

A Taxonomic Research Update of Cultivated Liriopogons

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Summary. A taxonomic revision of liriopogons (*Liriope* Lour., *Ophiopogon* Ker-Gawl) cultivated in the United States is in progress at North Carolina State Univ. Germplasm was obtained from nurseries, botanical gardens/arboreta, and private collectors. Nearly 17% of the germplasm was misidentified to genus; nearly 36% misidentified to species; and nearly 14% received under one name from one source contained mixed germplasm. Preliminary analysis of data indicate a minimum of five species of *Liriope* and eight species of *Ophiopogon* are in cultivation. Six additional taxa have not flowered. Polygonal graph analysis was used to visualize biometrical data and observe relationships among taxa. Additional taxonomic publications for segregation of genera and species of liriopogons, including an inventory of taxa, quantitative descriptions, illustrations, and keys, are in progress.

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Liriopogons (*Liriope* Lour., *Ophiopogon* Ker-Gawl) cultivated in the United States have complex taxonomic problems that need to be resolved (Fantz, 1993). These include: 1) an inadequate inventory of cultivated liriopogons, 2) a lack of quantitative descriptions of taxa, 3) the absence of keys to aid identification, 4) a lack of vouchers for morphological comparison, 5) the inaccessibility and scarcity of Asian floras and lack of liriopogon revisions in the literature, and 6) nomenclatural questions raised from the classification level of family to cultivar. Nursery practices of sexual propagation of cultivars, plant substitution, mislabeling of cultivars, and seedling invasion into cultivar stock lead to cultivar degradation that makes cultivar differentiation difficult.

Research was initiated at North Carolina State Univ. to address taxonomic problems associated with cultivated liriopogons (Fantz, 1993). The objective was to accumulate germplasm representative of all taxa of liriopogons cultivated in the United States, grow them together for morphological comparison, and prepare a taxonomic revision of liriopogons cultivated in the United States.

Materials and methods

Germplasm of liriopogons for this taxonomic research was obtained by purchased acquisition from nurseries, donations by nursery operators, liriopogon collectors and botanic gardens/arboreta, and through the plant exchange program of the North Carolina State Univ. Arboretum (Table 1). Germplasm of liriopogon is sold commonly in the nursery-landscape trade by "bibs," a term lacking in modern horticultural references (e.g., Bagust, 1992; Huxley, 1992). A bib is "a shoot or plantlet consisting of one crown with leaves and attached roots and/or stolons" according to a compilation of definitions from nursery operators.

Each taxa received was potted using a medium consisting of 2 potting soil :1 sand :1 peatmoss :1 bark humus (by volume) and placed in a greenhouse. One bib was maintained in the greenhouse as a stock plant. The other bibs were transplanted in the spring in beds at the Horticultural Field Laboratory, Raleigh. Beds were prepared by tilling the soil (Piedmont clay), fumigating, and adding 5 cm of ground pine bark mulch. The beds

were covered with a 55% shade cloth. Individual plants were tracked by a coding system.

A data sheet was prepared that included 78 morphological characters, 36 vegetative characters, and 42 reproductive characters. Herbarium vouchers were made of each collection at different stages of growth. Data were recorded from 947 herbarium vouchers of liriopogons and from observations and measurements obtained from live plants. Parallel quantitative descriptions of each taxa were prepared from these morphological data.

Polygonal graph analyses were made of similar taxa. Polygonal graphs are used to compare graphically the variation patterns within a taxa (Radford et al., 1974). This taxonomic tool permits visualization of biometric measurements and observation of differences or similarities. Both qualitative (e.g., flower color) and quantitative (e.g., leaf width) characters can be used. A series of axes are drawn equidistant through a central point. A minimum of reliable, segregating, morphological characters are chosen and plotted on the axes. Characters can be plotted by points on each axis, representing measurements, or by coded values whose distances represent a qualitative character (e.g., clumping, stoloniferous) or a range of measurements (e.g., narrow leaves, 1 to 5 mm; medium leaves, 5 to 7 mm; broad leaves, 7 to 11 mm). Each plotted

Table 1. An inventory of names of cultivated liriopogon species in research study.

<i>Liriope</i> sp.	<i>Ophiopogon</i> sp.
<i>L. exiliflora</i>	<i>O. arabicus</i>
<i>L. gigantea</i>	<i>O. bockianus</i> ^z
<i>L. graminifolia</i>	<i>O. bodineri</i> ^z
<i>L. grandiflora</i>	<i>O. bodinieti</i> ^z
<i>L. kansuensis</i> ^z	<i>O. chekangensis</i>
<i>L. minor</i>	<i>O. clarkei</i>
<i>L. muscari</i>	<i>O. graminifolia</i>
<i>L. platyphylla</i>	<i>O. intermedius</i>
<i>L. spicata</i>	<i>O. jaburan</i>
	<i>O. japonicus</i>
	<i>O. marmoratus</i> ^z
	<i>O. nana</i>
	<i>O. nigra</i>
	<i>O. nigrescens</i>
	<i>O. ohwii</i>
	<i>O. parviflorus</i> ^z
	<i>O. planiscapus</i>
	<i>O. spicatus</i>
	<i>O. wallichianus</i> ^z

^zRecent accessions.

point on art axis is connected by straight lines, resulting in a polygonal image of the taxa. These polygons can be compared with polygons of other taxa for similarities and differences.

Results and discussion

Germplasm accumulated for this project currently includes 22 named species (Table 1), eight labeled as *Liriope*, and 13 labeled as *Ophiopogon*. There are 88 labeled cultivars (Table 2). Four bibs were obtained for most taxa. Only one or two bibs of less-common clones and species could be obtained from sources because of the scarcity of the taxa and because of the higher cost (\$15 to \$26 per bib). Bibs received for this study from nursery operators varied in size from one plantlet with juvenile leaves 2 to 5 cm long with sparse roots, to several plantlets with mature leaves and well-developed root systems.

Morphology. Some accessions grew slowly, taking up to 4 years to bloom. Not all collections have flowered: some flowered, but did not set fruit. Reproductive material is required for accurate identification of taxa. Therefore, current descriptions for some accessions of *liriopegons* are incomplete. These accessions must be grown for one or more additional years in order for reproduction to occur and provide the necessary morphological structures needed for data accumulation.

Comparison and analysis of avail-

able morphological data indicated a minimum of 13 species in the trade, five species of *Liriope*, and eight species of *Ophiopogon*. Two distinguishable species of *Ophiopogon* currently lack an identification. Recent acquisitions from arboreta could add possibly six more different species (Table 1, recent accessions), or help in the identification of the two unknowns.

Misidentifications. Many *liriopegons* look similar vegetatively, and therefore are difficult to distinguish. Many nursery operators commonly define *Liriope* as growing taller with broader leaves and *Ophiopogon* as smaller in stature with narrower leaves. This is not accurate; therefore, errors in identification are expected. To date, 17% of the germplasm studied was misidentified to genus. Most of these misidentifications were species of *Ophiopogon* labeled as a *Liriope*. Commonly confused were *Liriope spicata* Lour. with *Ophiopogon japonicus* (Thunb.) Ker-Gawl., and *Liriope muscari* (Decne.) L.H. Bailey with "Aztec grass," an *Ophiopogon* as first reported by Adams (1989). Plants obtained for this study sold as *L. kansuensis* C.H. Wright and *L. graminifolia* Hort. were *Ophiopogon*. *Ophiopogon planiscapus* Nak. occasionally was misidentified as *L. spicata*.

Nearly 36% of the germplasm was labeled with the wrong specific epithet. Four names are commonly used in the trade: *L. muscari*, *L. spicata*, *O.*

planiscapus, and *O. japonicus*. Plants acquired as *L. muscari* in this study were a mixture of three species. Plants acquired as *O. japonicus* included four distinct species. In addition, *L. muscari* was misidentified as *L. spicata*. *Ophiopogon planiscapus* is distributed under the names *O. arabicus* Hort., *O. nigra* Hort. and *O. nigrescens* Hort. The latter three names are illegitimate.

Nearly 14% of the germplasm from one source under one name was improperly identified. For example, one accession (87-022), labeled as 'Lilac Beauty', contained four bibs. One bib had purple flowers with the erect flowering stalked unbranched (= 'Lilac Beauty'), whereas two bibs had pinkish flowers and a branched axis in the flowering stalk (= 'Christmas Tree'). The fourth bib died before flowering.

These errors of selling mixed germplasm under one name may result from misidentification of stock material, or from nursery cultural practices (sexual reproduction of clones, plant substitution, seedling invasion, labeling practices), as defined by Fantz (1993). It is obvious from material received for this study that accurate germplasm identification of *liriopegons* is a major problem in the nursery-landscape industries.

Polygonal graphs. Morphological data indicated that four species are being sold under the name *O. japonicus*. Polygonal graphs were prepared using vegetative and flowering characters to visualize data for these species (Fig. 1). Polygonal graphs 1A to 1C are impostors, quite dissimilar polygons to 1D, which represents the true *O. japonicus*.

Polygonal graphs (Fig. 2) were prepared using foliar and reproductive characters for four variegated cultivars reported as *L. muscari*. Adams (1989) reported much confusion over 'Silvery Sunproof', which is regarded as distinct from 'Variegata', but often has been confused with it. The polygonal graphs 2A ('Silvery Sunproof') and 2B ('Vanegata') substantiate the close relationships of these two clones, as the polygons are very similar in shape.

'Sunproof is regarded as an improved selection derived from 'Silvery Sunproof'. The polygonal graphs 2A and 2C (Fig. 2) indicate a remarkable difference in nearly all characters plotted raising skepticism that 'Sunproof' (2C) is derived from 'Silvery Sunproof' (2A). The main similarity appears to be only in name and the variegated

Table 2. An inventory of names of cultivated *liriopegon* cultivars in the research study.

Alba	Green Midget	Monroe	Silvery Dragon
Arabicus	Gyoku-Ryu	Monroe White	Silvery Sunproof
Aritaki	Hakuryu	Moores White	Sunproof
Aztec	Hakuryu Dwarf	Nana	Superba
Big Blue	Hakuryu Ko	New Orleans	Tamaryu Nishiki
Big Blue Regal	Hawks Feather	New Wonder	Tidwells Big Blue
Blue Cushion	Improved Muscari	Nigrescens	Torafu
Blue Spire	Ingwersen	Original Big Blue	Tracbert White
Border Gem	Intermedia	Peedee Ingot	Variegata
C.T. Tanner	Jeanerette	Platypus	Variegata Alba
Christmas Tree	John Burch	Purple Bouquet	Variegata White
Crows White	Kigimafukiduma	Regal	Variegated
Crested White	Korean Variegated	Rocket	Variegated Evergreen Giant
Curly Twist	Kioto	Royal Purple	Variegated White
Densiflora	Korean Variegated	Samantha	Flowered
Ebony	Kyoto Dwarf	Sheffield	Variegatus
Ebony Knight	Lilac Beauty	Shiro Tama Hime	Webber
Evergreen Giant	Magestic	Shiroshima Ryu	Webster Wideleaf
Franklin Mint	Majestic	Silver Banded	White on White
Gilner White	Majestic	Silver Dragon	Wonder Evergreen
Gold Banded	Majestic Variegated	Silver Mist	Xmas
Grandiflora	Miniature	Silver Showers	
Grandiflora White	Minor	Silvery Midget	

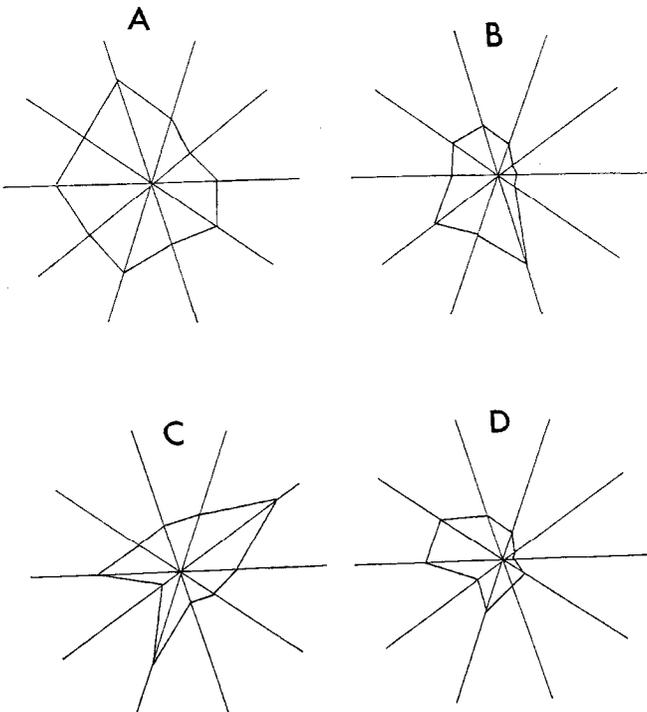


Fig. 1. Polygonal graphs of four species sold under the name of *Ophiopogon japonicus*. Ten axes counterclockwise from left horizontal represent style length, perianth lobe length, leaf length, leaf width, average scape length, average rachis length, pedicel length, number of fascicles, foliar bract length, and perianth tube length, respectively. (A) Imposter #1; (B) Imposter #2; (C) Imposter #3; (D) *Ophiopogon japonicus*.

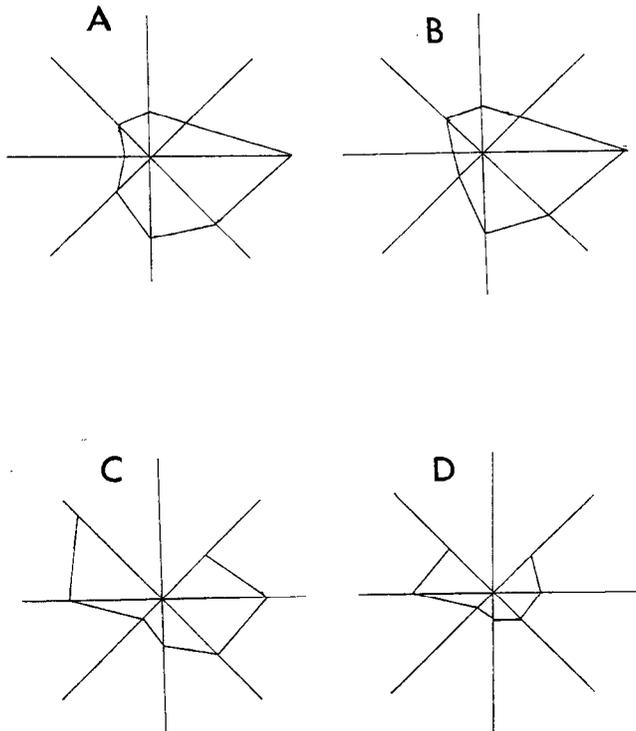


Fig. 2. Polygonal graphs of four variegated cultivars sold under the name of *Liriope muscari*. Eight axes counterclockwise from left horizontal represent peduncle rachis difference, bud persistence, fruit diameter, growth habit, average scape length, average peduncle length, average rachis length, and flower duration, respectively. (A) 'Silvery Sunproof'; (B) 'Variegata'; (C) 'Sunproof'; (D) 'Silver Midget'.

foliage. An unexpected relationship was discovered when a polygonal graph was prepared for 'Silvery Midget' (2D) and compared to these other varie-

gated clones. The polygon suggests that 'Silvery Midget' may be a dwarf selection of 'Sunproof'.

Polygonal graphs are being re-

vised using different morphological characters, as the database expands to obtain additional relationships. Characters used and the number of axes required also will change depending on the similarity of taxa and the classification level being compared.

Taxonomy. Cultivated liriopogons present a complex taxonomic problem. The magnitude of the problem has been a major obstacle since initiation of this research, particularly with new taxa entering the trade each year. Another major obstacle has been accurate species determination. Liriopogons are native to Asia, where floras are unavailable, hard to access when available, and sometimes difficult to translate when obtained. The number of impostors within species was a surprise. Morphologically, they can be segregated, but not all have been identified accurately with a name.

It is difficult to provide an inventory of cultivars when the problem with species segregation and identification is not completed. Originally, 25 to 30 cultivars were expected, but 89 named cultivars have been collected.

Conclusion

A taxonomic revision of liriopogons cultivated in the United States is currently in progress. Almost all cultivars in the study can be assigned to one of 13 morphologically defined species. Potentially, six additional species, not yet in the trade but available in aboretta collections, need further study. Further macromorphological research will be continued on cultivars and newer taxa to provide an inventory of cultivated liriopogons, quantitative descriptions, and keys to identification of taxa.

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