

**MULTIVARIATE MORPHOMETRIC CONFIRMATION
OF *SOLIDAGO CHILENSIS* (ASTERACEAE: ASTEREA)
IN THE AZORES**

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ABSTRACT

An herbarium collection of *Solidago* from near Pico Island, Azores, Portugal, is reported here to be *Solidago chilensis* Meyen. One collection (*Botelho Gonçalves 1825*, BM) was included in a multivariate morphometric analysis comparing *S. altissima*, *S. canadensis*, *S. chilensis*, and *S. gigantea*. The specimen has glabrous lower and mid stems, glabrous linear lanceolate upper stem leaves with ciliate entire margins, and secund pyramidal inflorescences that are much longer than wide.

Solidago chilensis Meyen is native to South American and is a member of *S.* subsect. *Triplinerviae* (Torr. & A. Gray) Nesom (Lopez Laphitz 2009; Lopez Laphitz & Semple, 2015). The species includes plants with densely very short canescent stems to plants with glabrous stems from base to into the inflorescence. The glabrous-stemmed morphs are most common in Argentina and occur as the only morph present in the La Plata to Buenos Aires region (Lopez Laphitz 2009); similar plants have been introduced into the West Indies and Madeira Is., Portugal (Conçalves Silva et al. 2009) and Australia (Semple et al. 2017).

During a visit to the British Museum of Natural History (BM) in November of 2014 a specimen from Pico Island, Azores, Portugal, collected by Ilídio Botelho Gonçalves, the former director of the Serviços Florestais at Horta and Angra do Heroísmo (*Botelho Gonçalves 1825* (BM; Portugal, Autonomous Region of the Azores: Pico Is., Santo António, Ginjal, 50 m, 25 Aug 1964, Figs. 1-2) was examined and thought to be *S. chilensis* based on upper leaf traits and inflorescences shape. The specimen was subsequently borrowed for detailed study in the laboratory in Waterloo and traits scored for inclusion of the specimen in a multivariate morphometric analysis of similar plants. The specimen was originally identified as "*Solidago hybrida?*" then annotated by J.R. Press in October 1995 as "*Solidago gigantea* prob. subsp. *serotina* but a form with very narrow leaves." The specimen has upper stems that are glabrous even in the inflorescence and upper stem leaves that are narrowly lanceolate, trinervate, and glabrous with entire ciliate margins, which is consistent with many specimens of *S. chilensis*. The third author has collected a number of specimens from Terceira Island (Fig. 3). *Solidago gigantea* Ait. subsp. *serotina* (O. Ktze) McNeill was listed as occurring on the Azorean islands Pico, São Jorge, and Terceira in the Nova Flora do Portugal, but no specimens were cited (do Amaral Franco, 1984, Vol. II, p. 351).



Figure 1. *Solidago chilensis* from Pico Island, Azores, Portugal — Botelho Gonçalves 1825 (BM).

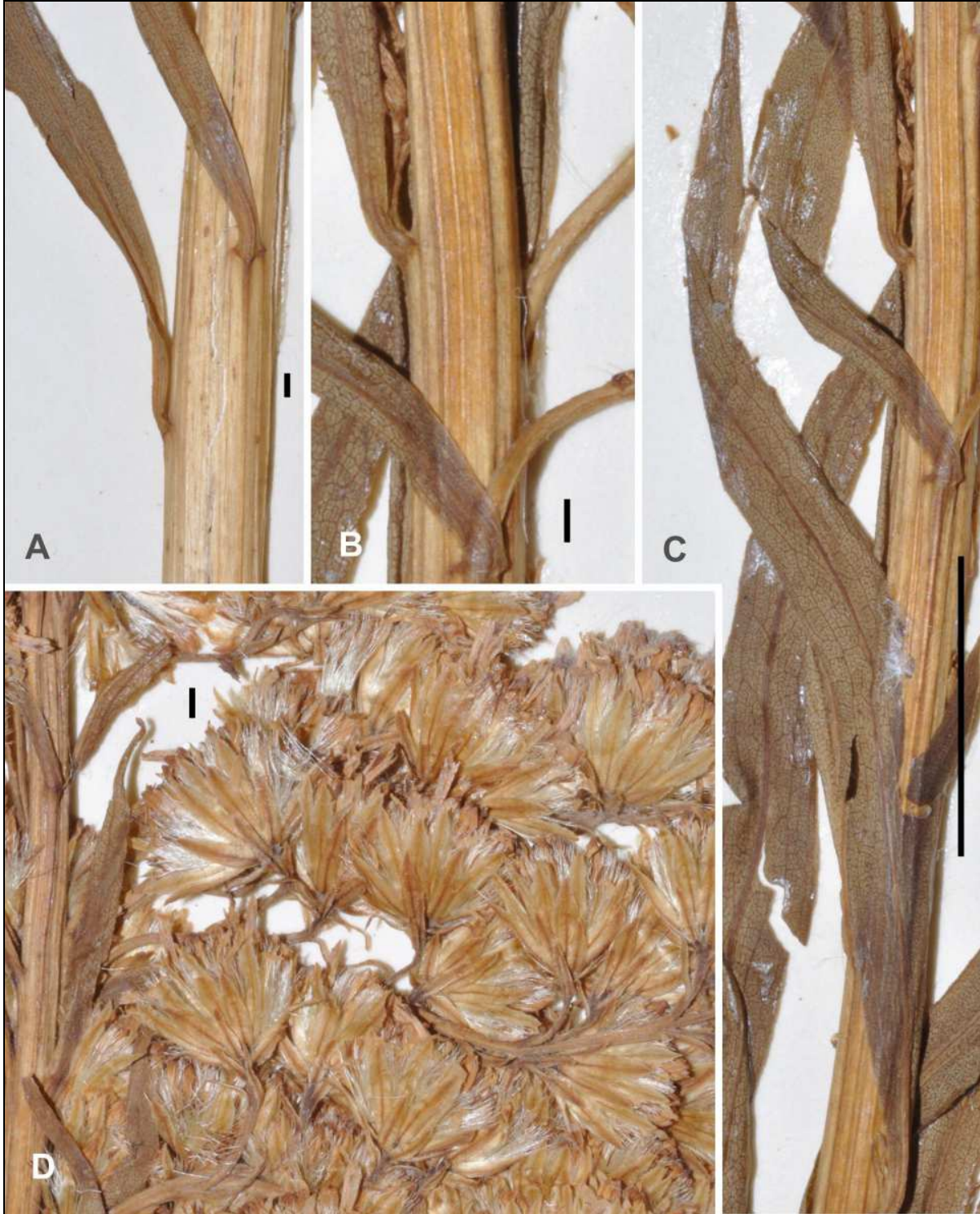


Figure 2. Details of *Solidago chilensis* from Pico Island, Azores, Portugal; *Botelho Gonçalves* 1825 (BM). **A.** Upper mid stem. **B.** Upper stem just below inflorescence. **C.** Upper stem leaf, abaxial surface. **D.** Heads. Scale bar = 1 mm in A, B, and D; = 1 cm in C.



Figure 3. *Solidago chilensis* from Terceira Island, Azores, Portugal. **A-B.** Habitat and flowering shoots; Paul da Praia, Terceira, 17 Sep 2015. **C.** Dried stem and leaves; Agualva, Aug 2014. Digital images by H. Schaefer.

MATERIALS AND METHODS

Herbarium specimens of *Solidago altissima*, *S. canadensis*, *S. chilensis*, and *S. gigantea* from BM, GH, F, K, LL, LP, MADS, MEL, MO, the J.K. Morton personal herbarium now deposited in TRT, MIN, NCU, NY, PERTH, TEX, USF, and WAT in MT were used in the multivariate analyses. A list of 14 vegetative and 16 floral traits scored was included in Semple et al. (2015) and is not repeated here.

Analyses were performed using SYSTAT v.10 (SPSS 2000). A STEPWISE discriminant analysis was performed on 296 specimens of *S. altissima* (88 specimens included in Semple et al. 2015), *S. canadensis* (57 included in Semple et al. 2015), *S. chilensis* (89 specimens mostly included in Lopez Laphitz and Semple 2015), and *S. gigantea* Ait. (40 specimens, nearly all from Canada and the USA) to confirm the identification of *Botelho Gonçalves 1825* (BM) as *S. chilensis*.

RESULTS AND DISCUSSION

Because *Botelho Gonçalves 1825* (BM) was incomplete and lacked lower and mid stem portions of the shoot, only upper stem leaf traits were included. Ray floret ovary/fruit body length at anthesis and ray floret pappus length at anthesis were also not included due to high correlations with the disc floret traits.

In the STEPWISE discriminant analysis including 296 specimens in four species level a priori groups (*Solidago altissima*, *S. canadensis*, *S. chilensis* and *S. gigantea*), the following ten traits were selected as useful in separating the four a priori groups in the analysis and are presented in order of decreasing F-to-remove values: number of upper leaf margin serrations (30.59), disc corolla length (21.28), outer phyllary length (21.31), number of disc florets (18.04), upper leaf width (13.91), disc corolla lobe length (11.24), upper leaf length (10.42), disc floret pappus length at anthesis (9.53), involucre height (9.98), and disc fruit body length at anthesis (8.95). Wilks's lambda, Pillai's trace, and Lawley-Hotelling trace tests of the null hypothesis that all groups were the samples of one group had probabilities of $p = 0.000$ that the null hypothesis was true. The F-matrix for the discriminant analysis presented in Semple et al. (2017 Table 1) and is not repeated here. F-values based on Mahalanobis distances between group centroids indicated the largest separation were between *S. canadensis* and *S. chilensis* (86.564), and the least separation was between *S. altissima* and *S. canadensis* (31.180).

In the Classificatory Discriminant Analysis, correct assignments of specimens for taxa ranged from 89% to 99%. The Classification matrix and Jackknife classification matrix were presented in Semple et al. (2017 Table 2) and are not repeated here. Eighty-eight of the 89 specimens of the *Solidago chilensis* a priori group were assigned a posteriori to *S. chilensis: Botelho Gonçalves 1825* (BM) with 96% probability (2% to *S. gigantea* and 1% to *S. altissima*). Additional details of the results are not presented here.

Two dimensional plots of CAN1 versus CAN3 and CAN1 versus CAN2 canonical scores for 296 specimens of *Solidago altissima*, *S. canadensis*, *S. chilensis*, and *S. gigantea* are presented in Fig. 4. Eigenvalues on the first three axes were 3.625, 1.369 and 0.883.

Botelho Gonçalves 1825 (BM) is a member of *Solidago chilensis* and not *S. gigantea*. The following additional collections originally identified as *S. gigantea* are also *S. chilensis*: Portugal. Azores: Terceira, Agualva, pasture, c. 140 m, 7 Aug 2014, *H. Schaefer 2014/171*(TUM); Praia da Vitoria, *H. Schaefer 2010/478* (GH), *H. Schaefer 2014/223* (TUM); Praia da Vitoria, Paul da Praia, lake shore, ca. 10 m, 11 Sep 2013, *H. Schaefer 2013/178* (TUM). Additional herbarium collections filed as *S. gigantea* from the Azores should be examined to determine if they are also in fact *S. chilensis*. Detailed descriptions of *S. chilensis* were given in Lopez Laphitz and Semple (2015) and Semple et al. (2017).

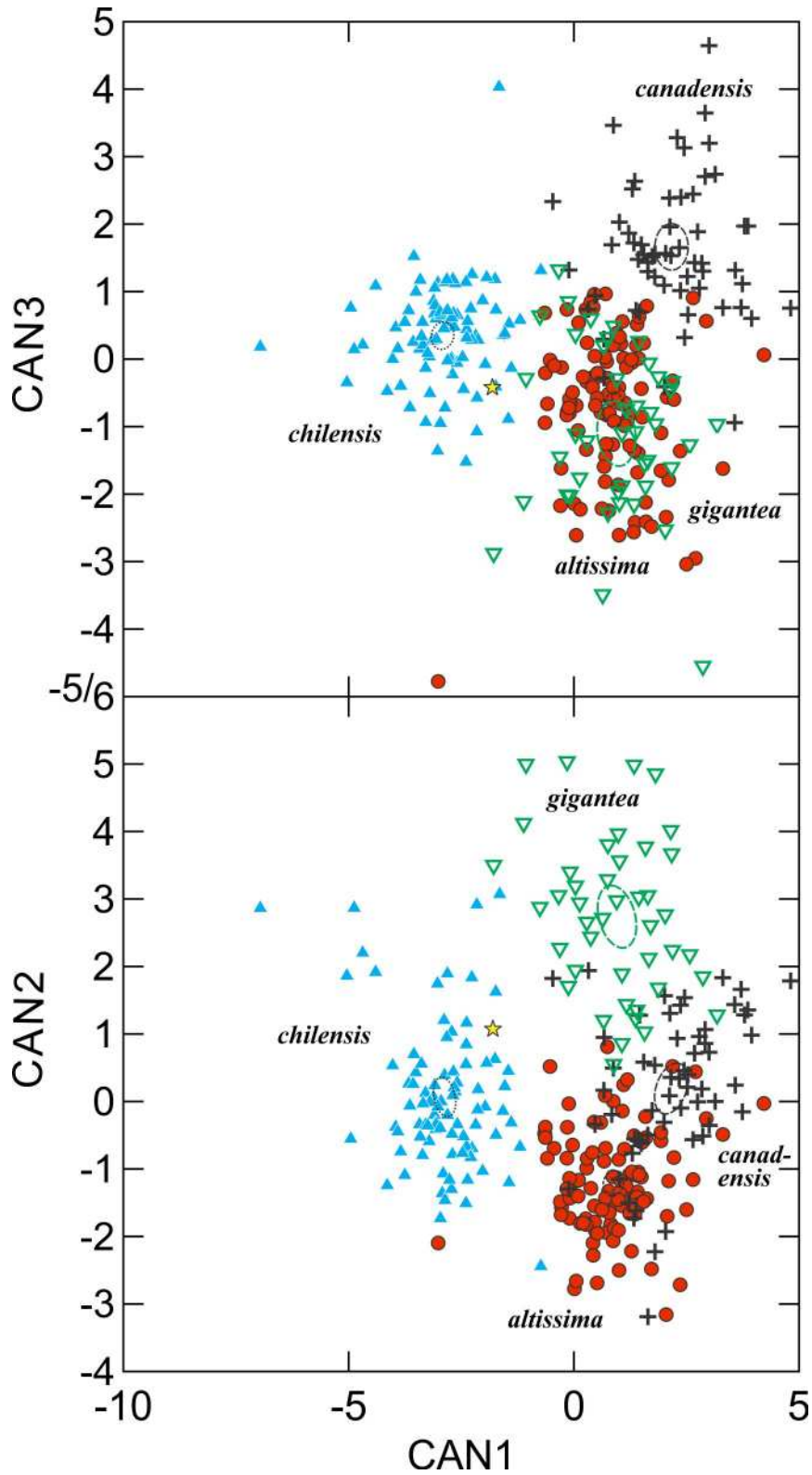


Figure 4. Plot of canonical scores CAN1 and CAN2 for specimens of *S. chilensis* (gray crosses), *S. leavenworthii* (circles), *S. microglossa* (red triangles), Botelho Gonçalves 1825 (BM; yellow star) obtained in a discriminant analysis treating Botelho Gonçalves 1825 (BM) as unassigned to an a priori group.

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