	2.6 ± 0.3	2.2 ± 0.5	3.5 ± 0.5
(mm)	0.8-5.1	2.3-4.4	2-3.1	0.5-3	2.1-4.4

3.3 *Multivariate Analyses*

3.3.1 Four taxa: A South American (*S. chilensis s.l.*) and related North American (*S. juliae*, *S. leavenworthii*, and *S. tortifolia*)

A set of 160 plants out of 313 examined was included on the statistical analyses. A total of fifty floral and vegetative characteristics were scored for each plant. Characteristics marked with an asterix in Table 1 were not used in the discriminant analyses as they were strongly correlated with one or more traits (correlation coefficient of |r|>0.7). Basal leaf traits (BLLENG, BWID, BLWTOE, and BSERAT) were not used due to the frequent lack of data in the matrix. Characteristics marked with a number sign (#) in Table 1 were also excluded from the discriminant analyses because they were used in the identification of the *a priori* groups.

In the discriminant analysis for the South American and related North American taxa, four putative taxa were included in the analysis as separate entities: *S. chilensis s.l.*, *S. juliae*, *S. leavenworthii*, and *S. tortifolia*. The following characters in order of decreasing F-statistic were found in a step-wise discriminant analysis of all 160 specimens were to be most useful in separating the four putative taxa: ILSERAT, ISTPUBD, CAPW, VRFLOR, MLLENG, IPHYLW, IPHYLV, DLOBL, DPAPL, OPHYLW, OPHYLL, and IPHYLL.

The F-matrix based on Mahalanobis distances between *a priori* group centroids and the associated probabilities among the four putative taxa are presented in Table 3. The shortest Mahalonobis distance and F-statistic was between the *S. juliae* and *S. tortifolia*. The low F-values between *S. juliae* and other putative taxa could be related to the small sample size. All three tests (Wilk's lambda, Pillai's trace, and Lawley-Hotelling trace) for equality of group centroids indicated that the groups were significantly different (Table 4). The highest F-values were for *S. chilensis* s.l. and each of the three North American species.

Geisser *a posteriori* assignment probabilities were determined for each of the 160 specimens and a Classification Matrix and a Jackknifed Classification Matrix for these specimens were created (Tables 5 and 6).

All specimens identified *a priori* as belonging to *S. tortifolia* were assigned *a posteriori* to that taxon with Geisser assignment probabilities ranging from 87-100% for all of the specimens. Seven of the specimens assigned *a priori* as *S. juliae* were placed *a posteriori* to that taxon with Geisser assignment probabilities between 93-100%, while the other two had assignments probabilities of 72% and 61%.

Ten of the specimens assigned *a priori* as *S. leavenworthii* were assigned *a posteriori* to that taxon with Geisser assignment between 84-100%. Three of the specimens had a probability assignment of 60%. Two of specimens were misclassified, one each to *S. chilensis* s.l. and *S. leavenworthii*.

A canonical analysis was performed as part of the discriminant analysis. The variant scores on the first and second, and in the first and third canonical axes (CAN 1, CAN 2, and CAN 3) were plotted for the four putative taxa (Fig. 17). The four *a priori* groups (*S. chilensis*, *S. juliae*, *S. leavenworthii*, *S. tortifolia*) were clearly separated on the first, second or third axes. The Eigenvalue associated with the first canonical discriminant function (4.046) had a relative percentage associated of 77.3 %, the second (0.835) had 15.9 %; and the third (0.354) had 6.8 %.

Table 1. F statistics $F_{0.05\,(6,353)}$ and associated null hypothesis probabilities P between the four putative species.

Taxon	*S. chilensis s.l.*	*S. juliae*	*S. leavenworthii*
S. juliae	F 17.186 P <0.0000		
S. leavenworthii	F 14.770 P <0.0000	F 7.523 P <0.0000	
S. tortifolia	F 35.342 P <0.0000	F 5.106 P <0.0000	F 14.555 P <0.0000

Table 2. Multivariate Statistics and F Approximations for the Wilk's Lambda, Pillai's Trace, and Hotelling-Lawley Trace Tests for the discriminant analysis of the four putative taxa.

Four putative taxa				
Statistics	Value	F-values	DF	P-tail
Wilk's lambda	0.080	15.574	36, 414	0.0000
Pillai's trace	1.518	12.122	36, 426	0.0000
Lawley-Hotelling trace	5.234	20.161	36, 416	0.0000

Table 5. Classification Matrix obtained by discriminant analysis for the four putative taxa.

			a posteriori		
a priori	***chilensis s.l.***	***juliae***	***leavenworthii***	***tortifolia***	**% correct**
chilensis s.l.	114	2	1	0	97
juliae	0	9	0	0	100
leavenworthii	1	1	13	0	87
tortifolia	0	0	0	14	100
Total	115	12	14	14	97

Table 6. Jackknifed Classification Matrix obtained in the classificatory discriminant analysis for the four putative taxa (specimens in row categories classified into columns).

			a posteriori		
a priori	***chilensis***	***juliae***	***leavenworthii***	***tortifolia***	**%correct**
chilensis s.l.	113	2	1	0	97
juliae	0	7	0	2	78
leavenworthii	2	2	10	1	67
tortifolia	0	1	0	13	93
Total	115	12	12	16	92

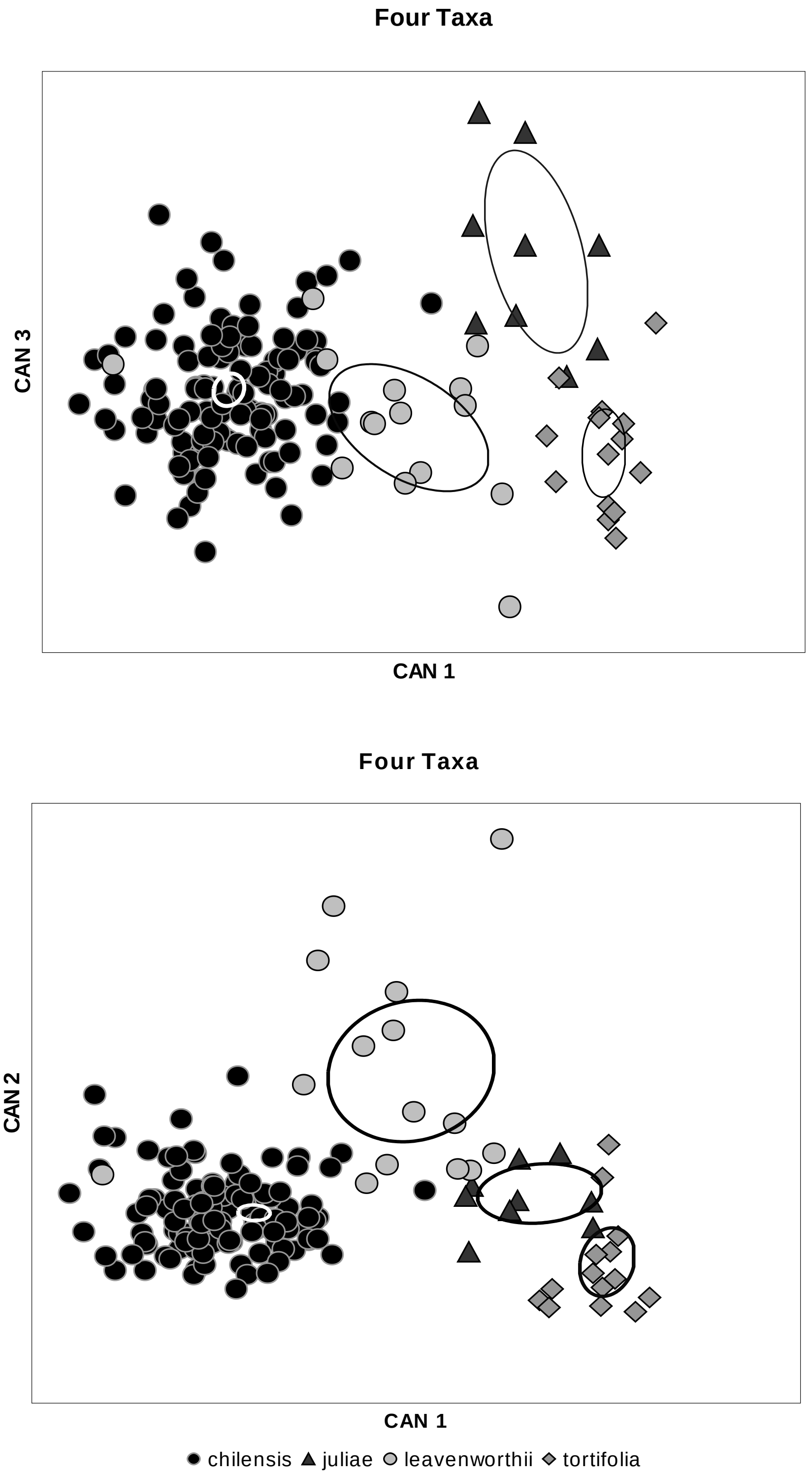


Figure 17. Scatterplots of canonical scores on the first and second, and first and third canonical axes (CAN 1, CAN 2, CAN 3) for four putative taxa.

3.3.2 Two taxa: South American *Solidago*

Discriminant analyses for two South American *a priori* groups were repeated three times on just the specimens of South American origin in order to test the existence of two taxa in the complex in South America. First, a discrimiant analysis tested for the two putative species (*“S. patagonica”* and *S. chilensis*) treated in the literature as members of the same complex. Subsequent work indicated that true *S. patagonica* was not part of the complex and the name as applied in the analysis was placed in quotations marks to indicate this. Two other discriminant analyses were undertaken to test for alternative ways of dividing the South American specimens of the S. *chilensis* complex into two groups. The first one assessed the existence of two putative taxa based on the length of stem hairs: *S. microglossa* with long hairs and *S. chilensis* with short hairs. The second one tested the existence of two possible taxa based on stem hair density: *S. chilensis* with very sparsely hairy stem and *S. chilensis* with more densely hairy stems.

3.3.2.1 Two putative taxa: “*S. patagonica”* (lax inflorescence) and *S. chilensis s.l.* (dense inflorescence)

The step-wise discriminant analysis generated four characteristics with the high discriminating value which were then used to complete the discriminat analysis. They were: ILLENG, CAPW, LONGBR, and ILSERAT (Table 1) in decreasing order of discriminatory power. The F-Matrix based on distances between groups and the associated probabilities showed strong support for two putative taxa (Table 7). The Wilk’s lambda, Pillai’s Trace, and Hotelling-Lawley Trace tests for equality of group centroids all indicate that the groups were significantly different (Table 8).

Geisser *a posteriori* assignment probabilities were determined for each of the 116 specimens and a Classification Matrix and a Jackknifed Classification Matrix for these specimens are shown in table 9 and table 10 respectively.

Thirty-three out of seventy-five specimens identified *a priori* as belonging to *S. chilensis* s.l. with dense inflorescence were assigned *a posteriori* to that taxon with posterior assignments probabilities between 81-99%, eighteen were misclassified with assignments probabilities between 8-49%, while the remainder had assignment probabilities to *S. chilensis* between 50-78%.

A canonical analysis was performed as part of the discriminant analysis. The variant scores on the first axis (CAN 1) were plotted for the two putative taxa (Fig. 18). While the two a priori groups ("S. patagonica" with lax inflorescence and S. chilensis s.l. with dense inflorescence) were statistically different, there was considerable overlap in the range of canonical scores of the two a priori groups. The Eigenvalue associated with first canonical discriminant function was 0.441.

Table 7. F statistics $F_{0.05\ (6.355)}$ and associated null hypothesis probabilities P between the two putative taxa.

Taxon	*S. chilensis*	*"S. patagonica"*
S. chilensis	F 0.000 P 1.000	
"S. patagonica"	F 12.236 P <0.000	F 0.000 P 1.000

Table 8. Multivariate Statistics and F Approximations for the Wilk's Lambda, Pillai's Trace, and Hotelling-Lawley Trace Tests for the discriminant analysis of the four putative taxa (*S.patagonica* and *S. chilensis*).

2 putative taxa				
Statistic	Value	F-value	DF	P-tail
Wilk's lambda	0.694	12.236	4, 111	< 0.0000
Pillai's Trace	0.306	12.236	4, 111	< 0.0000
Hotelling-Lawley Trace	0.441	12.236	4, 111	< 0.0000

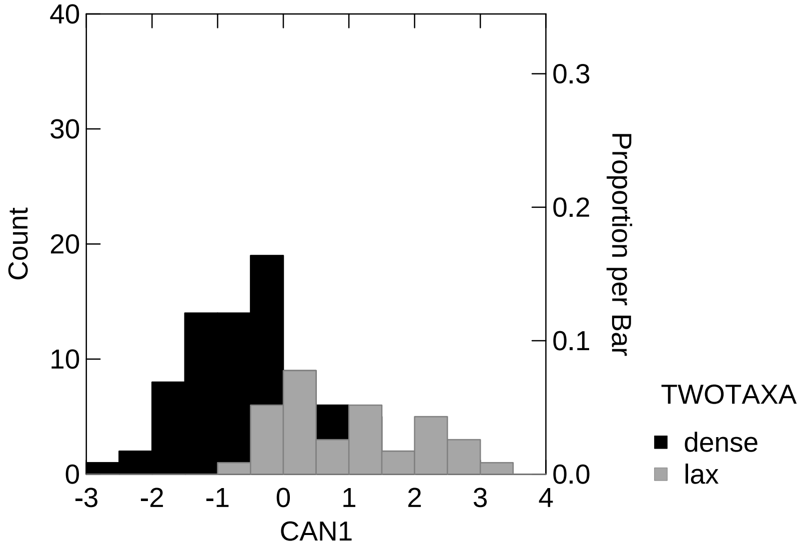
Table 9. Classification Matrix obtained by discriminant analysis for the two putative taxa of *S. chilensis* (with dense inflorescence or lax inflorescence).

		a posteriori	
a priori	*S. chilensis*	*"S. patagonica"*	% correct
S. chilensis	62	18	78
"S. patagonica"	14	22	61
Total	76	40	72

Table 10. Jackknifed Classification Matrix obtained by discriminant analysis for the two putative taxa of *S. chilensis* (with dense inflorescence or lax inflorescence).

	a posteriori		
a priori	*S. chilensis s.l.*	*"S. patagonica"*	% correct
S. chilensis s.l.	61	19	76
"S. patagonica"	14	22	61
Total	75	41	72

Figure 18. Histogram of canonical scores (CAN 1) for two putative taxa based on inflorescence density (dense= *S. chilensis;* lax= *S. "patagonica"*).



3.3.2.2 Two *a priori* groups based on hair density: *S. chilensis s.l.* hairy and not hairy

The step-wise discriminant analysis yielded four characteristics with the high discriminating value which were used to complete the discriminant analysis. They were: ISTHLN, MLLENG, MSERAT, RFLOR, and ULWID (Table 1) in decreasing order of discriminatory power. The F-Matrix based on the Mahalanobis distance between *a priori* group centroids and associated probabilities showed support for the two *a priori* groups (Table 11). The Wilk's lambda, Pillai's Trace, and Hotelling-Lawley Trace tests for equality of group centroids all indicate that the groups were significantly different (Table 12).

Geisser *a posteriori* assignment probabilities were determined for each of the 119 specimens and a Classification Matrix and a Jackknifed Classification Matrix for these specimens are shown in table 13 and table 14 respectively.

Twenty-five out of fifty-three specimens identified *a priori* as belonging to *S. chilensis* with hairy stems were assigned *a posteriori* to that group with Geisser probabilities between 80-100%. Thirteen specimens were assigned to *S. chilensis* with hairy stems with associated probabilities between 50-79%, while fourteen specimens were misclassified with assignment probabilities to the *a priori* group between 10-49%.

A canonical analysis was performed as part of the discriminant analysis. The variant scores on the first scored (CAN 1) were plotted for the four two probable varieties studied (Fig. 19). It showed the two *a priori* groups as different groups. The Eigenvalue associated for first canonical discriminant function was 0.692.

Table 11. F statistics F $_{0.05\ (6.355)}$ and associated null hypothesis probabilities P between the two putative taxa.

S. chilensis s.l.	hairy stem	not hairy stem
hairy stem	F 0.000 P 1.000	
not hairy stem	F 15.640 P <0.000	F 0.000 P 1.000

Table 12. Multivariate Statistics and F Approximations for the Wilk's Lambda, Pillai's Trace, and Hotelling-Lawley Trace Tests for the discriminant analysis of the four probable varieties (*S. chilensis* with long stem-hairs and *S. chilensis* with short setm-hairs).

2 putative taxa within *S. chilensis s.l.*				
Statistic	Value	F-value	DF	P-tail
Wilk's lambda	0.591	15.640	5, 113	< 0.0000
Pillai's Trace	0.409	15.640	5, 113	< 0.0000
Hotelling-Lawley Trace	0.692	15.640	5, 113	< 0.0000

Table 13. Classification Matrix obtained by discriminant analysis for the two probable varieties of *S. chilensis* (with hairy stems and with not hairy stems).

	a posteriori		
a priori	*S. chilensis* with hairy stems	*S. chilensis* with not hairy stems	% correct
S.chilensis with hairy stems	39	14	74
S.chilensis with not hairy stems	7	59	89
Total	46	73	82

Table 14. Jackknifed Classification Matrix obtained by discriminant analysis for the two probable groups of *S. chilensis* (with hairy stems and with not hairy stems).

	a posteriori		
a priori	*S. chilensis* with hairy stems	*S. chilensis* with not hairy stems	% correct
S. chilensis with hairy stems	37	16	70
S. chilensis with not hairy stem	7	59	89
Total	44	75	81

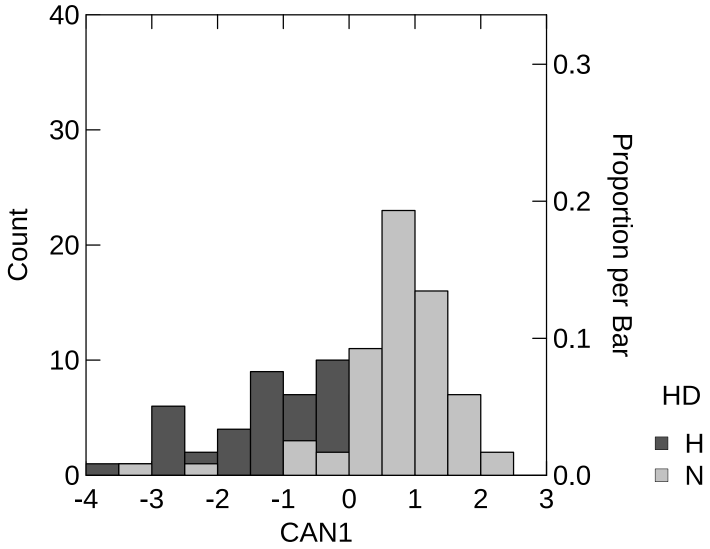


Figure 19. Histogram of canonical score on the first canonical axes (CAN 1) for two probable varieties (H= densely hairy; N= glabrate or sparsely hairy).

3.3.2.3 Two *a priori* groups based on hair length: *S. chilensis* with short hairs and *S microglossa* with long hairs

The step-wise discriminant analysis generated nine characteristics with the high discriminating value which were used to complete the discriminating analysis. They were: RFLOR, ISTPUBD, MLWID, DFLOR, LONGBR, BSTPUBD, IPHYLV, IPHYLL, and ULSERAT (Table 1) in decreasing order of discriminatory power.

The F-Matrix based on Mahalanobis distances between group centroids and the associated probabilities showed strong support for the two groups (Table 15). The Wilk's lambda, Pillai's Trace, and Hotelling-Lawley Trace tests for equality of group centroids all indicate that the groups were significantly different (Table 16).

Geisser *a posteriori* assignment probabilities were determined for each of the 118 specimens and a Classification Matrix and a Jackknifed Classification Matrix for these specimens were generated (Table 17 and Table 18, respectively).

Twenty-seven of the thirty specimens identified *a priori* as belonging to *S. microglossa* (long stem hairs) were assigned *a posteriori* to that group with Geisser assignment probabilities between 90-100%; five had probabilities between of 82% and 88%, while one had a probability of 69%. There were only three misclassified specimens with assigned probabilities between 12-48%.

Seventy-three out of the 88 specimens identified *a priori* as belonging to *S. chilensis* (short stem hairs) were assigned *a posteriori* to that group with Geisser assignment probabilities between 90-100%, five were assigned to *S. chilensis* with probabilities between 77-86%, and four were assigned with probabilities between 52-65%. Five specimens were misclassified with probabilities close to 0% of belonging in the *a priori* group *S. chilensis*. Results for the Jackknifed classification were only slightly less.

A canonical analysis was performed as part of the discriminant analysis. The variant scores on the first axis (CAN 1) were plotted for the two probable taxa studied (Fig. 20). It showed the two *a priori* groups (*S. microglossa* with long stem-hair and *S. chilensis* with short stem-hair) as different groups. The Eigenvalue associated for first canonical discriminant function was 1.655.

Table 15. F statistics F $_{0.05\ (6.355)}$ and associated null hypothesis probabilities P between the two putative taxa.

Taxon	*S. microglossa*	*S. chilensis*
S. microglossa	F 0.000 P 1.000	
S. chilensis	F 19.856 P <0.000	F 0.000 P 1.000

Table 16. Multivariate Statistics and F Approximations for the Wilk's Lambda, Pillai's Trace, and Hotelling-Lawley Trace Tests for the discriminant analysis of the four probable taxa (*S. chilensis* and *S. microglossa*).

2 probable taxa within *S. chilensis*				
Statistic	Value	F-value	DF	P-tail
Wilk's lambda	0.410	19.856	9, 108	< 0.0000
Pillai's Trace	0.590	19.856	9, 108	< 0.0000
Hotelling-Lawley Trace	1.441	19.856	9, 108	< 0.0000

Table 17. Classification Matrix obtained by discriminant analysis for the two probable groups *S. microglossa* and *S. chilensis* (with long stem-hairs or short stem-hairs, respectively).

	a posteriori		
a priori	*S. microglossa*	*S. chilensis*	% correct
S. microglossa	27	3	90
S. chilensis	5	83	94
Total	32	86	93

Table 18. Jackknifed Classification Matrix obtained by discriminant analysis for the two probable groups *S. microglossa* and *S. chilensis* (with long stem-hairs or short stem-hairs, respectively).

	a posteriori		
a priori	*S. microglossa*	*S. chilensis*	% correct
S. microglossa	27	3	90
S. chilensis	7	81	92
Total	34	84	92

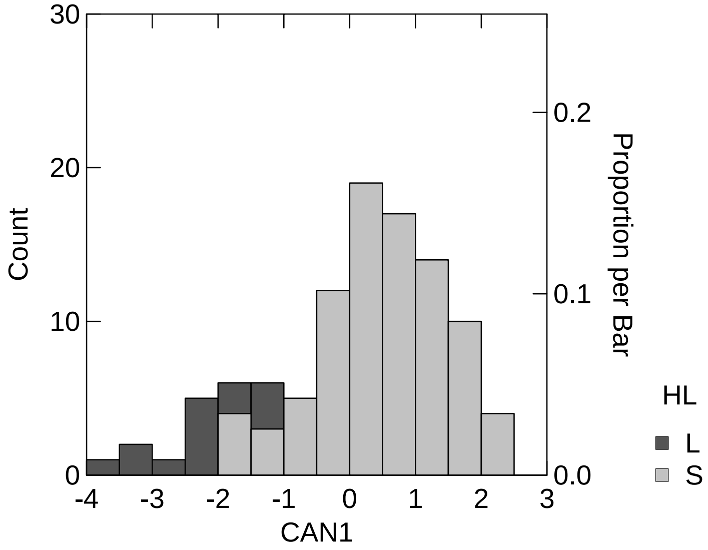


Figure 20. Histogram of canonical scores on the first canonical axes (CAN 1) for two probable species (L= long hair; S=short hair).

3.3.3 Five taxa: Two South American (*S. microglossa* with long hairs and *S. chilensis* with short hairs) and related North American taxa (*S. juliae*, *S. leavenworthii*, and *S. tortifolia*)

In the second discriminant analysis for the South American and related North American taxa, five putative species were included in the analysis as *a priori* groups: *S. microglossa, S. chilensis, S. juliae, S. leavenworthii*, and *S. tortifolia*. A step-wise discriminant analysis was performed including all 160 specimens to determine which characters were most useful in separating the five *a priori* groups. The eight traits with the highest F-values were included in a complete discriminant analysis: ISTPUBD, ULSERAT, CAPW, OPHYLL, RFLOR, BSTPUB, MLWID, and IPHYLV in decreasing order of discriminatory power.

The F-matrix based on Mahalanobis distances between group centroids, and associated probabilities indicate strong support for the five putative taxa is shown in Table 19. The F-values between *S. juliae* and *S. tortifolia* were the lowest. All three tests (Wilk's lambda, Pillai's trace, and Lawley-Hotelling trace) for equality of group centroids indicated that the groups were significantly different (Table 20). The highest F-value was between *S. chilensis* and *S. tortifolia*. The F-value between *S. microglossa* and *S. chilensis* was in the mid range of all F- values.

Geisser *a posteriori* assignment probabilities were determined for each of the 160 specimens and a Classification Matrix and a Jackknifed Classification Matrix for these specimens were generated and can be found in tables 21 and 22, respectively.

In the Classificatory Discriminant analysis, all specimens identified *a priori* as belonging to *S. tortifolia* were assigned *a posteriori* to that taxon with Geisser assignment probabilities ranging from 92-100% for eleven out of the fourteen specimens. Only three correctly classified specimens had probabilities in a range between 63% and 83%.

In the Classificatory Discriminant analysis, eight of the nine specimens assigned *a priori* to *S. juliae* were assigned *a posteriori* to that taxon. Five of these specimens had Geisser assignment probabilities between 93-100%, while the other three had assignments probabilities between 78-84%.

One specimen assigned *a priori* as *S. juliae* was treated as misclassified and assigned *a* posteriori very weakly to *S. leavenworthii* with Geisser assignment probabilities split among *S. leavenworthii* (42%), *S. juliae* (42%), and *S. tortifolia* (16%).

In the Classificatory Discriminant Analysis, ten of the specimens assigned *a priori* to *S. leavenworthii* were placed *a posterior* in that taxon. Nine of them had Geisser assignment probabilities between 99-100%, and one specimen had an assignment probability of 76%. Five of the specimens assigned *a priori* as *S. leavenworthii* were misclassified with assignment probabilities between 0 % and 41% to the *a priori* group. Two of them were placed *a posteriori* in *S. chilensis* (68% and 57% probability) and one specimen was placed in *S. juliae* (62% probability).

In the Classificatory Discriminant Analysis, 28 of the 30 specimens assigned *a priori* to *S. microglossa* were placed *a posteriori* in that taxon. Nineteen had Geisser probabilities assignment between 90-100%, while only four had those between 51% and 67%. The reminders (four) had probabilities between 73% and 84%. Only two were classified *a posteriori* as *S. chilensis* with probabilities assignment of 60% and 86%.

In the Classificatory Discriminant analysis, 77 of the 88 specimens assigned a priori to S. chilensis were placed a posteriori in that taxon. Sixty had Geisser probabilities assignment between 91-100%, and 17 had Geisser assignment probabilities between 62-88%. Eleven specimens were misclassified with Geisser assignment probabilities close to 0%. Seven of them were placed a posteriori in *S. microglossa* with probabilities assignments between 51-98%. Three of the specimens assigned a priori to *S. chilensis* were placed in *S. leavenworthii* with assignment probabilities 99-100%. Only one was placed in *S. juliae* (77% probability).

A canonical analysis was performed as part of the discriminant analysis. The variant scores on the first and second, and in the first and third canonical axes (CAN 1, CAN 2, and CAN 3) were plotted for the five putative taxa studied (Fig. 21). It showed the five *a priori* 95% confidence limits groups (*S. microglossa*, *S. chilensis*, *S. juliae*, *S. leavenworthii*, *S. tortifolia*) as different groups. The Eigenvalues associated for first canonical discriminant function (3.121) has a relative percentage associated of 87.5 %, the second (1.560) 11.2%; and the third (0.066) 1.3%.

Table 19. F statistics $F_{0.05(6,353)}$, and associated null hypothesis probabilities P between the five putative taxa.

Taxon	*S. microglossa*	*S. chilensis*	*S. juliae*	*S. leavenworthii*
S. chilensis	F 17.633 P <0.0000			
S. juliae	F 14.191 P <0.0000	F 27.430 P <0.0000		
S. leavenworthii	F 17.704 P <0.0000	F 16.336 P <0.0000	F 12.818 P <0.0000	
S. tortifolia	F 29.805 P <0.0000	F 40.429 P <0.0000	F 4.446 P <0.0000	F 16.694 P <0.0000

Table 20. Multivariate Statistics and F Approximations for the Wilk's Lambda, Pillai's Trace, and Hotelling-Lawley Trace Tests for the discriminant analysis of the five putative taxa.

		Five putative taxa		
Statistics	Value	F-values	DF	P-tail
Wilk's lambda	0.060	18.094	32, 532	0.0000
Pillai's trace	1.716	13.799	32, 588	0.0000
Lawley-Hotelling trace	5.022	22.364	32, 570	0.0000

Table 21. Classification Matrix obtained by discriminant analysis for the five putative taxa (specimens in row categories into columns).

	a posteriori					
a priori	*microglossa*	*chilensis*	*juliae*	*leavenworthii*	*tortifolia*	% correct
microglossa	28	2	0	0	0	93
chilensis	7	77	1	3	0	88
juliae	0	0	8	1	0	89
leavenworthii	1	3	1	10	0	67
tortifolia	0	0	0	0	14	100
Total	36	82	10	14	14	88

Table 22. Jackknifed Classification Matrix obtained by discriminant analysis for the five putative species (specimens in row categories classified into columns).

	a posteriori					
a priori	*microglossa*	*chilensis*	*juliae*	*leavenworthii*	*tortifolia*	%correct
microglossa	28	2	0	0	0	93
chilensis	8	76	1	3	0	86
juliae	0	0	6	1	2	67
leavenworthii	1	3	1	10	0	67
tortifolia	0	0	1	0	13	100
Total	37	81	9	14	15	88

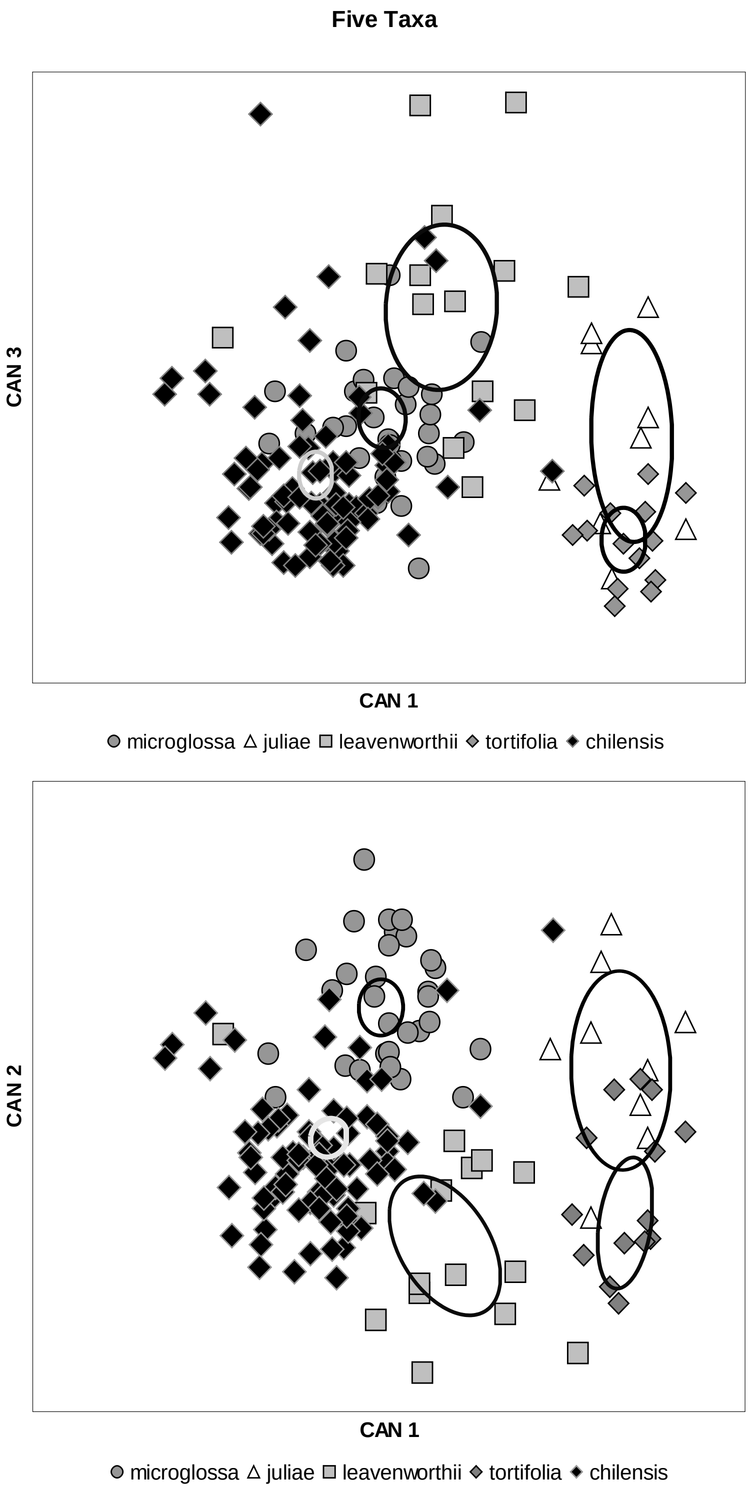


Figure 21. Scatterplot of canonical scores on the first and second, and first and third canonical axes (CAN 1,CAN 2, CAN 3) for five putative taxa.

3.4 Cytogeography of *Solidago chilensis* and *Solidago microglossa*

Chromosome counts were obtained for 31 plants grown at the University of Waterloo Department of Biology Green House from field-collected cypselae (Table 23). Five out of the total were identified as *S. microglossa*, while twenty-six were classified as *S. chilensis*.

All of the 32 specimens from *Solidago* of the Chilensis Complex counted were found to be diploid. One out of the total of plants was from Chile while the rest were from Argentina.

Table 23. Chromosome counts from plants growth in the greenhouse and their localities.

Taxon	Chromosome Count	Location and voucher (WAT, LP)*
Solidago chilensis	2*n*=18	Buenos Aires Prov.; *L&B 4*
		Catamarca Prov.; *L&B 27*
		Chubut Prov.; *L&B 6*
		Chubut Prov.; *L&B 7*
		Chubut Prov.; *L&B 11*
		Cordoba Prov.; *L&B 20*
		La Pampa Prov.; *L&B 19*
		La Rioja Prov.; *L&B 26*
		Mendoza Prov.; *L&B 23*
		Mendoza Prov.; *L&B 24*
		Neuquen Prov.; *L&B 14*
		Neuquen Prov.; *L&B 16*
		Neuquen Prov.; *L&B 17*
		Salta Prov.; *L&B 39*
		Santa Cruz Prov.; *L&B 9*
		Neuquen Prov.; *L&B 16*
		Santa Fe Prov.; *L&B 1*
		Santa Fe Prov.; *L&B 33*
		Santa Fe Prov.; *L&B 34*
		Santa Fe Prov.; *L&B 51*
		Santiago del Estero Prov.; *L&B 31*
		Region XI-Chile.; *L&B 10*
		Rio Negro Prov.; *L&B 13*
		Rio Negro Prov.; *L&B 15*
Solidago microglossa	*2n*=18	Chaco Prov.; *L&B 36*
		Chaco Prov.; *L&B 42*
		Corrientes Prov.; *L&B 47*
		Corrientes Prov.; *L&B 48*
		Entre Rios Prov.; *L&B 50*
		Formosa Prov.; *L&B 43*

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Chapter 4: Discussion

4.1 *Solidago* in South America: Introduced species

Based on morphological observations and literature (Semple and Cook 2006), two species of *Solidago* occur in South America that had been overlooked previously. The species have been identified tentatively as *S. virgaurea* L. (Fig. 22, 23) of subsect. *Solidago* and *S. missourensis* Nutt. (Fig. 24) of subsect. *Junceae*. Multivariate analyses on these two species were not carried out because scoring specimens of these and related species was beyond the scope of this M.Sc. thesis emphasizing *S*. subsect. *Triplinervae*, and the sample sizes were very small for the species in South America.

Figure 22. Herbarium specimen of *Solidago virgaurea* L., *Cabrera 5015* (LP).

Figure 23. Morphology of *Solidago virgaurea* L., *Cabrera 5015* (LP). **A.** Upper stem and leaves. **B.** Mid stem leaf. **C-D**. Lower and mid stems. **E** Heads. **F**. Involucre, multi-veined phyllaries.

Figure 24. Morphology of *Solidago missouriensis Nutt*. **A**. Mid-size shoot. **B**. Dwarf shoot, . **C**. Stem detail. **D.** Lower stem leaf . **E**. Upper stem and stem leaves. **F**. Heads. A, D, E-F, *Ruiz Leal 24529* (LP); B-D, *Troels, Myndel &Pedersen 14486* (MO).

A preliminary identification of all the specimens from South America was carried out and a tentative classification of the specimens was created that was in disagreement with Philippi (1894), Cabrera (1974) and Sancho and Espinar (2003). The single specimen of *S. patagonica*, *Cabrera 5015* (LP, Fig. 20) did not fit well in the general morphology of the *S. chilensis* complex. My identification of *S. patagonica* as *S. virgaurea* was based on the characteristic lax inflorescence of the *S. patagonica* specimen mentioned in the published keys of Cabrera (1974) and Sancho and Espinar (2003) which is remarkably different from all the other South American specimens. Consequently, I excluded this specimen from the complex and made preliminary identifications using the published key. Although the type of *S. patagonica* was not available for comparison, I compared the specimen *Cabrera 1051* (Fig. 22) with samples of North American species and with *S. virgaurea* (Eurasian taxon) available at WAT and pictures of the latter available on the web (www.rolv.no/urtemedisin/medisinplanter/soli_vir.htm). The reason why I tentatively classified the *S. patagonica* specimen as *S. virgaurea* is the similarity in the inflorescence shape. However, additional work is needed to confirm that *S. patagonica* should be not treated as separate species native to South America. *Solidago virgaurea* is thought to have been introduced into South America in post-Columbian times via human activity and may only be an escaped cultivar.

Solidago missouriensis had not been previously reported from South America. The specimens examined were compared with numerous samples of the species from North America in WAT. The South American material fit well within the description of the species (Semple and Cook 2006) although the phyllaries sometimes had multiple veins and were often minutely glandular. Detailed multivariate morphometric studies of members of subsect. *Junceae* are needed to confirm that the South American samples are not a cryptic species differing in technical traits from North American relatives. *Solidago missouriensis* is thought to be an introduction into South America in post-Columbian times via human activity. It appears to have naturalized and established itself at least for a number of years (1928-1968) in Argentina.

Dot distributions for the *S. virgaurea* and *S. missouriensis* are shown in Figure 6. The distributions of *S. missourensis* and the possible *S. virgaurea* overlap. Most of these specimens were collected in the area of the Nahuel-Huapi's Lake. This region is commonly known as Patagonia and was specifically identified as the distribution area of *S. patagonica* (Sancho and Espinar, 2003).

4.2 *Solidago* subsect. *Triplinervae* in South America and related taxa of North America

Discriminant analysis has been employed in taxonomic studies because it is a practical method for assessing differences between groups, finding additional distinguishing traits, and establishing the identities of atypical specimens (Heard and Semple, 1988; Semple *et al.*, 1990; Elliot *et al.*, 2006; Cook *et al.*, 2009). Therefore, discriminant analyses were undertaken to investigate morphological variation in members of the *S. chilensis* complex. Based on univariate analyses, discriminant analyses, and observations on plants in the field and greenhouse, the following species are recognized in South America within the complex: *S. chilensis* Meyen and *S. microglossa* DC. These taxa are part of the subsect. *Triplinervae*. The nomenclatural ranks accepted for the taxa were supported by the results of the analyses in this thesis and were determined after reviewing differences among taxa within the North American species of *Solidago* and the literature on *Solidago* (e.g., Semple *et al*., 1990; Semple and Cook, 2006; Cook *et al.,* 2009; and Semple and students, unpublished studies on different subsections of *Solidago*). Two sets of analyses were performed to reach the above conclusion. First, analyses were undertaken to determine how distinct the South American members of subsect. *Triplinervae* were from North American species. Second, the South American members of the subsection were analyzed to determine how many taxa should be recognized and at what rank.

4.3 South American Solidago as a taxonomically distinct group from the North American species

To assess differences between North American from the South American *S. chilensis* complex, three North American species belonging in subsect. *Triplinervae* were chosen for comparison because of their similarity with specimens of the *S. chilensis* complex: *S. juliae*, *S. leavenworthii*, and *S. tortifolia*. The only specimen available of *S. patagonica* was excluded from this discriminant analyses because, as previously noted above, I placed the plant in subsect. *Solidago.* In the four *a priori* species-level group analysis the p-values for the tests of the null hypotheses that all four groups were the same were well below α of 0.05. The South American taxon formed a group that was as distinct from the three North America species groups as these groups were from each other. The percentages of specimens correctly assigned *a posteriori* to the South American group in the classificatory analyses and the Geisser assignment probabilities of individual specimens were high. These results indicated that there was statistical support for the differentiation of each *a priori* group as a species. Thus, it was determined that *S. chilensis* complex specimens were a well defined taxonomic group and statistically different from those closely related species of North America. Some specimens were misclassified, but in a frequency similar to misclassified specimens for several of the North American species. This is not surprising because members of all four *a priori* groups were more similar to each other than to other species in the subsection that were not included in the analyses. Stronger results would have been obtained, if the South American specimens had been compared with the broader leaved species such as *S. gigantea* Ait. and *S. lepida* DC. Such a comparison would not have been a real test of the distinctiveness of the South American complex. Also, it is important to note that key characters were used to define the *a priori* groups and excluded from further analyses, thus only technical traits were available for use in the discriminant analyses. That these secondary characters also were useful in separating North and South American groups provide support for not simply including the South American specimens in one of the North America species. However, the four *a priori*-group analysis did not provide evidence for there being more than one South American species. This was explored in additional analyses.

4.4 *Solidago* in South America: How many taxa in subsect. *Triplinervae*?

I hypothesized the existence of two taxa at the species level within the *S. chilensis* complex based on the literature (Cabrera, 1974; Sancho and Espinar, 2003). This hypothesis was tested in three separate analyses, each time the *a priori* classification of the specimens was based on different vegetative characters. First, the accuracy of the keys published by Cabrera (1974) and Sancho and Espinar, (2003) were tested. Classification based on the inflorescence density was explored. Because the only specimen of *S. patagonica/S. virgaurea* had been immediately removed from the *S. chilensis* complex collections, I had assumed that all remaining specimens of the complex were either *S. chilensis* or *S. patagonica*. Based on this assumption, from 119 specimens scored I assigned 80 specimens *a priori* to *S. chilensis* (dense inflorescence) and 36 specimens to "*S. patagonica*" (lax inflorescence). The null hypothesis that the two groups were the same was rejected because p was less than 0.05. However, in the classificatory discriminant analysis, percentages of assignments *a posteriori* were often low and highly variable (21-98%). This was likely due to the *a priori* classification being based on a trait that is highly variable in the complex and consequently not a strong diagnostic trait. After examining all of borrowed specimens of the complex, I observed a large variation in the size of the inflorescence and consequently the distances between branches were also highly variable. When I applied the key, I based my *a priori* classification on the number of branches seen in the length of the inflorescence-stem as well as distances between these branches. As demonstrated by Jakobs *et al.* (2004), inflorescence size can be affected by different environmental factors. For this reason, when I carried out the discirminant analysis, the large range in assignment probabilities could have been the result of the plasticity of the inflorescence. In contrast to the rejection of the null hypothesis, the results of the classificatory analyses suggested that the key character to split the complex into two taxa was not a good predictor of *a priori* groups. Of course, the late realization that *S. patagonica* was not part of the *S. chilensis* complex accounted for why the inflorescence traits of lax versus compact in published keys did not apply well to just members of the *S. chilensis* complex. The analysis was reported here for completeness and to show that working with goldenrods often is complicated by misleading ideas in the literature.

The published keys (Cabrera, 1974; Sancho and Espinar, 2003) divided *Solidago chilensis* into two varieties: *S. chilensis* var. *chilensis,* with glabrous stems and *S. chilensis* var. *megapotamica* with pubescent stems. However, my observations on *S. chilensis* complex specimens showed no presence of truly glabrous plants, but the existence of two groups of plants with differences in their pubescence. The first group showed an average of more than 5 hairs along one mm length of stem (measured between nodes), while the other group had an average of less than 5 hairs along one mm length of stem with a glabrate aspect. The discriminant analysis of these two *a priori* groups generated a between group centroid Mahalanobis distance with a relatively high F-value and low probability of the two groups being samples of the same group, i.e., the null hypothesis was rejected. The *a posteriori* classification matrices showing high correct placements to *a priori* group (>90%) have been used in other studies as support for species level recognition (Owen *et al.*, 2006; Cook *et al.*, 2009). Following this criterion, I considered that the treatment of the *S. chilensis* complex as two species based on hair density was not statistically well supported. Nonetheless, hair density showed a geographical pattern; the specimens from the northeastern range of the complex in South America (Brazil, Paraguay, and northeastern of Argentina) mainly had densely hairy stems (Fig. 25 C), while in the southern part of the range in South America (central and southern of Argentina and Chile, and Uruguay) plants had sparsely hairy stems (Fig. 25 B), with an area where both types of hair density plants are found in Bolivia and northern Argentina.

After not finding strong support for classification based on pubescence density, I tested the hypothesis identifying two *a priori* groups within the *S. chilensis* complex based on the length of the hairs on the stem. Box plots showed two groups, one with a hair length average shorter than 0.4 mm and the other group with a hair length greater than 0.45 mm. Discriminant analysis for these two *a priori* groups had a high F-value and a low probability that the two *a priori* groups were samples of the same population. The null hypothesis was rejected. The classificatory analysis had high overall percentages of correctly assigned specimens *a posteriori* to their *a priori* groups in both the linear and jackknife analyses. Individual specimens had generally high Geisser assignment probabilities to their *a priori* group, although there were eight individuals which were placed in the other hair length group with variable probabilities. Four out of these eight specimens were misplaced *a posteriori* with probabilities between 88-100%, while the other half had low *a posteriori* probabilities (52-77%) and these had intermediate length hairs (Fig. 25 A). All of these misclassified individuals came from Bolivia and northern Argentina. No specimens from the area where the two groups overlapped in eastern South America were misclassified.

Although both hair-based *a priori* group analyses had high F-values and low probabilities of the null hypotheses being true, Geisser assignment probabilities for individual specimens were higher for the *a priori* taxa classification based on stem hair length. The distributions of the short and long haired plants were allopatric over much of their range overlapping only in northern Argentina and Bolivia. Plants grown in the greenhouse in Waterloo had stem hair lengths similar to their parent plants collected in Argentina. Thus, hair length is an inheritable trait little influenced by environmental conditions; however the selective pressures are unknown. Based on the results of the multivariate analysis and other observations, two species in *Solidago* subsect. *Triplinervae* were recognized in South America: *S. chilensis* Meyen and *S. microglossa* DC. The nomenclature was chosen after observations were made on available high-resolution photographs of the type specimens.

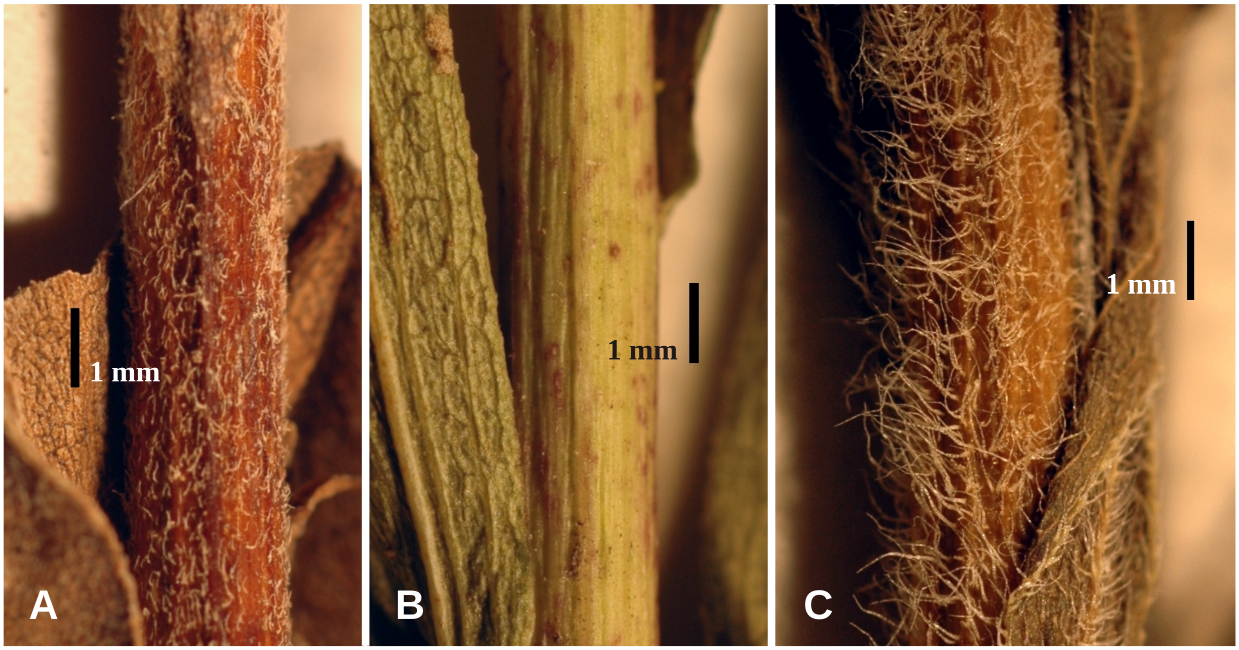

Figure 25. **A**. “Problematic specimen” with a densely hairy stem with short hairs (Salta province, Argentina). **B**. *Solidago chilensis* stem, glabrate (Buenos Aires, Argentina). **C**. *Solidago microglossa* densely hairy and long hairs (Central, Paraguay).

4.5 *Solidago* subsect. *Triplinervae* in South America (revised) and related taxa in North America

Following the decision to recognized two species native to South America, a discriminant analysis with five *a priori* groups was carried out: *S. juliae*, *S. leavenworthii,* and *S. tortifolia* from North America, and *S. chilensis* and *S. microglossa* from South America. The results showed that five *a priori* groups were well-supported . The F-values on Mahalanobis distances between groups were generally high and the probability of all samples being from the same population was well below 0.05. The null hypothesis was rejected and five species level groups accepted. Small F-values between *S. juliae* and other species could have been due to the small sample size. Percentages of correct placements *a posteriori* of specimens of the five putative taxa were high as well as Geisser assignment probabilities for correct placement of individual specimens *a posteriori*. The strong statistical support for *S. tortifolia* in the discriminant analyses with 100% correct placement *a posteriori* showed that *S. tortifolia* was the most distinct taxon among the five *a priori* groups.

Although the discriminant analysis showed five well separated groups (Fig. 21), classificatory analyses showed that some specimens of *S. leavenworthii, S. chilensis*, and *S. microglossa* were difficult to place with only weak support for placement *a posteriori* in their *a priori* group or were misclassified. Three specimens of *S. chilensis* were placed *a posteriori* in *S. leavenworthii* with high Geisser assigned probabilities (99-100%). This is not surprising considering the morphological similarity between these species observed in this study. Seven specimens assigned *a priori* as *S. chilensis* were classified *a posteriori* as *S. microglossa* with a range of Geisser assigned probabilities between 51-98%, while one was assigned *a posteriori* as *S. juliae*. However, the other South American species, *S. microglossa*, had only two specimens placed *a posteriori* as *S. leavenworthii*. After reexamination of these "problematic specimens", they were found to be restricted to two geographical areas: 1) the northwestern portion of the range in South America, including Bolivia and 2) northeastern Argentina in the provinces of Corrientes and Chaco.

Considering the geographical distribution of the two South American species and the areas of sympatry today, the following hypothesis on their origins is suggested. A single ancestor of both migrated via long distance dispersal from North American into South America during a peak glacial time 16,000 years ago or earlier. The likely point of origin of cypselae is northern Mexico or the adjacent United States in the area generally occupied now by *S. juliae*.

The specimens identified *a priori* as *S. chilenses* that were classified *a posteriori* as *S. microglossa* were restricted to Bolivia. These specimens have statistically support of fifty percent of their morpholigacl traits as *S.chilensis* and the other fifty as *S. microglossa* as a consequence of the ambivalent morphological traits. Bolivia, as the area where these specimens exist, is postulated as the start point for the subsequent divergence in South America into two species via subsequent founder effect events, isolation and adaptation to different local ecological conditions. The introduction of *Solidago* in South America has not been studied in detail. Two hypotheses to explain the presence of other North American taxa in central and southern South America have been proposed: 1) “island” hopping down the cordillera via similar habitats that no longer exist in Central America and northern South America and 2) chance long-distance transport of the fruit propagules attached to the feathers of migrating birds. Alan Graham, (email communication to J.C. Semple; based on two unpublished chapters in forthcoming books) suggested the latter is much more likely as there is little evidence for the existence of intermediate, temporary habitats similar to those found in northern Mexico and Bolivia today. The results of this thesis suggest that those three closely related species from southern North America (*S. juliae*, *S. leavenworthii*, and *S. tortifolia*) included in the discriminant analyses and the two species from South America (*S. chilensis* and *S. microglossa*) possibly shared a common ancestor in the Pleistocene and all five species are relatively recently evolved by the same processes of founder effect, isolation and adaptation. The times of divergences are speculative, but advances and retreats of glaciers would have provided a strong stimulus for expansion and contraction of ranges in North America. *Solidago altissima* L. ssp. *gilvocanescens* (Rydb.) Semple in the southern United States and *S. altiplanites* Taylor & Taylor native to the southern high Great Plains of Texas and Oklahoma are also morphologically similar to the five species analysed in this thesis and may have diverged from a common ancestor during an earlier glacial peak and contraction event. Of note, only the work done in this thesis provided the data needed to confirm that *S. chilensis* had much more recently long-distance dispersed back to two locations in the Northern Hemisphere; Puerto Rico in the West Indies and Madeira (Gonçalvez Silva *et al.*, in press) off the Coast of Africa in the North Atlantic. This clearly shows that long distance is not a barrier to migration and colonization by members of *S.* subsect. *Triplinervae*. Also of note is the fact that only in South America did the plesiomorphic short dense stem pubescence of the ancestral taxon evolve into both nearly glabrous and longer-haired conditions found in the two South American species. In North America, the three species remained short-haired and generally densely so. Only in *S. leavenworthii*, the only known polyploid species in the complex, did North American plants approach the glabrous/glabrate condition seen in the extreme in some plants in *S. chilensis* in South America. This visually obvious difference in pubescence might have been the result of very few or just one founder event and more critically different selection pressures encountered in South America.

There is a second hypothesis that was not tested in this M.Sc. thesis due to the lack of material and time. In northeastern Argentina in the provinces of Corrientes and Chaco, there is an overlapping distribution of *S. chilenis* and *S. microglossa* (Fig.26), where several of "problematic specimens" were collected, (two *a priori* placements in *S. microglossa* were classified *a posteriori* as *S. chilensis*). After reexamination of both specimens and observations of morphological similarilities of the traits of the two species, the possibility of interspecific hybridization was suggested. This process is common among

Solidago species in North America (Semple *et al.*, 1999) and it should not be excluded as a possible explanation for the presence of specimens with ambivalent identity in South America. For instance, observations of long hairs (characteristic of *S. microglossa*) in specimens classified *a posteriori* as *S. chilenis* showed possible evidence of hybridization. However, this hypothesis was not tested with experimental crosses between *S. chilensis* and *S. microglossa*. Semple and Semple (1978) noted that there was a greater variability in morphological characteristics of hybrids than expected in parental species. Therefore, similar variability might be seen in the wild populations of the "problematic specimens".

As an adaptation to distinct habitats *S. microglossa* has a northeastern distribution that includes Brazil, Paraguay and northern Argentina, while *S. chilensis* is mainly distributed in the rest of Argentina, Chile, and Uruguay. This pattern can be a result of the wide range of latitudes present in South America where the Tropic of Capricorn roughly split the continent into two regions: the Northern tropical warm areas and the Southern temperate zone with variable humid times in Uruguay and middle Argentina, but cold climates in the Patagonia (southern Argentina and Chile).

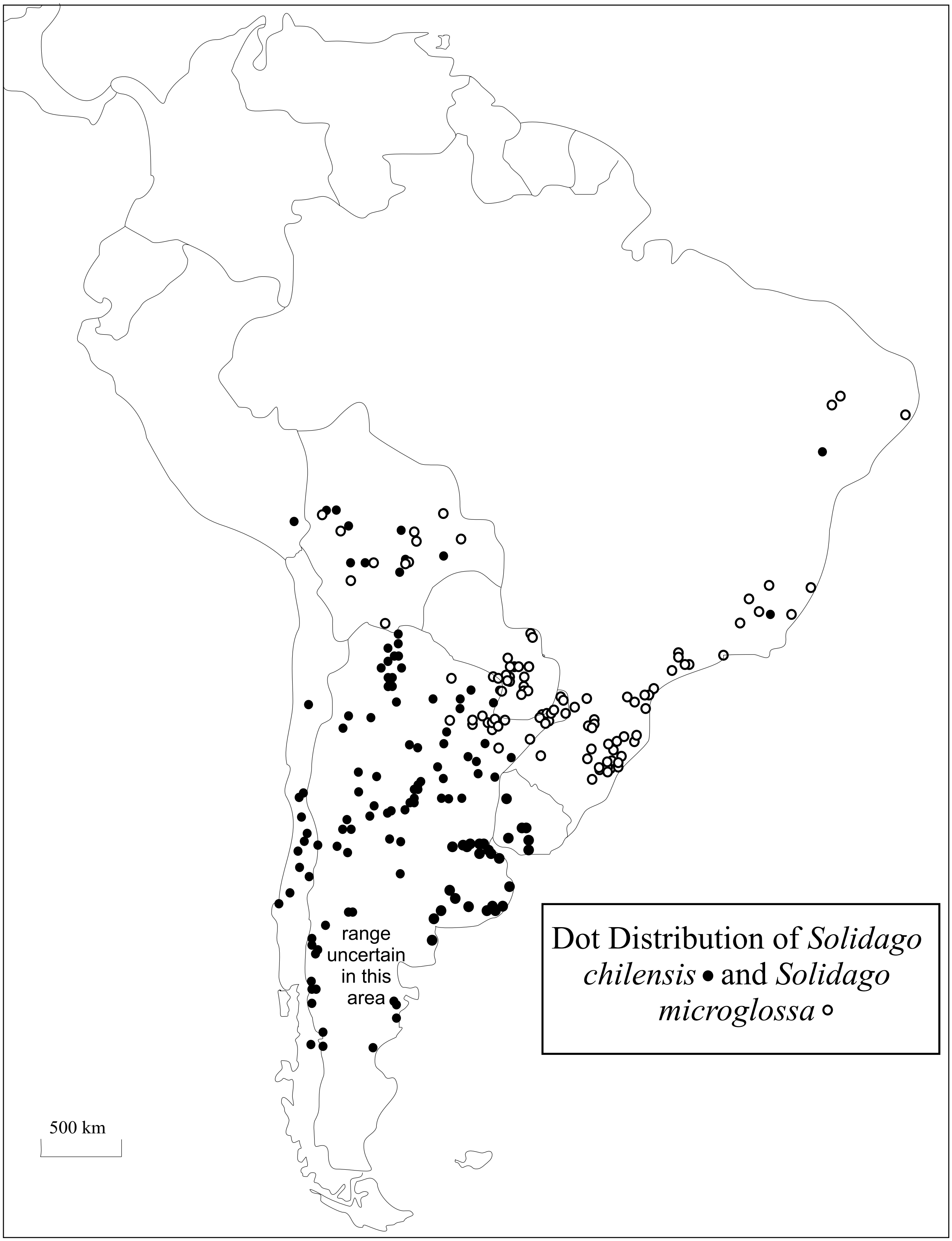

Figure 26. Dot distribution of *Solidago s.l.* in South America.

4.6 Cytogeography of *Solidago chilensis* and *S. microglossa* in South America

A cytogeography distribution map was plotted for *S. chilensis* and *S. microglossa* based on published counts and additional counts made as part of this thesis research (Fig. 25). In total, 29 diploid (2*n*=18) chromosome number determinations for populations of *S. chilensis* Meyen (24 locations newly reported in Table 22) and *S. microglossa*. These counts are in agreement with previous reports under various species and variety names (Covas and Schnack, 1946; Turner *et al.*, 1979; Huzinker *et al.*, 1989; Dematteis *et al.*, 2006). Chromosome counts were obtained from Buenos Aires, Catamarca, Chaco, Chubut, Cordoba, Corrientes, Entre Rios, Formosa, La Pampa, La Rioja, Neuquen, Mendoza, Santa Cruz, Santa Fe, Santiago del Estero, Salta, and Rio Negro within Argentina and Region XI (El Fachinal) within Chile. Although six additional counts were included in the literature [*S. chilensis*, 2*n* = 9II. Covas and Schnack (1946, 1947); 2*n* =18. Hunziker *et al.* (1989) from Salta Province, Argentina; 2*n* =18. Turner *et al.* (1979) for *S. chilensis* Meyen from Santa Fe Province, Argentina; *S. microglossa* 2*n* = 18 reported by Dematteis *et al.* (2007) as *S. chilensis* Meyen var. *megapotamica* (DC.) Cabrera from Paraguay], only three were included in the cytogeography map due to lack of information.

Figure 27. Cytogeography of *Solidago chilensis* and *Solidago microglossa* in South America based on chromosome counts reported here and those found in the literature. Grey areas indicate the distribution range.

4.7 Taxonomic Treatment: A key to the Taxa of *Solidago* in South America

1 Basal rosettes usually present at time of flowering; rosette and basal stem leaves the largest, pairs of small lateral branches leaves often present in axes of upper stem leaves; stems glabrous ……………………..*S. missourensis* (2)

1` Basal rosettes not present at time of flowering; lower-mid stem leaves largest or lowest stem leaves largest and stems pubescent; stem pubescence to glabrate

2 Inflorescence lax; stem leaves relatively few; stems glabrate ....…. .*S. virgaurea* (*S. patagonica*) (1)

2` Inflorescence congested; stem leaves many; stems glabrate, canescent or short villose.

3 Stem hairs short 0.1-0.4 mm long; stem pubescent to glabrate …….……....…….. *S. chilensis* (3)

3` Stem hairs 0.5-1.2 mm long; stems hispid-villose ……………..…..…........... *S. microglossa* (4)

1. *Solidago virgaurea* L., Sp. Pl. 880. 1753.

A detailed description based on multiple specimens could not be made due to a lack of available material. (Fig. 22, 23).

Flowering: missing data.

Distribution and Habitat in Argentina: Rio Negro (Fig. 6).

2. *Solidago missouriensis* Nutt., J. Acad. Nat. Sci. Phil. 7: 32. 1834.

Herbaceous perennials from short to long rhizomes. Stems erect, (1)3-8 dm tall, glabrous to sometimes very sparsely strigose in capitulescence. **Lower stem leaves** petiolate, blade tapering to a long winged petiole, oblanceolate to very linear oblanceolate, 5-10(20) cm long including petiole, (5)10-20(30) mm wide, glabrous, usually triple-nerved, margins entire to serrulate. **Mid to upper stem leaves** sessile, becoming rapidly reduced upwards, lanceolate to linear, 4-6 cm long, (2)4-14 mm wide, glabrous, margins entire, ciliate; often subtending clusters (fascicles) of small lateral branch leaves. **Capitulescence** paniculiform, broadly secund pyramidal or more rhombic to transversely rhombic in outline, (1.5)3-12(20) cm long, (1.5)3-12 cm wide; the glabrous branches with secund heads spreading and arching, sometimes ascending with non-secund heads; heads usually many. **Peduncles** 1.4-5 mm long, glabrous to very sparely strigose; bracteoles none to several, linear to lanceolate. **Involucres** narrowly to broadly campanulate, 2.5-4.5 mm high. Phyllaries in 3-4 strongly graduated series, the outer ones ovate to lanceolate, acute to rounded, the inner ones linear-ovate to oblong or linear lanceolate, obtuse to rounded, margins ciliate-fimbriate, especially apically. **Ray florets** 5-14, strap 1.5-2(4) mm long, 0.2-0.5(0.75) mm wide. **Disc florets** ca. (6)8-20, corollas (2)3-4 mm long, lobes 0.4-1 mm long. **Cypsellae** obconic, ca 1-2 mm long, glabrous to sparsely strigose; pappus bristles 2.5-3.0 mm long. $2n$ =18, 36 (description from Semple and Cook 2006 with permission; Fig. 24).

Flowering: Mid-late summer.

Distribution and Habitat in Argentina: Chubut, Mendoza, Neuquen, and Rio Negro (Fig. 6).

3. *Solidago chilensis* Meyen, Reise 1:311. 1834. TYPE (Holotype: B, destroyed in 1943; no Meyen collections of *Solidago chilensis* in B as of June 2008 according to Robert Vogt of B, email to J. Semple, 19 Jun 2008). NEOTYPE designated by Semple in Lopez Laphitz and Semple, in ed.: Type: “in campus chilesibus”, de Chile y Pampas (on label printed on sheet), Née (Neotype: GDC!, photo! GDC010427_1.jpg).

Solidago linearifolia DC., Prodr. 5:341. 1836. *S. microglossa* DC. var. *linearifolia* (DC.) Bak. In Mart., Fl. Bras. 6(3): 10. 1882. TYPE: “in campus Chilensibus,” *Née* (T: G-DC)

Solidago linearifolia DC. var. *poeppigii* DC., Prodr. 5: 341. 1836. TYPE: South America, without definite locality. *Poeppig ccxxvii* (T: not seen)

Solidago odora Hook. & Arn, Comp. Bot. Mag. 2: 45. 1836. non Aiton (1789). TYPE: (T: not seen)

Solidago coquimbana Phil., Linnaea 33: 138. 1864-65. TYPE: CHILE. Cordera. Cordillera de Thapel, Jan 1860, *Volikmann s.n.* (T: SGO, photo!)

Solidago laxiflora Phil., Anal. Univ. Chile 87: 429. 1894. TYPE: CHILE. S. Francisco del Monte, 1880, Martio s.n. (HT ?: SGO, photo!, annot. as "typus" by R. Acevedo de V. 1957)

Solidago floribunda Phil., Anal. Univ. Chile 87: 430. 1894. non *S. floribundus* Wall. (date?), nec Bush (1918). TYPE: CHILE. Ovalle, Jan 1880, Lautaro Navarro s.n. (T: SGO, photo! annot. cotypus)

Solidago araucana Phil., Anal. Univ. Chile 87: 431. 1894. TYPE: CHILE. (T: not seen)

Solidago valdiviana Phil., Anal. Univ. Chile 87: 431. 1894. TYPE: CHILE. Prov. Valdivi, San Juan, aestati1 887, *Philippi s.n.* (T: SGO, photo!, annot "typus", C. Muñez P., 1944)

Solidago recta Phil., Anal. Univ. Chile 87: 431. 1894. TYPE: CHILE. (T: not seen)

Solidago micrantha Phil., Anal. Univ. Chile 87: 432. 1894. TYPE: CHILE. (T: not seen)

Solidago parviflora Phil., Anal. Univ. Chile 87: 432. 1894. non Raf. (1820). TYPE: CHILE. Pirihuaico, Feb 1887, *Otto s.n.* (T: SGO, photo!) annot. as "typus" by R. Acevedo de V. 1957)

?*Aster sagei* Phil. Anal. Univ. Chile 87: 405. 1894. TYPE: CHILE. "Ex Araucania attulit orn, Carlos

Sage". (T: not seen)

Solidago linearifolia DC. var. *brachypoda* Sprg. Revist. Agron. La Plata, 3: 610. 1897. TYPE: ARGENTINA. (T: not seen)

Plants: 7-170 cm. **Stem** decumbent from a branching rhizome, glabrate stem. Leaves: with hairs in the edges. *Basal* oblanceolate, twisted, nearly always withering well before flowering; *proximal* persisting, in most of the cases the biggest one in the plant, sessile, blades linear to oblanceolate,; 13-130 x 2-32 cm, with 0-12 serrations, abaxial and adaxial faces glabrous or sparsely strigose; *distal* linear-lanceolate, smaller than proximal, 10-80 x 1-27 cm, with 0-10 serrations; *inflorescence leaves* linear to lanceolate, 4.4-45 x 0.5-18 cm with 0-5 serrations. **Heads**: pyramidal paniculiform or clubs arrays, braches recurved, second. **Involucre**: campanulate. **Phyllaries** in 3-4 series, outer ovate: 1.1-2.7 x 0.3-1.6 mm, inner oblanceolate: 0.29-5.1 x 0.3-1 mm, 1-3 nerves. **Ray florets** 7-21; laminae 0.4-3.1 x 0.1-0.9 mm. **Disc florets** 2-30; corollas 2.4-4.9 mm, lobes 0.12-3.9 mm. **Cypselae** body length at anthesis, 0.3-3.3 mm; longest pappus bristles 1.9-5.1 mm. $2n= 18$. Figure 28.

Flowering: Mainly between December and the end of April. One specimen showed the flowering stage in the late August.

Distribution and Habitat: Argentina (all provinces except for Misiones), Chile, Bolivia, Uruguay (Fig. 29). It has been found as an introduction in Brazil, Madeira Is., Portugal, Peru, and Puerto Rico in the West Indies. Latitude range: 14-47° South. Longitude: 56-73° West. Elevation range: 7-2600 m amsl Common on roadsides, open grassy plains, wet soil along streams and springs. Found on sandy soils (Fig. 30).

Discussion: *Solidago chilensis* Meyen is distinguished by its glabrate aspect. It is mainly from cold and template climates. With habitats such as along the roads and close to water sources (ponds, rivers). In the Patagonian Monte it forms patches along the road, while in pampas (flatlands) and jungle it has reached further distances from the road within the local flora.

Figure 28. Morphology of *Solidago chilensis* Meyen. **A**. Mid-size shoot, *Lopez Laphitz & Becker 2* (WAT). **B.** Dwarf shoot, *von Platen & Greiner 45* (MO). **C**-**D**. Stems of glabrate and pubescent plants; *Lopez Laphitz & Becker 35* (WAT) and *Bruch s.n.* (LP), respectively. **E**-**F**. Lower stem leaves mid-sized plants, *Lopez Laphitz & Becker 35* (WAT) and *Lopez Laphitz & Becker 2* (WAT). **G**. Mid stem leaf. **H**. Upper stem leaves. **I.** Heads. A- B, D, *Zardini 2745* (MO); I, *Lopez Laphitz et al. 18* (WAT).

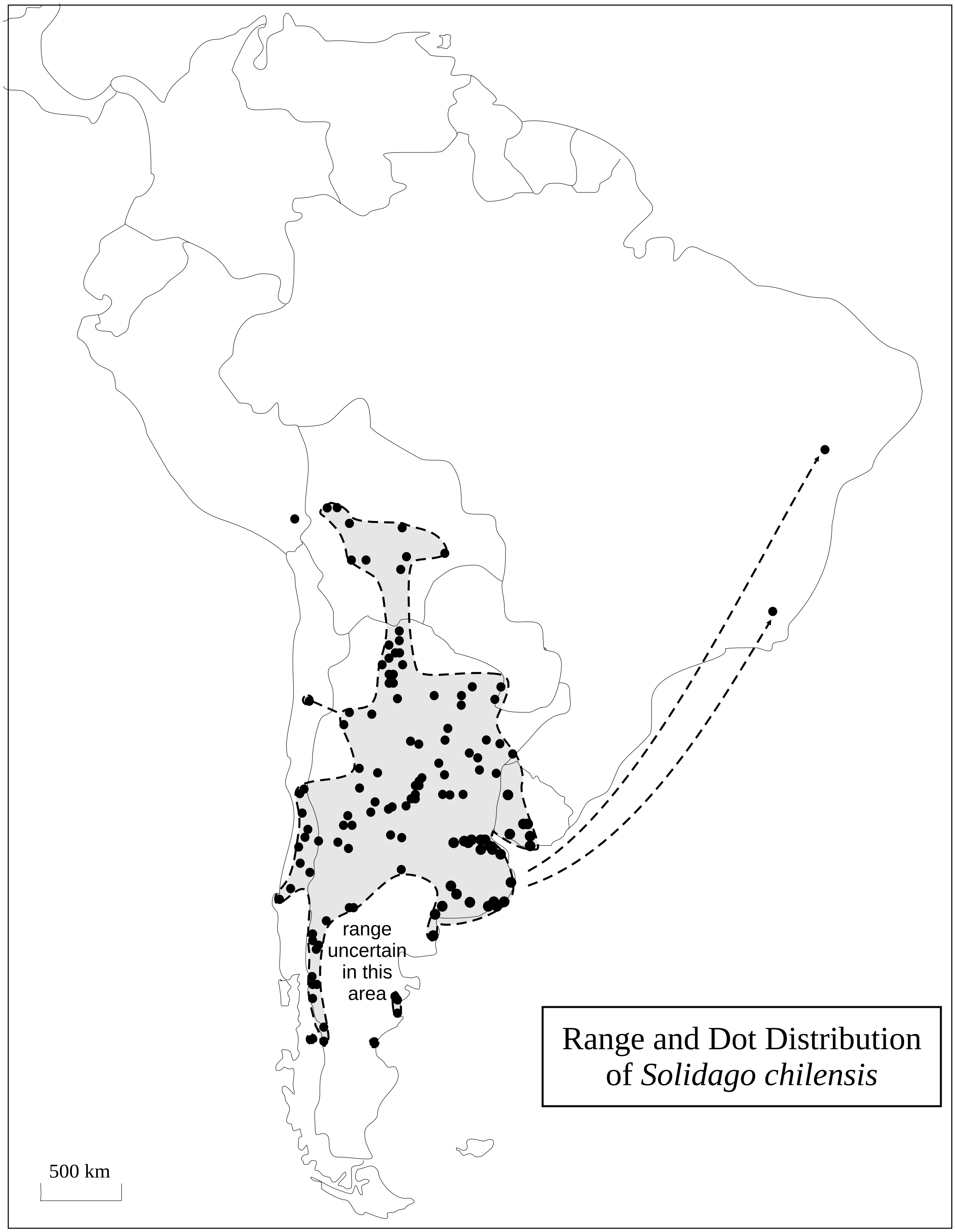

Figure 29. Dot distribution of *Solidago chilensis* in South America.

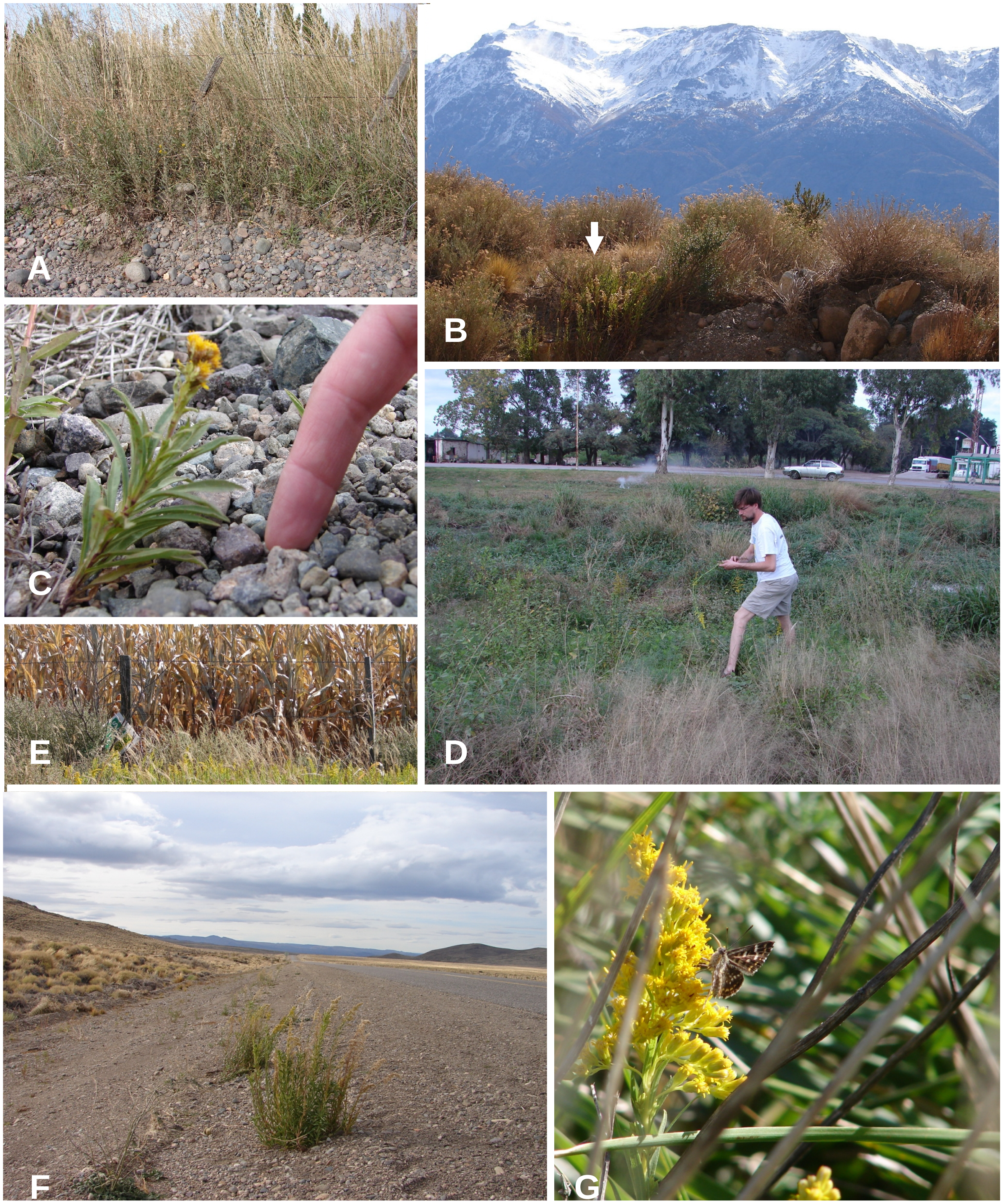

Figure 30. *Solidago chilensis* habitats. **A**. Road side populations in Gaiman, Chubut Prov., Argentina. **B**. Population in a valley at the Andes Cordillera**,** Chile. **C.** Dwarf specimen at the Alerces National Park, Chubut Prov., Argentina. **D.** Disturbed area near road, Tucuman Prov., Argentina. **E.** A population growing close to cultivated fields in Buenos Aires Prov., Argentina. **F**. National road 40 clusters along the road, Neuquen Prov., Argentina. **G**. Pollinator in a plant on Buenos Aires Prov., Argentina.

4. *S. microglossa* DC., Prodr. 5: 332. 1836. *Aster polyglossus* var. *microglossus* (DC.) O. Ktze., Revis. Gen. Pl. 3[3]: 131. 1898. TYPE: Brazil. *Bacle s.n.* Holotype. GDC!, photo sent by G GDC01425_1.jpg; Photo in MO ex Krukoff! Possible isotypes. G ex Herb. Moricand(2), photos! G00195248.jpg and G00195248_a.jpg).

Solidago microglossa DC. var. *megapotamica* DC., Prodr. 5: 332. 1836. *Solidago chilensis* Meyen var. *megapotamica* (DC.) Cabrera, Darwinia 16: 409. 1970. TYPE: BRAZIL. Prov. RIO GRANDE. in h. Mus. reg. Par. à Mus. imp. Bras. miss. sub n. 846, 854, et 857 (HT: G-DC, photo!; *Gaudichaud 854*, P photo in MO ex Krukoff!)

Solidago marginella DC., Prodr. 5: 332. 1836. TYPE: BRAZIL. Bacle (T: G-DC, photo!)

Solidago marginella DC. var. *sublanceolata* DC., Prodr. 5: 332. 1836. TYPE: BRAZIL. in h. Mus. reg. Par. à Mus. imp. Bras. sub n. 860 missa. (not seen)

Solidago polyglossa DC., Prodr. 5: 332. 1836. *Aster polyglossa* (DC.) O. Ktze., Rev. Gen. 1: 318. 1891. TYPE: BRAZIL. RIO GRANDE. v.s. in h. Mus. reg. Par. à Mus. imp. Bras. sub n. 860 missa. *Gaudichard 860* (T: G-DC, photo!, fragments; P photo in MO! ex Krukoff).

Solidago odora Hook. & Arn. var. *glabra* Hook. & Arn., Comp. Bot. Mag. 2: 45. 1836. TYPE: ARGENTINA. Mendoza. (T: not seen).

Solidago odora Hook. & Arn. var. *scabra* Hook. & Arn., Comp. Bot. Mag. 2: 45. 1836. TYPE: URUGUAY.(T: not seen)

Solidago odora Hook. & Arn. [var.] *glabriuscula* Hook. & Arn., Comp. Bot. Mag. 2: 45. 1836. TYPE: ARGENTINA. Buenos Aires & Mendoza. (T: not seen)

?*Solidago nitidula* Mart. ex Baker in Mart., Fl. Bras. 6(3): 10. 1882. TYPE: "Mss. inherb. proprio" (T: not seen)

?*Solidago repens* D. Don ex Baker in Mart., Fl. Bras. 6(3): 11. 1882. TYPE: Herb. Lambert (T: not seen)

?*Solidago vulneraria* Mart., Syst. Mat. Med. Bras. 9. nomen.

Solidago bonariensis D. Don ex Baker in Mart., Fl. Bras. 6(3): 11. 1882. non Larranaga (1923). TYPE: (T: not seen)

Solidago microglossa DC. var. *macrophylla* Niederl., Bol. Mens. Mus. Prodr. Argent. 3, no. 29: 186. 1890. nom. nud. TYPE: ARGENTINA. (T: not seen)

Solidago microglossa DC. var. *ramosa* Arech., Anal. Mus. Nac. Montevideo, 6: 197. 1907. Arech. Fl. Uruguay, 3: 197. 1907. TYPE: URUGUAY. (T: not seen)

Solidago bonaerensis Larranaga, Escritos D. A. Larranaga 2: 255 [Pub. Inst. Hist. Geog. Uruguay] 1923. Nomen nudum. TYPE: URUGUAY. (T: not seen)

Plants: 36-167 cm. **Stem** decumbent form branching rhizome, densely pubescent, canescent. **Leaves** with hairs in edges; *basal* oblanceolate, twisted, nearly withering well before flowering; *proximal* persisting, in most of the cases the biggest ones in the plant, sessile, blades lanceolate, 22-105 x 5-19 cm, with 0-8 serrations, abaxial and adaxial faces pubescent; *distal* linaer to lanceolate, 11-55 x 2-10 cm with 0-5 serrations; *inflorescence leaves* linear to lanceolate, 6-40 x 1-15 cm with 0-1 serration. **Heads**: pyramidal paniculiform, branches recurved, secund. **Involucre** campanulate 3-6 cm length. **Phyllaries** in 3-4 series, outer ovate: 0.17-2.6 x 0.3-0.7 mm, inner oblanceolate: 2.7-4.8 x 0.3-1 mm, 1-3 nerves. **Ray florets** 4-28; laminae 1-2.9 x 0.1-0.6 mm. **Disc florets** 2-14; corollas 2.7-4.5 mm, lobes 0.6-2.3 mm. **Cypselae** body length at anthesis, 0.4-3.4 mm; longest pappus bristles 1.8-4.4 mm. $2n = 18$. Figure 31.

Flowering: Between December until the end of April, with an extension of the flowering period due to favorable weather conditions until mid-spring (October).

Distribution and Habitat: Bolivia, Paraguay, Brazil and North of Argentina (Misiones, Corrientes, Formosa, Chaco; Fig. 32). Savannas, open grassy areas. Riverside. Secondary vegetation along road sides. Wet grasslands (Fig. 33). Latitude range: 7-39° South. Longitude range: 34-67° West. Elevation range: 200-2740 m.

Discussion: *Solidago microglossa* DC. is characterized by moderately to densely pubescence stems and leaves. It is mainly found in subtropical warm climates. The habitat it is along roads and close to water sources (ponds, rivers). It is inserted as part of the densely local vegetation, such as grasslands and jungle. In Brazil it is distributed along the coast.

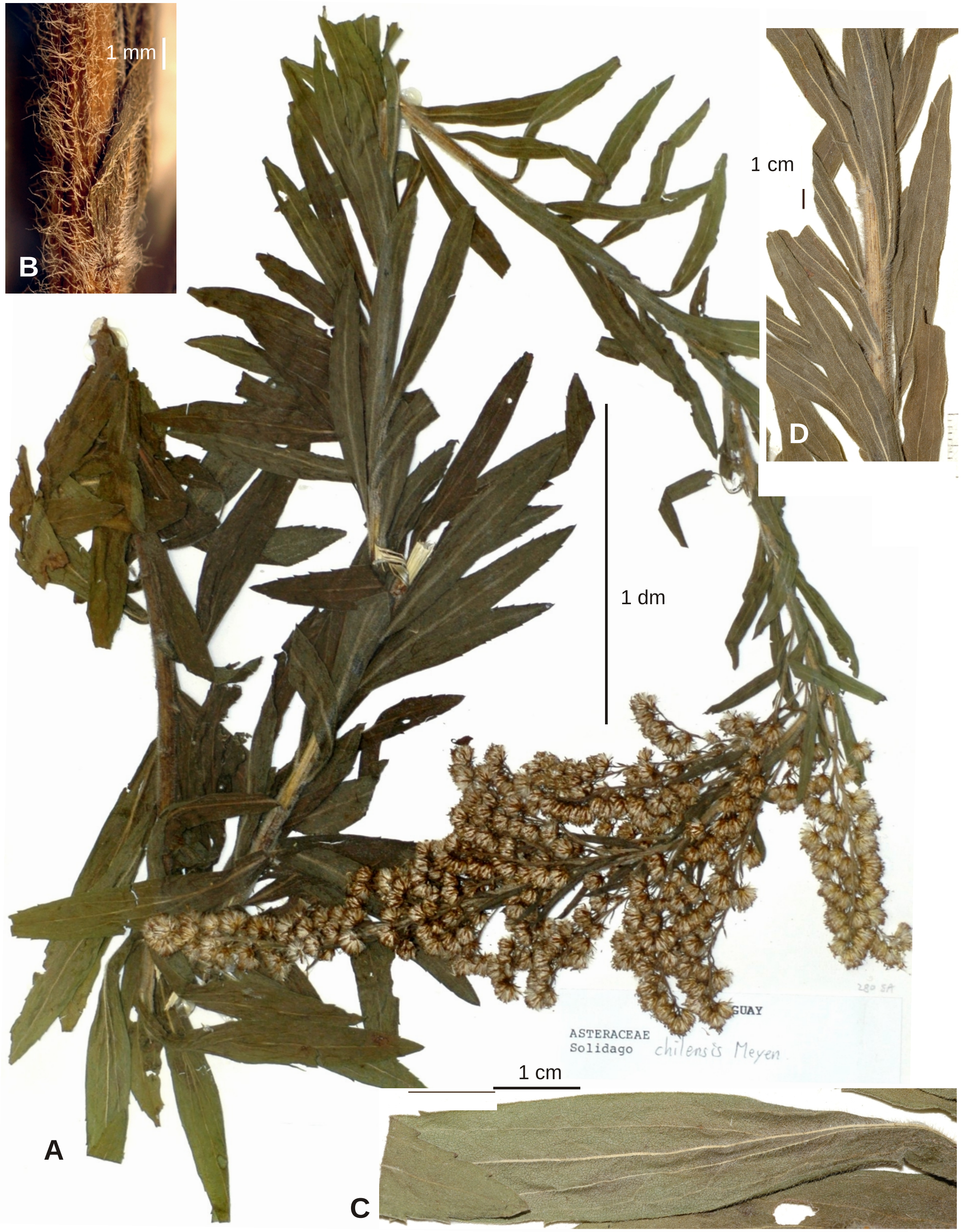

Figure 31. Morphology of *Solidago microglossa* DC. **A.** Robust shoot. **B.** Stem detail. **C.** Lower mid stem leaf. **D.** Upper stem leaves. A-C, *Zardini & Velazquez 22150* (TEX); D, *Zardini 2745* (MO).

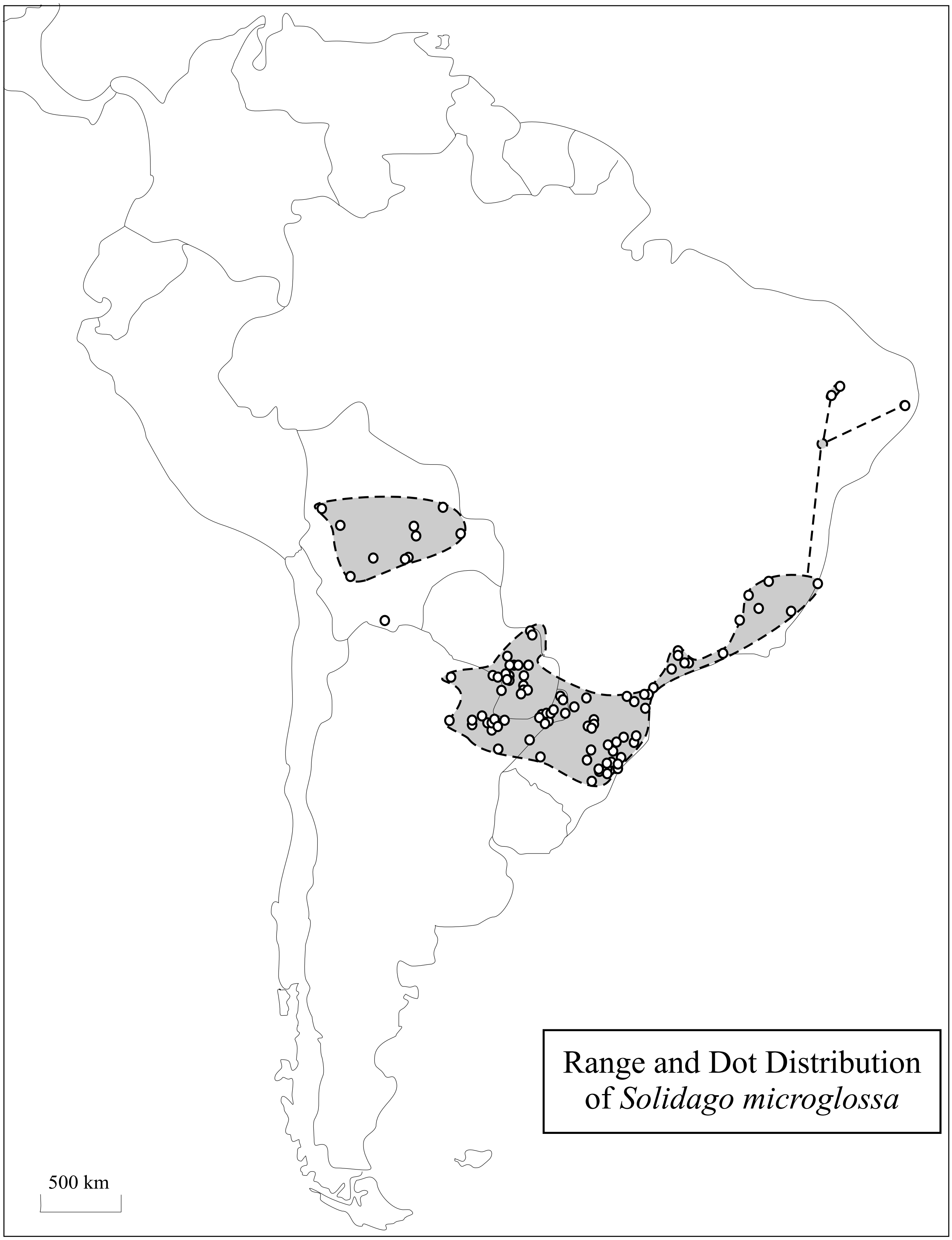

Figure 32. Dot dsitribution map of *Solidago microglossa* in South America.

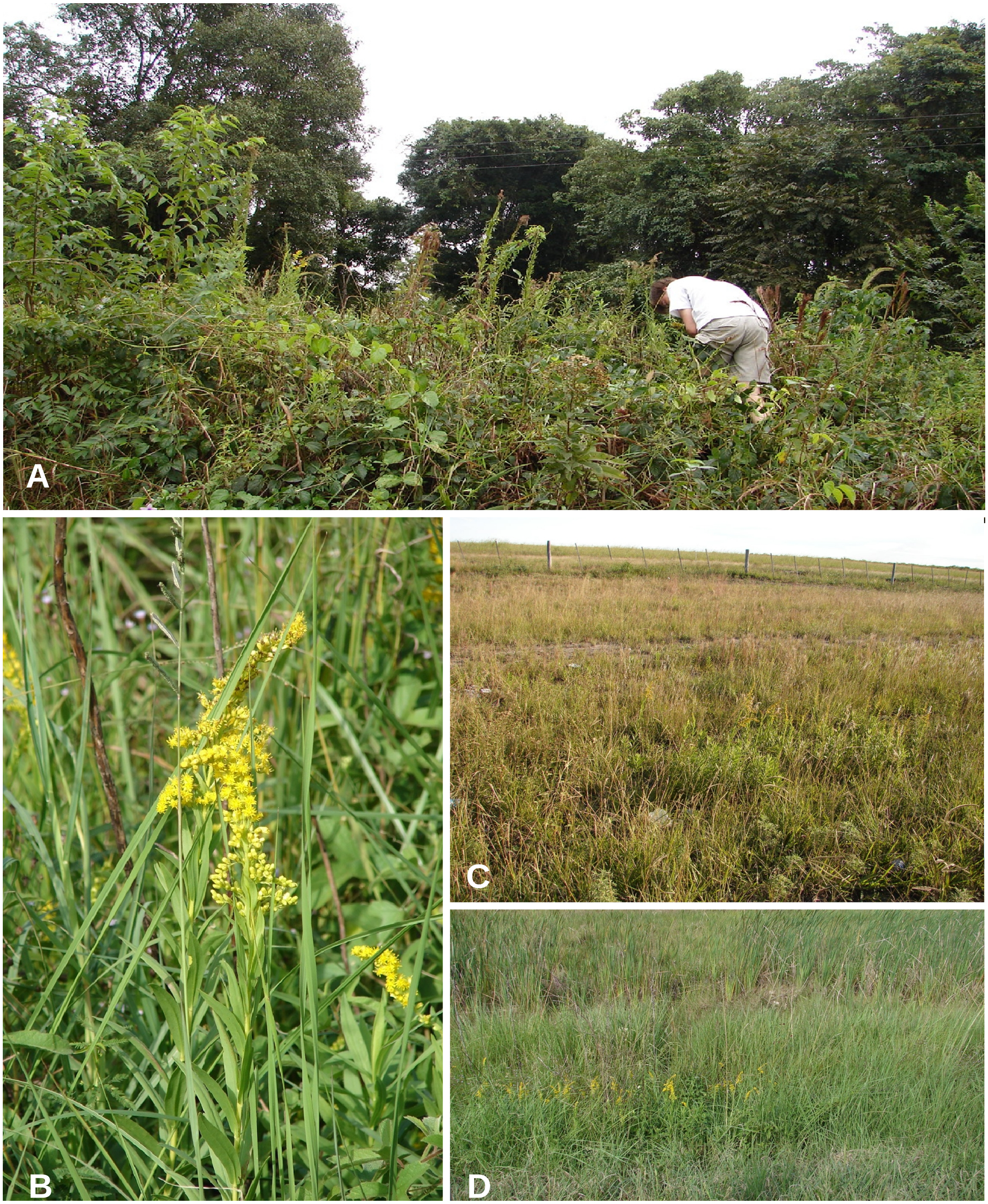

Figure 33. *Solidago microglossa* habitats in Argentina. **A.** Plants growing near road in riverine jungle forest system, Misiones Prov. **B.** Plants growing as part of the grassland, Formosa Prov. **C.** A population growing close to the road in the Mesopotamia Region, Corrientes Prov. **D.** A small population growing in roadside ditch in the humid northern grassland, Formosa Prov.

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Appendix A

Pearson's correlations matrix constructed for the 50 scored characters. Highlighted values have a correlation coefficient of |r| > 0.7.

	STEMHT	ISTPUBD	USTPUBD	MSTPUBD	BSTPUBD	ISTHLN
STEMHT	1					
ISTPUBD	0.193555	1				
USTPUBD	0.194675	**0.843651**	1			
MSTPUBD	0.141318	**0.770661**	**0.847205**	1		
BSTPUBD	0.099291	0.551652	0.647092	0.695974	1	
ISTHLN	0.203139	0.423618	0.438088	0.438508	0.446335	1
USTHLN	0.183005	0.461835	0.503659	0.487766	0.494505	**0.93186**
MSTHLN	0.111672	0.416239	0.477645	0.47674	0.537804	**0.884293**
BSTHLN	0.126302	0.417964	0.441223	0.487163	0.570891	**0.839991**
MLLENG	0.304545	-0.27211	-0.31831	-0.34439	-0.26957	-0.021
MWID	0.256267	0.105126	0.053448	0.035431	0.042758	0.367216
MLWTOE	0.336412	-0.24042	-0.29653	-0.29183	-0.22014	0.007997
MSERAT	0.205059	0.249959	0.05402	0.039572	-0.03036	0.063837
ULLENG	0.214881	-0.34614	-0.41196	-0.40187	-0.32864	-0.13989
ULWID	0.25241	0.008649	-0.02212	-0.02426	-0.02915	0.173896
ULWTOE	0.175809	-0.35586	-0.42752	-0.35671	-0.27404	-0.09097
VULSERAT	0.121474	0.17891	-0.01064	-0.00559	-0.08132	-0.08901
ILLENG	0.191152	-0.23127	-0.31781	-0.30065	-0.272	-0.04385
ILWID	0.169204	0.084583	0.053636	0.025895	-0.01003	0.147238
ILWTOE	0.173725	-0.20154	-0.29577	-0.26205	-0.21669	-0.01094
ILSERAT	0.135065	0.114708	-0.04341	-0.04885	-0.12081	-0.09556
CAPBRANG	0.096601	0.230912	0.211377	0.176919	0.129841	0.13042
CAPW	0.474572	0.082159	0.21497	0.116818	0.049917	0.077602
CAPL	0.290073	-0.11798	-0.04699	0.029012	0.030536	0.038657
LONGBR	0.238591	0.007264	0.044772	0.043207	-0.03404	-0.0308
HEADHT	-0.1897	-0.44687	-0.48337	-0.5139	-0.30988	-0.02666
OPHYLL	-0.21881	-0.48243	-0.50623	-0.55805	-0.34176	-0.06312
OPHYLW	-0.12777	-0.27875	-0.36224	-0.4453	-0.34291	-0.16547
OPHYLWTOE	-0.17287	-0.43191	-0.46856	-0.50834	-0.29946	0.002069
OPHYLV	-0.06604	-0.10797	-0.07226	-0.10851	-0.03428	-0.07831
IPHYLL	-0.21399	-0.47244	-0.51433	-0.5306	-0.34448	0.013873
IPHYLW	-0.06928	-0.15541	-0.2691	-0.34242	-0.26642	-0.09743
IPHYLWTOE	-0.17988	-0.43114	-0.46944	-0.50236	-0.32329	-0.09085
IPHYLV	0.017695	-0.12145	-0.11219	-0.17693	-0.07042	0.185152
VRFLOR	-0.00115	-0.31558	-0.31621	-0.37539	-0.2207	0.209559
RSTRAPL	0.02419	-0.13822	-0.12206	-0.11771	-0.06979	-0.08281
RSTRAPWD	-0.00054	-0.15736	-0.14605	-0.14344	-0.08437	-0.09644
RACHBL	0.041496	-0.11629	-0.08747	-0.08696	-0.03878	-0.07004

Appendix A cont'd

RPAPL	-0.20541	-0.4413	-0.515	-0.49012	-0.34515	-0.09556
VDFLOR	-0.16842	-0.36957	-0.37705	-0.41633	-0.31839	-0.05914
DCORL	-0.18764	-0.34599	-0.40047	-0.46607	-0.29715	-0.05873
DACHBL	-0.14288	-0.09818	-0.09671	-0.17181	-0.10919	-0.00157
DCORLIMB	-0.21751	-0.40279	-0.40506	-0.49165	-0.3291	-0.0733
DLOBL	-0.02076	-0.15106	-0.09892	-0.10284	-0.0996	-0.03563
DPAPL	-0.15824	-0.38241	-0.4566	-0.4952	-0.30085	-0.0427

	USTHLN	MSTHLN	BSTHLN	MLLENG	MWID	MLWTOE
USTHLN	1					
MSTHLN	**0.915228**	1				
BSTHLN	**0.847579**	**0.887377**	1			
MLLENG	-0.14697	-0.09607	-0.08357	1		
MWID	0.295304	0.30805	0.29949	0.568967	1	
MLWTOE	-0.09151	-0.0422	-0.02617	**0.918023**	0.458679	1
MSERAT	-0.01132	-0.02804	0.015611	0.232813	0.34953	0.166701
ULLENG	-0.21857	-0.186	-0.15141	**0.724397**	0.361228	0.668205
ULWID	0.153436	0.169739	0.157321	0.325595	0.407115	0.315228
ULWTOE	-0.1646	-0.13091	-0.09007	0.684507	0.34469	0.661236
VULSERAT	-0.11502	-0.10214	-0.06527	0.210133	0.251693	0.211192
ILLENG	-0.13024	-0.11516	-0.07343	0.554693	0.290025	0.530937
ILWID	0.134777	0.155375	0.162905	0.147591	0.24658	0.168675
ILWTOE	-0.09316	-0.07686	-0.02241	0.493011	0.281571	0.480045
ILSERAT	-0.14047	-0.09018	-0.0673	0.222801	0.126436	0.252251
CAPBRANG	0.07946	0.019193	0.097861	-0.0492	-0.00747	-0.04309
CAPW	0.095774	0.050827	0.012954	0.19875	0.153925	0.183561
CAPL	0.044324	0.047809	0.1331	0.066295	0.032165	0.151713
LONGBR	0.000356	-0.01328	-0.00452	0.093746	0.243012	0.07735
HEADHT	-0.04048	0.000966	-0.05212	0.199099	0.039823	0.133909
OPHYLL	-0.07929	-0.066	-0.07237	0.226055	0.031427	0.12163
OPHYLW	-0.14359	-0.14692	-0.15397	0.191879	0.058933	0.152865
OPHYLWTOE	-0.03833	-0.02809	-0.02649	0.250721	0.060019	0.154089
OPHYLV	-0.06341	-0.06622	-0.11765	0.028794	0.00017	-0.06482
IPHYLL	-0.00632	0.012661	-0.03902	0.222161	0.076032	0.135385
IPHYLW	-0.11492	-0.13025	-0.13847	0.20196	0.18259	0.139232
IPHYLWTOE	-0.1084	-0.08917	-0.12386	0.254654	-0.01141	0.144908
IPHYLV	0.187455	0.17522	0.092572	0.00585	0.113375	-0.0145
VRFLOR	0.214201	0.193198	0.10927	0.091051	0.132355	0.048478
RSTRAPL	-0.05715	-0.08977	-0.03989	0.084788	0.000858	0.081436
RSTRAPWD	-0.06837	-0.10374	-0.06032	0.084055	0.018204	0.068355
RACHBL	-0.04113	-0.07716	-0.03411	0.08777	0.015578	0.082339
RPAPL	-0.09987	-0.09601	-0.07593	0.139782	-0.06474	0.09204
VDFLOR	-0.06569	-0.0634	-0.10827	0.057222	-2.45E-05	-0.02604
DCORL	-0.05048	-0.05499	-0.08353	0.243307	0.130596	0.177533

Appendix A cont'd

DACHBL	-0.03314	-0.02812	-0.04902	0.185821	0.126563	0.128013
DCORLIMB	-0.05928	-0.08552	-0.17868	0.243515	0.087198	0.151867
DLOBL	0.022675	0.034454	0.02333	0.031698	-0.02611	0.078401
DPAPL	-0.05442	-0.04421	-0.06803	0.215133	0.094986	0.133407

	MSERAT	ULLENG	ULWID	ULWTOE	VULSERAT	ILLENG
MSERAT	1					
ULLENG	0.162908	1				
ULWID	0.137748	0.510945	1			
ULWTOE	0.156768	**0.93791**	0.343266	1		
VULSERAT	0.693777	0.27124	0.159681	0.264486	1	
ILLENG	0.245258	0.719965	0.440832	0.687397	0.315009	1
ILWID	0.185083	0.280866	0.788338	0.115137	0.151559	0.444312
ILWTOE	0.245189	0.668562	0.253394	0.708193	0.298465	**0.942555**
ILSERAT	0.619609	0.243811	0.135752	0.227023	0.641439	0.331214
CAPBRANG	0.004374	-0.05929	-0.00184	-0.05485	-0.02882	0.017422
CAPW	-0.01573	0.242717	0.370727	0.115963	0.03497	0.329536
CAPL	-0.16494	0.210509	0.178879	0.253928	-0.0975	0.186238
LONGBR	0.027488	0.162632	0.139908	0.140224	0.071492	0.161467
HEADHT	-0.06223	0.191989	0.023817	0.192658	-0.01271	0.1993
OPHYLL	-0.08299	0.326853	0.168558	0.264433	-0.00268	0.316199
OPHYLW	0.120444	0.293137	0.091687	0.28161	0.113559	0.139734
OPHYLWTOE	-0.04902	0.305314	0.126993	0.247405	0.011923	0.339325
OPHYLV	-0.01117	0.016538	0.018726	-0.01154	-0.1167	-0.12176
IPHYLL	-0.07288	0.273708	0.061462	0.270964	-0.03437	0.231698
IPHYLW	0.343426	0.245983	0.186879	0.216703	0.322562	0.261115
IPHYLWTOE	-0.16304	0.285117	0.043102	0.260456	-0.14462	0.189988
IPHYLV	0.08333	0.039637	0.032874	0.045921	0.010358	0.093918
VRFLOR	-0.02691	0.14461	0.11622	0.122362	-0.04351	0.155155
RSTRAPL	0.075273	0.089187	-0.03572	0.08118	0.086427	0.104969
RSTRAPWD	0.076493	0.101811	-0.02747	0.087485	0.088682	0.102833
RACHBL	0.087065	0.085325	-0.03488	0.074377	0.086596	0.094883
RPAPL	-0.0832	0.154795	-0.05767	0.188518	-0.09383	0.14443
VDFLOR	-0.04424	0.149774	0.117888	0.090569	-0.07468	0.142175
DCORL	0.097845	0.25604	0.086618	0.246079	0.147739	0.185474
DACHBL	0.020352	0.166932	0.03768	0.133652	0.073325	0.1409
DCORLIMB	0.031464	0.210705	0.063041	0.198159	0.011326	0.171836
DLOBL	-0.08613	0.100091	0.026579	0.102528	-0.0121	0.018555
DPAPL	0.019168	0.272773	0.111775	0.25182	0.026511	0.201218

Appendix A cont'd

	ILWID	ILWTOE	ILSERAT	CAPBRANG	CAPW	CAPL
ILWID	1					
ILWTOE	0.275314	1				
ILSERAT	0.168064	0.319701	1			
CAPBRANG	0.002791	0.029494	-0.04594	1		
CAPW	0.322467	0.237468	-0.01656	0.09974	1	
CAPL	0.09602	0.181273	-0.10347	0.08058	0.166967	1
LONGBR	0.117122	0.123137	0.170178	0.054604	0.250107	0.509528
HEADHT	0.034866	0.204503	-0.04743	-0.24317	-0.15272	0.033987
OPHYLL	0.146885	0.267589	-0.05896	-0.17791	-0.04359	0.065615
OPHYLW	0.133778	0.107012	0.085814	-0.20453	-0.18887	-0.08187
OPHYLWTOE	0.102561	0.303904	-0.0368	-0.20667	-0.04772	0.07645
OPHYLV	-0.07162	-0.14019	-0.08326	-0.09075	-0.063	0.012701
IPHYLL	0.039624	0.233151	-0.01021	-0.19901	-0.14279	0.001728
IPHYLW	0.227291	0.230121	0.286239	-0.11676	0.021989	-0.1545
IPHYLWTOE	-0.00344	0.173555	-0.04698	-0.16921	-0.14314	0.004389
IPHYLV	0.090415	0.076269	0.034346	-0.06085	0.015589	-0.08773
VRFLOR	0.070968	0.108284	-0.09315	-0.19002	-0.00413	0.125188
RSTRAPL	-0.03517	0.068435	0.051352	0.072984	0.007102	0.050419
RSTRAPWD	-0.02791	0.067585	0.051293	0.084332	-0.01518	0.025917
RACHBL	-0.03223	0.059801	0.061388	0.082276	0.030775	0.0523
RPAPL	-0.1032	0.14334	-0.01584	-0.16476	-0.27653	0.040046

Appendix A cont’d

	LONGBR	HEADHT	OPHYLL	OPHYLW	OPHYLWTOE	OPHYLV
LONGBR	1					
HEADHT	-0.05646	1				
OPHYLL	-0.01186	**0.721757**	1			
OPHYLW	-0.15035	0.39329	0.502341	1		
OPHYLWTOE	-0.01865	**0.733917**	**0.927959**	0.405388	1	
OPHYLV	-0.04613	0.103366	0.210234	0.334129	0.184395	1
IPHYLL	0.009031	**0.836931**	0.79232	0.378796	**0.78349**	0.213143
IPHYLW	-0.12597	0.431839	0.458584	0.611278	0.415281	0.222658
IPHYLWTOE	-0.01658	0.741505	0.749903	0.353953	0.759516	0.234334
IPHYLV	-0.15288	0.269202	0.246563	0.260637	0.225711	0.29174
VRFLOR	0.102157	0.481799	0.593038	0.282263	0.551862	0.053064
RSTRAPL	-0.0026	0.043405	0.099363	0.127196	0.095742	-0.01483
RSTRAPWD	-0.0185	0.079666	0.137594	0.16918	0.13072	0.00015
RACHBL	0.012432	0.024613	0.082039	0.116378	0.080697	0.019942
RPAPL	-0.04699	0.597346	0.537332	0.327072	0.525387	-0.01071

	IPHYLL	IPHYLW	IPHYLWTOE	IPHYLV	VRFLOR	RSTRAPL
IPHYLL	1					
IPHYLW	0.38722	1				
IPHYLWTOE	**0.889046**	0.330787	1			
IPHYLV	0.302976	0.329781	0.200863	1		
VRFLOR	0.510401	0.221643	0.412072	0.255832	1	
RSTRAPL	0.01968	0.156601	0.066707	0.136284	0.091337	1
RSTRAPWD	0.060907	0.209558	0.110848	0.146071	0.112264	**0.987639**
RACHBL	0.008436	0.159374	0.059231	0.13715	0.062616	**0.993183**
RPAPL	0.593082	0.261628	0.568411	0.209474	0.46706	0.424672
VDFLOR	0.561656	0.371265	0.553408	0.166477	0.692305	0.119255
DCORL	0.743238	0.54642	0.672782	0.199173	0.479514	0.029586
DACHBL	0.312864	0.351867	0.296065	0.009435	0.112203	-0.05184
DCORLIMB	0.657362	0.387642	0.60118	0.19379	0.469608	0.063052
DLOBL	0.228985	0.028773	0.215935	-0.03639	0.148717	0.010491
DPAPL	0.69246	0.489182	0.614532	0.219407	0.48994	0.014585

Apendix A cont’d

	RSTRAPWD	RACHBL	RPAPL	VDFLOR	DCORL	DACHBL
RSTRAPWD	1					
RACHBL	**0.980466**	1				
RPAPL	0.439161	0.363845	1			
VDFLOR	0.149655	0.098981	0.478858	1		
DCORL	0.077641	0.018187	0.549037	0.571589	1	
DACHBL	0.00159	-0.0347	0.13611	0.244987	0.398669	1
DCORLIMB	0.110734	0.052917	0.510341	0.536238	**0.767321**	0.350769
DLOBL	0.023459	0.012203	0.097555	0.103699	0.1617	0.048948
DPAPL	0.046321	-0.00482	0.587097	0.505333	0.717116	0.271502

	DCORLIMB	DLOBL	DPAPL
DCORLIMB	1		
DLOBL	0.158833	1	
DPAPL	0.500263	-0.18099	1

Appendix B

Collection information for all specimens scored for the multivariate statistical analyses, and examined for the construction of dot and cytogeographic distribution maps.

Solidago chilensis

Argentina.

Buenos Aires. Balcarce, sierra del autodromo, *Katinas 113* (MO). Canal 15, Cerro La Gloria, *O. Boelcke 12689* (MO). Centinela del Mar, *Julieta von Thungen 127* (MO). Sierras de Tandil, *D Abbiatti 4293* (LP). Olavarria, *D Abbiatti 3132* (LP). La PLata, *A L Cabrera 12220* (LP). San Fernando, *Miles Stuart Pennington 2* (MO). Ribera del Rio de la PLata Isla Santiago, *A L Cabrera 2052* (LL). Sierras del Tadnil, *391* (LP). Partido Junin, *Maria C. Telleria 14* (LP). RN 3. 5 km al sur de Mayor Buratovich, *Lopez and Becker 5* (LP, WAT). Las Talas, *E Mauri 104* (LP). Partido Tandil, *M M Job 1809* (LP). Isla Martin Garcia, *1444* (LP). Aproximadamente a 20 km sur cruce RP 76 y RP 85. Llegando a Sierra de la Ventana, *Lopez and Becker 3* (LP, WAT). La Plata, *A L Cabrera 169* (LP). Saldungaray. Al lado de la RP 72, *Lopez and Becker 4* (LP, WAT). City Bell, *J Cirsci 543* (LP). Del Viso, *Julio Brizuela 1541* (MO). Tres Arroyos. Balneario Orense, *C.B. Villamil et J. Caceres 4843* (MO). Villa Ortuzar, junto a las vias de ferrocarril, *15349* (MO). Buenos Aires, *Angel L. Cabrera 7010* (TEX). Buenos Aires. San Clemente del Tuyu, *Pedro Krapovickas 2869* (MO). Sierra Ventana, *11440* (LP). *L. von Platen et U. Grenier 45* (MO). Buenos Aires. Loberia, *A Scala* (LP). San Clemente-General Lavalle, *A L Cabrera 4256* (LP). Colonia Primavera-Departamento San Pedro, *Arthur Woolston 806* (LP). Chascomus, *89* (LP). Buenos Aires. Monte Hermoso, *E Carette* (LP). Buenos Aires. Peninsula San Blas, *E Mac. Dongu* (LP). Juancho, *A L Cabrera 2674* (LP). Rincon-Viedma, *E Ringuelet 370* (LP). San Clemente, Partido General Lavalle, *A L Cabrera 4954* (LP). *Jongensen 1281* (MO). ***Catamarca***. RN 38 hacia San Fernando del Valle de Catamarca, *Lopez and Becker 27* (LP, WAT). Belen, *A L Cabrera 1166* (LP). Catamarca., *Armando Reales 1669* (MO). ***Chaco***. Villa Angela, *P Boffa 1017* (LP). Llegando a Rio Muerto, RN 16, *Lopez and Becker 37* (LP, WAT). Resistencia, *T Rojas 11640* (LP). 12 Km de Resistencia, *J. Prause 24* (TEX). Entrada a Santa Sylvina limite entre Santa Fe y Chaco, *Lopez and Becker 35* (LP, WAT). Resistencia. Colonia Tirol, *S. Venturi 8646* (MO). ***Chubut***. Gaiman, camino La Angostura hacia Dolavon, *Lopez and Becker 6* (LP, WAT). Rio Percey-Lago Futaleufquen, *M Isabel, H Scott de Biraben y Max Biraben 623* (LP). Parque Nacional Los Alerces pasando Trevelin-Ruta 15, *Lopez and Becker 11* (LP, WAT). Rio

Pico, (LP). Gaiman, camino La Angostura hacia Dolavon, *Lopez and Becker 7* (LP, WAT). Comodoro Rivadavia. Centro de la ciudad, *Lopez and Becker 8* (LP, WAT). Nueva Lubecka, *Troels Myndel Pedersen 14486* (MO). ***Cordoba***. Rio Seco, *4172* (LP). Cosquin, *A P Quiroga 1* (LP). Entrada a Vicuna Mackemza, RN 35, *Lopez and Becker 20* (LP, WAT). Hacia Villa Mercedes(San Luis) RN 7, *Lopez and Becker 21* (LP, WAT). Villarica, *Fr. Friedrich* (LP). Tanti-Punilla, *A P Rodrigo 2191* (LP). Saturino M Laspiur RN 158, *Lopez and Becker 52* (LP, WAT). MuñozLossa, *Synanther 195* (MO). ***Corrientes***. Bella Vista, *A Schinini* (LP). Paso de los Libres, *A Schinini, E Cabral y R Vanni 17270* (LP). Esquina-Guayquiraro, *A Schinini, J M Gonzales y A Ishikama 2212* (LP). ***Entre Rios***. Parana, *J F Salellos 1419* (LP). Salto Grande, *William 128* (LP). RN 127, *Lopez and Becker 50* (LP, WAT). Entre San Jaime de la Frontera y Los Conquistadores RN 127, *Lopez and Becker 49* (LP, WAT). ***Formosa***. A 20 km de Clorinda RN 11, *Lopez and Becker 44* (LP, WAT). Palo Santo Station, F.C.C.N.A., 139 km NW of Formosa. Open grassy plains, *James West 8473* (MO). Laguna Vera, *Ismael Morel 4960* (MO). ***Jujuy***. Agua Negra-O de Ledesma, *Fabis, Tell, Cicchi 3049* (LP). RN 34, *Lopez and Becker 40* (LP, WAT). El Potrerillo San Antonio, *E. K. Bells 5922* (LL). ***La Pampa***. along Rio Santa Rosa at Santa Rosa Calamuchita, *Jim Conrad with Werner Dietrich 2439* (MO). Cartex, RN 35, empalme con la RP 10, *Lopez and Becker 19* (LP, WAT). Alpatacal, *Juan Fortuna 1978* (TEX). ***La Rioja***. RN 141 and 79, *Lopez and Becker 26* (LP, WAT). ***Mendoza***. Uspallata, near intersection of road to Las Cuevas and Chile, and road to Godoy Cruz. Truck stop, *Janice Saunders de Palacios with Ramon A. Palacios and Maria Aurora Agullo 3388* (LL). Monte Coman, camino a San Rafael, RP 171, *Lopez and Becker 23* (LP, WAT). Rio Diamante-San Rafael, *H A Lagiglia 1122* (LP). RP 82 hacia Lujan de Cuyo, *Lopez and Becker 24* (LP, WAT). Departamento La Paz-Villa la Paz-Rancho Totora, *Ruizleal 8478* (LP). Along route 143, ca 126 km generally NW of San Rafael, *Robert Merril King and Federico E. Heinz 9435* (MO). ***Neuquen***. RP 22, peaje hacia Plottier desde Neuquen city, *Lopez and Becker 18* (LP, WAT). San Martin de los Andes, *Mario Gentilli 511* (LP). Lago Fontana, (LP). Rio Limay desde la confluencia hasta Collon-Cura, *S Roth* (LP). Departamento Los Lagos- Confluencia del Traful-, *Eduardo Gonzales 469* (LP). RN 40 camino de Junin de los Andes a Zapala, *Lopez and Becker 17* (LP, WAT). Junin de los Andes, *Lopez and Becker 16* (LP, WAT). RN 40 km 2069 casi limite con provincia de Rio Negro, *Lopez and Becker 14* (LP, WAT). *Solidazo*. Confluencia de los rios Pichi-Neuquen y Neuquen pampa de las Yeguas, *O. Boelcke et al. 13680* (MO). ***Rio Negro***. Camino de Bariloche a Llao Llao a mitad del camino, *Lopez and Becker 13* (LP, WAT). Alrededores de Bariloche, (LP). *Limite* Rio Negro and Neuquen. RN40 pasando Dique Alicura, *Lopez and Becker 15* (LP, WAT). ***San Juan***. Calingasta, *Marquez Miranda 4* (LP). Villa Media Agua RN

40, *Lopez and Becker 25* (LP, WAT). . Zonda, *Martin Carrizo* (LP). San Juan. Ao. de las Puntas Negras, *R. Kielsing, I. Peralta et E. Ulibarri 7745* (MO). Calingasta-Cienaga del Medio-El Leoncito, *C Apochian, J Bono, A Carminati, A Ibanez y L Vivanco 124* (LP). Pismanta, *A L Cabrera 17935* (LP). ***Salta***. Ruta 9 proximo a puente de Rio Ancho, *Lazaro Juan Novara 2335* (MO). 2 lm S de Guemes; KM 1426 on Hway 34, *John D. Bacon 1611* (LL). Salta. Entre El Tunel y El Galpon, *Lopez and Becker 39* (LP, WAT). RN 16 entre EL Quebrachal y Nuestra Sra. de Talavera, *Lopez and Becker 38* (LP, MO). Departamento de lerna-Campo Quijano, *D Abbiatti y L Claps 150* (LP). Toldos a Ri Colorado- Departamento Santa Victoria, *Teodoro Meyer 17739* (LP). Cafayate, *17306* (LP). El Rincon, *F E Luna 1483* (TEX). Rio Blanco, *R. Filipovich 471* (TEX). ***San Luis***. RP 9 hacia Trapiche, aproximadamente a 12 km, *Lopez and Becker 22* (LP, WAT). 5 km northeast of Carolina., *Robert R. Brooks, O. Gaede & G. Hueyo MS122* (MO). ***Santa Fe***. Ceres, RN 34, *Lopez and Becker 33* (LP, WAT). RP 95, pasando Pozo Borrado, *Lopez and Becker 34* (LP, WAT). El Tostado-Rio Salado, *M M Job 1094* (LP). Camino de Reconquista A Romang, *M M Job 983* (LP). RN 127, *Lopez and Becker 51* (LP, WAT). 25 km E de Venado Tuerto, *B. L. Turner 9175* (LL). Venado Tuerto. Al lado de la RN 8, *Lopez and Becker 1* (LP, WAT). ***Santa Cruz***. Los Antiguos, *Lopez and Becker* 9.(LP, WAT). Canadon Leon, *Luis R Miccio 6* (LP). ***Santiago del Estero***. Rio Dulce, *J flores* (LP). RN 34 a 15 km sur del empalme con RP 92, *Lopez and Becker 31* (LP, WAT). Finca Sarita, (LP). RN 34 llegando a Selva, *Lopez and Becker 32* (LP, WAT). ***Tucuman***. RN38, *Lopez and Becker 28* (LP, WAT). River through San Miguel de Tucuman, *Jim Conrad with Werner Dietrich 2565* (MO). A 5 km de San Miguel del Tucuman hacia Santiago del Estero, RP 9, *Lopez and Becker 29* (LP, WAT). Sierra de Tucuman, *17302* (LP). Amicha del Valle, *James C. Solomon 13616* (MO). *J. O. Reche 27* (MO).

Bolivia. Valle de Cochabamba, *Jose Steinbach 8795* (MO). Vila Vila S. de Quillacollo, *R. Steinbach 171* (MO). Cochabamba, *Adolfo Jimenez 16* (LP). Quinchinlca, *Patanasio Hollermayer 126* (LP). Along the road to Irupana, ca 1 km from Chulumani, *Legerunt Robert Merrill King et Luther Earl Bishop 7425* (MO)*Solidago chilensis.*CHI.. Concepcion, *A L Cabrera 94* (LP). Cercado. 54.9 km E of Tarija-Padcaya road, on road to Entre Rios., *J. C. Solomon 10323* (MO). La Paz. Inquisivi. Climb between Rio Khara Bridge, through Comunidad Khara to unnamed summit between the, *Marko Lewis 35332* (MO). La Paz. Inquisivi. Hike along the road between the Cajuata turnoff of the Licoma Pampa-Miguillas Road, to, *Marko Lewis 882122* (MO). Santa Cruz. Ñuflo de Chavez, Concepcion, *Tim Killen 1186* (MO. Sara. Buena Vista, *Jose Steinbach 5304* (MO. Warnes. Pampa de Viru-Viru a 17 km al norte de ciudad de Sta.

Cruz, Aeropuerto Int. Viru-Viru zona N. Sabana, *M. Menacho y E. Gutierrez 490* (TEX). Yungas. cerca 4 lm al sur de Coroico, *St. G. Beck 14857* (MO). Ñuflo de Chavez. Laguna Brava, 10 km al NW d San Ramon, *Paollo Betella 27* (MO). Ñuflo de Chavez. Laguna Brava, 10 km al NW de San Ramon, *Paolo Betella 27* (TEX).

Brasil. Bahia. Catoles de Cima, *B. Stannard, W. Ganec e R.F. Queiroz H 51957* (MO). Parana. 6 km N of Mandirituba along Highway BR-116 to Curitiba, *G. Davidse, T.P. Ramamoorthy & D.M. Vital 11003* (MO)

Chile. Curico. Road Curico to Argentina, beyond Los Queñes, *Ynes Mexia 7856* (MO). Curico. Hacienda Monte Grande, *Art. Schirltes 679* (MO). Los Andes. Valle del rio Blanco, *2509* (LP). Region VI. Cachapoal. Rancagua, road from Coya to Mina La Juanita, c.a. 8.3 km above Reten de Carabineros, *L. R. Landrum with J. Martinez 8484* (MO). San Fernando. near baths El Flaco, on bordersof river Tinguiririca, *Otto Zöllner 16214* (MO). Santiago. In valle flum Volcan, *Gay IV 39* (MO). Valdivia. Valdivia, *P. Athan. Hollermayer 126* (MO). Ñuble. ca. 2 km W of Quillon on rte 148., *T. F. Stuessy 4614* (MO). *Solidago chilensis*.CHI.. Costas Peninsula Quetrihue, *A L Cabrera 5* (LP). Aconcagua. Vegas Las cruces, Rio Sobrante, *J.L. Morrison 17322* (MO). Aconcagua. Vegas las Cruces, Rio Sobrante; wet soil along stream and springs, *J.L. Morrison 17322* (MO). Region XI. Al lado de El Fachimal-Ruta 265 (camino Austral), *Lopez and Becker 10* (LP, WAT). Valdivia 40, *Dr. Otto Buchtien* (LL). Ñuble ca. 2 km W of Quillon on rte. 148. Roadside. 40 km, *T. F. Stuessy 4614* (TEX). Aconcagua. Vegas las Cruces, Rio Sobrante; wet soil along stream and springs, *J.L. Morrison 17322* (MO). Aconcagua. Vegas Las cruces, Rio Sobrante, *J.L. Morrison 17322* (MO). Colchagua. San Fernando, *Prof. G Montero 745* (MO). Coquimbo. Rio Nimari-Departamento Ovalle-, *Carlos Jiles P 1266* (LP)

Uruguay. Paysandu-Cañada del Juncal, *5904* (LP). Departamento Montevideo-Arroyo Miquelete, *424* (LP). Gallinal, Aragone, Bergalli, Campal, Rosengurt, *Soriano, Juan Jackson, Monzon-Heber PE-5232* (MO). Atahualpa, *Dr. Guillermo Herter 495B* (MO). Flores. Cañada Varela, 9 km S of Trinidad on RT 3; common on roadside, *Robert S. and Deanna Irving U-33* (LL).

Peru. Lambayeque. Lambayeque. Ciudad Universitaria, *S. Llatas Quiroz 1070* (TEX)

Portugal. Island Madeira. Cabo da Vargem (Rosario-San Vicente), *Juan Silva & Miguel Sequeria s/n* (EL Funchal).

Puerto Rico. Municipio de Yauco. *George R. Proctor 48867* (MO).

***Solidago microglossa* DC.**

Argentina

Chaco. Saliendo del Puente Gral Belgrano RN 16, *Lopez and Becker 42* (LP, WAT). Fontana, *Teodoro Meyer 77* (LP). RN 16 a 10 km Oeste de Roque Saenz Pena, *Lopez and Becker 36*. Colonia Benitez, *145 A G Schulz* (LP). ***Corrientes***. Itati, *M R Malvarez 1549* (LL). 16 km. NE de Ituzaingo, csta Rio Parana, *O. Ahumada 2302* (MO). Santo Tome entrada al pueblo, *Lopez and Becker 47* (LP, WAT). Entre empalme RP 119 and RP 29, RN 123, *Lopez and Becker 48* (LP, WAT). Santo Domingo, *G J Schwarz 9297* (LP). San Luis del Palmar, *Robert K Jansen 743* (LP). Costas Rio Parana, *J Jvenon* (LP). ***Chubut***. Patagonia-Rio Pico, (LP). ***Formosa***. *Pedro Jongrusris 2738* (MO). Pasando Estanislao del Campo RN 81, *Lopez and Becker 41* (LP, WAT). Llegando a Formosa capital, RN 11, *Lopez and Becker 43* (LP, WAT)..***La Pampa***. Carilo, *Y Biraben, H Scott, M Biraben 797* (LP). ***Mendoza***. Maipu- Paso Augusto, *3901* (LP). Las Heras-Villavicencio, (LP). Puerto Rico, *J. E. Montes 15174* (MO). Loreto, *Jose E. Montes 27516* (MO). Pasando RP 11, entrada a Alcazar RN 12, *Lopez and Becker 46* (LP, WAT). Entrada Parque Nacional Iguazu RP 101, *Lopez and Becker 45* (LP, WAT). Nancanguazu- San Ignacio, *G J Schwarz 3142* (LP). Apostoles, *Elsa Zardini 1011* (LP). San Pedro, *Maria Amelia Torres 34* (LP). Posadas, *A Burkart 14074* (LP). Departamento Loreto, *J E Montes 1824* (LP). San Miguel, *E D Gautier 7238* (LP). 6 km E de Cerro Azul Ruta 14, *V. Maruňak 640* (MO). Depto San Rafael, Rio Salado Superior entre Arroyos Vertientes Amarillas y Los Moros, *Ruiz Leal 24529* (LP). ***Neuquen***. Traful Norte, *A. Soriano 84* (LP). Enrtada del camino Huechulaufquen desde junin de los Andes, *M. Lazago 3377* (LP). Piedra Pintada, *C Castagnet 150* (LP). Region del Lago Nahuel Huapi, camino al Tronador, *C Castagnet 74* (TEX). Entre La Rinconada y junin de los Andes, *A. L. Cabrera 19130* (LP, MO). ***Rio Negro***. Vecinity of General Roca, *Walter Fischer 109* (MO). Rio Colorado, *363* (LP). Bariloche, *Alfredo Corle 291* (LP). San Carlos de Bariloche, *A Burkart 6586* (LP). Region of Lago Nahuel Huapi Puerto Pañuelo, angustura entre los dos lagos, *I. Rafael Cordini 121* (LL, LP). Lago Mascardi, *A L Cabrera 5015* (LP). ***Salta***. *S. Venturi 8208* (MO).

Bolivia Province Nor-Yugas 3.4 km from Yolosa Junction on road to Coroico. Open roadside. Mixed coffe and, *J. C. Solomon 4844* (MO). *Miguel A. Bang 2049* (MO, LL). Caballero. 2.5 km N of Tambo, Rio San Isidro (Rio Pulquina), *Greg and Donna Schmitt 47* (MO). Cochabamba. cerca de San Benito, a unos 44 km de la capital en direccion a Santa Cruz, *Javier Fernandez Casas FC 7726* (MO). Ichilo. Buena Vista; 2-5 km north of town on road to community of Madrejon; open grassy areas and, *J. Richard Abbott 16489* (TEX). Las Yungas. 7.8 km SE (above) Yolosa road to San Juan de la Miel, *J. C. Solomon 4844* (MO). Nor Yungas. 7.8 km de Yolosa on road to San Juan de La Miel, *JC Solomon 9327* (MO) *Solidago microglossa.*BOL. Santisteban. 5 km N of center of General Saavedra on road to Mineros. Roadside and adjacent pastures, very flat,, *M. Nee 45087* (TEX). Sur Yungas. trail Chulumani to Ocobaya; open fields along trail, *Ynes Mexia 4289* (MO). Sur Yungas. trail Chulumani to Ocobaya; open fields along trail., *Ynes Mexia 4289* (MO). Yungas., *A. Miguel Bang 449* (MO). Ñuflo de Chavez. Concepcion. Eroded tertiary planation surface overlying precambrian shield; weedy fields aroud, *Ti m Killen 1186* (TEX)

Brasil Canoas, *Irmao Alfonso 38* (MO, LP). Loma Pora-Chaco Paraguayo, *T Rojas 2938* (LP). Estacion SP-Municipio Ibluna-Bairro Vierinha, *Keiichi Mizoguchi 27510* (MO).0 Tunuyan-Colonia de las Rosas, *A E Ragonese 17* (LP). Avitapolis-Palhoca, *R Klein 471* (LP). Bento Pires, Belo Horizonte, *Louis Williams 5367* (LP). Salto-Belmont-Descanso, *R Klein 5123* (LP). Pernambuco. Tapera, *Bento Pickel 1322* (LL). Municipio Campo Alegre, *12029 Smith & Klein* (LP). Curitiba, *Gunter Tessman 785* (LP). Tapera, *D. Bento Pickel* (TEX). Esc Agronomia e Vetrinaria-Porto Alegre, *PN Capparelli 453* (LP). Morro da Gloria-Porto Alegre, *L.Rambo 30611* (LP). Colombo, *W. Maschio & A. Souza 21 1960* (TEX). 6 km N of Mandirituba along Highway BR-116 to Curitiva Open grassland without shrubs dominated, *G. Davidse, T. P. Ramamoorthy & D. M. Vital 11003* (TEX). Garuva. Tres Barras-San Fransisco do Sul, *Reitz & Klein 6520* (LP). ES. Santa Teresa, proxima a Cooperativa avicola, *Wilson Boone 11 2080* (MO). Minas Gerais. State Agricultural School, Vicosa, *2620* (TEX). Minas Gerais., *Ynes Mexia 4350* (MO). Minas Gerais. Juiz de Fora, *Agnes Chase 8541* (MO). Minas Gerais. Sao Tome das Letras, *Regina Duarte Macedo 5724* (MO) *Solidago microglossa.*BRA. Parana. Tibagy, *Rudolph Reiss 83A* (TEX). Parana. Colombo, *W Maschio & A Zouza 21 1960* (TEX). Parana. Curityba in campo, *P. Dusen 19a* (MO). Parana. Fazenda Reserva, 85 km SW of Guarapuava, campo Rio Reserva, *J. C. Lindeman & J. H. Haas 4829* (MO). Parana. Juguariaiva, *R Kummrow 442* (LP). Porto Alegre. Cuiritba, *Dombrowski 1618 a*

Saito 1365 (LP). Porto Alegre. Morro da Gloria, *B Rambo 538* (LP). Rio Grande do sul. Viamae, *B. Rambo 46675* (TEX) .Rio Grande do Sul. Vila Manresa, Porto Alegre, *B Rambo 40368* (MO). Rio Grande do Sul. Vila Manresa, prope Porto Alegre, *B. Rambo 46078* (MO). Rio Grande do Sul. Barra de Ribeiro, *B. Rambo 46593* (MO). Rio Grande do Sul. Cai, prope Gramado, *B. Rambo 46423* (MO). Rio Grande do Sul. Caixas de Sul-Campus UCS, *R. Molon 8 10026* (MO). Rio Grande do Sul. Caixas do Sul. Ana Rech. Faxinal em beira de estrada, *R. Wasum et alii 5596* (MO). Rio Grande do Sul. Caixas do Sul. CAmpus UNiversitario, *R. Molon 1 10019* (MO). Rio Grande do Sul. Caixas de Sul-Jardim Botanico, *R. Wasum 9036* (MO). Rio Grande do Sul. Caixas do Sul, *R. Molon e S. Locha 12130* (MO). Rio Grande do Sul. Caixas do Sul-Universidade, *R. Molon et S. Locha 12130* (MO). Rio Grande do Sul. Caixas do Sul-Campus UCS, *F. Soares 9534* (MO). Rio Grande do Sul. Caxias do Sul-Santo Antonio em beira da estrada, *R. Wasum et alii 8358* (MO). Rio Grande do Sul. Costa Rio Ilvira-Puitan, *Palacios-Cuezzo 1848* (LP). Rio Grande do Sul. Farroupilha- San Roque. Beira de estrada, *R. Wasum et alli 661* (MO). Rio Grande do Sul. Flores da Cunha estrada para Antonio Prado em Beira da estrada, *R. Wasum et R.C. Molon 12616* (MO). Rio Grande do Sul. Lagoa de Pinguela, prope Osorio, *B. Rambo 46485* (MO). Rio Grande do SUl. Mun. de Caixas do Sul-Santa Justina, *L. Scurr 36 13316* (MO). Rio Grande do Sul. Municipio Guaiaba, Bairro Passopetim, *K Mizoguchi 2331 30780* (MO). Rio Grande do Sul. Municipio de Canoas, *Keiichi Mizoguchi 2635* (MO). Rio Grande do Sul. Pareci, prope Montenegro, *B. Rambo 46547* (MO). Rio Grande do Sul. Porto Alegre, *O. Camargo 63691* (LL). Rio Grande do Sul. Teutonia-Lagoa da Harmonia, *R. Molon et alii 8483* (MO). San Paulo. Campinas, *Jose Campos Novas 3173* (LP). Santa Catarina. Sombria, *R Ritz C1065* (LP). Santa Catarina. Rio do Meio-Lauro Muller, *Reitz & Klein 8679* (LP). Santa Catarina. Siriu-Garopaba, *A Bresolin 232* (LP). Catarina. Lacerdopolis-Capinzal, *Reitz & Klein 14722* (LP). Santa Catrina. Campos Novos, *Reits & Klein 14640* (LP). Santa Catarina. along road Tiburão- Lauro Mueller, *J C Lindeman & J H de Haas 1948* (TEX). *Solidago microglossa.*BRA. Sao Paulo. Municipio: Ibiuna. Bairro Vierinha, *Keiichi Mizoguchi 1855 27510* (MO). Sao Paulo. Municipio de Sao Roque, 40 km w of Aizen-Do, *Keiichi Mizoguchi 1515* (MO). Sao Paulo. Municipio de San Roque. 40 km w of Aizen-Do, *Keiichi Mizoguzhi 1515 23050* (MO). Sao Paulo. Sao Paulo, Parque do Estado (on old maps "Parque de Agua Funda", grounds of Instituto de Botanica, *C. G. Fonseca 46* (MO). Rio Grande do Sul., *E. A. Fridericks 538* (LL)

Paraguay Cerro Acahay, Compiña Virgen de Fatima. 5 km al sur de la ruta entre Carapegua y Ybycui., *Davod R. Brunner 1117* (MO). Parque NAcional Ybycu'i. Secondary vegetarion along road from

Asuncion. Reserva Natural, *B. Perez 175* (TEX). Central. Limpio- Paso Correo, *Elsa Zardini 2745* (MO). Central. Tavarory, Acosta Ñu, 5 km E of Rio Paraguay, *E. Zardini & R. Velazquez 25342* (MO). Central. Trindad Asuncion, *Blas Perez 1036* (MO). Guaira. Cordillera de Ybytyruz. Road Melgajer-Atena. Secondary vegetation alng road., *E. Zardini & C. Velazquez 11648* (MO). Guaira. Cord del Ybyturuzu. Villa San Pedro, *I. Basualdo 001862* (MO). Guaira. Cumbre del Cerro Acatil, *M. Ortiz 001171* (MO). Guaira. Tororo camino al Cerro Acati, *N. Soria 003466* (MO). Cordillera. 5 km of Emboscada on road to Nueva Colombia, *E. Zardini & E Velazquez 21292* (MO). Cordillera. Central area of Rio Piribebuy basin, 22 km Arroyos y Esteros., *E. Zardini & M. Velazquez 20236* (MO). Cordillera. 5 km SE of Emboscada. "Isla ALta", *E. Zardini & M. Velazquez 20730* (MO). Cordillera. Eastern side of Rio Piribebuy basin, 17 km W of Arroyos y Esteros, *E. Zardini & U. Velazquez 20163* (MO). Cordillera. Eastern Rio Piribebuy basin, 17 km W of Arroyos y Esteros., *E. Zardini &E. Velazquez 19262* (MO). Cordillera. Tobati "Ybytu Silla" mesa. Northern Area. Scrub on sandstone, *E. Zardini & R. Velazquez 27250* (MO). Cordillera. Tobati. "Ybytu Silla" mesa. Central Area, *E. Zardini & C. Velzquez 27151* (MO). A. Parana. Hernandarias, *Iatipu Binancional 228* (MO). Amambay. Rincon del Julio, Pedro Fuan Caballero, near to border of Brazil, *Keiichi Mizoguchi 428* (MO). Amambay. Cerca y al sur de Bellavista, *J. Fdez. Casas & J. Molero FC 6319* (MO). San Lorenzo Campus Universidad, *M Ortiz 913* (TEX). Tavarory, Acosta Ñu, 5 km E of Rio Paraguay. Savanna, *E. Zardini & R. Velazquez 25342* (TEX). Campus Universitario, *M. Ortiz 913* (MO). Tavarory, 1 km E of Rio Paraguay, *. Zardini & A. Salinas 24496* (TEX) .5 km SE of Emboscada on road to Nueva Colombia. On a plane. Savanna, *E. Zardini & U Velazquez 21170* (TEX). Tobati. "Ybutu Silla". Middle area. Inundated savanna., *E. Zardini & C. Velazquez 26631* (TEX). Eastern side of Rio Piribebuy basin, 17 km W of Arroyos y Esteros. Savana, *E. Zardini & U Velazquez 22150* (TEX) . Villarica, *Pedro Jorgensen 4171* (LL). Cordillera de Ybytyruzu. Road Megarejo-Antena. Secondary vegetation along road, *E. Zardini & C. Velazquez 11648* (MO). Caazapa. Tavai-Prop. de la flia Bogado, *M. Ortiz 001117* (MO). Parque NAcional Ybycu'i. Secondary vegetation along road from administration area to Cesar, *E. Zardini 12132* (MO). Parana. Rva. Tati Yupi, *Itaipu Binancional 46* (MO).

***Solidago virgaurea* [synonym: *S. patagonica*]**

Argentina

Rio Negro. Lago Mascardi. *A. L. Cabrera 5015* (LP).

Solidago missouriensis

Argentina

Chubut. Rio Pico *s.n.* (LP).

Mendoza. Depto San Rafael, Rio Salado Superior entre Arroyos Vertientes Amarillas y Los Moros. *Ruiz Leal 24529* (LP).

Neuquen. Entre La Rinconada y junin de los Andes. *A. L. Cabrera 19130* (LP). Enrtada del camino Huechulaufquen desde junin de los Andes. *M. Lazago 3377* (LP). Piedra Pintada. *C. Castagnet 150* (LP). Traful Norte. *A. Soriano 84* (LP). Region del Lago Nahuel Huapi, camino al Tronador. *C. Castagnet 74* (LP).

Rio Negro. Region of Lago Nahuel Huapi Puerto Pañuelo, angustura entre los dos lagos. *I. Rafael Cordini 121* (LP). San Carlos de Bariloche. *A. Burkart 6586* (LP). San Carlos de Bariloche. *A.Corle 291* (LP).