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A MULTIVARIATE MORPHOMETRIC ANALYSIS OF THE BUSHY ASTER COMPLEX: *SYMPHYOTRICHUM DUMOSUM* AND *S. SIMMONDSII* (ASTERACEAE: ASTEREAE)

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ABSTRACT

The Bushy Aster complex of eastern North American includes a dozen named taxa, only a few of which have been accepted in floras. A multivariate morphometric analysis of herbarium specimens was undertaken to investigate the range of variation and to test possible taxonomic treatments. Based on preliminary analyses, cytological data, and field observations, a matrix was constructed of 125 individuals in five *a priori* groups by 41 characteristics. Incomplete data for some traits and high correlations among floral traits reduced the number of characters included in discriminant analyses. Two species — *Symphyotrichum dumosum* (diploids and tetraploids) and *S. simmondsii* (octoploids) — separated strongly on the first canonical axis in a discriminant analysis. In an analysis of just *S. dumosum*, four varietal groups separated on the first three canonical axes with some misplacement of specimens in the classificatory analyses. Two northern and two southern varieties defined on morphology and geography can be recognized in *S. dumosum*: var. *dumosum*, var. *strictior*, var. *coridifolium*, and var. *subulifolium*.

The Bushy Aster complex of eastern North American includes a dozen named taxa, only a few of which have been accepted at some rank in floras either in the very broadly defined genus *Aster* L. or more recently in the primarily North American genus *Symphyotrichum* Nees: *Aster dumosum* L., *Aster coridifolius* Michaux (1803), .*A. dumosum* var. *coridifolium* Torrey & Gray (1841), *A. dumosus* var. *subulifolius* Torrey & Gray (1841), *A. dumosum* var. *strictior* Torrey & Gray (1841), *A. dumosum* var. *dodgei* Fernald (1909), *A. dumosus* var. *gracilepis* Wiegand (1928), *A. dumosus* var. *pergracilis* Wiegand (1928), *Symphyotrichum dumosum* (L.) Nesom (1994), *S. dumosum* var. *dumosum*, *S. dumosum* var. *strictior* (Torr. & Gray) Nesom (1994), *S. dumosum* var. *dodgei* (Fern.) Nesom (1994), and *S. dumosum* var. *subulifolium* (Torr. & Gray) Nesom (1994). *Aster simmondsii* Small (1913) is likely the most closely related taxon. Semple (2024) reviewed the nomenclature of the *S. dumosum*-*S. simmondsii* complex and recognized four varieties within *S. dumosum* and proposed the new combination *S. dumosum* var. *coridifolium* (Michx.) Semple, Horsburgh, and Hayter.

Brouillet et al. (2006) recognized *Symphyotrichum dumosum* (Fig. 1) and *S. simmondsii* (Fig. 2) and discussed possible varieties in the former but did not recognize or key out any. The following description of *S. dumosum* is modified from Brouillet at al. (2006):

Perennials, (20–)30–100(–145) cm, colonial or cespitose; usually long-rhizomatous, often thick, woody, sometimes short, or with short, stout caudices. **Stems** 1–5+, erect (straight, often slender, brittle), densely or sparsely strigose to glabrescent or glabrate. **Leaves** firm, margins entire to crenulate-serrate, recurved, scabrous, apices sharply white-mucronate, abaxial faces glabrous or glabrate to sparsely strigillose, adaxial glabrous or glabrate to submarginally scabrous (short-strigose), cauline withering by flowering (except on array branches), often with axillary leaf clusters; basal withering by flowering, petiolate, petioles winged, strigose-ciliate, blades oblanceolate to spatulate (often declined), 8–50 × 3–15 mm, bases attenuate to cuneate, margins crenate-serrate, apices obtuse or rounded to ± acute; proximal cauline (mostly declined) subpetiolate (petioles widely winged, clasping) or sessile (then not or barely clasping), blades linear-oblanceolate, 25–120 × 1.5–9 mm, bases cuneate to slightly attenuate; distal (ascending or spreading) sessile, blades oblong or linear-lanceolate to linear, 2–45 × 0.5–4 mm, reduced distally (abruptly on branches), bases cuneate to rounded, not clasping, margins entire or serrate. **Heads** in remote, diffuse, open, paniculiform arrays, branches few to numerous, ascending to stiffly ascending, secondary ones stiff, racemiform. **Peduncles** slender, usually stiff (sometimes lax), (0.5–) 1–5 cm (rarely subsessile), progressively reduced distally, usually not secund, sparsely strigillose or glabrous, bracts 5–16+, spreading to ascending, linear-oblong or -elliptic to subulate or linear, progressively reduced distally, grading into phyllaries. **Involucres** cylindro-campanulate, (3–)4.5–6.3 mm. **Phyllaries** in 4–6 series, appressed or slightly spreading, oblong-oblanceolate (outer) to linear-oblanceolate or linear (innermost), strongly unequal, bases indurate, margins hyaline, scarious, erose, distally ciliolate, green zones oblanceolate to elliptic (subapical), apices acute to obtuse (scarious), sometimes faintly reddish, mucronulate, faces usually glabrous, sometimes glabrate. **Ray florets** 15–33; corollas pale blue, pink, or lavender to white, laminae (4–)5–7(–8) × 1–1.7 mm. **Disc florets** 15–30; corollas cream to pale yellow turning pink, 3.5–4.5 mm, tubes shorter than to equal to narrowly funnelform throats, lobes lanceolate, (0.4–)0.6–1.1 mm. **Cypselae** pink or stramineous with pink streaks, or gray (± dark, nerves stramineous), oblong-obovoid, sometimes ± compressed, 1.5–2.5 mm, 3–4-nerved (nerves prominent), faces strigillose; **pappi** white to sordid, 4 mm. **2*n*** = 16, 32.

Figure 1. *Symphyotrichum dumosum*. **A.** Var. *coridifolium*; *Semple & Chmielewski 6040*, South Carolina. **B**. Var. *strictior*; *Semple 2961*, Ontario. **C.** Var. *subulifolium*; *Semple 11683* (WAT), Florida.

The common name Bushy Aster is derived from the sometimes numerous-stemmed individuals occurring throughout the range of the species (Fig. 1A). Individual shoots range in height from 20–100(-145) cm, although mid-height shoots are most common and consist of stems with numerous narrow leaves gradually reduced upward on the stem and terminating in an often much branched inflorescence with numerous blue or pinkish-blue to white rayed heads (Fig. 1B-C).

A distinctive feature of *Symphyotrichum dumosum* is the significant reduction in leaf length on lateral branches with rameal leaves being as little as ¼ the length of the main stem leaf subtending the lateral branch. This reduction is repeated with secondary and tertiary branch leaves. Leaf orientation is also varied in *S. dumosum* with leaves ranging from ascending to patent to strongly reflexed down the stem (Fig. 3). Plants treated here as *S. dumosum* var. *dumosum*, var. *strictior*, and var. *coridifolium* have leaves in various orientations on the same shoot (Fig. 4). Leaves of var. *subulifolium* are generally oriented upward resulting in an obvious difference between plants of var. *coridifolium* and var. *subulifolium*. In contrast, lower stem leaves of *S. simmondsii* can be relatively broad with numerous large serrations (Fig. 6). Such big serrate leaves are not always present on shoots of *S. simmondsii*, but they do not occur in *S. dumosum*, although basal rosette leaves can be broad and serrate, at least in greenhouse grown plants (Fig. 5C).

Stems in *Symphyotrichum dumosum* are generally glabrous to sparsely short strigose distally, but rarely much more hairy stems occur, although stem hair density grades from glabrous (Fig. 5A) to densely strigose (Fig. 5B), with the latter having been treated as *S. dumosum* var. *dodgei*, which Semple (2024) did not recognize.

Figure 2. *Symphyotrichum simmondsii*. **A-B.** *Semple 11693* (WAT), Florida. **C.** *Semple 5360* (WAT); Florida.

Figure 3. Upper stem leaf orientation in varieties of *Symphyotrichum dumosum*. **A.** var. *dumosum*; *Semple & Brouillet 3590* (WAT) from Rhode Island. **B.** Var. *strictior* (*dodgei*); *Oldham 6233*, Ontario. **C.** Var. *coridifolium Semple, Brammall & Hart 3064* (WAT), Virginia. **D.** Var. *subulifolium*; *Semple & Chmielewski 6112* (WAT), South Carolina.

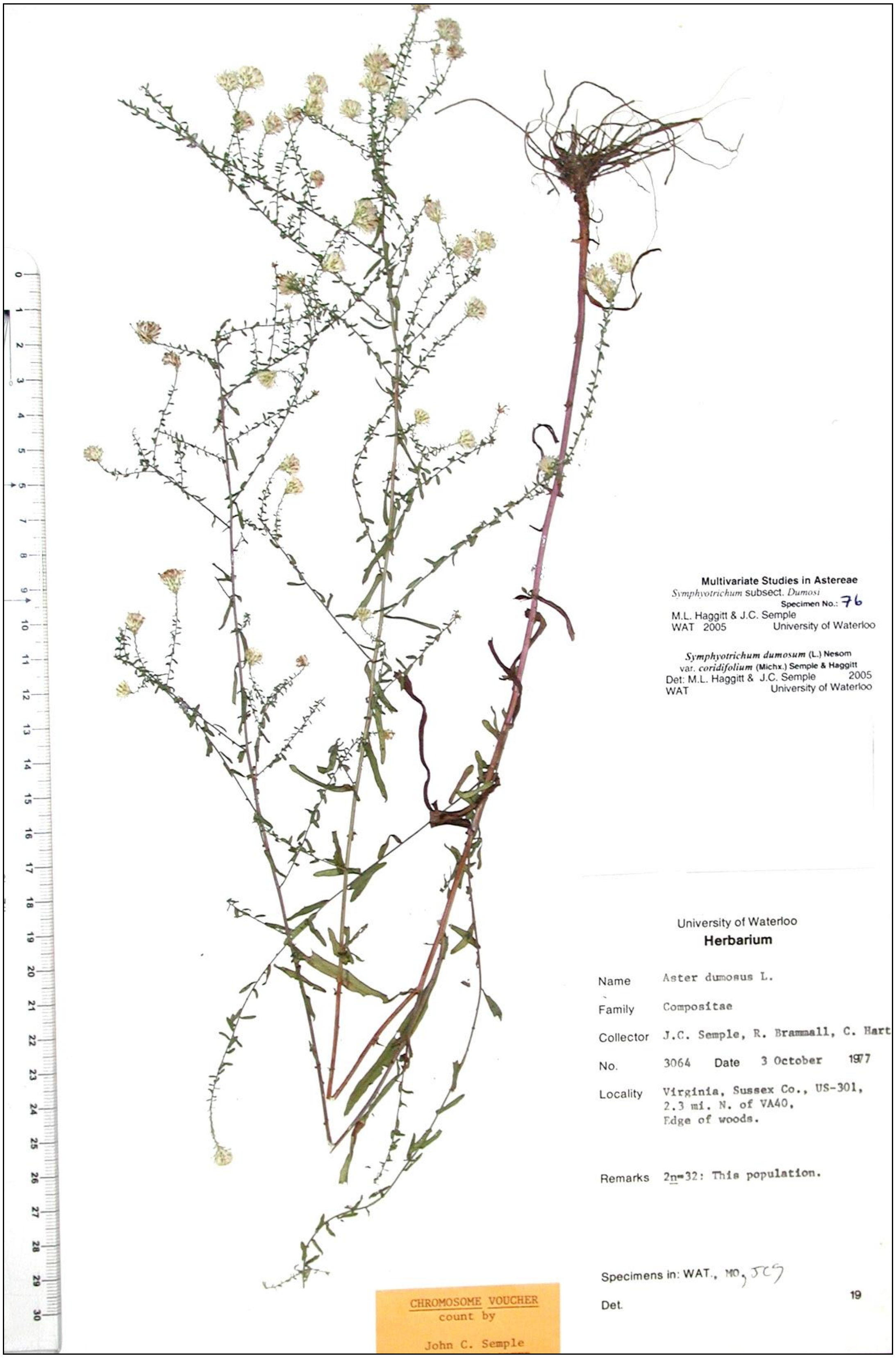

Figure 4. *Symphyotrichum dumosum* var. *coridifolium* from Sussex Co., Virgina; *Semple, Brammall & Hart 3064* WAT.

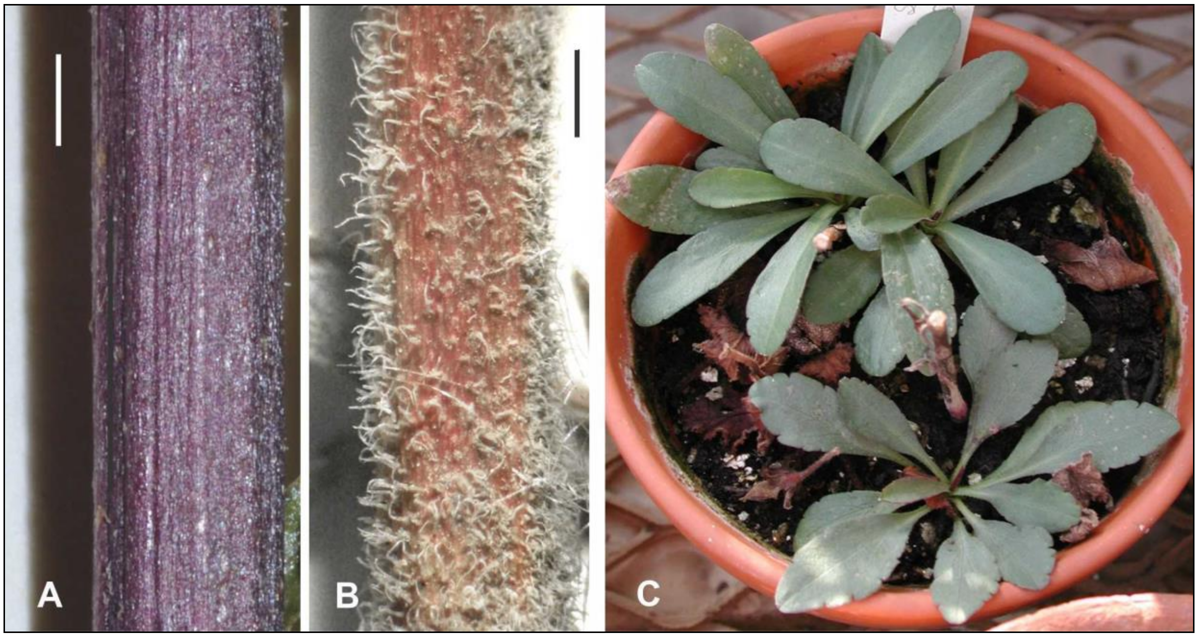

Figure 5. Details of morphology of *Symphyotrichum dumosum*. **A-B.** Var. *strictior*, lower stems. **A.** *Smith s.n.* (MICH). B. Hairy *dodgei* morph, *Semple et al. 6797* (WAT), Ontario. **C.** Var. *coridifolium*, basal rosette leaves, *Semple & B. Semple 11206* (cultivated in greenhouse at U. Waterloo), from Georgia.

MATERIALS AND METHODS

In total, 67 traits were scored on an initial sample of 138 specimens in WAT or borrowed from MICH, OAC, TRT, and USF (Thiers, continuously updated). Basal rosette and lower stem leaves were not present on many specimens and these traits were dropped from the multivariate analyses. Traits used to define *a priori* groups were excluded from the discriminant analyses. Only one trait of those with correlations of $|r| > 0.700$ were used in the discriminant analyses. The final matrix analyzed consisted of 33 traits × 120 specimens (with some missing data points). All analyses were performed using SYSTAT v.10 (SPSS 2000).

Details on the methodology were presented in Semple et al. (2016) and are not repeated here.

Multiple analyses were run to determine which specimens and traits to include in the final two analyses presented here. Traits scored are listed in Table 1. Many of the traits were found to be significantly correlated and only one of these correlated traits was included the final analyses. In the first analysis, *S. dumosum* (96 specimens) and *S. simmondsii* (15 specimens) were included in a STEPWISE discriminant analysis. In the second analysis, *S. dumosum* var. *dumosum* (18 specimens), var. *coridifolium* (20 specimens), var. *strictior* (32 specimens), and var. *subulifolium* (26 specimens) were included in a STEPWISE discriminant analysis.

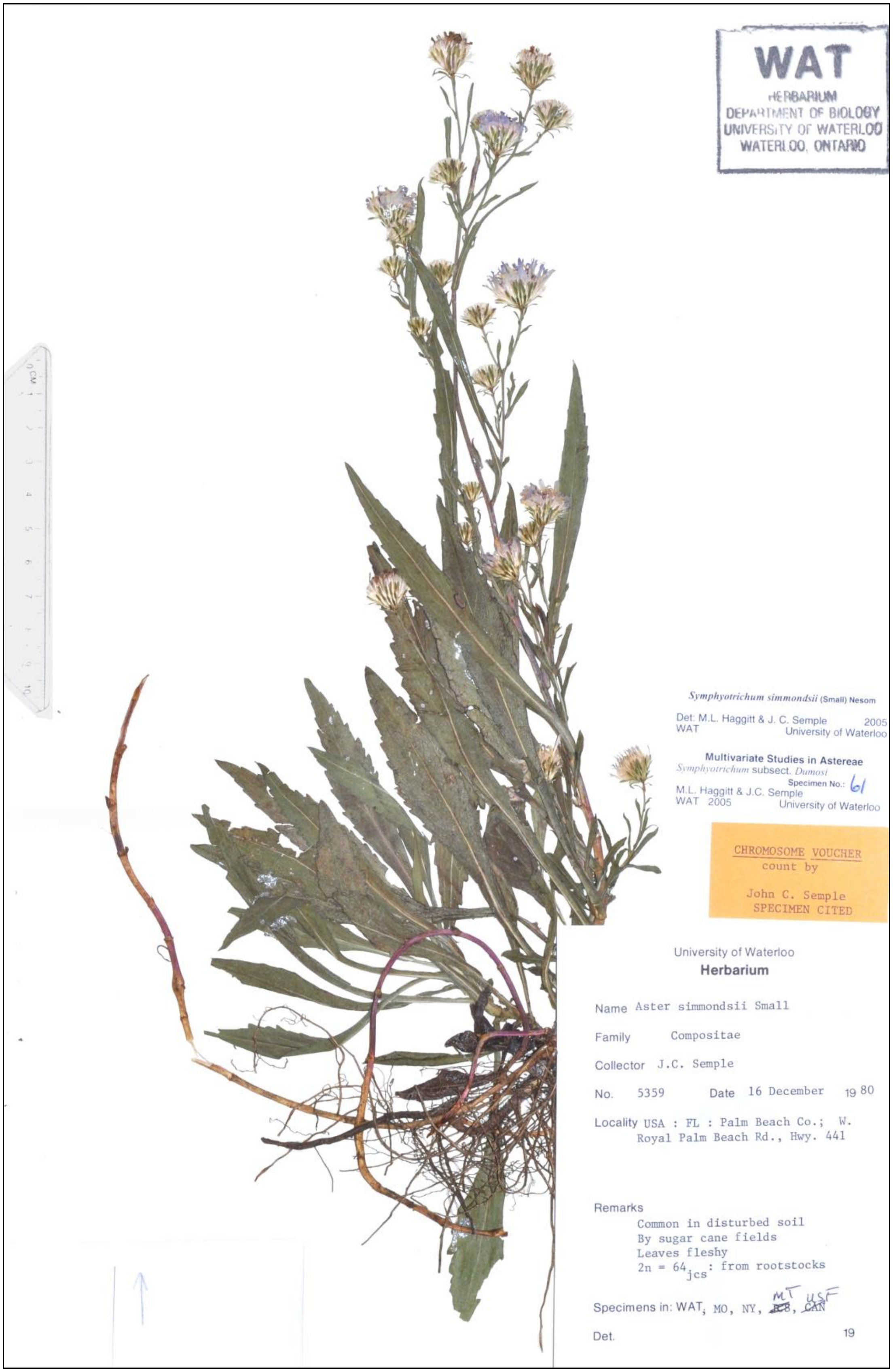

Figure 6. *Symphyotrichum simmondsii*, Semple 5359 (WAT in MT).

Table 1. Traits scored for the multivariate analyses of 138 specimens of *Symphyotrichum dumosum* and *S. simmondsii*.

Abbreviation	Description of trait scored
STEMHT	Stem height measured from the stem base to tip (mm)
STHAIRS	Number of hairs on 1 cm of stem
MLFLN	Mid leaf length measured from the leaf base to tip (mm)
MLFWD	Mid leaf width measured at the widest point (mm)
MLFWTOE	Mid leaf measured from the widest point to the end (mm)
MLFSER	Mid leaf margin-number of serrations of mid leaf
MLFAPEX	Mid leaf apex shape score (1-10) using diagram reference card (Fig. 5)
MLFBASE	Mid leaf base shape score (1-10) using diagram reference card (Fig. 5)
ULFLN	Upper leaf length measured form the leaf base to tip (mm)
ULFWD	Upper leaf width measured at the widest point (mm)
ULFWTOE	Upper leaf measured from the widest point to the end (mm)
ULFSER	Upper leaf margin-number of serrations
ULFAPEX	Upper leaf apex shape score (1-10) using diagram reference card (Fig. 5)
ULBASE	Upper leaf base shape score (1-10) using diagram reference card (Fig. 5)
RAMLFLN	Branch leaf length measured form the leaf base to tip (mm)
RAMLFWD	Branch leaf width measured at the widest point (mm)
RAMLFWTOE	Branch leaf measured from the widest point to the end (mm)
RAMLFSER	Branch leaf margin-number of serrations
RAMLFAPEX	Branch leaf apex shape score (1-10) using diagram reference card (Fig. 5)
RAMLBASE	Branch leaf base shape score (1-10) using diagram reference card (Fig. 5)
INVOLHT	Involucre height at anthesis (mm)
OPHYLLN	Outer phyllary length (mm)
INPHYLLN	Inner series phyllary length (mm)
RAYNUM	Number of ray florets per head
RSTRAPLN	Ray strap length top of the corolla tube to the tip of the strap (mm)
RSTRAPWD	Ray strap width measured at the widest point (mm)
RACHLN	Ray floret ovary/fruit body length at anthesis (mm)
RPAPLN	Ray floret pappus length at anthesis (mm)
DCORLN	Disc floret corolla length from the base to tip of the corolla lobes (mm)
DLOBLN	Disc floret corolla lobe length lobe (mm)
DACHLN	Disc floret ovary/fruit body length at anthesis (mm)
DPAPLN	Disc floret pappus length at anthesis (mm)
DACHPUB	Number of hairs on disc floret ovary/fruit body

RESULTS

Two-species analysis

In the initial analysis of 138 plants, the Pearson correlation matrix yielded r > |0.7| for most vegetative and floral traits and thus most traits were excluded from the final discriminant analyses. This appeared to be a ploidy-level effect: diploid (2*n*=16), tetraploid (2*n*=32) and octoploid (2*n*=64) plants were included in the study. This pattern is illustrated in Figure 7.

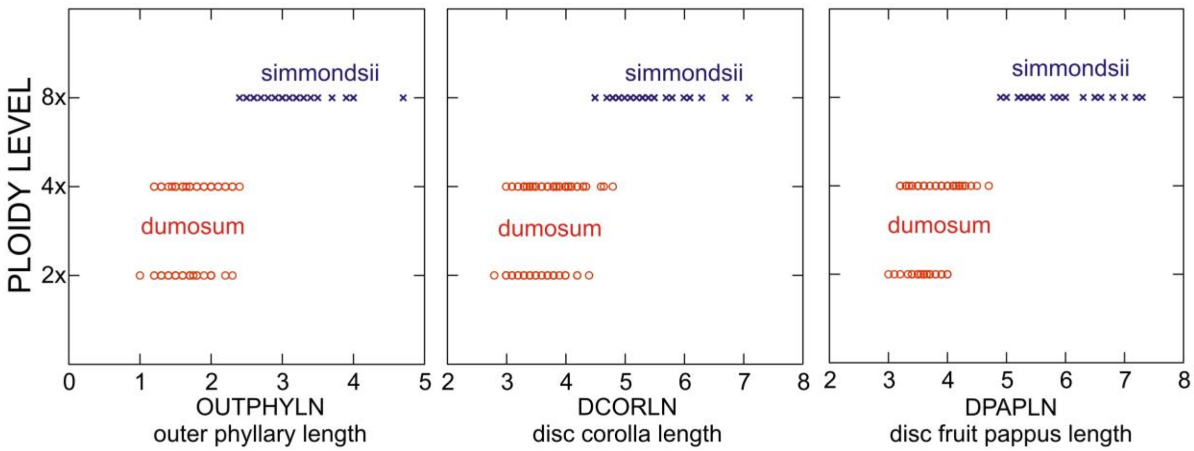

Figure 7. Plots of outphyllary lengths (left), disc corolla lengths (center), and disc fruit pappus lengths (right) of 96 specimens of *Symphyotrichum dumosum* (left) and 15 specimens of *S. simmondsii* (right).

Means and ranges of varition in traits were determined for *Symphyotrichum simmondsii*, *S. dumosum*, *S. dumosum* var. *dumosum*. var. *strictior*, var. *coridifolium*, and var. *subulifolium* and are presented in Appendix Table 1. Average stem height was similar in all taxa (51-64 cm) with the mean height for var. *dumosum* being the shortest (44 cm). The tallest plants occurred in the southern *S. simmondsii* (172 cm) and southern *S. dumosum* var. *subulifolium* (114 cm), which we attribute to the longer growing season in the southeastern portion of the USA. Stem height is likely influenced by differences in growing condition from one year to another, with drier years resulting in shorter stems. *Symphyotrichum simmondsii* had on average the largest mid and upper stem leaves. Lower stem leaves were not included in the analyses because most of the *S. dumosum* plants lacked lower stem leaves, but the largest again were produced by individuals of *S. simmondsii* (see Fig. 6 illustrating a short plant with very larger lower stem leaves). Involucre height was largest in *S. simmondsii* in part due to the octoploid ploidy level (2*n*=64) in all individuals sampled in the species. Within *S. dumosum*, var. *subulifolium* had slightly taller involucres on average (5.3 mm) even though the sample included diploid and tetraploid plants, while involucres of var. *strictior* were average for the species although the variety is only known at the tetraploid level.

Two-species analysis

In a STEPWISE discriminant analysis of 96 specimens of *Symphyotrichum dumosum* and 15 specimens of *S. simmondsii*, including just midstem leaf width, upper stem leaf length, primary branch leaf width, disc corolla length, and disc pappus length, the following three traits were selected as the most significant discriminating traits in order of decreasing F-to-remove values: disc floret corolla length (132.92), midstem leaf width (21.33), and upper stem leaf length (7.54). The classification matrix and Jackknifed classification matrix are presented in Table 2. Frequencies of CAN1 canonical scores for specimens of *S. dumosum* and *S. simmondsii* are presented in histograms in Fig. 8. The eigen value on the first axis was 3.007.

In the Classificatory Discriminant Analysis of 96 specimens of *Symphyotrichum dumosum* and 15 specimens of *S. simmondsii*, the percents of correct a posterori assignment to the same a priori group were 100% for *S. dumosum* and 93% for *S. simmondsii*. Ninety-one specimens of the *S. dumosum* a priori group were assigned a posteriori into the *S. dumosum* group with 100% probability, 2 specimens with 99-98% probability, 2 specimens with 90% probability, and 1 specimen with 82% probability. Thirteen specimens of the *S. simmondsi* a prior group were assigned a posteriori to *S. simmondsii* with 100% probability and 1 specimen with 95% probability. One specimen of the *S. simmondsii* a priori group was assigned a posteriori to *S. dumosum* with 59% probability (*Semple*

7491 WAT in MT from Hardy Co., Florida; a small plant with damaged stem and few heads and 2*n*=64).

Table 2. Linear and jackknife classification matrices from the Classificatory Discriminant Analysis of two a priori groups; a posteriori placements to groups in rows.

Group	*dumosum*	*simmondsii*	% correct
dumosum	96	0	100
simmondsii	1	14	93
Totals	97	14	99

Jackknifed classification matrix

Group	*dumosum*	*simmondsii*	% correct
dumosum	96	0	100
simmondsii	1	14	93
Totals	97	14	99

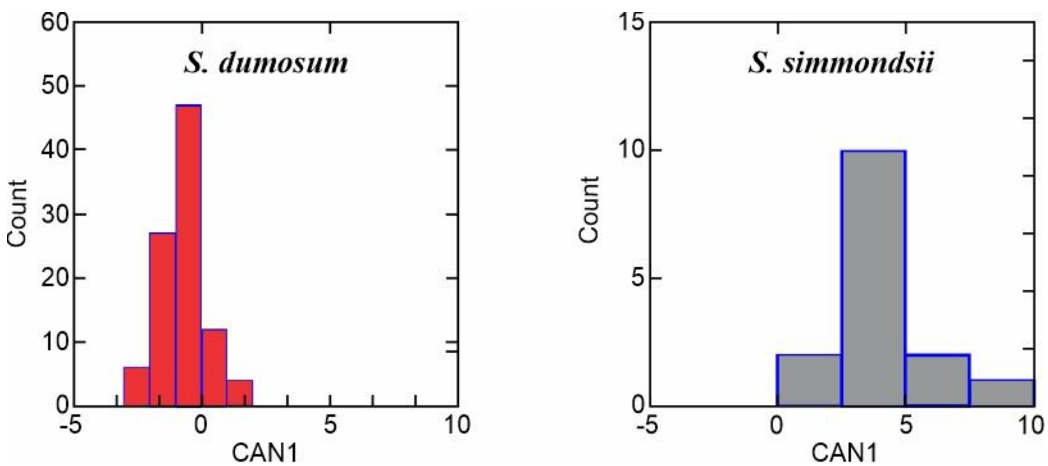

Figure 8. Histograms of CAN1 canonical scores for 96 specimens of *Symphyotrichum dumosum* (left) and 15 specimens of *S. simmondsii* (right).

One-species/four-varieties analysis

The Pearson correlation matrix yielded r > |0.7| for most leaf traits reducing the number used to upper leaf length and upper leaf width. High correlations or missing data resulted in just involucre height, the number of ray florets, ray floret strap length, the number of disc florets, disc floret corolla length, disc floret pappus length, and disc floret ovary/fruit body at anthesis were includes in the discriminant analysis of the 4 varieties of *Symphyotrichum dumosum*.

In the STEPWISE discriminant analysis of 95 specimens of four-varietal level a priori groups within *Symphyotrichum dumosum* (var. *dumosum*, var. *strictior*, var. *coridifolium*, and var. *subulifolium*) the following 7 traits were selected in a STEPWISE analysis and are listed in order of decreasing F-to-remove values: number of ray florets (15.40), disc floret ovary/fruit body length at anthesis (11.70), disc floret pappus length at anthesis (6.61), upper leaf length (6.60), ray floret strap length (6.56), number of disc florets (6.03), and disc floret corolla length (2.80). Wilks's lambda, Pillai's trace, and Lawley-Hotelling trace tests of the null hypothesis that all groups were samples of one group had probabilities of p = 0.000 that the null hypothesis was true. The F-matrix for the discriminant analysis is presented in Table 3. F-values based on Mahalanobis distances of the between group centroids indicated the largest separation was between var. *coridifolium* and var. *strictior* (22.956) and the smallest separations were between var. *dumosum* and var. *strictior* (6.188) and var. *coridifolium* and var. *subulifolium* (6.975). Plots of CAN1 versus CAN2 and CAN1 versus CAN3 are shown in Fig. 9. The eigen values on the first three axes were 2.312, 0.648, and 0.344.

Table 3. Between-groups F-matrix for the four variety level a priori groups analysis (df = 7 85).

Group	*coridifolium*	*dumosum*	*strictior*
dumosum	15.115		
strictior	22.956	6.188	
subulifolium	6.975	12.760	15.101

Wilks' lambda = 0.1363 df = 7 3 91; Approx. F= 11.6418 df = 21 244 prob = 0.0000

In the Classificatory Discriminant Analysis of 95 specimens of four varietal level a priori groups within *Symphyotrichum dumosum* (var. *coridifolium*, var. *dumosum*, var. *strictior*, and var. *subulifolium*), the percents of correct a posterori assignment to the same a priori group ranged from 86-76%. The Classification matrix and Jackknife classification matrix are presented in Table 4. Eighteen of the 21 specimens of the var. *coridifolium* a priori group (86%) were assigned a posteriori to the var. *coridifolium* group; 9 specimens with 100-91% probability, 5 specimens with 89-84% probability, 2 specimens with 77% and 73% probabilities, 1 specimen with 60% probability, and 1 specimen with 47% probability (42% to var. *subulifolium*; *Semple & Chmielewski 6182* WAT in MT from Oconee Co., South Carolina). Three specimens of the var. *coridifolium* a priori were assigned to other varieties: 79% to var. *subulifolium* (27% to var. *coridifolium*; *Semple & Chmielewski 6040* WAT in MT from Wayne Co., North Carolina, leaves strongly reflexed), 65% to var. *subulifolium* (33% to var. *coridifolium*; *Semple & Chmielewski 6403* WAT in MT from Dallas Co., Arkansas, leaves strongly reflexed), and 45% to var. *strictior* (28% to var. *subulifolium*, 20% to var. *dumosum*, and 7% to var. *coridifolium*; *Semple & Brammall & Hart 3064* WAT in MT from Sussex Co., Virginia). Twenty-five of the 32 specimens of var. *strictior* (78%) were assigned *a posteriori* to var. *strictior*; 11 specimens with 100-91% probabilities, 7 specimens with 89-82% probabilities, 2 specimens with 78% and 70% probabilities, 3 specimens with 67-60% probabilities, and 2 specimens with 56% probability (*Gaiser 799I* OAC from Lambton Co., Ontario) and 51% probability (*Smith s.n.* MICH from Lenawee Co., Michigan). Seven specimens of var. *strictior* were assigned a posteriori to other varieties; 4 specimens to var. *dumosum* with 88% probability (*Calvert s.n.* WAT in MT from Kent Co., Ontario), 84% probability (*Oldham 5515* WAT in MT from Kent Co., Ontario), 71% probability (*H.A. Senn. & Soper 607* TRT from Essex Co., Ontario), and 68% probability (*Semple 2964A* WAT in MT from Haldimand-Norfolk Regional Mun.; 2*n*=32); 2 specimens to var. *subulifolium* with 63% probability (*Gaiser 801I* OAC from Lampton Co., Ontario), and 60% probability (*Bennett 7166* USF from LaPorte Co., Indiana); and 1 specimen to var. *coridifolium* with 40% probability (35% to var. *strictior* 22% to var. *dumosum*; *Smith 388* MICH from Lenawee Co., Michigan). Thirteen of the 17 specimens of var. *dumosum* specimens (76%) included a priori were assigned a posteriori to var. *dumosum*; 6 specimens with 99-93% probabilities, 3 specimens with 89-85% probabilities, and 3 specimens with 67-64% probabilities. Five specimens of var. *dumosum* were assigned a posteriori to other varieties: 3 specimens to var. *strictior* with 73% probability (*Henshaw s.n.* MICH from Middlesex Co., Massachusetts), 65% probability (35% to var. *dumosum*; *Bean et al. s.n.* From Barnstable Co., Massachusetts; only included a posteriori), and 52% probability (*Semple 3704* left hand shoot WAT in MT from Tolland Co., Connecticut); and 2 specimens to var. *subulifolium* with 65% probability (*Driesbach 1958* MICH from Cumberland Co., New Jersey; distal leaves mostly patent to reflexed) and 46% probability (*Hill 17432* USF from Prince Georges Co., Maryland; distal leaves patent to reflexed). Nineteen of the 25 specimens of var. *subulifolium* specimens (76%) were assigned a posteriori to var. *subulifolium*; 7 specimens with 99-94% probabilities, 8 specimens with 88-81% probabilities, 2 specimens with 78% probabilities, 1 specimen with 65% probability, and 1 specimen with 57% probability. Six specimens of var. *subulifolium* were assigned a posteriori to var. *coridifolium* with 92% probability (*Lakela 25517* USF from Hillsborough Co., Florida, distal leaves ascending), 83% probability (*Godfrey 69065* USF from Grady Co., Georgia), 72% probability (*G. Morton 4619* USF from Duval Co., Florida; distal leaves ascending), 70% probability (*Daubenmire s.n*. Lake Co., Florida, ploidy level unknown; distal leaves ascending, annotated as *S. simmondsii* by J.C. Semple in 2012 but placed here in *S. dumosum* with 100% probability), 45% probability (43% to var. *subulifolium*; *Semple, Canne, and Brouillet 4083* WAT in MT from Laurens Co., Georgia; 2*n*=16), and 43% probability (30% to var. *subulifolium*, 17% to var. *strictior*, and 10% to var. *dumosum*; *Sundberg 2318* WAT in MT from Collier Co., Florida; distal leaves ascending).

Table 4. Linear and jackknife classification matrices from the Classificatory Discriminant Analysis of four a priori groups; a posteriori placements to groups in rows.

Group	*coridifolium*	*dumosum*	*strictior*	*subulifolium*	% correct
coridifolium	17	0	1	2	86
dumosum	0	13	2	2	76
strictior	1	4	25	2	78
subulfolium	6	0	0	19	76
Totals	24	17	28	25	79

jackknife classification matrix

Group	*coridifolium*	*dumosum*	*strictior*	*subulfolium*	% correct
coridifolium	17	2	1	3	81
dumosum	0	13	2	2	76
strictior	1	4	25	2	78
subulfolium	6	0	0	19	76
Totals	24	17	28	26	78

DISCUSSION

The results of the two multivariate analyses confirm the conclusions reached during field work over multiple decades by the first author that *Symphyotrichum dumosum* and *S. simmondsii* are separate species and that 4 varieties in *S. dumosum* can be distinguished in the majority of cases without much difficulty and ought to be recognized in floras more than they have been. Of course, there are collections that can be difficult to assign to one variety in areas where the ranges of the varieties are sympatric. This is the nature of varietal-level versus species-level recognition.

The results of the first multivariate analysis clearly indicate that *Symphyotrichum dumosum* and *S. simmondsii* are distinct at a level warranting species recognition. Disc corolla length was the most significant trait separating the two species and this is likely a consequence of the difference in ploidy levels with diploid-tetraploid *S. dumosum* having a mean disc corolla length of 3.89 mm and octoploid *S. simmondsii* having a mean disc corolla length of 5.4 mm. Mid stem leaf widths and upper stem leaf lengths are noticeably shorter in *S. dumosum* (mean of 3.35 mm mid stem leaf width; mean of 25.4 mm long upper stem leaves) than in *S. simmondsii* (mean of 7.34 mm mid stem leaves; mean of 46.05 mm long upper stem leaves). In the field, the two species are almost always easily recognized. The lower stem leaves are obviously longer and broader in *S. simmondsii* than *S. dumosum*, but these are often not present in the latter species.

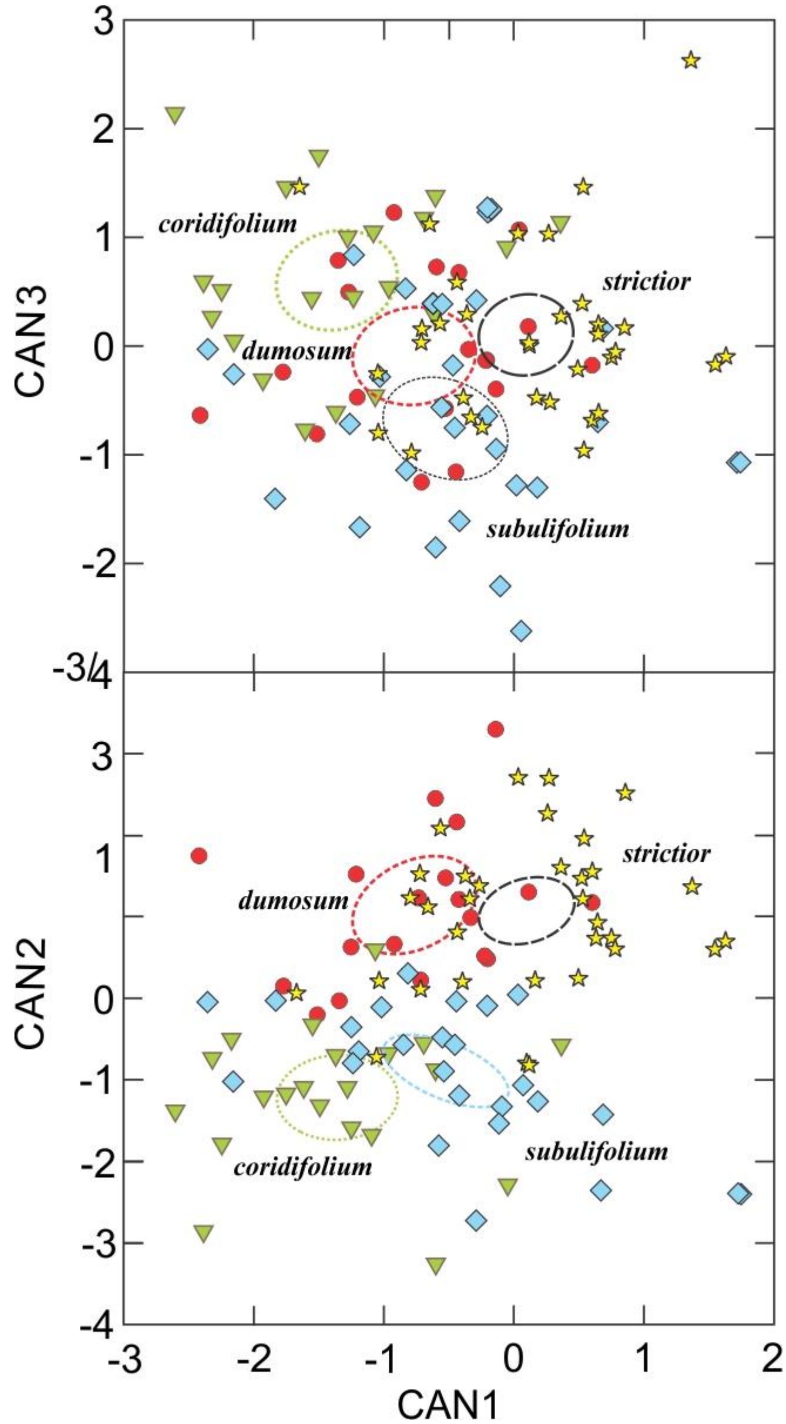

Figure 9. Plot of canonical scores (CAN1 vs CAN2 and CAN1 vs CAN3) for 95 specimens of *Symphyotrichum dumosum*: var. *dumosum* (red dots), var. *coridifolium* (inverted green triangles), var. *strictior* (yellow stars), and var. *subulifolium* (light blue diamonds).

The results of the second multivariate analysis indicate that, while there are traits that separate the four varieties of *Symphyotrichum dumosum*, slightly less than 25% of the collections of each variety were assigned to other varieties. This confirms field observations that collections of *S. dumosum* were sometimes difficult to place into a particular variety with confidence. Of note is the fact that the two northern varieties, var. *dumosum* and var. *strictior* were statistically more similar to each other than to the two more southern varieties, var. *coridifolium* and var. *subulifolium*, which were also more similar to each other than to the two northern varieties. Ray floret color is generally white in var. *strictior* over its whole range, but white-rayed individuals do occur in the other three varieties which are more often slightly to obviously bluish-rayed. Seven traits were selected in the STEPWISE discriminant analysis as useful in distinguishing varieties. Ray floret number and disk floret ovary/fruit body length at anthesis were most significant but these are not easily assessed in the field. Mean values of ray floret number were 15 for var. *coridifolium* and 16 for var. *subulifolium*, which makes that trait of little value in separating the two southern races of the species. Leaf orientation is useful in the field and herbarium in separating these two varieties with upper stem or branch leaves of var. *coridifolium* varying on the same individual from the most distal being generally ascending but mid and upper stem leaves that are often curved-patent to strongly downwardly oriented. In var. *subulifolium* nearly all leaves are strongly ascending. This difference results in generally easy assignment in the field of specimens to one of the two southern varieties.

Although historically var. *coridifolium* has not been separated from var. *dumosum* (e.g., Jones 1980; Nesom 1994; Weakley et al. 2024), var. *coridifolium* had the highest a posteriori placement of specimens to var. *coridifolium* (86%). Although in the field, sympatric var. *coridifolium* and var. *subulifolium* plants are generally easily distinguished by leaf orientation, the two varieties had the second smallest between group F to remove value (6.975). Large numbers of specimen images were accessed via SERNEC in February and March of 2024 to map the distribution of the varieties by state and province, and in most cases, the upward orientation of mid, upper, and branch leaves was sufficiently consistent to identify a specimen as var. *subulifolium*, while at least some branch and upper stem leaves were patent or downwardly oriented on specimens of var. *coridifolium*.

The smallest between group F to remove value (6.188) was between the two northern varieties var. *dumosum* and var. *strictior*. The ranges of the two varieties are shown as allopatric in the cytogeographic study of the *Symphyotrichum dumosum* and *S. simmondsii* (Semple, Chmielewski and Horsburgh 2024), again based on all specimens included in the multivariate analysis and images seen via SERNEC. Upper stem and rameal leaves of these two varieties are similar in size and orientation, but specimens of var. *strictior* almost always have white to nearly white ray florets while specimens of var. *dumosum* nearly always have pinkish to bluish ray florets, although pinkish to white rayed specimens also occur rarely in var. *dumosum*. From Essex Co., Ontario, a specimen of var. *strictior* (*Oldham 19599* WAT in MT; upper stems strigose) had pinkish ray florets. Thus, bluish rays is a useful trait in distinguishing var. *dumosum* from var. *strictior* in nearly all specimens examined.

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Appendix Table 1. Statistics on selected traits of *Symphyotrichum simmondsii*, *S. dumosum*, and the varieties of *S. dumosum*. Trait descriptions given in Table 1.

Taxon/Trait	***S. simmondsii***	***S. dumosum***	**var. *dumosum***	**var. *strictior***	**var. *coridifolium***	**var. *subulifolium***
STHT	**51.6 cm** 8-145 cm	**53 cm** 29-114 cm	**44 cm** 29-71 cm	**51.5 cm** 18-76 cm	**51.8 cm** 6-84 cm	**63.6 cm** 31-114 cm
MIDLFLN	**7.9 cm** 2.5-13.6 cm	**5.1 cm** 1.6-9.8 cm	**4.3 cm** 2.3-9 cm	**6.5 cm** 1.9-9.8 cm	**4.6 cm** 2.7-7.6 cm	**4.5 cm** 1.6-7.9 cm
MIDLFWD	**7 mm** 0.8-15	**3.4 mm** 0.8-8.5 mm	**3.9 mm** 2.5-6.7 mm	**4.1 mm** 1-5.5 mm	**3.7 mm** 1.5-6.2 mm	**2.5 mm** 0.8-5.5 mm
MLFSERR	**3** 0-12	**0.24** 0-4	**0.3** 0-2	**0.4** 0-4	**0.13** 0-2	**0.11** 0-3
UPLFLN	**4.5 cm** 1.4-9 cm	**2.48 cm** 0.8-8 cm	**2.32 cm** 1.0-4.3 cm	**3.2 cm** 1.2-8 cm	**2.1 cm** 0.8-4.0 cm	**2.16 cm** 0.8-5.0 cm
UPLFWD	**3.2 mm** 1.4-6.6 mm	**2.1 mm** 0.7-13 mm	**2.5 mm** 1.1-4.8 mm	**2.3 mm** 1-5.5 mm	**1.8 mm** 0.9-6.0 mm	**1.8 mm** 0.7-13 mm
RAMLFLN	**12.5 mm** 5-27 mm	**8.0 mm** 2.3-26 mm	**6.3 mm** 2.3-13.5 mm	**8.5 mm** 3.3-18 mm	**8.0 mm** 3-22 mm	**8.5 mm** 2.5-26 mm
RAMLFWD	**4.5 mm** 1.4-6.6 mm	**1.2 mm** 0.4-3.3 mm	**1.4 mm** 0.75-3.3 mm	**1.3 mm** 0.7-2.5 mm	**1.3 mm** 0.6-3 mm	**1.6 mm** 0.4-3 mm
INVOLHT	**6.95 mm** 5.1-9 mm	**5.0 mm** 3-7.1 mm	**4.7 mm** 3-5.6 mm	**5 mm** 3-6.4 mm	**4.8 mm** 3.5-6.5 mm	**5.3 mm** 3.5-7.1 mm
OUTPHYLN	**2.8 mm** 1.7-4.7 mm	**1.75 mm** 1-2.8 mm	**1.5 mm** 1.1-2.3 mm	**1.8 mm** 1.3-2.6 mm	**1.6 mm** 1-2.3 mm	**1.9 mm** 1.2-2.8 mm
RAYNUM	**25** 18-33	**18** 4-33	**21** 6-31	**22** 13-33	**14** 7-24	**17** 4-26

RSTRAPLN	**7.45 mm** 4-10 mm	**5.7 mm** 2.2-10 mm	**4.9 mm** 0.3-7.5 mm	**5.5 mm** 3.8-7.1 mm	**5.9 mm** 2.3-9.5 mm	**6.1 mm** 2.2-10 mm
RSTRAPWD	**1.3 mm** **0.6-2**	**0.96 mm** 0.3-2.2	**0.97 mm** 0.4-2 mm	**0.9 mm** 0.4-1.75 mm	**0.93 mm** 0.3-1.65 mm	**1 mm** 0.6-2.2 mm
DISCNUM	**27** 15-38	**21** 10-38	**23** 12-38	**21** 10-35	**19** 10-37	**20** 11-36
DCORLN	**5.4 mm** 4.1-7.3	**4.0 mm** 2.6-5.5	**3.7 mm** 2.7-4.5	**3.7 mm** 2.8-5	**4.4 mm** 2.9-5 mm	**4.2 mm** 2.6-8 mm
DLOBLN	**0.94 mm** 0.65-1.6 mm	**0.88 mm** 0.4-2 mm	**0.62 mm** 0.4-1.9 mm	**0.8 mm** 0.45-1.4 mm	**1.2 mm** 0.5-2 mm	**0.8 mm** 0.5-2
DACHLN	**1.17 mm** 0.7-1.8 mm	**1.0 mm** 0.5-2 mm	**0.93 mm** 0.5-2.1 mm	**0.94 mm** 0.5-1.5 mm	**1.2 mm** 0.7-2.0 mm	**1.0 mm** 0.6-2 mm
DPAPLN	**5.5 mm** 4-7.3 mm	**3.8 mm** 2-5.6 mm	**3.6 mm** 2.7-4.7 mm	**3.9 mm** 3-5 mm	**3.7 mm** 2-4.9 mm	**4.1 mm** 2.5-5.6