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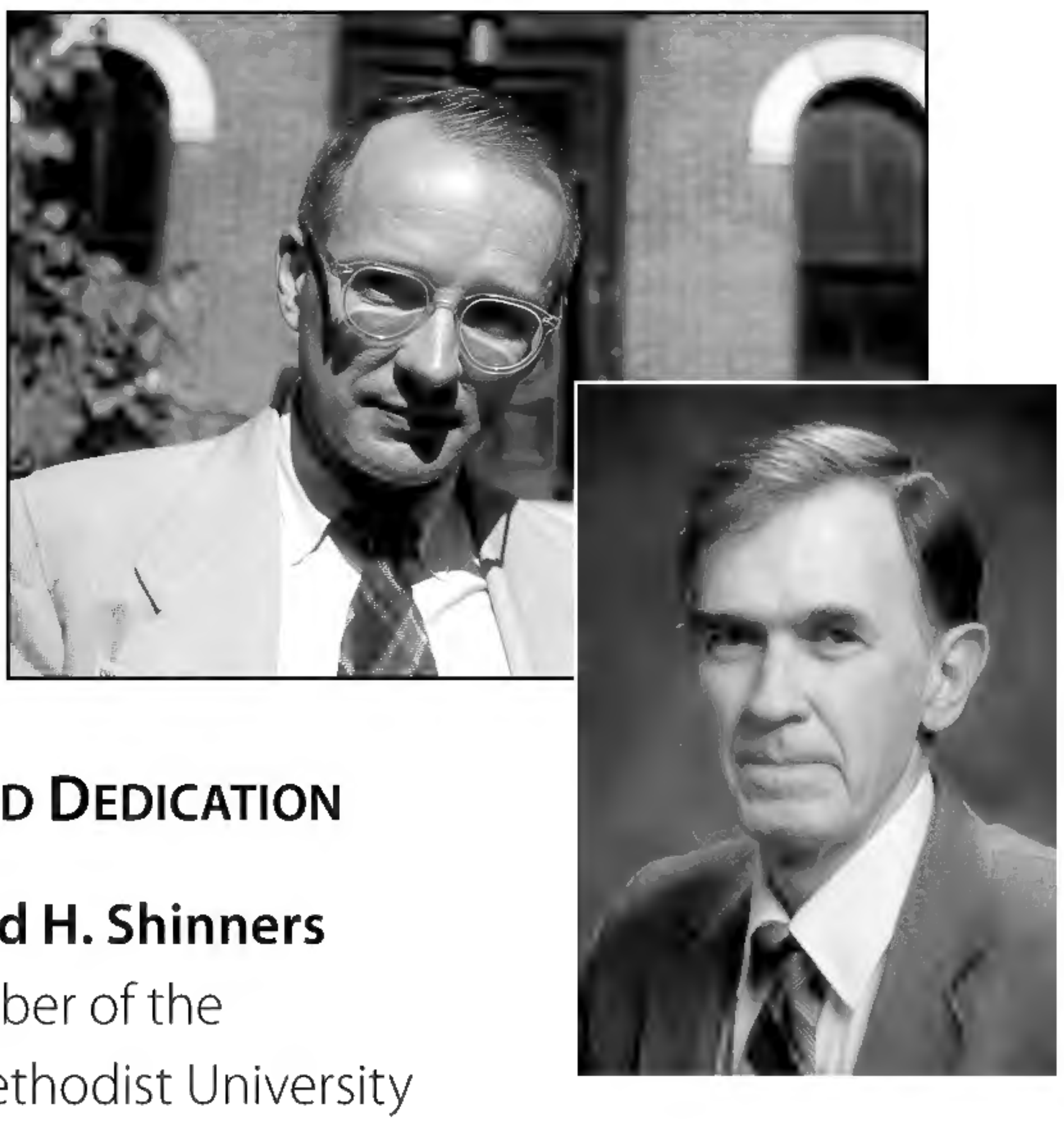

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1962—Lloyd H. Shinners (left), a member of the Southern Methodist University (SMU) faculty and a prolific researcher and writer, published the first issues of *Sida, Contributions to Botany* (now *J. Bot. Res. Inst. Texas*)

1971—William F. Mahler (right), professor of botany at SMU and director emeritus of BRIT, inherited editorship and copyright.

1993—BRIT becomes publisher/copyright holder.

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Electronically tinted botanical illustration of *Liatris aestivalis* originally used on BRIT's anniversary poster 2001. Summer gayfeather flowers mid Jul–Aug(–Sep) and is endemic to Oklahoma and Texas. Sida 19:768. 2001. Botanical illustration by Linny Heagy ©2001.

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THE WORLD'S SMALLEST BAMBOO: *RADDIELLA VANESSIAE* (POACEAE: BAMBUSOIDEAE: OLYREAE), A NEW SPECIES FROM FRENCH GUIANA

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ABSTRACT

Raddiella vanessiae (Poaceae: Bambusoideae: Olyreae), a new species of herbaceous bamboo, is described and illustrated. It is probably the smallest bamboo in the world. Known only from savannas in French Guiana, it appears to be related to **R. esenbecki***i* and **R. minima,** differing from both in its much smaller size and leaf blades.

Key words: Bamboo, Bambusoideae, French Guiana, Olyreae, Poaceae, **Raddiella**

RESUMEN

Raddiella vanessiae (Poaceae: Bambusoideae: Olyreae), una nueva especie de bambú herbáceo probablemente el más pequeño del mundo, es descrita e ilustrada. Es conocido solamente de las sabanas de la Guyana Francesa y está relacionado con *R. esenbeckii* y *R. minima*, pero difiere de ambas especies por su menor tamaño y hojas también mucho más pequeñas.

While some of the approximately 1,000 members of the Bambusoideae may be over 30 m tall, those of the herbaceous tribe Olyreae can be only a few tens of centimeters tall (Judziewicz et al. 1999). I herein describe a new species of *Raddiella* Swallen from French Guiana that, at maturity, is only 2 cm tall and is thus world's smallest bamboo:

Raddiella vanessiae Judz., sp. nov. (**Figs. 1–2**). Type: FRENCH GUIANA: Savane Lambert 1 (near Montsinery), 4°53'N, 52°31'W, elev. 10 m, savanes herbacées, 15 May 2001, flowering, Vanessa Hequet 1281 (holotype: US!; isotypes: CAY, K, P).

A *Raddiella minima* differt statura minore (10–20 mm), lamina minore (2.7–3.3 × 1.8–2.1 mm), flosculis femina minoribus (0.7–0.9 mm), et caryopsides hilo brevi-lineare.

Mat-forming annual grass with freely-branching culms 10–20 mm tall; culm terete, glabrous, purplish, shining, the nodes retrorsely ciliolate. Leaves in loose complements of 3–5, with sheaths 1.8–3.2 mm long, inflated, striate, 7-nerved, retrorsely pubescent with hairs ca. 0.2 mm long; outer ligule absent; inner ligule a line of erect cilia 0.2–0.3 mm long; pseudopetioles 0.2–0.3 mm long, puberulent; blades 2.7–3.3 mm long, 1.8–2.1 mm wide (area ca. 3.8–5.5 sq. mm), ovate, acute to slightly apiculate at apex, truncate and slightly asymmetrical at base, apparently folding upwards (involute) under drought stress or at night, with a central midvein and 6–7 pairs of lateral veins, the upper (adaxial) surface with veins with scattered appressed macrohairs 0.05–0.15 mm long, especially near the blade base and margins, the abaxial (lower) surface purple, glabrous, the blade margins antrorsely scaberulous. Female inflorescences barely protruding from middle and upper leaf sheaths, a reduced, contracted panicle bearing 2–5 spikelets, the branches and pedicels 0.3–1 mm long, filiform, glabrous, slightly cupulate at the apex; female spikelets 1–1.4 mm long, ultimately deciduous but the floret falling first; rachilla internode between glumes somewhat swollen and adherent to the base of the lower glume; glumes as long as spikelet, subequal, ovate-lanceolate, acute, green, membranous, somewhat laterally compressed, gaping 20–30° at maturity, 1–3-nerved, retrorsely pubescent with macrohairs ca. 0.2 mm long, the margins cartilaginous; floret 0.7–0.9 mm long, 0.35–0.45 mm wide, lanceolate-ellipsoid to ovoid, 3-nerved, white, shining, cartilaginous at maturity, deciduous, glabrous, the apex of the lemma acute and slightly cucullate; lemma much-enfolding the rounded, bicarinate palea, the palea of the same texture as

Fig. 1. Photograph of plant of *Raddiella vanessiae* showing leaf blades that fold involutely to expose their purple undersurfaces. Based on *Hequet 1281* (US).

the lemma; female flower with two subplumose stigmas. Caryopsis 0.65–0.95 mm long, 0.35–0.4 mm wide, ovoid-ellipsoid, tan to brown, glabrous, slightly dorsally compressed, the embryo basal, 0.1 mm long and 0.2 mm wide, the hilum short-linear, 0.15 mm long, dark brown, located about 0.1 mm above the base of the caryopsis. Male inflorescence a reduced panicle included in or barely protruding from terminal leaf sheath, consisting of just one or two spikelets on filiform, glabrous, slightly cupulate pedicels; male spikelets 1.1–1.2 mm long, narrowly lanceolate, hyaline, glabrous, soon deciduous; glumes absent, the lemma 3-nerved, the palea ca. 1 mm long, bicarinate; stamens 3, the mature anthers brown, 0.4–0.5 mm long.

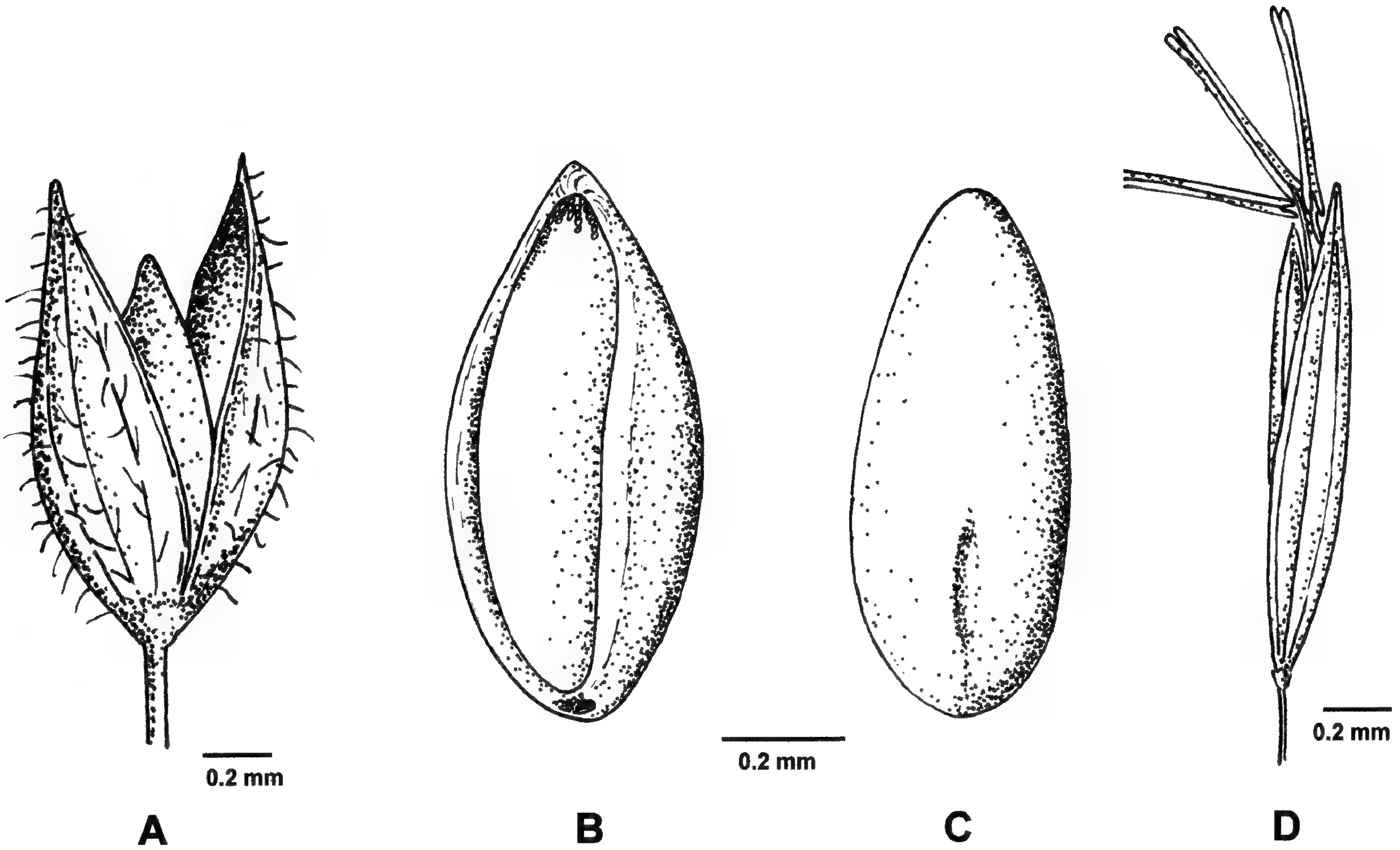

Fig. 2. ***Raddiella vanessiae*. A. Female spikelet, lateral view showing gaping glumes and exposed apex of floret. B. Female floret, slightly oblique ventral view. C. Caryopsis, ventral view showing short-linear hilum. D. Male spikelet, lateral view. Based on *Hequet 1281* (US). Illustration by E.J. Judziewicz.**

Additional collection examined (paratype): **FRENCH GUIANA:** Roura, savane marécageuse incluse dans la forêt á 8 km ESE du degrad de Roura [approximately 4°40'N, 52°20'W], bord de mare, trés petite herbs en touffes, sur la berge nue, au ras de l'eau; feuilles rougeâtres dessous; epillets axillaries, sessiles, vert clair, en partie caches dans les gaines foliares, 21 Apr 1979, A. *Raynal-Roques & J. Jérémie 21288* (CAY).

LEAF AND SPIKELET ANATOMY

A Hitachi S3400 scanning electron microscope was used in the environmental mode to record features of the leaves and spikelets of *Raddiella vanessiae*; uncoated, air-dried material was used. Hand cross-sections of the leaf blades were also made after softening in Pohlstoffe wetting agent. The descriptions below follow the format of Watson and Dallwitz (1992 onwards):

Abaxial leaf blade epidermis (Fig. 3). *Papillae* present and abundant in both costal and intercostal zones, simple, 4–5 µm in diameter, the *papillae* on intercostals long cells generally in two rows. *Intercostal long cells* with very sinuous walls. *Bicellular microhairs* present, elongated, clearly two-celled, ca. 40 µm long, the distal cell ca. 23 µm long, ca. 8 µm in diameter and remaining inflated in the SEM, the apical cell ca. 17 µm long and deflated by the SEM. *Stomata* common, 18–23 µm long, the subsidiary cells papillate (two on each but fairly inconspicuous). *Intercostal silica bodies* vertically elongated, ca. 20 µm tall, nodular.

Leaf blade transverse section. *Blade* ca. 40 µm thick at midnerve. *Mesophyll* consisting or a single abaxial palisade of arm cells. *Fusoid cells* absent. *Bulliform cells* in discrete, regular, intercostals, adaxial, fan-shaped groups of 3–6 cells, the largest cells 22–25 µm tall and 18–22 µm wide. *Marginal scabrae* 15–20 µm long. *Vascular bundles* all accompanied by sclerenchyma.

Female floret (Fig. 4). Floret smooth except for a few short vertical files of 6–12 µm long circular excavations or pits near the summit of the palea, or occasionally one or two ca. 40 µm long bicellular microhairs present on the uppermost margins of the lemma.

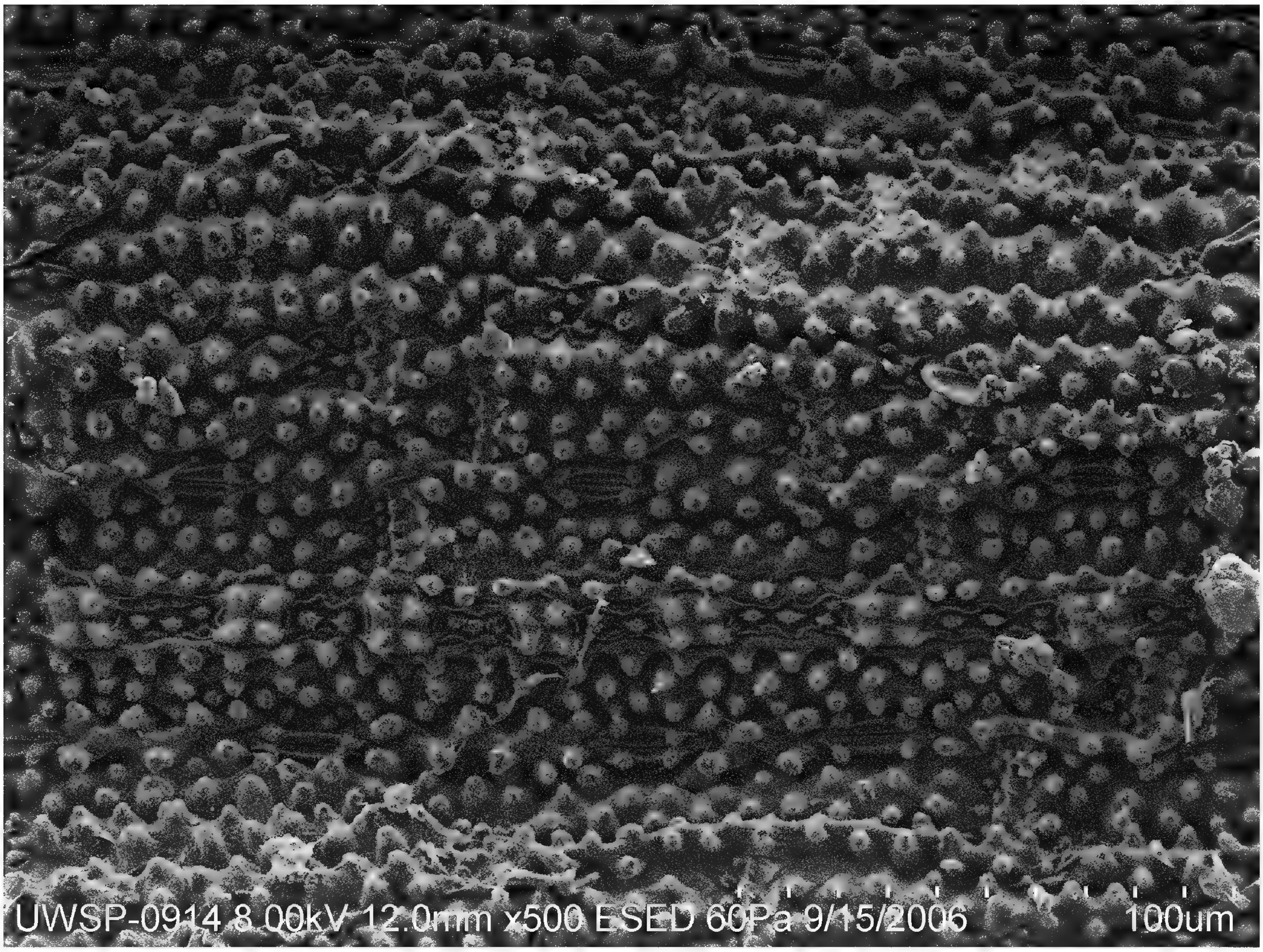

Fig. 3. Scanning electron micrograph of lower (abaxial) leaf blade surface of *Raddiella vanessiae* showing papillate long cells, stomates, bicellular microhairs with collapsed apical cells, and vertically oriented olyroid silica bodies. Based on *Hequet 1281* (US).

DISCUSSION

Raddiella vanessiae is the smallest bambusoid grass yet known, even smaller than *Raddiella minima* Judz. & Zuloaga (Zuloaga & Judziewicz 1991; Zuloaga et al. 1993; Judziewicz et al. 1999). Table 1 shows that both *R. minima* and *R. vanessiae* have smaller leaves than the endemic Cuban olyroid *Mniochloa pulchella* (Griseb.) Chase (Zuloaga et al. 1993). The new species appears to be related to both *R. minima* (known only from the Brazilian type collection made about 1600 km to the south of French Guiana) and the widespread Neotropical species *R. esenbeckii* (Steud.) C.E. Calderón & Soderstr. but is much smaller than either one. The new species is also distinguished from these related species by its smaller female florets and female lemmas that are slightly cucullate at the apex. The follow key distinguishes the three taxa in the *Raddiella esenbeckii* species complex:

1. Plants 8–40 cm tall, perennial; leaf blades 9–22 mm long, 4–11 mm wide, with fusoid cells present; female spikelets 1.9–2.7 mm long, the glumes firmly membranous, the floret 1.6–2 mm long; anthers 1.3–3 mm long; widespread in tropical South America, Trinidad, and Panama __________ **Raddiella esenbeckii**
1. Plants 1–6 cm tall, annual; leaf blades 2.7–6 mm long, 1.8–3.3 mm wide, with fusoid cells absent, at least in R. vanessiae; female spikelets 1–1.4 mm long, the glumes just membranous, the floret 0.7–1.2 mm long; anthers 0.4–0.6 mm long; rare endemics of tropical South America (French Guiana and Pará, Brazil)
   2. Plants 3–6 cm tall; leaf blades 4–6 mm long, 2.7–3.3 mm wide (area ca. 8.5–15.5 sq. mm); female glumes 3-nerved; female floret 0.9–1.2 mm long; hilum punctiform; southern Pará, Brazil __________ **Raddiella minima**
   2. Plants 1–2 cm tall; leaf blades 2.7–3.3 mm long, 1.8–2.1 wide (area ca. 3.8–5.5 sq. mm); female glumes 1–3-nerved; female floret 0.7–0.9 mm long; hilum short-linear; French Guiana __________ **Raddiella vanessiae**

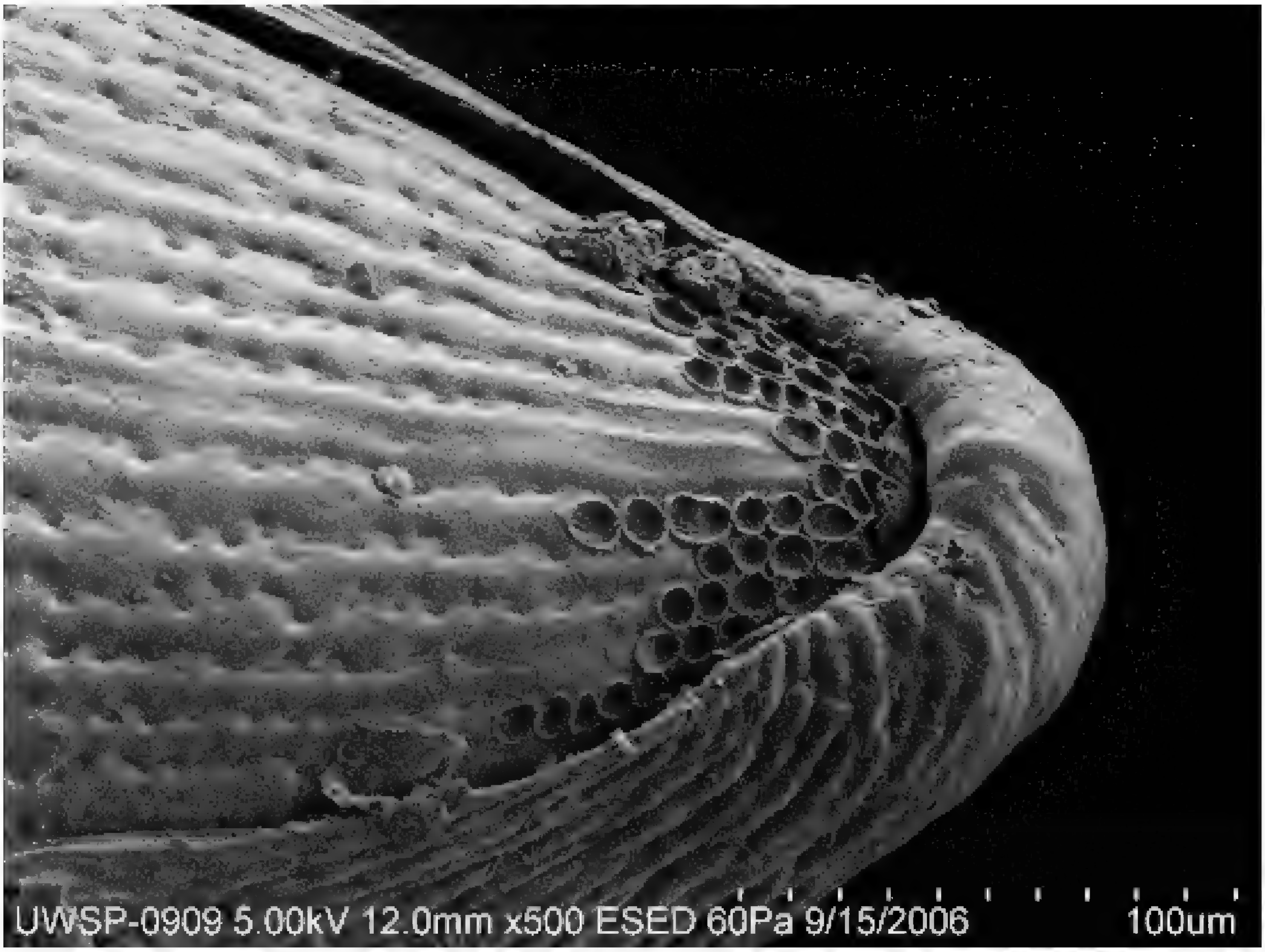

Fig. 4. Scanning electron micrograph of summit of ventral side of female floret of *Raddiella vanessiae* showing circular excavations or pits at summit of palea (note also the slightly cucullate apex of the enfolding lemma). Based on *Hequet 1281* (US).

All three species in the putative *Raddiella esenbeckii* complex share 1) asymmetrically-based leaf blades that are often anthocyanic (purple) beneath; 2) leaves that exhibit sleep movements (the blades folding upwards); 3) female spikelets with essentially glabrous, smooth, shining florets that fall before the tardily deciduous glumes; and 4) an open savanna rather than waterfall-base habitat. The remaining species of *Raddiella* generally have elliptical leaf blades lacking anthocyanic pigment and apparently not exhibiting sleep movements; female florets that are variously papillate throughout; and a waterfall-base (phreatophyte) habitat.

Raddiella vanessiae may be one of the few, or perhaps the only, member of the Bambusoideae with a truly annual habit. The Cuban herbaceous bamboos, although small, are all cormose perennials (Zuloaga et al. 1993); congeneric *Raddiella* species are apparently all perennial except possibly for *R. minima*; and the only other putative annual is *Olyra filiformis* Trin. from Bahia, Brazil, which is reported (Soderstrom & Zuloaga 1989) to be either a cespitose perennial or perhaps an annual. In any case it is a much larger plant 40–125 cm tall.

HABITAT

The type locality of *Raddiella vanessiae* is a lightly-vegetated savanna dominated by grasses (Poaceae), especially *Andropogon bicornis* L. and *Panicum cyanescens* Nees, and sedges (Cyperaceae) including *Rhynchospora holoschoenoides* (Rich.) Herter and *Scleria cyperina* Kunth. The soil is sandy and the lower parts of the savanna seasonally flood, but *Raddiella vanessiae* grows in the driest (highest) part, where it is uncommon (Chaix et al. 2002). See http://www.cayenne.ird.fr/aublet2/Selection_Collecteur.php3 for a complete list of Vanessa

TABLE 1. Comparison of *Raddiella vanessiae* with related species and *Mniochloa pulchella*. Approximate leaf blade area was calculated from the formula a = πlw/4 (the formula for the area of an ellipse), where l is leaf blade length and w is the blade width.

Character	***Raddiella esenbeckii***	***Raddiella minima***	***Raddiella vanessiae***	***Mniochloa pulchella***
Habit	Cespitose perennial	Annual?	Mat-forming annual	Cormose perennial
Plant height (cm)	8–40	3–6	1–2	3–12
Leaf blade length (mm)	9–22	4–6	2.7–3.3	7–15
Leaf blade width (mm)	4–11	2.7–3.3	1.8–2.1	2–4
Leaf blade area (square mm)	28–104	8.5–15.5	3.8–5.5	11–47
Fusoid cells	present or absent	?	absent	absent
Leaf blade sleep movements?	yes	yes	yes	no?
Female spikelet length (mm)	1.9–2.7	1–1.4	1–1.4	2.2–2.8
Female spikelet glume texture	firmly membranous; becoming blackish at maturity	membranous; remaining green at maturity	membranous; remaining green at maturity	delicately membranous, green at maturity
Female spikelet glume nerve number	3	3	1-3	3
Female floret length (mm)	1.6–2	0.9–1.2	0.7–0.9	2.2–2.8
Male spikelets/inflorescence	(1–)2–4	1	1 or 2	(3–)7–12
Male spikelet length (mm)	3–5	ca. 1.3	1.2	1.3–1.7
Anther length (mm)	1.3–3	0.6	0.4–0.5	0.8–1
Caryopsis length × width (mm)	1–1.2 × 0.7–0.8	0.7 × 0.6	0.65–0.95 × 0.35–0.4	1.5–2 × 0.5–0.6
Hilum morphology	short-linear	punctiform	short-linear	linear
Distribution	Panama, tropical South America, Trinidad	Southern Pará, Brazil	French Guiana	Cuba

Hequet's specimens (1238–1245, 1250–1263, 1268–1284) collected on 15 May 2001 in the Savane Lambert. Google Earth (http://earth.google.com/) shows "Savane Lambert" to be several square kilometers in area and situated about 20 km WSW of the city of Cayenne. The Raynal-Roques & J. Jérémie specimen of *Raddiella vanessiae* is from a swamp savanna on the Roura-Kaw road, about 27 km by air from the type locality.

Although widespread in South America, there are only two records of the related species *Raddiella esenbeckii* from French Guiana, from Passoura and the Savane des Singes (Judziewicz 1991), about 25 km NW of the type locality of *R. vanessiae*.

LEAF AND SPIKELET ANATOMY

The leaf anatomy of *Raddiella vanessiae* is more or less consistent with descriptions of the anatomy of *R. esenbeckii* (Watson & Dallwitz 1992 onwards) with one possible exception. Fusoid cells are absent in *Raddiella vanessiae*, but apparently can be either absent (Calderón & Soderstrom 1967; Renvoize 1985; this study, based on hand sections of *R. potaroensis* Soderstr. (*Redden et al. 1465,* Guyana, UWSP)), or present (Watson & Dallwitz 1992 onwards, based on *R. esenbeckii*; this study, based on hand sections of *R. esenbeckii* (*Schwab 491,* Aripo Savanna, Trinidad, UWSP) in species of *Raddiella*. While fusoid cells are a characteristic feature of the leaf blades of most species of the Bambusoideae, they are absent in several distantly related taxa in the herbaceous Olyreae (Judziewicz et al. 1999: 33), and this absence is probably a derived condition: the small Cuban genera *Ekmanochloa* Hitchc. and *Mniochloa* Chase (Zuloaga et al. 1993) and the Brazilian *Parodiolyra ramosissima* (Trin.) Soderstr. & Zuloaga (Renvoize 1985; Soderstrom & Ellis 1987) all lack fusoid cells.

In leaf blade transverse section, Watson and Dallwitz (1992 onwards) could not discern arm cells in *Raddiella esenbeckii*; however, these were easily visible in hand-cut sections of *R. vanessiae* blades and in blades of *R. esenbeckii* (based on *Schwab 491*). The micromorphology of the female floret of *Raddiella vanessiae* is similar to that of *R. esenbeckii* (Zuloaga & Judziewicz 1991): its surface is essentially smooth except for small longitudinal files of curious tiny "excavations" or "pits" at the summit of the palea that may represent deflated cells. Seemingly identical "pits" are present on the female paleas of other olyroid bamboos such as *Parodiolyra lateralis* (Nees) Soderstr. & Zuloaga and various species of *Olyra* such as the widespread common species *O. latifolia* L. (Soderstrom & Zuloaga 1989).

ETYMOLOGY

At the suggestion of my colleague Isabelle Girard, we had considered naming this new species for the mythical country of Lilliput (from Jonathan Swift's novel *Gulliver's Travels*) where it would be an appropriately-sized bamboo for the use of the Lilliputians. Instead, we have chosen to recognize Vanessa Hequet, whose type collection and careful and detailed characterization of the species' savanna community habitat was so useful in preparing this paper. The epithet seems doubly appropriate: Vanessa was Swift's nickname for his close friend Esther Van Homrigh.

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We thank Fernando O. Zuloaga and Reyjane Patricia de Oliveira for helpful reviews, Lynn G. Clark and Carol Annable for useful advice, Paul M. Peterson and Steve Smith (both US) for the loan, Jean-Jacques de Granville (CAY) for type specimen information and alerting me to the presence of a second collection, type specimen collector Vanessa Hequet for extensive habitat information, to Virginia Freire for help with the Spanish translation, and Isabelle Girard for suggesting species epithets. Funding for this research was provided by a University of Wisconsin-Stevens Point Faculty Development Grant for travel to Washington, D.C. (Judziewicz) and National Science Foundation CCLI Program grant #0511131 for the purchase of the Hitachi S3400 SEM (Sepsenwol).

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BOOK REVIEWS

Pierre Delforge. 2006. **Orchids of Europe, North Africa and the Middle East.** (ISBN-13: 9780881927542; ISBN-10: 0881927546, hbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax). $39.95, 640 pp., 1270 color photos plus several line drawings and watercolors, 5" × 7½" (190 × 125 mm).

Delforge's previous works have always been well received as they should be. His work is meticulous and although limited to brief entries for each species, as complete as space permits. The gallery of photographs is mind-boggling. This current book is no exception. It combines the best of all of his other books and presents a single volume that is both an update of previous works and much new material as well as needed revisions both taxonomically and nomenclaturally. Technically a 3rd edition of his original work of the same name it has more than 200 additional pages than previous French editions.

Introductory chapters on basic orchid information—anatomy, life cycles, reproduction and orchid identification are detailed and easy to understand with many excellent graphics. The following chapters of species accounts are broken into four chapters and arranged by subtribes and the genera arranged systematically. Although this arrangement is excellent for the botanist, it does make it difficult to find a specific genus or species quickly without consulting the index. Because of the large geographic area covered by the book, one must read through the descriptions very carefully to find those species that might occur where the reader is exploring. This is not necessarily a negative aspect of the book but does force the reader into reviewing many more species.

A few synonyms are given with each species entry and fortunately they are in the index as well. Several taxonomical and nomenclatural points should be mentioned.

The genus *Listera* is nested into *Neottia*, *Pseudorchis* into *Gymnadenia*. *Coeloglossum* is maintained in its own genus rather than in *Dactylorhiza*. Hybrids are treated extensively as are aberrant and unusual forms such as albinos, white-flowered forms and other various color variants.

The largest genera treated—*Epipactis*, *Dactylorhiza*, *Orchis*, and *Ophrys* are as complete as they can possibly be with extensive illustrations to help sort out the oft-confusing species and forms. *Ophrys* alone has over 250 pages devoted to the genus!

Pierre Delforge has studied orchids, observed the evolution of their habitats, and protected them for more than 35 years in Europe, North Africa, and the Middle East and is an expert on European orchids for the IUCN—the World Conservation Union.

I can recommend this new work with no reservations and at $39.95 it is one of the best buys in orchid literature available!—*Paul Martin Brown, Author, Wild Orchids of Florida, The Wild Orchids of North America, Wild Orchids of the Southeastern United States, 10896 SW 90th Terrace, Ocala, FL 34481, U.S.A., naorchid@aol.com.*

Note.—This title has been published in Great Britain by A & C Black (ISBN 9780713675252) and cooperatively with Timber Press in the North America. They have different cover images but the body of the books is the same.

Mary Toomey with Everett Leeds and Charles Chesshire. 2006. **Timber Press Pocket Guide to *Clematis*.** (ISBN 0-88192-814-3, pbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax). $19.95, 232 pp., 319 color photographs, 1 b/w map of USDA Hardiness Zone, 1 full color map of European Hardiness Zones, 5¾" × 8¾".

The famous Timber Press Pocket Guides are always first-rate and this particular one does not disappoint. From its soft, pliable cover with rounded corners that one can fit into a large pocket, purse, or garden trug, to its brilliant color photography and design; what's not to like. It must have been a daunting task, indeed, to condense the selection of Clematis from 550 in the original beautifully published version, *An Illustrated Encyclopedia of Clematis* (2001) to the 300 in this 'pocket' version, but what a success! Diminutive in size but packed with brilliant full-color photography of each of the 300 stunning Clematis cultivars that any gardener would be proud to have in their garden. Though packed with brilliance, it is not busy looking. Just the right amount of margin and leading between the lines of san serif type to give ease of readability and space around the photos. Complete with Nursery Sources for 16 countries, a Glossary, Further Reading resources, and Index.

The authors' premise is to have the gardener carefully select the right Clematis for the proper locations in the garden and Clematis for specific purposes. *"Careful selection, cultivation, judicious pruning—never let that tax your mind—along with a modicum of patience and diligence will pay handsome dividends."—Linny Heagy, Linny/Designer, Illustrator, email: a0005835@airmail.net.*

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KALMIOPSIS FRAGRANS (ERICACEAE), A NEW DISTYLOUS SPECIES FROM THE SOUTHERN CASCADE MOUNTAINS OF OREGON

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ABSTRACT

The azalea-like genus *Kalmiopsis* Rehder (Ericaceae) is endemic to southwestern Oregon, U.S.A., and has two disjunct centers of distribution. One is found in the Klamath (Siskiyou) Mountains of Curry and Josephine cos., within the U.S. Forest Service administered Kalmiopsis Wilderness Area. The other is located approximately 150 km northeast in the southern Cascade Mountains of Douglas Co. *Kalmiopsis* is horticulturally significant, and plants from both localities have been established in the garden trade since shortly after their initial discoveries in 1930 and 1954, respectively. The genus has traditionally been considered monotypic, consisting only of *Kalmiopsis leachiana* (Hend.) Rehder. However, comparative studies of the morphology, floral biology, and ecology of the northern and southern population groups have determined they are best treated as distinct taxa. The northern populations are described here as the new species **Kalmiopsis fragrans,** a rare endemic occurring on silicified tuffaceous outcrops within a narrow segment of the Umpqua National Forest.

RESUMEN

El género de azaleas *Kalmiopsis* Rehder (Ericaceae) es endémico del suroeste de Oregón, U.S.A., y tiene dos centros disyuntos de distribución. Uno se encuentra en las montañas Klamath (Siskiyou) de los condados de Curry y Josephine, en la Kalmiopsis Wilderness Area administrada por el U.S. Forest Service. La otra esta localizada a unos 150 km al noreste en el sur de las Cascade Mountains de Douglas Co. *Kalmiopsis* es importante desde el punto de vista de la horticultura, y hay plantas comercializadas de ambas localidades desde poco después de su descubrimiento inicial en 1930 y 1954, respectivamente. El género ha sido considerado tradicionalmente como monotípico, únicamente con *Kalmiopsis leachiana* (Hend.) Rehder. Sin embargo, estudios comparativos de la morfología, biología floral, y ecología de los grupos de poblaciones del norte y del sur han determinado que es mejor tratarlos como taxa distintos. Las poblaciones del norte se describen aquí como la especie nueva **Kalmiopsis fragrans,** una especie endémica que aparece en afloramientos silíceos en una pequeña parte del Umpqua National Forest.

INTRODUCTION

Kalmiopsis Rehder is the only vascular plant genus endemic to the state of Oregon. The interesting circumstances of its discovery are chronicled in Kirkpatrick et al. (1994). Populations were first observed by botanists in 1930 in the mountains of southwestern Oregon (Henderson 1931; Rehder 1932), a rugged area with few trails and limited access. Although this craggy and remote region was already gaining significance as a haven for unusual and relict species (Whittaker 1960), the report of this beautiful, low-growing shrub, reminiscent of *Kalmia* and various cultivated azaleas (*Rhododendron* spp.), attracted considerable taxonomic and horticultural interest (Love 1991). Within months of its discovery, efforts were underway to introduce *Kalmiopsis* to the nursery industry. Although early tradesmen found *Kalmiopsis* a difficult subject for propagation (Love 1991; Kirkpatrick et al. 1994), plants may be grown with perseverance (Mulligan 1973; Kruckeberg 1982) and are today occasionally established in private and public gardens in the Pacific Northwest, Europe, and elsewhere.

Kalmiopsis has a bimodal distribution pattern, occurring most abundantly in the Klamath (Siskiyou) Mountains of Curry and Josephine cos., Oregon, just inland from the Pacific Ocean near the California border. A second, more restricted series of populations is clustered approximately 150 km to the northeast within the Umpqua River watershed of the southern Cascade Mountains, an area with a very different geologic and vegetative history (Whittaker 1960; Marquis 1977). The older Klamath Mountains connect the Coast Ranges

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of Oregon and California, and encompass a complex series of Mesozoic (Jurassic) formations including breccias, tuffs, sandstones, cherts, and conglomerates, much of which has been altered to metavolcanics (Baldwin 1974; Ramp 1975; Marquis 1977). Ultramafic substrates are widespread in the Klamath Mountains, where *Kalmiopsis* populations routinely occur on harsh, open serpentine habitats, though they are not necessarily restricted to them. The geology of the North Umpqua River drainage in the southern Cascades is mostly of Cenozoic origin (Peck et al. 1964), with the handful of *Kalmiopsis* populations here endemic to localized pinnacles of siliceous tuff, mostly in deep coniferous forests.

Henderson (1931) described the newly discovered species as *Rhododendron leachianum*, initially aligning it with the arctic-alpine *R. lapponicum*. Shortly thereafter, Rehder (1932) evaluated the new species and considered it to be closely related to the montane Eurasian genus *Rhodothamnus*, with possible affinities to the circumboreal genera *Kalmia*, *Rhododendron*, and *Phyllodoce*. Rehder ultimately concluded that the Oregon plants were unique enough to merit establishing the monotypic genus *Kalmiopsis*. Copeland (1943, 1954) subsequently placed *Kalmiopsis leachiana* (Hend.) Rehder within *Rhodothamnus*, proposing to drop the new genus based primarily on anatomical similarities between the taxa. However, Davis (1962), in his more recent study of *Rhodothamnus*, disagreed with the assessments by Copeland, and *Kalmiopsis leachiana* remains the currently accepted epithet (Stevens 1971; Harborne and Williams 1973). Recent phylogenetic studies of the subfamilies Rhododendroideae and Phyllodoceae (Kron and King 1996; Kron 1997; Kron et al. 2002) likewise align *Kalmiopsis* with *Rhodothamnus*, supporting the earlier conclusions by Rehder (1932) and Copeland (1943, 1954). However, based on *matK* and *rbcL* sequence data, Kron (1997) and Kron et al. (2002) consider *Kalmiopsis* most closely related to *Phyllodoce*, the genera also being linked by their distinctive multicellular hairs with biseriate stalks.

The discovery of *Kalmiopsis* populations in the Cascade Mountains raised questions about the relationship between these plants and those from the Klamath Mountains to the southwest. Well before taxonomic questions were posed, nurserymen noticed apparent differences between the disjunct populations, recognizing the hardier nature and comparative ease in transplanting of the Cascadian plants (Love 1991). Callan (1971) and Marquis (1977) acknowledged potential morphological differences between the populations as well, implying that recognition as distinct taxa might be warranted. However, neither author proposed any formal taxonomic separation.

In the last few years, opportunities have arisen for more extensive field studies of the genus in the Klamath and Cascade Mountains. The research described here, undertaken to evaluate the suitability of separating the groups as discrete taxa, contrasts the morphology, floral biology, and ecology of the northern and southern populations of *Kalmiopsis*. Herbarium material (including the holotype of *K. leachiana*) and live specimens from eleven populations (four from the Cascades and seven from the Klamath Mountains) were utilized in the comparisons. Measurements were taken from fresh flowers, as many herbarium specimens of *Kalmiopsis* tend to have shriveled corollas that underrepresent floral dimensions. Results from our studies support the recognition of the isolated northern populations as a distinct species.

Kalmiopsis fragrans Meinke & Kaye, sp. nov. (**Figs. 1–4**). Type: U.S.A. OREGON. Douglas Co.: ca. 0.7 km W of Dry Cr. settlement, above N Umpqua R. on S exposure of cliffs along Panther Leap, Umpqua National Forest, T 26S R2E S19 NE ¼, elev. ca. 570 m, in mixed coniferous forest with *Pseudotsuga menziesii, Tsuga heterophylla, Whipplea modesta, Castanopsis chrysophylla, Polystichum munitum,* and *Linnaea borealis, 18 May 1993, R. Meinke and T. Kaye 6280* (holotype: OSC; isotypes: HSC, NY, RSA, UC, US, UTC, WS, WTU).

Plantae ab *Kalmiopsis leachiana* habitu erecto aut serpenti, limbo corollae fisso ad 2–3 mm prope tubum, limbo et tubo corollae fere plano et rotato ubi maturo, ovario luteolo, ciliis densis ad bases filamentorum et in tubo corollae, odore florum simili ad azaleam differt.

Evergreen **shrub**, ± woody below (depending on age and size), usually openly branched (although internodes will shorten and habit become condensed in full sun), mature plants tenaciously rooted in shallow soils on the forest floor, or more often loosely attached and clambering over rocky substrates with thin organic mats, sometimes draped over or hanging from vertical cliffs, occasionally suspended under rock overhangs, capable of vegetative propagation by subterranean stems (often through rock fissures) or via adventitious rooting,

Fig. 1. Flowers of *Kalmiopsis fragrans*, growing in the Limpy Rock Research Natural Area, Umpqua National Forest, Douglas Co., Oregon.

occasionally crown-sprouting, locally forming populations consisting of one or few clones; **stems** few to numerous, (2–)4–12(–30) dm long, ± erect to trailing and occasionally ± matted, arising from a thickened base, glabrous or rarely with sparse, fine, white pubescence, often brittle, exfoliaceous, epidermis reddish to gray, terminally leafy and mostly naked below, the new growth ± stipitate-glandular and often fragrant with a faintly sweet scent; **leaves** numerous, crowded above (or less so in deep shade), thinly coriaceous with a thick cuticle above and below, dark green, glabrous, and shining above (or reddish in anthocyanic individuals in full sun), paler and punctately dotted with golden-crystalline, sweetly aromatic glands below, blade (5)8–30(–45) mm long, elliptic to obovate, apiculate, petioles glabrous to finely puberulent, less than one-fifth the length of the blades, erect to horizontally oriented; **inflorescence** terminal, corymbose to ± racemose, (2–)4–8(–12) per corymb, floral bud scales 2–3 mm long, membranaceous, glabrous or with scattered crystalline glands, pale to reddish-pink, broadly lanceolate; **flowers** dimorphic, consisting of long- and short-styled forms on separate plants, ± aromatic with a spicy-sweet odor, somewhat azalea-like, the aroma persisting and often intensifying with age; **pedicels** 0.5–2.5(–3.3) cm long, mostly glandular-pubescent; **calyx** glabrous, urceolate to campanulate, greenish to mostly pale pink or red, sepals 3–6(–8) mm long, overlapping at the base, thin, broadly lanceolate, margins ± involute; **corolla** pale reddish-purple to deep pink when fresh, deciduous, actinomorphic, lacking a defined throat, the shallow tube <2 mm deep, the limb 16–28(–33) mm across, broadly cupped to campanulate in early anthesis but becoming essentially rotate with age as the petal lobes reflex, lobes deltoid-ovate, 6–12 mm long and 4–8 mm wide, with two parallel, ventral ridges giving petals the appearance of thickness, petal sinuses divided to within 2–3 mm of the corolla tube, the lower edges of the petal lobes overlapping; **stamens** 10, nestled along the petal ridges in

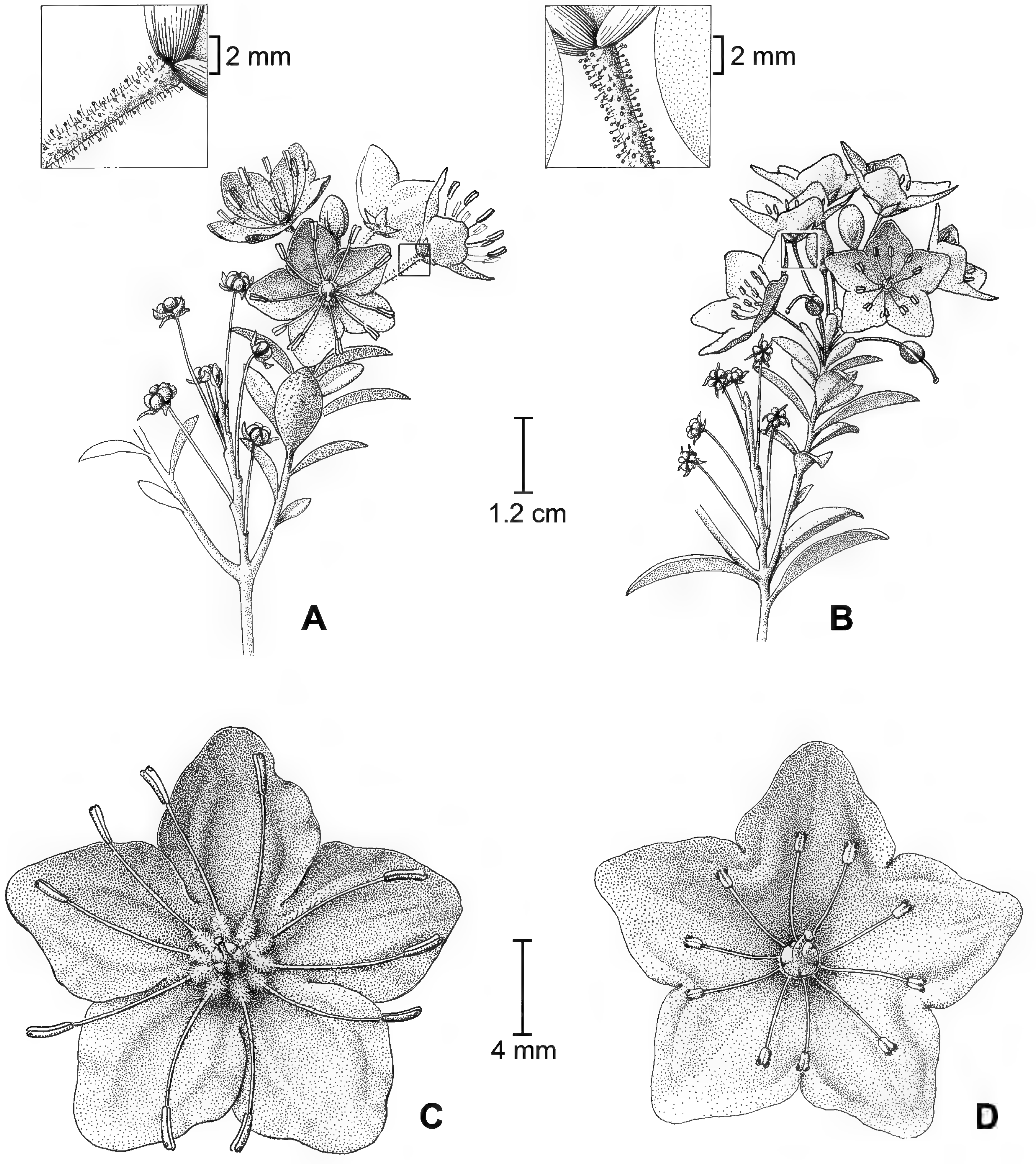

Fig. 2. Inflorescences (with capsules) of *Kalmiopsis fragrans* (A) and *K. leachiana* (B). Insets depict floral stem pubescence – young stems of *K. fragrans* often possess both glandular and non-glandular hairs, while *K. leachiana* is often only glandular, though this trait is variable. Corollas of *K. fragrans* (C) and *K. leachiana* (D) at early anthesis (18–24 hrs after bud break), showing petal sculpturing and stamen positioning.

bud and as corollas open, spreading to erect and well exserted at full anthesis, those of long-styled flowers 7–13 mm long and those of short-styled flowers 11–16 mm long, filaments light pink or paler, basally dilated, glabrous or with scattered hairs above, typically with a copious tuft of pale yellow to golden translucent hairs present at the very base (rarely subglabrous throughout), these joining to form a dense ring of pubescence in the floral tube that surrounds and generally conceals the base of the ovary; **anthers** light purple, narrow-oblong, often slightly curved, 1.2–3.0 mm long, the terminal pore openings <0.4 mm across; **pollen** cream to

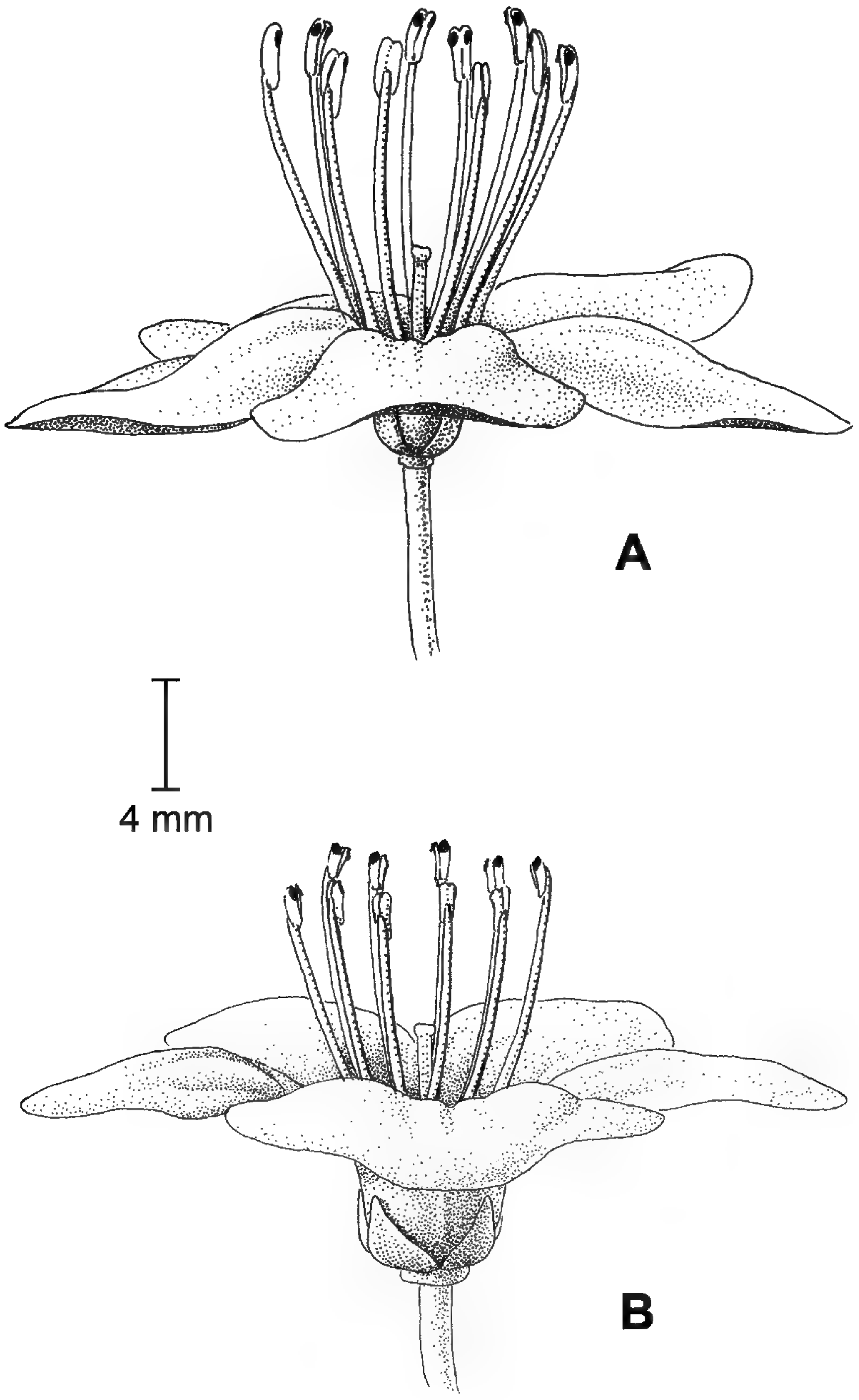

Fig. 3. Flowers of *Kalmiopsis fragrans* (A) and *K. leachiana* (B) at late anthesis (ca. 3–4 days after bud break), showing relative reflexing of petals and change in position (contrast with Fig. 2) of stamens.

ochroleucous, tetrads, 50–60 µ, no differences noted between floral morphs; **styles** red to purple, usually glabrous or rarely with a few isolated hairs, 11–15 mm long in long-styled morphs and 5–8 mm long in short-styled morphs; **stigma** pale, rounded, ± capitate to shallowly bi-lobed, obviously sticky, no differences noted between floral morphs; **ovary** 2–3 mm wide and high, globose, pale yellowish gold, glandular, ovules numerous; **capsule** ± depressed, 3–5 mm broad, shallowly five-lobed, glandular-warty; **seeds** minute, 0.3–0.7 mm long, oblong, shallowly pitted, potentially over 150 per capsule (although abortion may result in far fewer).

Distribution and Habitat.—*Kalmiopsis fragrans* is endemic to a narrow area along the west slope of the southern Cascade Mountains in Douglas Co., Oregon, with a known elevational range of 450 to 1325 m. It is apparently restricted to lands administered by the Umpqua National Forest, mostly within the drainage of the North Umpqua River in the vicinity of Steamboat and along Ragged Ridge. Populations normally occur in deeply shaded to partially open sites, commonly on or closely adjacent to talus slopes, boulder piles, or immense pillars of silicified tuff with south-facing aspects. The new species occurs in mixed coniferous forests variously dominated by *Pseudotsuga menziesii*, *Abies grandis*, *Tsuga heterophylla*, *Calocedrus decurrens*, *Arbutus menziesii*, *Thuja plicata*, and *Pinus lambertiana*. Understory associates include *Berberis nervosa*, *Holodiscus discolor*, *Gaultheria shallon*, *Oxalis oregana*, *Whipplea modesta*, *Castanopsis chrysophylla*, *Polystichum munitum*, *Linnaea borealis*, *Rosa gymnocarpa*, *Pterospora andromedea*, *Pleuricospora fimbriolata*, *Allotropa virgata*, *Rhododendron macrophyllum*, *Acer circinatum*, *Rhus diversiloba*, *Goodyera oblongifolia*, *Thermopsis montana*, *Iris chrysophylla*, *Pyrola picta*, *Sanicula graveolens*, *Viola orbiculata*, *Calypso bulbosa*, *Erythronium citrinum*, and *Luzula campestris*.

Most reproductive individuals and seedling recruitment are found in areas of filtered sunlight on rocky slopes, as well as on rock columns and other semi-moist outcrops that extend into or through the forest canopy. A few populations occur on exposed, rocky ridges. However, *K. fragrans* is a shade-tolerant species, capable of surviving for years within shallow caves and overhangs while growing from high rock ceilings or along deeply sheltered cliffs, persisting in such sites (although with reduced reproductive output) in what are essentially twilight conditions. Populations from deeper forests appear generally intolerant to sudden exposure, and are apt to decline over the long term in response to habitat disturbance that results in reduced soil moisture and increased sunlight. In particular, plants remaining after clear-cuts will persist for a short time, but have been noted to eventually become anthocyanic, more susceptible to disease, and to suffer higher mortality when compared to those from adjacent undisturbed sites.

Flowering.—Populations typically flower from mid-April to early June, depending on elevation. Seed production and dispersal occurs into August. The intensity of flowering in *Kalmiopsis fragrans* appears largely correlated with habitat quality. Plants located in densely shaded conditions may seldom, if ever, bloom or

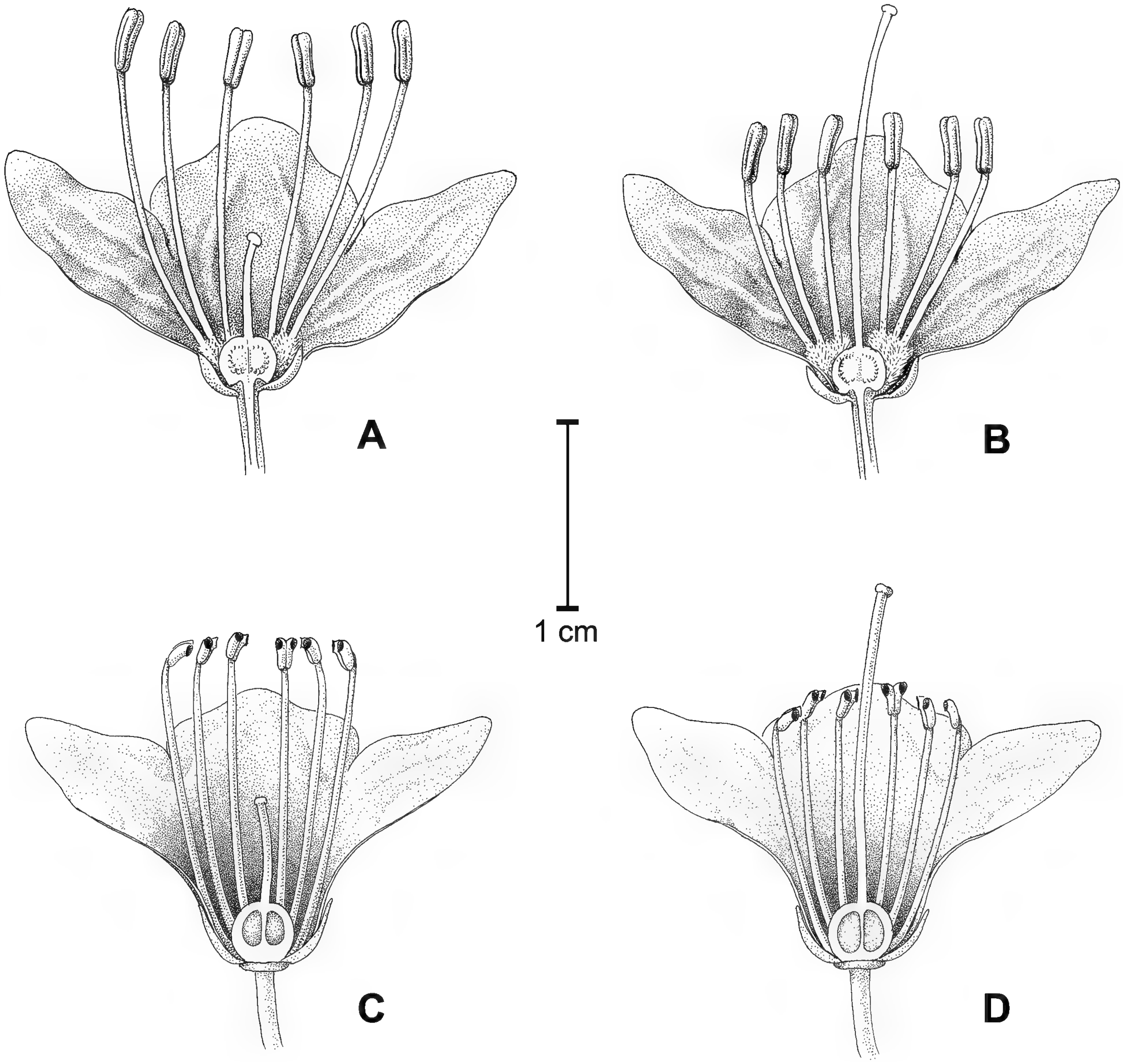

Fig. 4. Cutaway views of short- and long-styled flowers of *Kalmiopsis fragrans* (A and B) and *K. leachiana* (C and D), with details of petal sculpting.

produce seed, while those in areas of consistent, filtered light often flower profusely. Flowering in populations that become highly exposed due to logging or other site disturbance tends to decline over time.

COMPARISON WITH *KALMIOPSIS LEACHIANA*

Overall differences between *Kalmiopsis fragrans* and *K. leachiana* are summarized in Table 1. The floral and inflorescence morphologies of the species are illustrated and contrasted in Figs. 2–4.

Habit.—*Kalmiopsis leachiana* is described as being a small, copiously branched shrub up to 3 dm high (Rehder 1932; Abrams 1951; Peck 1961), but field work associated with this paper indicate that plants of this species may occasionally trail and grow to several dm long on steep terrain. The typical habit, however, is low and compact, with plants often flowering in dense, nearly monospecific stands on hot, barren ridges and open slopes. *Kalmiopsis fragrans*, on the other hand, exhibits marked plasticity in growth form. Plants from the few populations known to occupy exposed ridges may have a habit comparable to *K. leachiana*. However, most individuals are found in forested sites, where they exist as dense, trailing mats on rock outcrops or as loosely erect, openly branched shrubs in the more shaded areas. Plants range from a few dm to nearly

Table 1. Selected morphological, geographic, and habitat characteristics of *Kalmiopsis fragrans* and *K. leachiana*.

Trait	**Kalmiopsis fragrans**	**Kalmiopsis leachiana**
Habit	Erect to trailing or matted	Usually erect
Stem length	To 12 dm, rarely up to 30 dm	2–4 dm, rarely up to 8 dm
Inflorescence size	(2–)4–8(–12) flowers	(5–)7–12(–15) flowers
Corolla size	16–28(–33) mm across	(12–)14–20 mm across
Petal sculpting (best observed on fresh flowers)	Ridges connected within petals	Ridges connected between petals
Petal sinuses	Deeply cleft, to within 2–3 mm of the floral tube	Moderately cleft, to within 4–7 mm of the floral tube
Corolla expansion	Becoming nearly flat and rotate as petal lobes reflex	Petals reflexing but floral tube remaining tubular-cupulate
Corolla color	Light pink or reddish-purple	Rose to deep pink
Style length (long-style)	11–15 mm long	7–10 mm long
Stamen length (long-style)	7–13 mm long	3–7(–9) mm long
Anther size and apical pore dimensions	Narrowly oblong or curved linear, 1.2–3.0 mm, pore ± round, <0.4 mm	Oblong, 0.7–1.8 mm long, pore flared, 0.5–0.9 mm
Ovary color	Pale yellow to gold	Greenish gold
Floral pubescence	Yellowish cilia densely tufted at base of filaments surrounding ovary, evident in floral tube (tube area rarely subglabrous)	Flowers completely glabrous, or occasionally with fine cilia lining basal interior of floral tube, but not tufted or attached to filaments
Floral pollinator attractant	Spicy-sweet "azalea-like" scent and pollen (nectar merely a trace or typically absent)	Nectar pooling in floral tube and pollen (flowers lacking pronounced odor)
Breeding system	Clearly protogynous, pollen shed from a few hours to a day after corolla expansion	Slightly protandrous to slightly protogynous, pollen shed about the time of corolla expansion
Habitat	Mostly on tuffaceous outcrops and within shaded mesic coniferous forest, rooted in rock crevices or in very shallow soil at the base of cliffs or boulders	Plants preferring open sunny ridges, in xeric shrub community or open woodland, in shallow or more often deeper soils on a range of substrates (including ultramafics)
Geographic distribution	Endemic to the southern Cascade Mountains, at elevations ranging from ca. 450–1325 m	Endemic to the Klamath (Siskiyou) Mountains at elevations ranging up to 2100 m

3 m in length, far exceeding the largest examples of *K. leachiana*. Both species are capable of vegetative propagation in nature. This trait is evidently more common in *K. fragrans*, where several populations exceeding 100 individuals are known that appear to consist of one or few clones, based on the presence of only a single floral morph (i.e., long- or short-styled). However, at least two small populations of *K. leachiana* (encompassing <300 m^2) have been reported with only short-styled individuals (Marquis 1977). Moreover, excavations of several apparently separate plants revealed a below ground connection of nearly 2 m in one instance. *Kalmiopsis leachiana* is known to crown sprout after wildfires (Marquis 1977), and *K. fragrans* reportedly may as well (Richard Helliwell, personal communication), although evidence for this was not noted by the authors.

Floral Differences.—Divergence between *K. fragrans* and *K. leachiana* is most apparent in the flowers. The inflorescence of the new species is typically more floriferous (see Figs. 2A and 2B) and the corolla is larger and more deeply cleft than in *K. leachiana* (Figs. 2C and 2D). The proportional differences between the species are evident in corolla width and the size of floral organs, including the anthers, which are nearly twice as long in *K. fragrans* but with much smaller terminal pores. The significance of this is unknown, but the results may include a more prolonged release of pollen in *K. fragrans* (due to the larger anthers and smaller pores)and the deposition of larger pollen loads on individual pollinators in *K. leachiana*. Another interesting feature in *K. fragrans* is the copious pubescence (± golden in nature but pale in dried specimens) often found at the base of the filaments (Figs. 1, 2C), which forms a soft tuft around the base of the ovary. This is all but lacking in *K. leachiana*, a notable exception being the type collection (*Leach and Leach 2915*, ORE), which has some flowers with scattered cilia at the base of the filaments —see Fig. 4 in Rehder (1932). The flower of *K. fragrans* is otherwise subglabrous to glabrous, while *K. leachiana* often exhibits a fine covering of cilia inside the lower corolla tube.

Corollas of both species will remain open up to a week. In the greenhouse, *K. leachiana* flowers may be slightly protandrous or slightly protogynous, with anthers dehiscing at or about the time of initial corolla expansion. The flowers of *K. fragrans* have a more significant female phase, with anthers usually releasing pollen from a few hours to over a day after buds begin to open. Expanded flowers of both species shift from narrowly to broadly campanulate during the first day, with stamens initially splayed out along the corolla away from the receptive stigma (Figs. 2C and 2D). After 1–2 days, stamens become erect and well-exserted (Figs. 3A and 3B), with the filaments encircling the style. The corolla of *K. leachiana* retains a shallow, but well-defined tube that is several mm deep throughout floral ontogeny, with the lobes eventually reflexing perpendicular to the tube (Fig. 3B). The comparatively shallow petal sinuses of *K. leachiana* ensure that the shape of the floral tube remains more or less unchanged even as the lobes reflex, and that it continues to surround the ovary until the corolla drops. Corollas of *K. fragrans* have significantly deeper sinuses, and as flowers age and petal lobes fully reflex the corolla becomes essentially flat and rotate (Fig. 3A), typically exposing the ovary prior to corolla senescence.

Flowers of *K. leachiana* produce a rather viscous nectar (2–10 µL per flower per day in greenhouse plants) and are essentially odorless. Flowers of *K. fragrans* are nectarless, or yield only minute traces, but have a spicy sweet scent that increases in strength after anthers dehisce, and remains evident until corollas are shed. The aroma is especially notable when cut branches are placed indoors, with buds allowed to bloom and age in a confined area. The deeper floral tube of *K. leachiana* serves as a vessel for accumulating nectar, whereas the dense basal ring of stamen hairs in *K. fragrans* may help to delay the dissipation of tiny amounts of nectar or to trap fragrance compounds. Beeflies, syrphid flies, and bumblebees are common visitors to flowers of both species, although foraging patterns differ depending on whether pollen or nectar is being sought. Hummingbirds have also been noted making rapid visits to *K. leachiana* flowers, their foreheads covered in pollen.

Stigma-Height Dimorphism.—*Kalmiopsis* has been described as heterostylous (Callan 1971; Marquis 1977; Love 1991), although the evidence for true heterostyly is circumstantial. *Kalmiopsis* floral morphology (especially *K. fragrans)* is not typical of heterostylous species, which tend to have strongly tubular, campanulate, or funnelform corollas (Ganders 1979). Distyly is otherwise unknown in the Ericaceae, with the possible exception of *Epigaea repens,* a dioecious species that exhibits a continuum of long- and short-styled flowers but lacks other evidence of heterostyly (Darwin 1877; Vuilleumier 1967; Clay and Ellstrand 1981).

While both *K. leachiana* and *K. fragrans* have distinct short- and long-styled floral morphs (Fig. 4), the degree to which the two species also possess the other primary traits that define heterostyly (i.e., reciprocal anther heights and diallelic self-incompatibility – see Ganders 1979) requires further evaluation. Barrett et al. (2000) report that *K. leachiana* flowers clearly are dimorphic with respect to style length, though not for stamens, providing evidence of a stigma-height dimorphism but not necessarily heterostyly (in the sense of intramorph incompatibility). Observations of living and herbarium specimens during this study suggest that reciprocal anther heights may occur in some populations of *K. leachiana*, but this was not confirmed. Conversely, data for *K. fragrans* do show significant reciprocal differences between the floral morphs for both stamen and style lengths (Fig. 5). Field observations of pollinators indicate that this high degree of herkogamy apparently facilitates outcrossing in *K. fragrans*, but is the species functionally heterostylous?

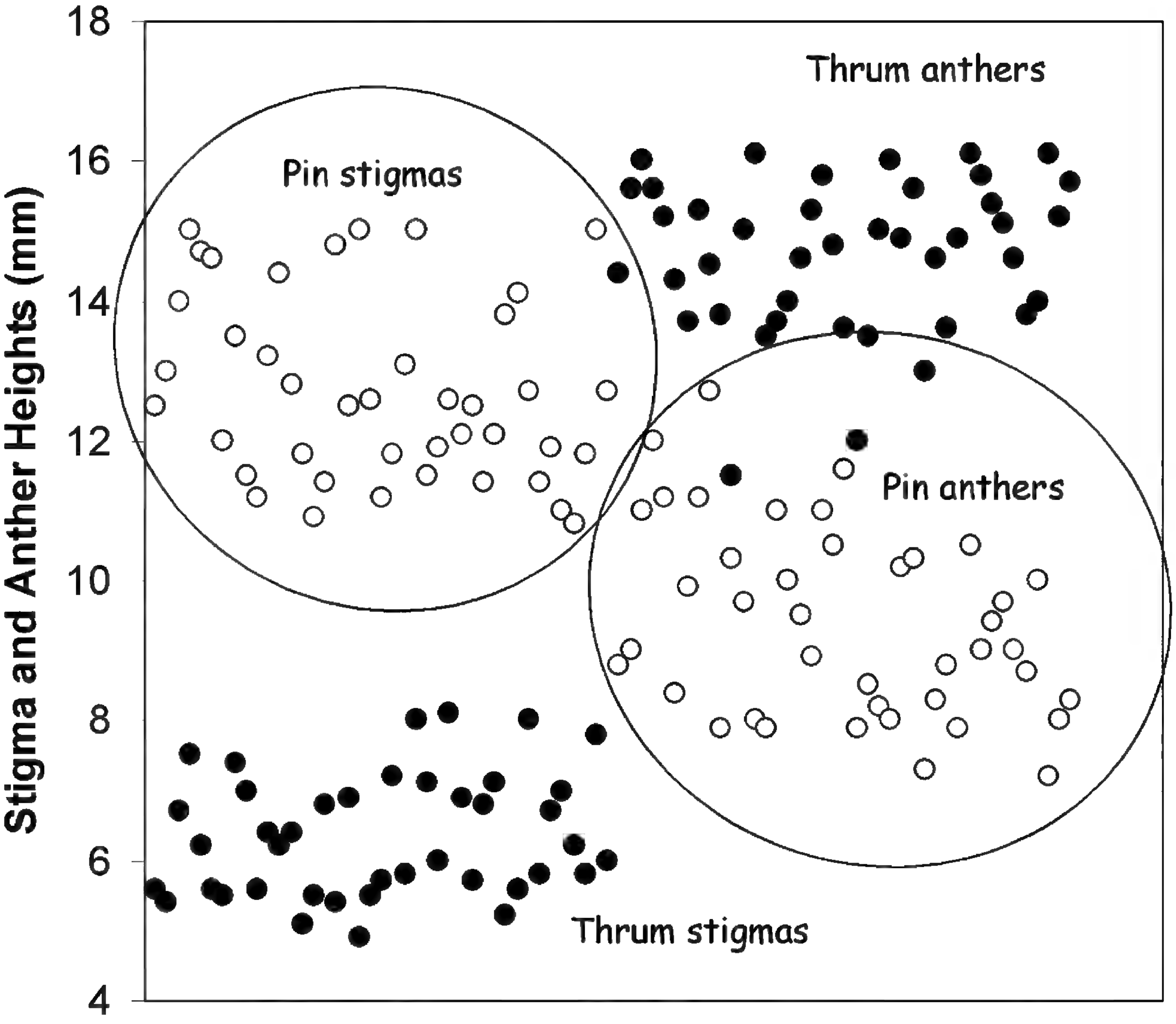

Fig. 5. Spatial relationship between anther and stigma heights for long-styled (pin) and short-styled (thrum) flowers in *Kalmiopsis fragrans* (N=41 for all groups). Data were taken from 24 randomly selected wild plants, 12 for each floral morph (estimated flower age 3–4 days). The mean stamen lengths for pin (9.46 mm) and thrum (14.66 mm) flowers (equivalent to anther height in mature flowers) were significantly different (P<.0001, t=19.266, SE=0.273). Reciprocal herkogamy is a key trait used to define heterostylous species.

Efforts to further evaluate the floral biology of *K. fragrans* through a series of experimental intra- and intermorph pollinations in wild populations were frustrated due to drought. Unseasonably warm, dry weather coincided with sporadic fruit set and a high percentage of abortion among experimental flowers and controls, suggesting that reproduction in our field trials may have been affected by factors other than pollen compatibility. Flowers that were manually selfed, and then bagged, set small numbers of fruit which contained no obvious seeds, but these results may have been similarly skewed by limited rainfall. However, Marquis (1977) also reports evidence for self-incompatibility, albeit in a single greenhouse plant of *K. fragrans*. Although fruit set occurred in 18 out of 28 undisturbed flowers, and in 34 out of 35 flowers self-pollinated by hand, seed production was far below flowers of open-pollinated plants in nature (with an average of less than one seed per capsule in the greenhouse versus 105 seeds from open-pollination). Finally, observations during the current study indicate that fruit set may be depressed or absent within populations consisting of only long- or short-styled ramets, suggesting that self-incompatibility may broadly affect seed production within patches. This was also noted by Marquis (1977). Additional breeding system studies of *Kalmiopsis* are planned.

CONSERVATION STATUS OF *KALMIOPSIS*

Rehder (1932) considered the collection and cultivation of *K. leachiana* essential to its preservation, feeling that the beauty and apparent rarity of the species might eventually lead to its extinction. His concern was evidently justified, as the conservation campaign he advocated quickly attracted the wrong sort of plant enthusiasts.

Commercial collectors almost immediately began to decimate the new species (Love 1991; Kirkpatrick et al. 1994), and entire populations in the Klamath Mountains were wiped out in the 1930's, with one collector reportedly apprehended with 50,000 cuttings on pack horses. Another nurseryman in Portland attempted to raise over 100,000 wild-collected plants for the retail trade (Kirkpatrick et al. 1994), but all died after a single growing season in the wet climate of northern Oregon. Although unbridled commercial collecting was once a legitimate threat to *K. leachiana*, the horticultural novelty of the species has declined and most populations today are considered relatively secure. Moreover, the area in which *K. leachiana* grows is now largely off limits to development due to federal wilderness designation. The species is the namesake for the Kalmiopsis Wilderness Area, a region rich in endemic species and remarkable habitats (Love 1991).

There is no record of *K. fragrans* being mass collected in the wild, and its introduction into the alpine and rock garden trade has evidently been less traumatic. Clones of the species identified as the "LePiniec" form, or occasionally as the "Umpqua River" cultivar (Kruckeberg 1982; Love 1991), are still in cultivation and available today. Recent research at Oregon State University has also demonstrated the relative ease with which *K. fragrans* may be grown from seed (Kelly Amsberry, unpublished).

Of the two species, *K. fragrans* has the narrower geographic range, and it is significantly rarer than *K. leachiana*. Most *K. fragrans* populations are not in designated protected areas, and the species is treated as *sensitive* by the Umpqua National Forest (UNF), a status that affords it more security than most native plants yet less than those formally listed as threatened or endangered. In a few areas the species benefits by sharing its vertical environment with federally-managed peregrine falcons. While frequenting such habitats may shield *K. fragrans* from the effects of timber harvest activity at selected sites, other areas appear less secure. Forest Service staff report that the rocky habitat required by *K. fragrans* is not necessarily a deterrent to either logging or road building, since surveys in advance of both activities have uncovered populations of the new species (Richard Helliwell, personal communication). Fortunately, many populations reside within the Limpy Rock Research Natural Area, which was designated with the preservation of its unique flora in mind. In response to the on-going timber harvest program on the UNF, studies are presently underway to assess how the removal of forest overstory along the edges of tuffaceous outcrops might impact *K. fragrans*.

Representative collections. ***Kalmiopsis fragrans*. U.S.A. OREGON. Douglas Co.:** Limpy Rock, Dog Cr. drainage off the N Umpqua R., 19 Jun 1976, *Chambers 4218* (ORE); same location, 17 May 1975, *Chambers 4041* (OSC); Happy Camp, Umpqua R., Umpqua National Forest, 25 May 1955, *Wright s.n.* (OSC); N Umpqua Hwy., steep hillsides above Horseshoe Bend, on basalt rocks and cliffs, 23 Apr 1967, *Williams s.n.* (ORE**). *Kalmiopsis leachiana*. U.S.A. OREGON. Josephine Co.:** Panther Cr., T37S R9W S6, Siskiyou Mtns., 8 Jul 1950, *Whittaker s.n.* (WS); Kalmiopsis Wilderness, Siskiyou National Forest, T37S R10W S1, 10 May 1997, *Dennis 4838* (OSC); Illinois R., S side of York Peak, 5 May 1957, *Davis s.n.* (OSC). **Curry Co.:** dry rocky spur of Horse Sign Butte, 8 mi S of Agnes, *Applegate 7229* (OSC); Collier Bar, T36S R11W S32, 1–2 May 1931, *Leach 3180* (ORE, WTU, WILLU); the Big Craggy, 19 Jun 1938, *Leach 5247* (OSC); near Game Lake Peak, Siskiyou National Forest, 15 Aug 1938, *Hanson s.n.* (OSC); along Illinois R. Trail, just before the E Fork of York Cr., 24 Apr 1960, *Kezer & Faberge s.n.* (OSC); Siskiyou National Forest, T37S R10W S34, 18 May 1939, *Colville 1* (OSC); Horse Sign Butte, T36S R12W S24, 1 May 1931, *Leach 3179* (OSC, WTU); higher Siskiyou Mtns. of Curry Co. (**holotype**), 14 Jun 1930, *Leach 2915* (ORE).

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Matthew Carlson, Kelly Amsberry, Shannon Datwyler, Armand Rebischke, Nancy Fredricks, Sahni Burkhart, and Steve Gisler offered valuable assistance during the field work. John Megahan provided the illustrations in Figs. 2–4. The photograph (Fig. 1) of *K. fragrans* is by Melissa Carr, who also worked diligently at improving the overall quality of the images in this paper. Kenton Chambers (OSC) graciously assisted with the Latin diagnosis, and the Oregon State University herbarium collections and library facilities (including OSC, ORE, and WILLU) were made available by Richard Halse. We thank USDA Forest Service staff, particularly Richard Helliwell and Linda Mullins, for facilitating our collecting on the Umpqua and Siskiyou National Forests. The Umpqua National Forest and the Oregon Department of Agriculture provided grant funding. And thanks to Dan Luoma for suggesting the specific epithet.

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BOOK REVIEWS

Robert H. Mohlenbrock. Foreword by Mike Dombeck. 2006. **This Land: A Guide to Western National Forests.** (ISBN 0-520-23967-9, pbk.). The University of California Press, Berkeley, CA 94704, U.S.A. (**Orders:** California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A. www.ucpress.edu, 609-883-1759, Fax 609-883-7413). $24.95, 391 pp., 63 color illustrations, 9 b/w photographs, 71 maps, 19 figures, 6" × 9".

The Mohlenbrock family spent virtually all their vacations exploring U.S. national forests. Because he is a botanist, Robert H. Mohlenbrock focused on special areas within the National Forest System, Research Natural Areas, which are "designated in perpetuity for research and education, to maintain biological diversity on National Forest System lands…." In 1984 he began writing a monthly column in *Natural History* magazine, published by the American Museum of Natural History in New York. He was asked to write in this column about areas in the national forests which he found interesting; not always because they were pretty, rather because they had a biological or geological story to tell. He called his column "This Land", and the theme is the same as that of his book, titled *THIS LAND: A Guide to Western National Forests*.

In his Foreword, Mike Dombeck, Chief Emeritus of the U.S. Forest Service, gives the reader a sweeping history of actions taken in the United States to honor and protect our forests:

—1864 Henry David Thoreau called for establishment of "national preserves" of virgin forests, "not for idle sport or food, but for inspiration and our own true re-creation."

—1864 President Abraham Lincoln signed legislation which granted Yosemite Valley and Mariposa Big Tree Grove to the care of the state of California "for public use, resort, and recreation."

—1891 Our first forest reserve, Yellowstone Park Timber Land Reservation, was created by President Benjamin Harrison.

—Toward the end of the nineteenth century, President Grover Cleveland established another 21 million acres of forest reserves.

—President Theodore Roosevelt expanded our forest reserves and established our first national wildlife refuges and national monuments, moving the country toward an ethic of conservation. In 1905 The USDA Forest Service was established to manage the national forests "for the greatest good for the greatest number for the long run."

The strength of this publication is its organization, which makes it easy to use by interested lay citizens as well as seasoned outdoorsfolk and professional scientific sorts. The eight chapters focus on eight western states: Alaska, Arizona, California, Idaho, Nevada, Oregon, Utah and Washington. Each chapter begins with a map of the state and its national forests; chapter subsections on those forests (in alpha order) begin with a map of the national forest and its surrounding area including cities, highways and ranger stations. Within the text are descriptions of special characteristics of each of the forests - natural, political and recreational features. Mohlenbrock has included many black and white botanical drawings throughout the book and an index of plant names. Also, there are a number of black and white photos and sixty-two color plates.

The author's relaxed narrative style creates an easy conversational tone as the reader travels with him through these western forests. He notes useful details, such as milepost numbers, trail names (and directions for finding them!), weather and terrain characteristics, and practical definitions of terms specific to each area. Personal anecdotes add colorful interest points and contribute to the reader's sense of sharing in his experiences.—*Karen Burkett, Herbarium Volunteer, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

Anton Rajer. 2006. **Museums, Zoos & Botanical Gardens of Wisconsin: A Comprehensive Guidebook.** (ISBN 0-9664180-0-X, pbk.). Fine Arts Publishing in cooperation with University of Wisconsin Press, 1930 Monroe Street, 3rd Floor, Madison, WI 53711-2059, U.S.A. (**Orders:** http://www.wisc.edu/wisconsinpress/). $17.95, 304 pp., illustrated, maps, 6" × 9".

A lifetime of experiences have gone into the making of this guidebook. The author has grown up visiting the museums, zoos, and botanical gardens in his native state. He has described over 540 institutions is this fascinating, well-researched guidebook which covers the full gamut of cultural and natural history institutions in Wisconsin.

The book is arranged geographically into four regions, and then by town in each region. A map accompanies each and locates the cities in which an attraction is located. Each site is described and includes the street address, contact numbers, hours of operation, admission fees, and collection highlights. There are indexes to help visitors find interesting sites by: institutional type, institution, and by city. He also includes a listing of helpful contacts. The botanical garden entries are very complete and include web information and specific opening hours, and days, where appropriate. Each entry has a detailed narrative paragraph, or two, about the site and the attractions to be found there.

Well illustrated and arranged. Recommended reading for those who will be traveling in the Badger State.—*Gary Jennings, Library, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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TAXONOMIC OVERVIEW OF THE *HETEROTHECA FULCRATA* COMPLEX (ASTERACEAE: ASTEREAE)

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ABSTRACT

Heterotheca fulcrata (Greene) Shinners has recently been treated as comprising four broadly sympatric varieties. These plants are viewed here as four species, corresponding in part to the varietal taxa: (1) *Heterotheca fulcrata* (including *H. fulcrata* var. *senilis* and *H. fulcrata* vars. *fulcrata* and *amplifolia* in part, sensu Semple), (2) *Heterotheca foliosa* (Nutt.) Shinners (including *H. fulcrata* vars. *fulcrata* and *amplifolia* in part, sensu Semple), (3) **Heterotheca arizonica** (Semple) Nesom, comb. et stat. nov. (= *H. fulcrata* var. *arizonica*), and (4) **Heterotheca nitidula** (Woot. & Standl.) Nesom, comb. nov., endemic to the Mogollon Mountains of southwestern New Mexico and White Mountains of immediately adjacent Arizona, previously treated as a synonym primarily of *H. fulcrata* var. *amplifolia*. County-level distribution maps for these taxa are provided (based on collections examined in the current study). *Heterotheca viscida* (Gray) Harms is included in the consideration because it is similar in geographic range to *H. arizonica* and occasionally confused with that taxon and expressions of *H. fulcrata*. *Heterotheca zionensis* Semple is recognized as a distinct species essentially as previously treated by Semple, but it is here observed to occur more widely in New Mexico and to extend into trans-Pecos Texas.

RESUMEN

Heterotheca fulcrata (Greene) Shinners ha sido recientemente tratada como poseedora de cuatro variedades ampliamente simpátricas. Estas plantas son consideradas aquí como cuatro especies, correspondientes en parte a los taxa varietales: (1) *Heterotheca fulcrata* (incluyendo *H. fulcrata* var. *senilis* y *H. fulcrata* vars. *fulcrata* y *amplifolia* en parte, sensu Semple), (2) *Heterotheca foliosa* (Nutt.) Shinners (incluyendo *H. fulcrata* vars. *fulcrata* y *amplifolia* en parte, sensu Semple), (3) **Heterotheca arizonica** (Semple) Nesom, comb. et stat. nov. (= *H. fulcrata* var. *arizonica*), y (4) **Heterotheca nitidula** (Woot. & Standl.) Nesom, comb. nov., endémica de las Mogollon Mountains del suroeste de Nuevo México y White Mountains en la adyacente Arizona, previamente tratada como sinónimo de *H. fulcrata* var. *amplifolia*. Se aportan mapas de distribución a nivel de condado de estos taxa (basados en las colecciones examinadas en el presente estudio). *Heterotheca viscida* (Gray) Harms está incluida en las consideraciones porque es similar en rango geográfico a *H. arizonica* y ocasionalmente confundida con ella y ejemplares de *H. fulcrata*. *Heterotheca zionensis* Semple se reconoce como una especie distinta tal como fue tratada previamente por Semple, pero aquí se ha observado que aparece ampliamente en Nuevo México y se extiende por los trans-Pecos en Texas.

Heterotheca fulcrata (Greene) Shinners has been treated by Semple (1996, 2006) as comprising four strongly sympatric varieties. My approach to the taxonomy of *Heterotheca* (Nesom 1997, 2006) is different from that of Semple and the current study documents a different taxonomic interpretation of the *H. fulcrata* group. *Heterotheca fulcrata* sensu Semple is treated here as four separate species; *H. viscida* (A. Gray) Harms is included in the consideration because it is similar in geographic range and occasionally confused with expressions of *H. fulcrata*. *Heterotheca zionensis* Semple also is included, though not closely related to *H. fulcrata*, to document an increased understanding of its identity.

The current study is based primarily on study of collections from ASU, BRIT-SMU, NMC, MO, SJNM, SRSC, and TEX-LL. Distribution maps are based on specimens examined.

KEY TO THE SPECIES OF THE *HETEROTHECA FULCRATA* GROUP AND *H. VISCIDA*

1. Leaves 5–15(–20) mm long, 2–5(–7) mm wide, with a thick-indurate, sharp-pointed, often recurving terminal mucro ____ **Heterotheca arizonica**
1. Leaves 15–40 mm long, 3–20(–25) mm wide, without a thick-indurate terminal mucro.
   2. Heads not immediately subtended by foliar bracts; glands usually stipitate ____ **Heterotheca viscida**
   2. Heads immediately subtended by foliar bracts; glands present or absent, usually sessile if present.
      3. Plants eglandular; nonglandular hairs very thin, with all cells equal in width, appressed, stem hairs appressed to closely ascending ____ **Heterotheca nitidula**

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3. Plants usually glandular; sometimes sparsely so; nonglandular hairs relatively thicker, with expanded basal cells, spreading or arching erect, stem hairs spreading or often deflexed.
    4. Midstem cauline leaves (10–)15–30 mm long, 3–7(–10) mm wide, mostly oblong to oblanceolate-oblong or lanceolate-oblong ______ **Heterotheca fulcrata**
    4. Midstem cauline leaves 25–60 mm long, (5–)10–18 mm wide, mostly oblanceolate-obovate ______ **Heterotheca foliosa**

Heterotheca fulcrata sensu stricto

Heterotheca fulcrata (Greene) Shinners, as treated here, is recognized by its heads immediately subtended by foliar bracts, the bracts prominently ciliate with coarse, spreading hairs. Stems are densely hirsute-villous. The range of the species extends from north-central Mexico into Texas, southern New Mexico, Arizona, and Utah (Fig. 1), exclusive of the population system in Colorado and Wyoming mapped by Semple as *H. fulcrata*. The latter are treated here as *H. foliosa* (Nutt.) Shinners (see below).

From typical *Heterotheca fulcrata*, Semple differentiated *H. fulcrata* var. *senilis* (Woot. & Standl.) Semple by "distal margins of uppermost leaves with numerous long hispid-strigose hairs" [var. *senilis*] vs. "leaf margins of upper leaves lacking long hairs or [with] only a few basally" [var. *fulcrata*] (1996, p. 28, key couplet 17). The types of both taxa were collected in the Organ Mountains of Dona Aña Co., New Mexico, and variability within the species accounts for the difference in vestiture. 'Senilis'-like plants are the common form in Arizona, New Mexico, Texas, and Mexico; bract and leaf margins become less coarsely and densely ciliate northward, but there does not appear to be a discontinuity. Some plants of *H. fulcrata* from this area show reduced nonglandular vestiture on the leaf faces (e.g., the type of *Chrysopsis cryptocephala*, below), while others produce denser nonglandular vestiture. Analogous variation in density of nonglandular vestiture occurs in Colorado and Wyoming populations of *H. foliosa* (comments below). Plants identified as *H. fulcrata* from northern Utah (i.e., Cache, Duchesne, Salt Lake, Summit, Utah, Wasatch counties) perhaps represent a distinct, separately evolved population system; compared to typical, southern populations of *H. fulcrata*, these plants occur at significantly higher elevations and consistently are more glandular with reduced nonglandular vestiture.

Heterotheca fulcrata (Greene) Shinners, Field & Lab. 29:71. 1951. *Chrysopsis fulcrata* Greene, Bull. Torrey Bot. Club 25:119. 1898. Type: U.S.A. NEW MEXICO. Lincoln Co.: White Mts., near Cherokee Bill's Spring, 6300 ft, 21 Aug 1897, *E.O. Wooton 511* (lectotype, Shinners 1951: ND-G; isolectotypes: NY, NY [internet image!], US [internet image!]).

From among ND-G syntypes *Wooton 510*, *511*, and *512*, Shinners (1951) selected *511* as the lectotype. Harms (1968a, p. 17) entered a caveat, noting that "This choice causes some confusion since Wooton and Standley (1913, 1915) obviously considered the first cited specimen, *Wooton 510* from the Organ Mountains, as the true type of *C. fulcrata*, and their subsequent descriptions of *C. cryptocephala* and *C. senilis* seem based upon this understanding." *Wooton 512* was cited as a paratype in the protologue of *C. cryptocephala*, but there was never an explicit or formal statement by Wooton and Standley regarding lectotypification of *C. fulcrata*. Semple (1987) stated that "I consider all three Wooton syntype collections to be members of [*Heterotheca fulcrata*] var. *fulcrata* and accept Shinners' lectotype designation, *Wooton 511* (ND-G)." Semple's 1987 position is affirmed here and Shinners' choice appears to remain valid, notwithstanding Semple's later citation (1996, pp. 68, 70) and 1995 and 1997 annotations (e.g., NY, US) of *510* as lectotype, in which he apparently accepted Harms' implication that the original lectotypification was made implicitly by Wooton and Standley.

Chrysopsis senilis Woot. & Standl., Contr. U.S. Natl. Herb. 16:179. 1913. *Heterotheca fulcrata* (Greene) Shinners var. *senilis* (Woot. & Standl.) Semple, Brittonia 39:380. 1987. Type: U.S.A. New Mexico. Dona Ana Co.: Organ Mts., 4800 ft, 1 Sep 1897, *E.O. Wooton 509* (holotype: US [internet image!]; isotypes: MIN, MO!, NDG, NY [internet image!]).

Chrysopsis cryptocephala Woot. & Standl., Contr. U.S. Natl. Herb. 16:179. 1913. Type: U.S.A. New Mexico. [Lincoln Co.]: White Mts., V Pasture, sect. 23, 23 Jul 1905, *E.O. Wooton s.n.* (holotype: US [internet image!]; isotype: US).

Status of *Chrysopsis nitidula*

Populations recently identified mostly as *Heterotheca fulcrata* in the Mogollon Mountains of southwestern New Mexico and White Mountains of immediately adjacent Arizona (Fig. 1) are recognized here as a separate species, originally described as *Chrysopsis nitidula* Woot. & Standl. The protologue noted that the leaf surfaces are "finely sericeous, the leaf as a whole appearing green and remarkably soft and smooth; ... This is very unlike any of our other species, being strongly marked by its peculiar pubescence and long rays [10–12 mm long]." Compared to *H. fulcrata*, the leaves of *H. nitidula* also tend to be narrow and elongate with acute apices.

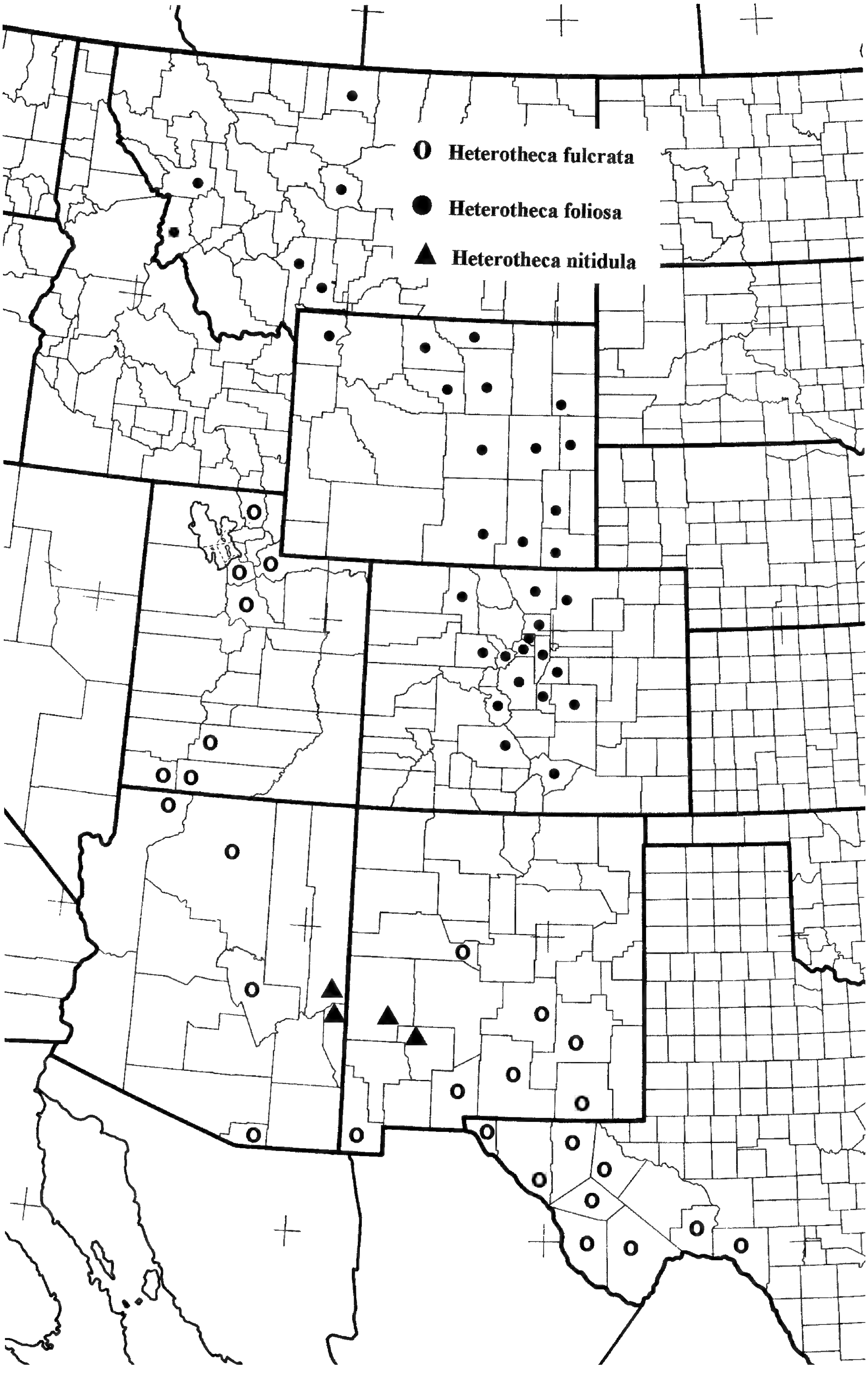

Fig. 1. Geographic range of *Heterotheca fulcrata, H. foliosa, and H. nitidula*. See text for specimen citations for *H. nitidula*.

Heterotheca nitidula (Woot. & Standl.) Nesom, comb. nov. *Chrysopsis nitidula* Woot. & Standl., Contr. U.S. Natl. Herb. 16:179. 1913. Type. NEW MEXICO. "Socorro Co.:" Mogollon Mts., on or near the West Fork of the Gila River, 7500 ft, 20 Aug 1903, *O.B. Metcalfe 552* (holotype: US [internet image!]; isotypes: GH, MO!, NMC!, RM). Redefined county boundaries now place the type locality in Catron County.

Diagnostic description of *Heterotheca nitidula*: Stems 10–35 cm tall, arching upward from the base, antrorsely strigillose. Cauline leaves mostly narrowly oblanceolate, 3–5.5 cm long, 3–8 mm wide, attentuate to the base, apices acute. Heads solitary or usually in clusters of 2–6, usually immediately subtended by lanceolate foliar bracts. Stems, leaves, bracts, and phyllaries eglandular, sparsely to moderate strigillose with nonglandular vestiture of extremely thin, slightly flexuous, closely appressed hairs 0.5–1.5 mm long, without enlarged basal cells; leaves eciliate or with a few weak, spreading cilia along the proximal margins; foliar bracts eciliate to ciliate. Heads on some plants of the type collection are pedunculate, lacking foliar bracts, but bracteate heads are the normal condition for the species, hence the association with *H. fulcrata*.

Numerous collections of *Heterotheca nitidula* have been made since its original description—all are consistent in morphology and all occur within a radius of 35–40 miles. Its geographic range apparently lies within that of *H. fulcrata* (Fig. 1), but no collections of typical *H. fulcrata* have been examined from within the range boundary of *H. nitidula*. *Heterotheca nitidula* occurs at elevations of (7000–)7400–9200 feet; *H. fulcrata* occurs at 4600–6900(–8000) feet in Texas, 2100–7200 feet in New Mexico, and 4900–7100(–8700) feet in Arizona. Plants of *H. nitidula* grow on open rocky slopes and flower Aug–Sep(–Oct). A diploid chromosome number ($2n = 18$) has been documented for *H. nitidula* by Semple (see citation for *Semple & Heard 8021*, below) and Turner (*Turner 5700*).

The holotype of *Chrysopsis nitidula* was annotated by Semple in 1985 as *Heterotheca villosa* var. *pedunculata*. In 1995, he re-annotated the specimen as *H. fulcrata* var. *amplifolia*, and later (1996, 2006) he cited *C. nitidula* as a synonym of the latter. NMC specimens of *H. nitidula* were annotated by Semple as *H. fulcrata* var. *fulcrata* and as *H. fulcrata* var. *amplifolia*. Similarly, Semple (1996) cited "*Rusby 168* (MIN, NY(3), PH)" under three different taxa: *H. fulcrata* aff. var. *fulcrata* (p. 74), *H. fulcrata* var. *amplifolia* (p. 76), and *H. villosa* aff. var. *pedunculata* (p. 126). A duplicate of the same collection (*Rusby 168*, MO!) is identified here as *H. nitidula* (as cited below).

Additional collections examined: **ARIZONA. Apache Co.:** Apache Natl. Forest, Mount Baldy area, W Fork Little Colorado River, parking area off State Rd 273, locally abundant in dry grassland, 2787 m, 21 Sep 1998, *Brant & Stone 4128* (MO, TEX); White Mts., 6–15 Aug 1903, *Griffiths 5329* (MO); along Forest Rd 275 in Stone Creek drainage, above stream in gravelly soil, 8000 ft, 11 Aug 1998, *Hammond 11478* (TEX); White Mts., dry road shoulders, 8500 ft, 15 Aug 1973, *Moldenke 27846* (LL); near Greer, 8300 ft, 19 Aug 1935, *Peebles 12555* (LL); E edge of Alpine on US 180, road embankment, red shale substrate, limber pine forest, 8030 ft, 19 Sep 1985, *Semple & Heard 8021* [voucher $2n = 18$] (BRIT); 12 mi N of Alpine, common in roadside cuts, 13 Aug 1967, *Turner 5700* [voucher $2n = 18$] (TEX); Sitgreaves Natl. Forest, 5.4 mi S of jct US 666 and US 180 on 666, E of road in meadow, 15 Aug 1978, *Warnock 1677* (TEX). **Greenlee Co.:** Apache Natl. Forest, 10 mi E of Big Lake on Forest Rd 249 and 8 mi from Alpine, near turnoff to Sierra Blanca and on hillside above lake in rocky soil, open areas in spruce forest, 8900 ft, 16 Aug 1972, *Hess 2937* (SMU). **NEW MEXICO. Catron Co.:** Mogollon Mts., Gila Natl. Forest, Indian Creek drainage and Bear Wallow Mt., common perennial on E-facing slope and drier areas, 1 ft tall, 9200 ft, 4 Sep 1968, *Hess 2394* (NMC, SMU); Mogollon Mts., 1.4 road mi N of Gilita Campground, ponderosa pine, ca. 8100 ft, 7 Sep 1978, *Moir & Fitzhugh s.n.* (NMC); Mogollon Mts., high rocky summits, 7 Sep 1881, *Rusby 168* (MO); Gila Natl. Forest, 13 mi straight line NNE of Beaverhead Ranger Station, near NM 163 and FS 150, montane grassland and pinon-juniper woodland, SW-facing slope, sandy, rocky ashflow, 7500 ft, 3 Oct 1995, *Williams 2600* (NMC). **"Socorro Co.:"** Middle Fork of Gila, 7500 ft, 5 Aug 1900, *Wooton s.n.* (NMC). **Sierra Co.:** Taylor Creek, ca. 14 air mi E of Beaverhead, rocky S-facing slope with ponderosa pine, 7400 ft, 14 Aug 1982, *Spellenberg et al. 6598* (NMC).

Identity of *Heterotheca foliosa*

Harrington (1954) divided Colorado *Heterotheca* with prominent foliar bracts subtending the heads between *H. fulcrata* ("involucres sparingly to definitely glandular") and *H. foliosa* (Nutt.) Shinners in part ("involucres pubescent but the glands obscure or none"). Wyoming plants were similarly identified in Dorn's key (2001). Weber and Wittmann (1990) identified these plants primarily as *H. fulcrata* but later (1996) called them *H. foliosa*, noting that the name *H. fulcrata* would be incorrectly applied.

Semple (1996, 2006) treated most of the same plants within *Heterotheca fulcrata*—some as var. *fulcrata* ("sparsely to moderately glandular") and some as var. *amplifolia* ("glandless or nearly so"). Regarding distinctive features of *H. foliosa* (treated by him as *H. villosa* var. *foliosa*), he noted (1996, p. 117–118) that its "upper stem leaves … are oblong ... and its heads ... are often subtended by narrow oblanceolate bracts." His key couplet 15 (1996, pp. 28–29) separated *H. fulcrata* from *H. villosa* with foliar-bracteate heads by the shape of the bracts—*H. fulcrata* with ovate-lanceolate bracts, *H. villosa* var. *foliosa* with oblanceolate to linear-oblanceolate bracts. Even as identified and annotated by Semple, however, variation in bract shape exists in plants that otherwise are clearly referable to the *H. fulcrata* var. *fulcrata-amplifolia* forms.

Among the plants in Colorado and southern Wyoming with bracteate heads, there is a tendency for sessile glands to be abundantly developed on all parts and for nonglandular hairs to be reduced in density. Such green-glandular plants are typified by *Chrysopsis resinolens* A. Nels. (see below). At the other extreme, leaves and stems are eglandular or nearly so and distinctly grayish-strigose with denser nonglandular vestiture (e.g., *Chrysopsis amplifolia* Rydb.). Intermediates in vestiture are common (as noted also by Semple 2006); glands may be absent on the leaves but present on the foliar bracts. If two taxa are distinguished on the basis of vestiture, the resulting two are similar in variability of leaf shape and size and in variability of size and shape of foliar bracts. Further, they are ecologically similar and their geographic ranges are congruous (see Semple 1996, Fig. 28, A and B) and disjunct from other taxa of the *Heterotheca fulcrata* complex (Figs. 1, 2). Their treatment here as a single taxon, *Heterotheca foliosa*, emphasizes the (1) geographic and ecological coherence of the extended population system and its disjunction from related ones, and (2) intergradation in vestiture and apparent impossibility of identifying more than a single entity without relying on a typological concept.

The geographical coherence of *Heterotheca foliosa* in Colorado and Wyoming, also as recognized by Semple (1996) in his identification of *H. fulcrata* in that region, substantiates its evolutionary coherence. As identified here, the range of *H. foliosa* extends into southwestern Montana (Fig. 1), slightly further north and west than mapped by Semple for *H. fulcrata* in the Rocky Mountains. Semple indicated the geographic range of *H. villosa* var. *foliosa* to continue southward (into New Mexico) and much further north and west (into Idaho, Oregon, Washington, and Canada), but as in my previous study (Nesom 2006), most plants identified and mapped by Semple as *H. villosa* var. *foliosa* are regarded here as variants within *H. villosa* var. *villosa*.

The morphological distinction of *Heterotheca foliosa* from *H. fulcrata* sensu stricto is not great, but they differ conspicuously in leaf size, as noted in the key above. Further, as treated here, the two are geographically disjunct and appear to have different ecological tendencies. Closely similar but allopatric population systems are often treated as conspecific, but recognition of both taxa at specific rank also is justified, here emphasizing the differentiation and disjunction.

Heterotheca foliosa (Nutt.) Shinners, Field & Lab. 29:71. 1951. *Heterotheca villosa* var. *foliosa* (Nutt.) Harms, Wrightia 4:15. 1968. *Chrysopsis villosa* var. *foliosa* (Nutt.) Cronq., Bull. Torrey Bot. Club 74:150. 1947. *Chrysopsis foliosa* Nutt., Trans. Amer. Philos. Soc. 2, 7:316. 1841. Type: U.S.A. [Wyoming.] "In the Rocky Mountain plains, near the banks of the Platte. Flowering in August" [protologue], [Jun 1834], *T. Nuttall s.n.* (holotype: K; isotypes: GH 2 sheets). Nuttall, with Wyeth's expedition, crossed the North Platte River in southern Wyoming in June 1834, probably in Carbon County. If the collection of *Chrysopsis foliosa* were made in June, the nature of his reference to "Flowering in August" is not clear, but perhaps he observed that full flowering would be reached by that month. Nuttall's description of *C. foliosa*, especially features of the leaves, clearly aligns it with the present concept of the taxon: "About foot high, sending up many hairy stems from the same root. Nearly allied to *C. villosa* but far more pubescent and hoary, with the leaves widest at the base. ... sericeously villous, and more or less canescent ... flowers fastigiate, corymbose; leaves entire, oblong or oblong-ovate, subamplexicaule ... ."

Chrysopsis resinolens A. Nels., Bull. Torrey Bot. Club 28:232. 1901. Type: U.S.A. Wyoming. Albany Co.: Moist mountain valleys, Laramie Peak, 13 Jul 1900, *A. Nelson 7583* (holotype: RM; isotypes: GH, MIN, MO!, NY 2 sheets [internet images!], RM, US [internet image!]). The protologue notes for the habitat and locality: "open slopes in the foothills of Laramie Peak." A handwritten label (NY 163187) notes "Open, grassy slopes, Laramie Peak," while printed labels (NY 163216, RM, US) note "Moist mountain valleys, Laramie Peak." Nelson's collection book has "In the open valleys." Other label information is identical among the specimens. The plants are similar in morphology and plausibly from the same gathering.

Chrysopsis resinolens var. *ciliata* A. Nels., Bull. Torrey Bot. Club 28:233. 1901. *Chrysopsis viscida* var. *ciliata* (A. Nels.) Blake in Tidestrom, Contr. U.S. Natl. Herb. 25:537. 1925. Type: U.S.A. Wyoming. Albany Co.: sandy river bottoms, Dunn's Ranch, 16 Jul 1900, *A. Nelson*

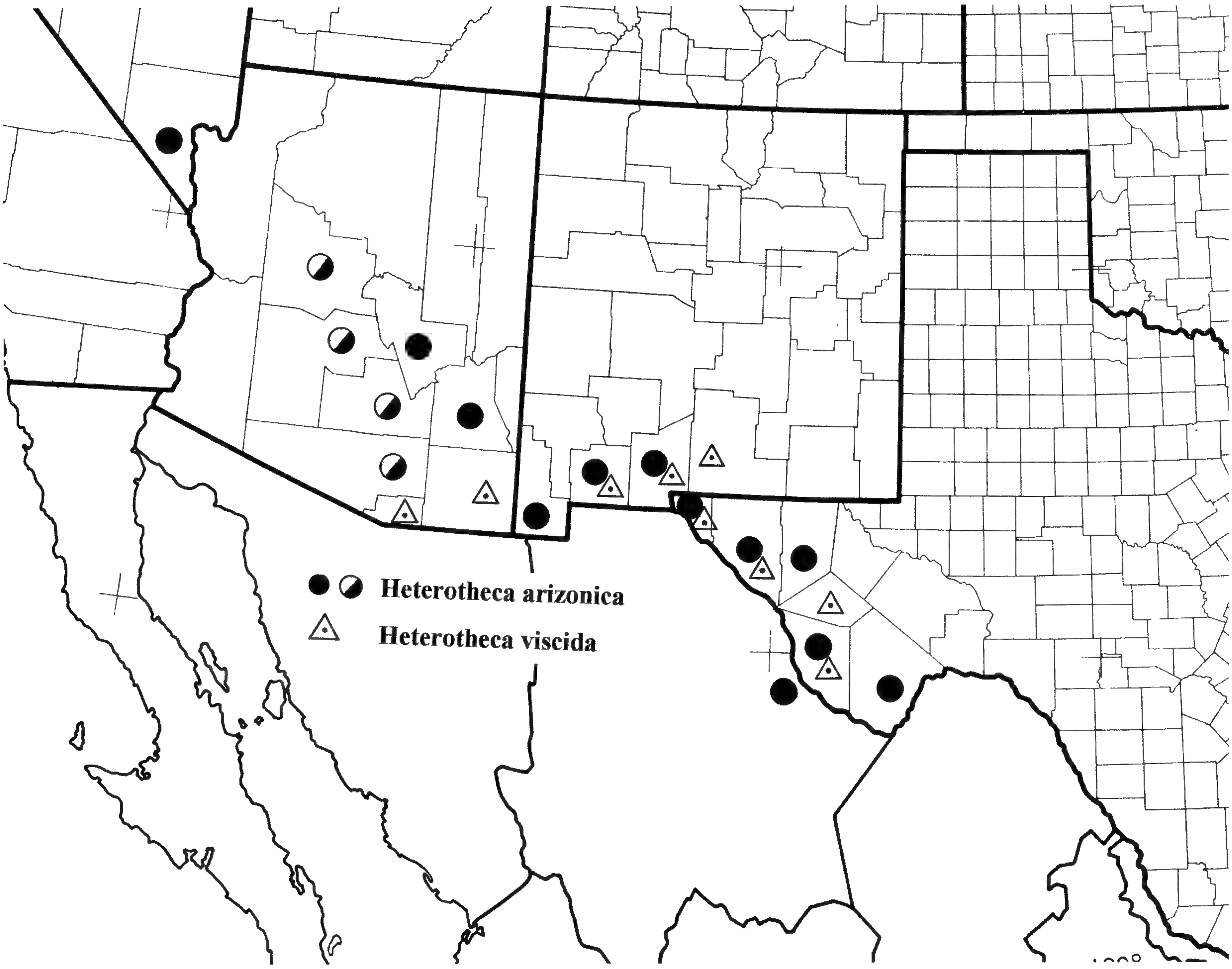

Fig. 2. Geographic range of *Heterotheca arizonica* and *Heterotheca viscida*. Half-filled circles are added from Semple (1996).

7566 (holotype: RM; isotype: NY [internet image!]). "*Nelson 7560*" is the collection number cited in the protologue, and the NY isotype is labeled as "7560 .... n. var." on a label (ex Rocky Mountain Herbarium) apparently handwritten by Nelson. The RM specimen, however, is labeled *7566* and Nelson's original notes state that *7566* = *Chrysopsis resinolens* var. *ciliata*; *Nelson 7560* is listed as a moss (*Mnium serratum*). Thus the collection number in the protologue as well as the label on the NY collection are interpreted as resulting from errors in transcription.

Chrysopsis amplifolia Rydb., Bull. Torrey Bot. Club 31:648. 1904. *Chrysopsis foliosa* var. *amplifolia* (Rydb.) A. Nels. in Coult. & Nels., Man. Bot. Rocky Mts. 5493. 1909. *Heterotheca fulcrata* var. *amplifolia* (Rydb.) Semple, Univ. Waterloo Biol. Ser. 37:74. 1996. Type: U.S.A. Colorado. [Boulder Co.:] Plains and foothills near Boulder, Longmont, Jul 1902, *F. Tweedy 4898* (holotype: NY [internet image!]; isotype: RM).

Chrysopsis caudata Rydb., Bull. Torrey Bot. Club 31:648. 1904. Type: U.S.A. Colorado. [El Paso Co.: Pike's Peak,] Ruxton Dell, 2950 m, 2 Aug 1901, *F.E.* & E.S. *Clements 143* (holotype: NY [internet image!]; isotypes: DH, GH, MIN, MO!, RM, US [internet image!]).

Chrysopsis imbricata A. Nels., Bot. Gaz. 37:263. 1904. *Chrysopsis foliosa* var. *imbricata* (A. Nels.) A. Nels. in Coult. & Nels., Man. Bot. Rocky Mts. 493. 1909. Type: U.S.A. Colorado. El Paso or Teller Co.: Pike's Peak, open slopes, 1 Sep 1901, *A. Nelson 8616* (holotype: RM).

Chrysopsis alpicola var. *glomerata* A. Nels., Bot. Gaz. 40:64. 1905. Type: U.S.A. Colorado. Larimer Co.: Estes Park, 9000 ft, Aug 1904, *W.S. Cooper 174* (holotype: RM).

Chrysopsis butleri Rydb., Bull. Torrey Bot. Club 37:129. 1910. Type: U.S.A. Montana. Gallatin Co.: Gateway, 17 Aug 1908, *B.T. Butler 620* (holotype: NY [internet image!]).

Heterotheca fulcrata var. *arizonica* at specific rank

Semple's description of *Heterotheca fulcrata* var. *arizonica* Semple was a useful advance in resolving problems of identification in the *H. fulcrata* group. As mapped by Semple (1996), however, and as confirmed here, var. *arizonica* occurs sympatrically with typical *H. fulcrata* (including var. *senilis*) in Texas, New Mexico, and

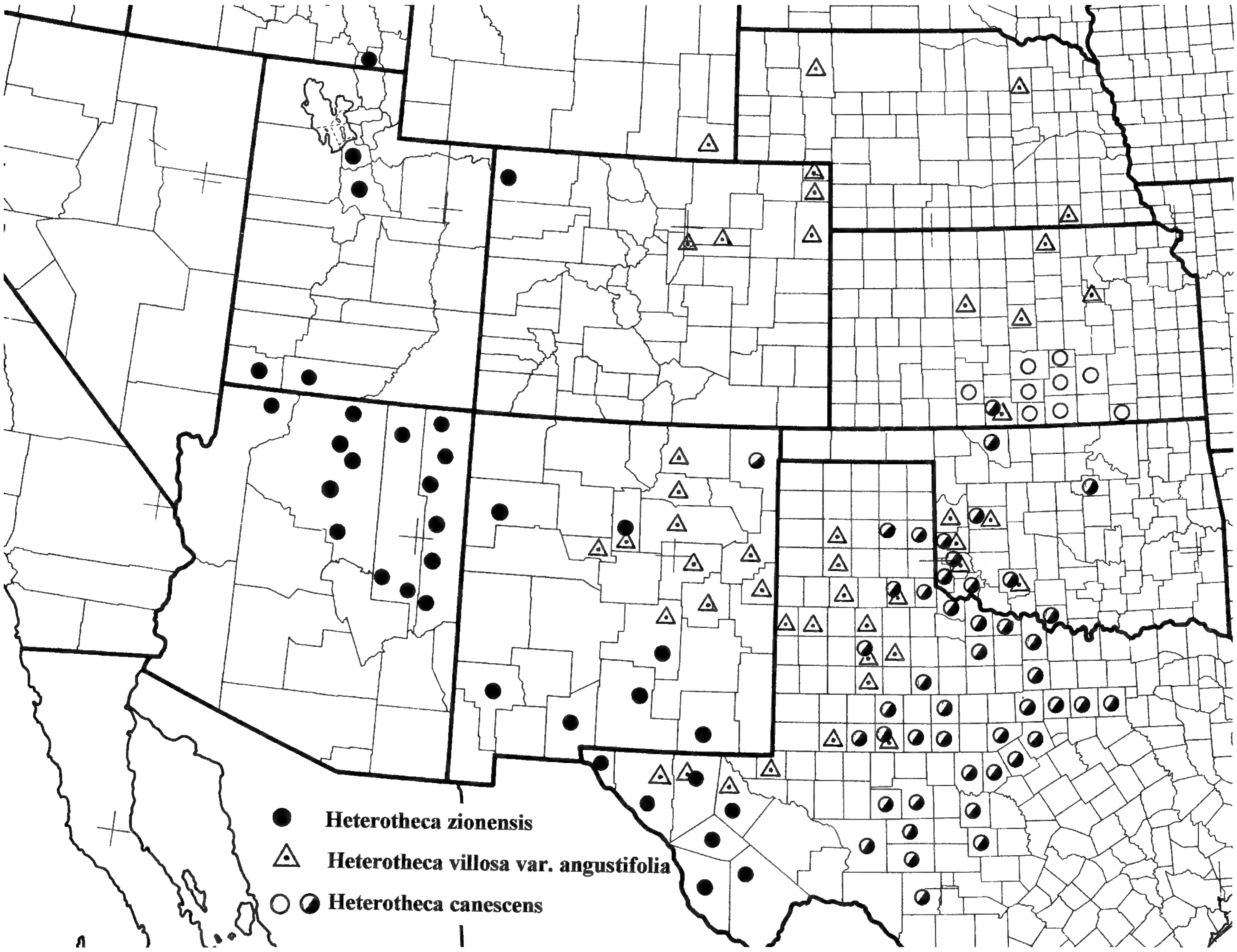

Fig. 3. Geographic range of *Heterotheca zionensis*. Representative localities for *H. villosa* var. *angustifolia* also are shown; the range continues northward to South Dakota. The only collection of *H. canescens* in New Mexico seen in this study is mapped: Union Co., Clayton, 24 Sep 1907, *Evans s.n.* (NMC); an indication of the total range of *H. canescens* is shown, based on specimens examined, to show the New Mexico locality in context—the range continues to the southeast in Texas. Some of the localities (open circles) for *H. canescens* in Kansas are added from Great Plains Flora Association (1976).

southern Arizona (Fig. 2). Intermediates, if they occur at all, are not common. Biologically, var. *arizonica* fits criteria for recognition of a taxon at specific rank, and it is so treated here.

Heterotheca arizonica (Semple) Nesom, comb. et stat. nov. *Heterotheca fulcrata* (Greene) Shinners var. *arizonica* Semple, Brittonia 39:380. 1987. Type: U.S.A. Arizona. Gila Co.: 0.3 km NW of East Verde River, AZ Hwy 87, NW of Payson, 13 Sep 1985, *J.C. Semple and S. Heard 7923* (holotype: NY; isotypes: ASU, MO, US, WAT). The herbaria cited are from the protologue; specimens apparently have not been deposited at ASU, MO, NY, or US. The concept of the taxon is from annotations by Semple on TEX-LL specimens.

Heterotheca arizonica is characterized as follows: (1) stems and leaves densely and prominently sessile-glandular, essentially green-colored because of the sparsely to moderately hirsutulous nonglandular vestiture; (2) cauline leaves elliptic to elliptic-oblanceolate or elliptic-lanceolate, 5–15 mm long, usually relatively even-sized, spreading or ascending, often with only the midvein visible and distinctly thickened and raised on abaxial surface, with a thick-indurate, sharp-pointed, often recurving terminal mucro; (3) heads often (sometimes not) immediately subtended by small, linear to oblanceolate foliar bracts; and (4) phyllaries glabrous to sparsely minutely glandular to sparsely strigose.

Status of *Heterotheca viscida*

Heterotheca viscida (A. Gray) Harms (Fig. 3) has been identified with relative consistency. It is included in the consideration here because of its similarity in geographic range to *H. arizonica* and its occasional confusion with that taxon and expressions of *H. fulcrata*. *Heterotheca viscida* is characterized by its conspicuously glandular (usually stipitate-glandular) vestiture; because of the characteristic lack or paucity of nonglandular hairs, stems and leaves are generally distinctly green. Leaves and stems of some collections from Jeff Davis Co., Texas, are minutely and inconspicuously glandular but prominently villous; *H. viscida* of typical vestiture also is common in the area and intermediates occur. Leaves are oblong-obovate to obovate-oblong, sessile and sometimes subclasping, 15–40 mm long and (7–)10–20(–25) mm wide. Heads are on peduncles without immediately subtending foliar bracts. Plants commonly grow on cliff faces and ledges and in crevices. Semple (1996) mapped *Heterotheca viscida* in Pima Co., Arizona, but did not cite specimens from there.

Heterotheca viscida (A. Gray) Harms, Rhodora 70:302. 1968. *Chrysopsis villosa* (Pursh) Nuttall var. *viscida* A. Gray, Synopt. Fl. N. Amer. 1(2):123. 1884. *Chrysopsis viscida* (A. Gray) Greene, Erythea 2:96. 1894. Type: U.S.A. Arizona. Santa Cruz Co.: Santa Rita Mts., clefts of dry ledges, 7500 ft, 28 May 1881, *C.G. Pringle s.n.* (lectotype, Harms 1968b: GH!; isolectotypes: NY 3 sheets [internet images!], PH).

Status of *Heterotheca zionensis*

In an earlier study (Nesom 2006) I noted that *Heterotheca zionensis* Semple was difficult to distinguish from *H. villosa* var. *pedunculata* (Greene) Semple, based on criteria provided by Semple. With further study and perspective, *H. zionensis* is accepted here as a distinct species, essentially as previously described by Semple (1996), but occurring more widely in New Mexico and extending into trans-Pecos Texas (Fig. 4). The apparently disjunct plants in northwestern Colorado (e.g., Moffatt Co.: along Hwy 40, 30 Aug 1930, *Baker 4833b*, LL; Pat's Hole, near the confluence of Green and Yampa rivers, 8 Jul 1945, *Porter 3635*, SMU) also were recorded by Semple (1996). A single collection from Idaho has been recorded in this study: Bear Lake Co.: Bear Lake, 6 Aug 1898, *Mulford 327* (MO).

Plants of *Heterotheca zionensis* are distinctive in their relatively large stature—stems strictly erect from the base, commonly 4–10 dm tall (grazed or damaged plants may be smaller), up to 2–4 mm thick in the proximal portions, and often 10–20 stems per clump—and in their silvery to silver-gray, sericeous to densely strigose vestiture of thin-based, closely appressed nonglandular hairs. Cauline leaves are oblanceolate-obovate, spreading to ascending, and relatively even-sized up the stem; basal leaves are absent by flowering. Capitula are pedunculate, and often numerous in a subcorymboid arrangement. Cauline vestiture is antrorsely appressed to ascending, rarely spreading. Semple (1987, p. 385) noted that "Non-glandular forms of *H. zionensis* occur in north-central Utah; glandular and non-glandular forms occur in the Utah-Arizona border region." In New Mexico and Texas they are mostly non-glandular but glandular plants also have been collected, especially near the range of *H. villosa* var. *angustifolia*.

The type of *Heterotheca villosa* var. *pedunculata* (isotypes: MO!, NMC!) was collected in Archeluta Co., Colorado, outside the geographic range of *H. zionensis*. It is similar in habit to many other plants of the regional form of *H. villosa* (var. *minor*, as identified by Semple), but it is at the denser extreme of a variable range in nonglandular vestiture density in the species, which gives it a silvery-gray aspect. The leaves of *H. villosa* usually are basally narrowed to a petiole-like region and gradually diminished in size up the stem.

New Mexico plants treated here as *Heterotheca zionensis* apparently have been identified mostly as *H. villosa* var. *pedunculata* by Semple (1996, and by annotation). Those in trans-Pecos Texas were referred by him to a disjunct population system of *H. canescens* (DC.) Shinners and to *H. villosa* var. *angustifolia*. In 2003 I also identified and annotated these trans-Pecos plants as the "trans-Pecos form" of *H. canescens*, but later (Nesom 2006, as mapped in Fig. 1) I included these as part of the range of *H. villosa* var. *angustifolia*. In the current study, the ranges of *Heterotheca zionensis* and *H. villosa* var. *angustifolia* are recognized to overlap in the trans-Pecos region and in central New Mexico (Fig. 4), where they sometimes are closely similar in habit and aspect and perhaps hybridize. *Warnock 6230* from Reeves Co., Texas (cited below), is densely sericeous but like var. *angustifolia*, the plants produce some axillary leaves and are slightly glandular beneath the nonglandular vestiture—they may be of hybrid origin. Some collections from San Miguel Co. and Santa Fe Co., New Mexico, also suggest the occurrence of gene flow.

Some New Mexico collections of *Heterotheca villosa* var. *angustifolia* were identified as *H. canescens* by Semple, some as *H. villosa* var. *pedunculata* (1996, and by NMC annotation).

The following key distinguishes these taxa as they occur in Texas and New Mexico.

1. Heads pedunculate, without closely subtending leaves or bracts; axillary clusters of small leaves usually not produced along stems; leaves usually without sessile glands beneath the nonglandular hairs __________ **Heterotheca zionensis**
1. Heads on leafy stems, often with immediately subtending, narrowly lanceolate foliar bracts; numerous axillary cluster of small leaves usually produced along stems; leaves with or without sessile glands beneath the nonglandular hairs.
   2. Stems thicker and obscurely lignescent, originating from a thick, woody caudex; leaves narrowly oblanceolate to narrowly obovate, strigose but gray-green, almost always with orange, sessile glands often sparse but evident beneath the nonglandular hairs __________ **Heterotheca villosa** var. **angustifolia**
   2. Stems thin, distinctly lignescent, originating from relatively thin, adventitiously rooted caudex branches; leaves narrowly oblanceolate, usually silvery-sericeous, without sessile glands beneath the nonglandular hairs __________ **Heterotheca canescens**

Because *Heterotheca zionensis* has not been previously recognized in Texas, specimens are cited here (below); occurrences in New Mexico also are documented.

TEXAS. Brewster Co.: 2 mi W of Alpine, south side Hwy 90, left of first underpass to Marfa, infrequent, 4300–4500 ft, 4 Oct 1946, *Brown B95* (LL, SMU-2 sheets, SRSC); limestone soil at Althida, ca 20 mi E of Alpine, 4000 ft, 24 Sep 1935, *Fletcher 487* (SRSC); Glass Mts, arroyo at Altuda Pass, 8 Aug 1940, *Warnock 279* (GH, SRSC, TEX); frequent on Alpine Golf Course, Alpine, 13 Aug 1937, *Warnock T439* (GH, TEX); Paradise Canyon, 4 mi W of Alpine, infrequent in igneous soil, 4600 ft, 8 Aug 1947, *Warnock 6656* (LL, SMU 2 sheets, SRSC, TEX). **Jeff Davis Co.:** Davis Mts, Mitre Peak, 16 Aug 1927, *Cory 45386* (LL). **Presidio Co.:** between railroad and Hwy 90, ca. 1/2 mi NW of Paisano Campground, 4900 ft, 3 Aug 1947, *Hinckley 3962* (SMU, SRSC). **Reeves Co.:** common along hwy to Carlsbad, limestone soil, 11 mi N of Pecos, 4000 ft, 3 Jul 1947, *Warnock 6230* (SRSC, TEX); 3 mi N of Arno on Hwy 285, barren ridge with mesquite-yucca association, 22 Aug 1942, *Waterfall 4248* (MO).

NEW MEXICO. Doña Ana Co.: Mesilla Valley, 2 mi NW of San Miguel, sandy wash, 1200 m, 18 Aug 1930, *Fosberg S3850* (LL); Mesilla Valley, sand hills, no date, *Mead s.n.* (NMC); Little Mt., near Las Cruces, 26 Aug 1902, *Metcalfe s.n.* (NMC); E Las Cruces at University Ave. E of Telshor Drive, 2 km E of IH-25, NE side of Tortugas Mtn., roadside drain in limestone soil, 1360 m, 24 Aug 2001, *Spellenberg & Brouillet 13268* (BRIT, NMC); S edge of Las Cruces, roadside of Hwy I-10, abundant roadside weed for many miles along road edges and borrow pits, 3900 ft, 31 Aug 1981, *Ward 81-550*, voucher for $n = 9$ (NMC); Organ Mountains, Bishop's Cap, 4 Oct 1903, *Wooton s.n.* (NMC); mesa W of the Organ Mountains, 4000 ft, 1 Oct 1907, *Wooton s.n.* (MO, NMC); Bishop Cap, 2 air km NNW of the top of Bishop Cap, 1400 m, 24 Sep 1988, *Worthington 17524* (TEX); Bishop Cap, 2 air km NNW of the top of Bishop Cap, limestone arroyo, 1400 m, 2 Oct 1988, *Worthington 17560* (TEX); Organ Mts., Butterfield Park, soil from igneous substrate, 4600 ft, 22 Sep 1999, *Worthington 28700* (TEX). **Eddy Co.:** Queen Quadrangle, Last Chance Canyon, canyon bottom of limestone boulders, 5000 ft, 24 Jun 1999, *Baker 13358* (NMC); Guadalupe Mts., 2.6 mi by road NE of Sitting Bull Falls, 24 Jun 1981, *Van Devender & Oler s.n.* (BRIT); Last Chance Canyon, 1400 m, 29 Aug 1988, *Worthington 27964* (TEX). **Grant Co.:** near Silver City, 30 Sep 1880, *Greene 12857* (MO); Silver City, bank of Hwy 180 West, near corner of Hill and Mississippi streets, 6000 ft, 20 Oct 1985, *Zimmerman 2984* (TEX); NW edge of Silver City, along Hwy 180, 6000 ft, 12 Sep 1987, *Zimmerman 3001* (TEX). **Lincoln Co.** [label says "Chaves Co."]: 35 mi W of Roswell, ca. 3800 ft, Aug 1900, *Earle 510* (MO). **McKinley Co.:** Zuni Mts., 8 mi E of NM Hwy 32 on road to McGaffey, sandy soil, just inside Cibola National Forest, 16 Aug 1973, *Spellenberg 3527* (NMC). **Otero Co.:** Mayhill, low, rocky, open woods, 13 Aug 1969, 6670 ft, *Demaree 60793* (SMU). **Santa Fe Co.:** Santa Fe, Old Cemetery, 2120 m, 28 Sep 1935, *Arsène 22126* (SMU); Santa Fe, SE part of city near Musem of Internatl. Folk Art, dry open ground, 7200 ft, 3 Aug 1963, *Bennett 8296* (TEX); Broken Hill Ranch near Rte 10, 3 mi NE from Los Cerillos, 6000 ft, 13 Aug 1963, *Bennett 8298* (TEX); 4 mi N of Madrid, locally abundant on roadsides, 6800 ft, 15 Aug 2001, *Neff 01-08-15-01* (TEX); Santa Fe Creek at Santa Fe, 23 Jul 1908, *Standley 4503* (NMC).

Status of *Chrysopsis elata*

Chrysopsis elata Osterhout was cited by Semple (1996) as a synonym of *Heterotheca fulcrata* var. *fulcrata* and the isotype (NY) was annotated by him as such in 1997. The NY isotype had been earlier annotated by Semple (in 1993) as *H. villosa* var. *minor. Chrysopsis elata* is identified here as *H. villosa* var. *villosa*.

Chrysopsis elata Osterhout, Bull. Torrey Bot. Club 57:560. 1931. TYPE: U.S.A. COLORADO. Eagle Co.: Red Cliff, 16 Aug 1906, *G.E. Osterhout 3359* (HOLOTYPE: RM; ISOTYPE: NY [internet image!]). The protologue states that Osterhout "3335" is the type, but the RM and NY sheets both are labeled with the collection number "3359." The original manuscript, in Osterhout's hand, is stapled to the RM holotype and has "3359" as the type number. On Osterhout's unique red type label, C.L. Porter in 1950 noted that publication of the number "3335" was in error.

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GENERIC REALIGNMENTS IN TRIBE *POTENTILLEAE* AND REVISION OF *DRYMOCALLIS* (ROSOIDEAE: ROSACEAE) IN NORTH AMERICA

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ABSTRACT

The convergence of morphology-based research by J. Soják and molecular analysis by T. Erikkson et al. supports the resurrection of *Comarum, Dasiphora, Drymocallis, Sibbaldia,* and *Sibbaldiopsis* from *Potentilla* s.l. These segregate genera, which were used by P.A. Rydberg in the last continent-wide treatment of tribe *Potentilleae* in North America, will be used in the forthcoming treatment of *Potentilleae* in *Flora of North America North of Mexico.* The genus *Drymocallis* in North America is revised to encompass 15 species and seven additional varieties, in place of the three species of *Potentilla* (*P. arguta, P. fissa, P. glandulosa*) and 11 additional varieties recognized by D.D. Keck. **Drymocallis pseudorupestris** var. **saxicola** Ertter (widespread), **D. pseudorupestris** var. **crumiana** D.D. Keck ex Ertter (California), and **D. deseretica** Ertter (central Utah) are described as new, and several new combinations are made: **D. lactea** var. **austiniae** (Jeps.) Ertter, **D. glandulosa** var. **wrangelliana** (Fisch. & Avé-Lall.) Ertter, **D. glandulosa** var. **reflexa** (Greene) Ertter, **D. glandulosa** var. **viscida** (Parish) Ertter, **D. campanulata** (C.L. Hitchc.) Ertter, and **D. cuneifolia** var. **ewanii** (D.D. Keck) Ertter. The last combination results from the recent rediscovery of *D. cuneifolia* var. *cuneifolia,* which is currently known from a single population in the San Bernardino Mountains of California.

Key Words: Rosaceae, Potentilleae, *Drymocallis*, *Dasiphora*, *Comarum*, generic realignment, new species, *Sibbaldiopsis*

RESUMEN

La convergencia entre la investigación basada en la morfología realizada por J. Soják y los análisis moleculares realizados por T. Erikkson et al. soportan la resurrección de *Comarum, Dasiphora, Drymocallis, Sibbaldia,* y *Sibbaldiopsis* desde *Potentilla* s.l. Estos géneros segregados, que se usaron por P.A. Rydberg en el último tratamiento a nivel continental de la tribu *Potentilleae* en Norte América, será usado en el próximo tratamiento de *Potentilleae* en la *Flora of North America North of Mexico.* El género *Drymocallis* en Nore América es revisado para incluir 15 especies y siete variedades adicionales, en lugar de las tres especies de *Potentilla* (*P. arguta, P. fissa, P. glandulosa*) y 11 variedades adicionales reconocidas por D.D. Keck. **Drymocallis pseudorupestris** var. **saxicola** Ertter (de amplia distribución), **D. pseudorupestris** var. **crumiana** D.D. Keck ex Ertter (California), y **D. deseretica** Ertter (Utah central) se describen como nuevas, y se hacen varias combinaciones nuevas: **D. lactea** var. **austiniae** (Jeps.) Ertter, **D. glandulosa** var. **wrangelliana** (Fisch. & Avé-Lall.) Ertter, **D. glandulosa** var. **reflexa** (Greene) Ertter, **D. glandulosa** var. **viscida** (Parish) Ertter, **D. campanulata** (C.L. Hitchc.) Ertter, **D. cuneifolia** var. **ewanii** (D.D. Keck) Ertter. La última combinación resulta del reciente redescubrimiento de *D. cuneifolia* var. *cuneifolia,* que es conocida actualmente de una única población en las montañas de San Bernardino de California.

Tribe *Potentilleae* Sweet (Rosoideae: Rosaceae*)* is comprised of *Potentilla* L. and variously recognized segregate and related genera, including *Fragaria* L., *Ivesia* Torrey & A. Gray, and *Sibbaldia* L. All of these genera have at one time or another been included within *Potentilla*, and multiple segregate genera have been proposed. *Potentilla* s.s. is widespread throughout arctic and temperate regions of the northern hemisphere, with southward extensions along the American cordilleran system and mountains of southeast Asia and adjacent Malesian archipelago. The last attempt at a worldwide monograph of *Potentilla* s.l. (excluding *Ivesia, Horkelia* Cham. & Schltdl., and related segregate genera endemic to western North America) was by Wolf (1908), who tallied over 300 species along with numerous varieties and hybrids. This number is a poor indicator of the current status, given the significant number of taxa that have been described, reduced to synonymy, or otherwise been subject to taxonomic realignment during the intervening century.

Two relatively recent developments have contributed to an improved understanding of worldwide diversity and generic circumscriptions in *Potentilleae*, one political, one scientific. On the geopolitical front, the collapse of the Soviet bloc and renewed relations between the United States and China made essential comparisons of American and Asian variation significantly easier. Collaboration among researchers with expertise in their respective geographic areas are paving the way for a modern monographic synthesis of

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Potentilleae, including the Panarctic Flora project (Elven et al. 2007) and the Flora of China project (*Potentilleae* by Li et al. 2003). In the scientific realm, a molecular phylogenetic underpinning of *Potentilleae* has now been generated by Torsten Eriksson et al. (1995, 1998, 2003) with additional efforts underway by Christoph Dobes (pers. comm. 2006), Bente Eriksen (pers. comm. 2007), and their colleagues.

The present paper summarizes the historical and current nomenclatural framework in *Potentilleae* resulting from these developments. It also provides a revision of one of the resurrected generic segregates, *Drymocallis* Fourr. ex Rydb., including several new taxa and combinations. This synopsis serves to introduce nomenclatural adjustments to *Potentilleae* that will be implemented in vol. 9 of *Flora of North America North of Mexico*, scheduled for publication in late 2008.

NOMENCLATURAL AND PHYLOGENETIC OVERVIEW OF *POTENTILLEAE*

The last continent-wide treatments of North American *Potentilleae* were by Per Axel Rydberg (1898, 1908), who argued that "Either the whole tribe, *Fragaria* also included, must constitute a single genus, or else both *Potentilla* and *Ivesia* be divided into several genera" (1898, p. 16). Choosing the latter option in his 1898 monograph of North American *Potentilleae,* Rydberg accordingly recognized the genera *Argentina* Hill, *Chamaerhodos* Bunge, *Comarella* Rydb., *Comarum* L., *Comocarpa* Rydb., *Drymocallis, Duchesnea* Sm., *Horkelia* (encompassing *Ivesia*), *Sibbaldia, Sibbaldiopsis* Rydb., and *Stellariopsis* Rydb., in addition to *Fragaria* and a significantly reduced *Potentilla* s.s. This generic framework was largely retained in his 1908 treatment of Rosaceae for *North American Flora,* except for the replacement of *Comocarpa* with *Dasiphora* Raf., the resurrection of *Ivesia* as distinct from *Horkelia,* and the addition of *Horkeliella* Rydb. and the recently described *Purpusia* Brandegee.

Rydberg was considered a consummate "splitter" by contemporary and later generations of botanists, such that most of his generic segregates disappeared into synonymy in subsequent regional floras in North America. Most European authors also adopted an inclusive circumscription of *Potentilla*, following the world monograph by Theodor Wolf (1908). David D. Keck (1938) retained and revised *Horkelia* and *Ivesia* as distinct genera, but submerged *Comarella, Horkeliella,* and *Stellariopsis* within *Ivesia.* Keck (in Clausen et al. 1940) also submerged *Drymocallis* within *Potentilla,* with most of Rydberg's species reduced to subspecies or synonyms of a single species, *P. glandulosa* Lindl. In the opinion of Keck and his collaborators, "there is no justification for excluding *Drymocallis* from *Potentilla.* Certain species undoubtedly belonging to *Potentilla* closely link *Drymocallis* to the main body of the genus. We do believe, however, that the morphological distinctions of the anther and the position of the style, combined with a homogeneity of form, justify the maintenance of *Drymocallis* as a section or subsection of *Potentilla.*"

Keck's circumscriptions of genera and species in the *Potentilleae* were largely adopted by subsequent regional floras in North America, though *Ivesia* and *Horkelia* were sometimes included in *Potentilla* (e.g., Howell 1949; Kearney & Peebles 1951). An element of confusion was introduced by Hutchinson (1964), who cited Keck's revision of *Ivesia* and *Horkelia* in his synthesis of flowering plant genera but failed to incorporate the conclusions in his opus. Hutchinson's indication of 35 species of *Ivesia*, three species of *Horkeliella*, two species of *Comarella*, and one species of *Stellariopsis* conflicts with Keck's recognition of only 22 species of *Ivesia* s.l., which includes the species placed in the segregate genera recognized by Hutchinson. Researchers who rely on Hutchinson for generic delineations of these western North American genera are accordingly at odds with current usage as reflected in recent floristic treatments (e.g., Hitchcock & Cronquist 1961; Ertter 1993; Holmgren 1997; Welsh et al. 1993). Subsequent to Keck's revision of *Ivesia* and *Horkelia,* no flora has used either *Comarella* or *Stellariopsis,* and when *Horkeliella* was resurrected it contained only two species (Ertter 1993). *Purpusia,* which Keck (1938) had retained as a distinct genus, has also been submerged into *Ivesia,* along with several species of *Potentilla* that were morphologically nearly identical to certain species of *Ivesia* except for details of flower structure that apparently form an evolutionary sequence (Ertter 1989).

Further generic resurrections are now supported by the felicitous convergence of independent morphological and molecular studies. In 1989, Czech botanist Jiří Soják published his conclusion that *Potentilleae* was divided into two fundamental evolutionary lines. The *Fragaria*-line, characterized by sub-basal or lateral styles and anthers with a single horseshoe-shaped theca that opens by a marginal slit, consisted not only of *Fragaria* but also those species sometimes placed in *Comarum, Dasiphora* (as *Pentaphylloides* Duhamel), *Drymocallis, Sibbaldia, Sibbaldiopsis* and two small Asian genera (*Farinopsis* Chrtek & Soják and *Schistophyllidium* [Juz. ex Fed.] Ikonn.). The second evolutionary line, comprised of *Potentilla* s.s., *Ivesia,* and *Horkelia,* was characterized by subterminal styles and anthers with two thecae divided by the connective apex that opens by two lateral slits. The species potentially comprising *Argentina* (e.g., *P. anserina* L.) and the Asian genus *Tylosperma* Botsch. were more problematic.

Soják was then faced with the three options of 1) lumping everything in a single swollen genus, which in his understanding would need to be *Fragaria*: 2) treating the two evolutionary lines as separate genera, with all species of *Potentilleae* included in either *Fragaria* or *Potentilla;* or 3) breaking the components of each line into narrower, more homogeneous genera. Echoing Rydberg's decision, Soják chose the last option, as the simplest, most straight-forward solution that required the least nomenclatural disruption, and accordingly recognized the genera listed above and created the new combinations needed in Eurasian *Drymocallis.* Except for *Drymocallis,* Soják was therefore in concordance with the nomenclature used by his Russian colleague Boris A. Yurtsev in a flora of the arctic Soviet Union (1984). Although Soják's seminal paper was not widely available, being published in the journal of the National Museum in Prague while Czechoslovakia was just emerging from behind the Iron Curtain, his generic conclusions are reflected in more recent papers (e.g., Soják 2004), in which the superfluous and thus illegitimate *Pentaphylloides* is replaced by *Dasiphora* and *Argentina* is sometimes treated as distinct. An unpublished outline of North American *Potentilleae* Soják prepared in 1993 also reflects this generic framework, expanded by the addition of two subtribes to accommodate *Chamaerhodos, Alchemilla* L., *Aphanes* L., and *Lachemilla* Rydb.

Several years after Soják first published his generic outline, Torsten Eriksson and Michael Donoghue (1995) presented a molecular phylogenetic analysis of the *Potentilleae* that provided independent confirmation of the fundamental distinction between a potentilloid clade and a fragarioid clade, essentially corresponding to Soják's evolutionary lines. Further studies (Eriksson et al. 1998, 2003) confirmed and expanded the results, showing moreover that *Chamaerhodos* and the alchemilloids were also nested in the fragarioid clade and that the position of *P. anserina (Argentina)* was indeed ambiguous. *Comarella, Purpusia,* and *Stellariopsis* were specifically targeted for inclusion in further studies, indicating a reliance on Hutchinson (1964) as a generic starting point rather than Keck (1938) and all more recent floras. As it happens, preliminary ITS analysis of representative species of *Ivesia* (including *Comarella, Purpusia,* and *Stellariopsis*), *Horkelia,* and *Horkeliella* by the Christopher Baysdorfer lab (California State University, Hayward) results in a monophyletic polytomy (Ertter et al. 1998, unpublished data).

GENERIC DELIMITATIONS FOR *FLORA OF NORTH AMERICA*

There is no question that the species currently treated as *Potentilla* s.l. that fall into the fragarioid clade cannot be retained in *Potentilla* without that genus being polyphyletic, unless *Fragaria* and possibly *Chamaerhodos, Alchemilla, Aphanes,* and *Lachemilla* are also included. The two options are towards a more inclusive *Potentilla*, or the removal of all taxa in the fragarioid clade from *Potentilla*. In their discussion of nomenclatural implications, Eriksson et al. (1998, 2003) noted that if all taxa in the clades containing *Potentilla* s.l. were combined in a single genus, *Fragaria* apparently had priority. They were understandably reluctant to do a wholesale transfer of hundreds of species of *Potentilla* s.l. into *Fragaria* and instead, using the situation as an example of the purported advantages of phylogenetic nomenclature, proposed several rankless names for the best resolved clades (e.g., "Fragariinae"). Taking an alternative approach, Mabberley (2002) concluded that *Fragaria* need not take precedence and accordingly provided several new combinations to allow *Fragaria* to be included in *Potentilla* s.l.

Mabberley based his decision on a trend toward more inclusive genera in economically important taxa (e.g., *Prunus* s.l., *Lycopersicon* combined with *Solanum*). In contrast, the dominant trend affecting generic usage in North America has been in the opposite direction; e.g., Grimes' (1990) work on the *Psoraleeae* (Fabaceae) and Baldwin's (1999) work on the *Madiinae* (Asteraceae), often resulting in the resurrection of generic segregates first proposed by Rydberg and his fellow splitters. This latter approach is easily implemented in *Potentilla,* in that all of the essential generic names are already available and were used in the most recent continent-wide treatment of the family (Rydberg 1908). Initial steps have already been taken towards floristic implementation of the fragarioid generic segregates in both Europe (Kurtto & Eriksson 2003) and North America (e.g., Weber 1987; Weber & Whittman 1992; Pojar 1999; Aiken et al. 2006). Full implementation in North America will occur in volume 9 of *Flora of North America North of Mexico* (scheduled for publication in 2008), in which the following fragarioid genera that have sometimes been included in *Potentilla* will be recognized:

Comarum L.—*Comarum palustre* L. replaces *Potentilla palustris* (L.) Scop. One other Asian species sometimes placed in *Comarum* has been placed in its own genus as *Farinopsis salesoviana* (Stephan) Chrtek & Soják (1984).

Dasiphora Raf.—*Dasiphora fruticosa* (L.) Rydb. replaces *Potentilla fruticosa* L. Several previous treatments that initiated this generic change in North American (e.g., Holmgren 1997; Pojar 1999; Weber 1987) adopted *Pentaphylloides*, but this name has been subsequently interpreted as an illegitimate superfluous name for *Potentilla* (as noted by Kurtto & Eriksson 2003; Reveal et al. 1999).

Drymocallis Fourr. ex Rydb.—*Drymocallis* is the generic segregate from *Potentilla* with the most species, with centers of radiation in western North America, central Asia, and southeastern Europe. My provisional revision (below) recognizes fifteen species with an additional seven varieties in North America. Around thirteen Old World species are currently recognized, with most of the necessary combinations established by Soják (1989) and Kurtto & Eriksson (2003). The elevation of *Drymocallis* to generic status allows it to be used more definitively in making biogeographic comparisons between the southern Rocky Mountains of North America and the Altai of central Asia, as has recently been done by Weber (2003).

Fragaria L.—The treatment of *Fragaria* being prepared by Gündter Staudt will reflect his recent revision of North American strawberries (Staudt 1999).

Sibbaldia L.—*Sibbaldia procumbens* L. var. *procumbens* replaces the nomenclaturally invalid *Potentilla procumbens* (L.) Clairv. (a later homonym of the unrelated *P. procumbens* Sibth.), *P. sibbaldi* Haller f., and *P. sibbaldia* Kurtz. Soják (pers. comm. 2006) recognizes only six species of *Sibbaldia,* with most others placed in *Potentilla.*

Sibbaldiopsis Rydb.—*Sibbaldiopsis tridentata* (Soland.) Rydb. replaces *Potentilla tridentata* Soland. Soják (ined.) is also transferring two Asian species (*P. cuneifolia* Bertol. and *P. miyabei* Makino) into this genus, which corresponds to Wolf's (1908) "Grex *Tridentatae.*"

The potentilloid segregates *Duchesnea, Ivesia, Horkelia,* and *Horkeliella* will be retained as in the current treatment for California (Ertter 1993) and the Intermountain Region (Holmgren 1997). Although it has long been assumed that these genera most likely evolved from and are accordingly nested within *Potentilla* s.s., as is now supported by molecular evidence (Erikkson et al. 1995, 1998, 2003), I strongly concur with Brummitt (2002), Diggs and Lipscomb (2002), and Hörandl (2006) that paraphyly alone is insufficient grounds for dictating generic delimitations. *Comarella, Purpusia,* and *Stellariopsis* will be retained in *Ivesia*, although Soják (ined.) argues that the distinctive anthers of *Stellariopsis* (= *Ivesia santolinoides* A. Gray), which dehisce by subterminal pores, justify recognition as a separate genus.

REVISION OF NORTH AMERICAN *DRYMOCALLIS*

The North American members of *Drymocallis*, as *Potentilla glandulosa* and allies, were among those studied by Jens Clausen, David D. Keck, and William M. Hiesey in their seminal experiments on biosystematics (Clausen et al. 1940; Clausen & Hiesey 1958). They confirmed that the complex, which they considered to be "one of the most satisfactory in the transplant investigations, and … the most important" (Clausen et al. 1940, p. 26), consists of a wide diversity of ecotypes, often highly localized, differing from one another ecologically, physiologically, and morphologically. They also demonstrated that hybrids between these ecotypes are readily generated, aided by a diploid chromosome number of n=7 shared by all species thus far counted, and intergradation zones where ecotypes intersect are the norm. In contrast to the *Potentilla gracilis* complex, which they also investigated, apomixis is not known to play a role in *Drymocallis*. The responsibility of converting this biosystematic complexity into a functional taxonomic framework fell on Keck (in Clausen et al. 1940), whose compromise approach reduced Rydberg's (1908) 28 species of *Drymocallis* to only three species of *Potentilla* (*P. arguta* Pursh, *P. fissa* Nutt., *P. glandulosa* Lindl.), with most of the ecotypic variation treated as subspecies of *P. glandulosa*.

My initial intent for *Flora of North America* was to adopt Keck's taxonomy, as modified by Ertter (1993) and Hitchcock et al. (1969), with the requisite new combinations in *Drymocallis* and the description of a new taxon from California. I reluctantly concluded, however, that Keck's outline did not adequately accommodate current evidence of variation in North American *Drymocallis,* especially outside of central California where the biosystematic experiments had taken place. For one thing, it is not clear that Keck's subspecies are more closely related within a species than between species, as indicated, for example, by the narrow inflorescences of *P. arguta* subsp. *convallaria* (Rydb.) D.D. Keck and *P. glandulosa* subsp. *hansenii* (Greene) D.D. Keck*,* or the numerous leaflets of *P. fissa* and *P. glandulosa* subsp. *arizonica* (Rydb.) D.D. Keck. At the same time, there are extremes of variation beyond those addressed by Keck's abbreviated taxonomic treatment, such as the narrowly opened flowers of *P. glandulosa* subsp. *ewanii* D.D. Keck and *P. glandulosa* var. *campanulata* C.L. Hitchc. Rather than perpetuate an unacceptable taxonomic framework, I accordingly have decided to take the opportunity of a nomenclatural overhaul to introduce an alternate framework. This effort is unabashedly provisional, in that the time frame for *Flora of North America* does not allow for the complete revision that *Drymocallis* clearly deserves. My hope is that it is nevertheless a step forward in approximating the natural variation in *Drymocallis,* until such time as a more complete study can be undertaken that incorporates molecular analysis in combination with extensive studies of variation in the field.

At heart is the question of whether the goals of taxonomy are better served by sharply defined groupings, however polymorphic, or by more finely parsed natural variation, even at the expense of crisp circumscriptions. I have opted for the latter, even though this approach runs counter to that of several recent floristic works (e.g., Holmgren 1997; Welsh et al. 1993), in which many of Keck's subspecies are relegated to synonymy. My approach, comparable to that currently implemented in some other rosaceous genera (e.g., *Rosa* and sections of *Potentilla* s.s.), is to give taxonomic recognition at the species or subspecies level if a significant core of populations share a relatively cohesive suite of unique characters underpinned by a definable ecogeographic setting. Varieties are used where the core differences are less distinct and/or the intergradations more complex. Such a taxonomic approach can only be done with full understanding that any attempt to recognize formal taxa in North America *Drymocallis* will be compromised by wide zones of intergradation and populations that defy placement. The alternative is to accept such broadly defined taxa that extensive variation within an ecogeographic setting is glossed over, even that which would easily qualify as distinct species if the inconvenient zones of intergradation went extinct. Given this situation, and the current sociopolitical setting, it would be most unfortunate if valid components of biodiversity failed to receive the conservation attention they deserve for lack of sharp boundaries (Ertter 1997). Indeed, my suspicion is that at least some of the purported intergradation actually represents additional unrecognized entities, and that a cleaner taxonomy might result with the recognition of even more, not fewer, taxa. At the very least, I believe that the resultant taxonomic framework will lead to a better appreciation of diversity within *Drymocallis* and encourage more studies on a complex and fascinating genus.

Presented here is a complete synopsis of species of *Drymocallis* that will be recognized in *Flora of North America.* Synonyms used in recent floras are listed, new combinations are provided as needed, three new taxa are described, and some nomenclatural issues are discussed. A complete key, descriptions, and additional discussion will be available in vol. 9 of *Flora of North America,* and the California species will be covered in the pending new edition of *The Jepson Manual.* Additional synonymy can be found in Clausen et al. (1940), Rydberg (1908), Hitchcock and Cronquist (1961), Holmgren (1997), and the upcoming treatment in *Flora of North America.*

1. **Drymocallis fissa** (Nutt.) Rydb., Mem. Dept. Botany Columbia Coll. 2:197. 1898. = *Potentilla fissa* Nutt.

2. **Drymocallis arizonica** Rydb., N. Amer. Fl. 22:373, 1908. = *Potentilla glandulosa* Lindl. subsp. *arizonica* (Rydb.) D.D. Keck, not *Potentilla arizonica* Greene

3. **Drymocallis arguta** (Pursh) Rydb., Mem. Dept. Bot. Columbia Coll. 2: 192. 1898. = *Potentilla arguta* Pursh.

In his treatment for *North American Flora,* Rydberg (1908) replaced *D. arguta* with *Drymocallis agrimonioides* (Pursh) Rydb., presumably because the conspecific *Geum agrimonioides* Pursh (Fl. Amer. Sept. 351) was on an earlier page than *Potentilla arguta* Pursh (Fl. Amer. Sept. 736). According to the International Code of Botanical Nomenclature, page sequence has no bearing on priority in a single work that was published as a unit, which is the situation for *Flora Americae Septentrionalis* since both volumes were distributed in the last two weeks of 1813 (Reveal et al. 1999). Rydberg's (1898) initial use of *D. arguta,* in which *Geum agrimonioides* is cited in synonymy, confirms that the more familiar epithet can be retained.

4. **Drymocallis convallaria** (Rydb.) Rydb., Mem. Dept. Bot. Columbia Coll. 2:193. 1898. = *Potentilla arguta* Pursh subsp. *convallaria* (Rydb.) D.D. Keck; *P. arguta* Pursh var. *convallaria* (Rydberg) Th. Wolf.

5. **Drymocallis micropetala** Rydb., N. Amer. Fl. 22:375. 1908. = *Potentilla glandulosa* Lindl. subsp. *micropetala* (Rydb.) D.D. Keck; *P. glandulosa* Lindl. var. *micropetala* (Rydb.) S.L. Welsh & B.C. Johnst.

6. **Drymocallis hansenii** (Greene) Rydb., Mem. Dept. Bot. Columbia Coll. 2:200. 1898. = *Potentilla hansenii* Greene; *P. glandulosa* Lindl. subsp. *hansenii* (Greene) D.D. Keck.

7. **Drymocallis lactea** (Greene) Rydb., N. Amer. Fl. 22:369. 1908.

7a. Drymocallis lactea var. **lactea** = *Potentilla glandulosa* Lindl. var. *nevadensis* S. Watson; *P. glandulosa* subsp. *nevadensis* (S. Watson) D.D. Keck; not *P. nevadensis* Boiss. (1838).

This taxon has a well-established identity as *Potentilla glandulosa* var. (or subsp.) *nevadensis,* but the epithet *lactea* has priority at species rank and its use avoids possible confusion with *P. nevadensis* Boiss.

7b. Drymocallis lactea var. **austiniae** (Jeps.) Ertter, comb. nov. Basionym: *Potentilla glandulosa* Lindl. var. *austiniae* Jeps., Fl. Calif. 2:181. 1936.

Jepson (1936) called *P. glandulosa* var. *austiniae* a nom. nov. for *P. glandulosa* var. *fissa* Jepson, the combination he had used in his *Manual* (Jepson 1925). According to K. Gandhi (pers. comm. 2006), var. *austiniae* stands as a legitimate taxon distinct from *P. fissa* Nutt., since this species was explicitly excluded by Jepson (1936), but var. *fissa* Jeps. must be considered a synonym of *P. fissa* and is furthermore an isonym of *P. glandulosa* var. *fissa* (Nutt.) Th. Wolf (1908).

This variety was erroneously treated as *Potentilla glandulosa* subsp. *ashlandica* (Greene) D.D. Keck by Ertter (1993), but I now understand both to be separate entities.

8. **Drymocallis ashlandica** (Greene) Rydb., Mem. Dept. Bot. Columbia Coll. 2:200. 1898. = *Potentilla glandulosa* Lindl. subsp. *ashlandica* (Greene) D.D. Keck; *P. ashlandica* Greene, Pittonia 3:248, 1897; *P. ciliata* Howell, Fl. N. W. Amer. 1:1715. 1898; not *P. ciliata* Raf. (1840) or *P. ciliata* Greene (1887).

Potentilla ashlandica Greene is sometimes said to be a nom. nov. for *Potentilla ciliata* Howell (e.g., Keck in Clausen et al. 1940), the latter illegitimate as a result of being a later homonym, but Greene's name was published first and makes no reference to *P. ciliata.* Both names are based on a collection by Howell from Ashland Butte, the only known collection of which is in Howell's herbarium in ORE (now housed in OSC).

9. **Drymocallis pseudorupestris** (Rydb.) Rydb., Mem. Dept. Bot. Columbia Coll. 2:194. 1898. = *Potentilla*

glandulosa Lindl. subsp. *pseudorupestris* (Rydb.) D.D. Keck; *P. glandulosa* var. *pseudorupestris* (Rydb.) Breitung; *P. rupestris* L. var. *americana* Th. Wolf.

Many populations of *Drymocallis pseudorupestris* from Montana and Wyoming, including the type of *Potentilla pseudorupestris* Rydb. (Long Baldy, Little Belt Mountains, Montana, *Flodman 598* [NY!]) are significantly larger plants than is the norm elsewhere, with bigger petals and longer filaments. I am treating these populations as *D. pseudorupestris* var. *pseudorupestris,* with further research needed to determine the optimum circumscription and resultant geographic range. Two new varieties are described here: var. *saxicola* to accommodate the majority of populations previously placed in *Potentilla glandulosa* var. *pseudorupestris,* and var. *crumiana* to accommodate a variant from the Sierra Nevada proposed but not published by Keck.

9a. **Drymocallis pseudorupestris** var. **pseudorupestris**

9b. Drymocallis pseudorupestris var. **saxicola** Ertter, var. nov. (**Fig. 1, M–R**). TYPE: UNITED STATES. IDAHO: Lemhi Co.: Bighorn Crags ca 30 air mi W of Salmon, head of drainage W of Welcome Lake, at N end of saddle to Barking Fox Lake, ledges in granite, T21N R16E S28 N1/2 of SW, ca 9000 ft, 31 Jul 1990, *B. Ertter 9493 with D. Atwood, R. Moseley, S. Bernatas, M. Mancuso* (HOLOTYPE: UC; ISOTYPES: BRY, ID, NY).

A var. *pseudorupestris* statura minore (< 2.5 dm), floribus parvioribus, filamentis brevioribus (1–2.5 mm) differt.

Herbaceous perennial from openly branched caudex or spreading rootstocks, sometimes ± rhizomatous, forming clumps to 6 dm across. **Stems** few to many, erect, 0.6–2.5(–3) dm tall, the base 1–2(–3) mm diam. with sparse to abundant peglike glands and septate glandular hairs to 2 mm long, short eglandular hairs sparse to abundant (lacking in some collections from Custer Co., ID). **Basal leaves** 3–9(–16) cm long with (2–)3(–4) pairs of lateral leaflets; sheathing leaf-bases often sparsely strigose; terminal leaflet broadly obovate-cuneate with a ± rounded apex, 0.8–2(–4) cm long, 0.7–2(–3) cm wide, usually with abundant peglike glands and sparse to moderately abundant eglandular hairs to 1.5 mm long, the margins single- to ± double-toothed ca ¼–⅓ to base with 3–8(–12) teeth per side. **Cauline leaves** 0–1(–2), 2–5(–8) cm long with 2–3 pairs of lateral leaflets. **Inflorescence** relatively open, comprising ¼–¾ of plant height, not particularly leafy; subtending bract ± trilobed, 1–2.5(–3) cm long; branches diverging at a (10–)20–40(–50)° angle; pedicels 3–15(–20) mm long, with sparse to abundant (never absent) septate glandular hairs and 0 to abundant eglandular hairs 0.1–0.5 mm long. **Flowers** (2–)3–12(–20); hypanthium saucer-shaped, 2.5–4(–5) mm diam., with highly variable proportions of peglike glands, septate glandular trichomes, and eglandular hairs to 1 mm long; epicalyx bractlets linear-lanceolate to broadly elliptic, 2–5 mm long, ± 1–1.5 mm wide, often toothed or lobed; sepals 4–6(–7) mm long, the vestiture like that of hypanthium, the apex obtuse (to acute), often mucronate, entire; petals cream to ± yellow, not red-tinged, narrowly to broadly obovate, 4–9 mm long (longest in Washington), 3.5–6(–8) mm wide, exceeding sepals, the apex rounded; stamens 20–25, the filaments 1–2.5 mm long, not red-tinged, the anthers ovate-elliptic, 0.7–1.2 mm long; styles ± fusiform, ± 1 mm long, most often golden brown. **Achenes** ± obliquely pyriform, generally short-beaked, ca 1 mm long, light brown.

Ecology and phenology.—Cliffs, ledges, outcrops, ridges, talus slopes, lava beds, and other generally rocky situations, 1000–3400 m elev. Flowering May–Aug.

As circumscribed here, *Drymocallis pseudorupestris* var. *saxicola* accommodates the bulk of specimens previously placed in *Potentilla glandulosa* var. *pseudorupestris,* minus the extremes at the northeastern and southern ends of the range. The current circumscription encompasses significant heterogeneity, which might be resolved into additional taxa upon further analysis. Plants from southeastern Oregon, including the type of *D. pumila* Rydb. from Steens Mountain, combine the habit of *D. pseudorupestris* and the vestiture of *D. lactea*.

REPRESENTATIVE SPECIMENS: **CANADA. ALBERTA:** Bellevue Hill, Waterton Lakes National Park, *J. Nagy & W. Blais 682* (DS). **UNITED STATES. CALIFORNIA: Eldorado Co.:** Mt. Tallac, *J.T. Howell 22949* (CAS). **Shasta Co.:** ridge overlooking Lake Helen, Lassen Volcanic National Park, *H. Bailey & V. Bailey 2949* (UC). **Siskiyou Co.:** W side of Shastina, Mt. Shasta, *W.B. Cooke 15372* (UC). **Fresno Co.:** Simpson Meadow, Middle Fork of Kings River, *J.T. Howell 33794* (CAS). **Tulare Co.:** Bullfrog Lakes 6 mi SE of Mineral King, *B. Rice 430* (CAS). **IDAHO. Adams Co.:** Black Lake, *J.H. Christ 8674* (UC). **Boise Co.:** Middle Fork Boise River 2 1/2 mi upstream from Twin Springs,

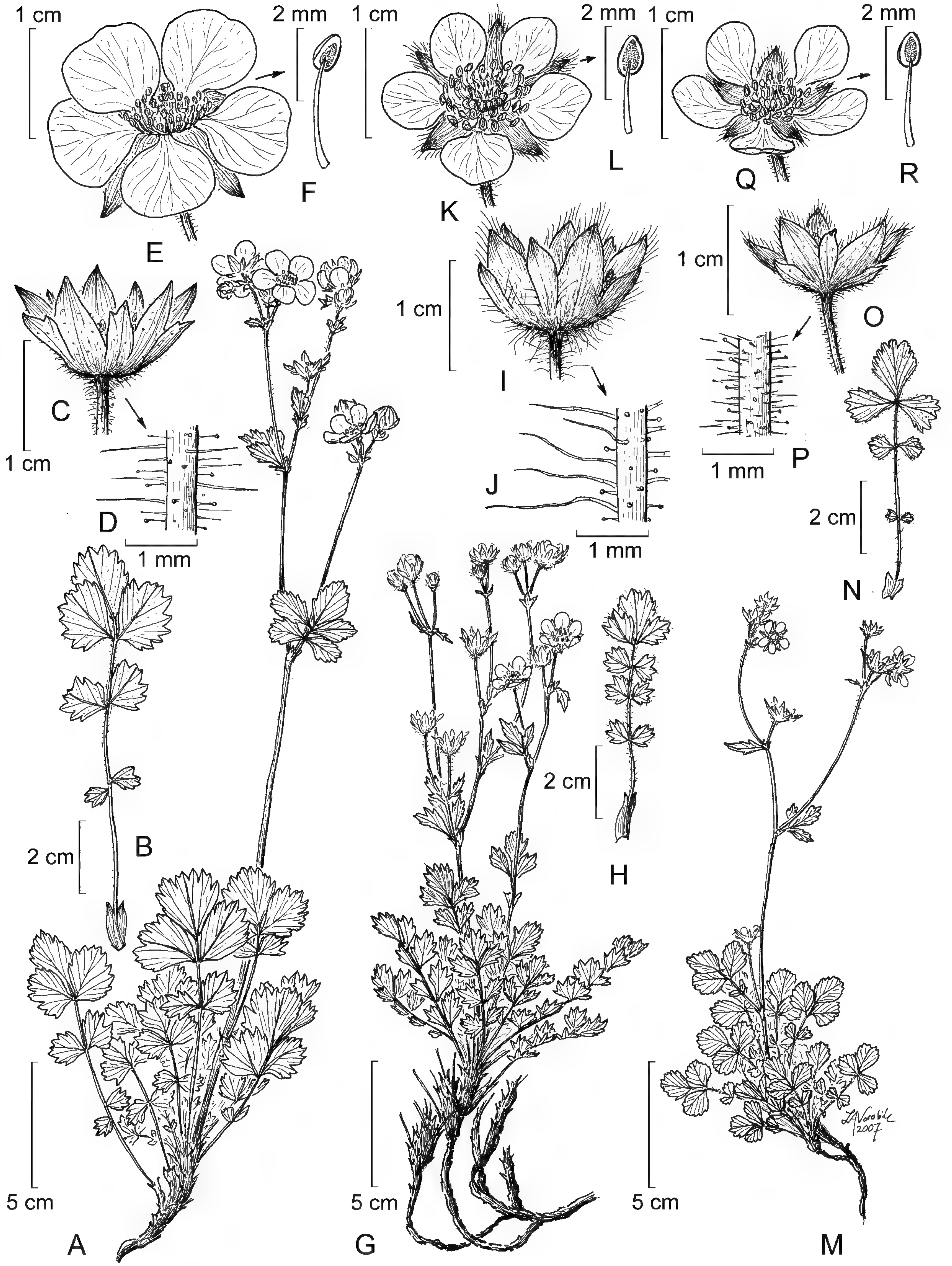

Fig. 1. Varieties of *Drymocallis pseudorupestris*. A–F: var. *pseudorupestris*. A: habit. B: basal leaf. C: hypanthium and calyx. D: vestiture of pedicel. E: flower. F: stamen. G–L: var. *crumiana*. G: habit. H: basal leaf. I: hypanthium and calyx. J: vestiture of pedicel. K: flower. L: stamen. M–R: var. *saxicola*. M: habit. N: basal leaf. O: hypanthium and calyx. P: vestiture of pedicel. Q: flower. R: stamen.

B. Ertter & C. Prentice 8703 (UC). **Butte Co.:** 10 mi N of Craters of Moon, 13 May 1941, *G. Williams s.n.* (UC). **Camas Co.:** summit of Featherville-Ketchum road, *C.L. Hitchcock & C.V. Muhlick 10426* (UC, WTU). **Custer Co.:** 3.5 mi SW of Stanley Lake, *C.L. Hitchcock & C. V. Muhlick 9626* (NY, UC, WTU). **Fremont Co.:** Shot Gun, *R.J. Davis 746* (UC). **Idaho Co.:** Seven Devils Ridge, *J. H. Christ 12473* (ID, UC). **Lemhi Co.:** Sleeping Deer Mountain, *B. Hayse 35* (WIS). **Valley Co.:** above Snowslide Lake 10 air mi NE of McCall, *B. Ertter & S. D'Alcamo 7805* (UC; to be distributed). **OREGON: Deschutes Co.:** Broken Top, Cascade Range, *B. Ertter & S. Garrett 15052* (UC). **NEVADA: Elko Co.:** 1.2 km NE of Matterhorn, Jarbidge Mts., *D. Charlet 445* (UC). **White Pine Co.:** Schell Creek Range, *A. Tiehm & S. Crisafulli 11797* (NY, RM, WIS). **UTAH: Juab Co.:** divide between Toms Creek and Basin Creek drainage, Deep Creek Range, *N.H. Holmgren & P.K. Holmgren 11185* (NY, UC). **Piute Co.:** S of Bullion Creek Canyon, Tushar Mts., *N.H. Holmgren, P.K. Holmgren, & C.S. Keller 10897* (NY, UC). **Sevier Co.:** 0.75 mi NW of Mt. Terrill, *S. Goodrich 24194* (BRY). **WASHINGTON: Asotin Co.:** Big Butte 6 mi W of Anatone, *H. St. John & R. Palmer 9594* (UC). **Chelan Co.:** Mission Ridge, Wenatchee Mts., *J.W. Thompson 14943* (NY, UC). **WYOMING:** Teton Mts., *A. Nelson & E. Nelson 6578* (RM, UC).

9c. Drymocallis pseudorupestris var. **crumiana** D.D. Keck ex Ertter, var. nov. (**Fig. 1, G–L**). TYPE: UNITED STATES. CALIFORNIA: Inyo Co.: Rock Creek Lake Basin, recess or cirque on east side, 11,500 ft, 21 Jul 1934, *F.W. Peirson 11272* (HOLOTYPE: UC 638452; ISOTYPES: DS 318001, DS 688601).

A var. *saxicola* foliolis plerumque 9, calycis setis conspicuis 1–1.5 mm longis, stylis plerumque vinosis differt.

Herbaceous perennial from openly branched caudex or spreading rootstock, with abundant stalked glands that generate an abundant golden resin. **Stems** few, erect, (0.3–)0.8–2(–2.5) dm tall, the base 1–2 mm diam. with sparse to abundant peglike glands and septate glandular hairs to 2 mm long, eglandular hairs generally lacking. **Basal leaves** (2–)3–9(–15) cm long with 3–4(–5) pairs of lateral leaflets; sheathing leaf-bases ± strigose; terminal leaflet broadly obovate to flabellate with rounded apex, 0.2–1.2(–2) cm long, 0.5–1.5 cm wide, with subsessile golden glands and sparse to moderately abundant spreading to ascending rigid setae 0.5–1 mm long, the margins predominantly single-toothed ca ⅓–½ to base with 2–5 teeth per side. **Cauline leaves** 0–2, 2–3.5(–6) cm long with 2–3 pairs of lateral leaflets. **Inflorescence** open, comprising ¼–½(–¾) of plant height, not leafy; subtending bract 0.5–2.5 cm long; branches diverging at a 10–40° angle; pedicels 5–12(–20) mm long, with ± abundant subsessile glands and septate glandular trichomes, eglandular hairs sparse to 0. **Flowers** 2–8; hypanthium saucer-shaped, 4–6 mm diam., with both scattered glandular trichomes and ± rigid spreading setae 1–1.5 mm long; epicalyx bractlets elliptic-ovate to lanceolate, 2–3.5(–4) mm long, 1–2 mm wide; sepals 4–6(–7) mm long, often red-tinged, the vestiture like that of hypanthium, the apex obtuse, generally mucronate, sometimes shallowly erose; petals cream to pale yellowish, often red-tinged, narrowly to broadly obovate, 5–7(–9) mm long, 3–5 mm wide, exceeding sepals, the apex rounded; stamens 25–30, the filaments 1.5–2(–3) mm long, often red-tinged, the anthers ovate-elliptic to nearly round, 0.7–1 mm long; styles thickly to narrowly fusiform, 1.2–1.5 mm long, most often dark red (golden brown in White Mts.). **Achenes** ± obliquely pyriform, ca 1 mm long, pale golden-brown with reddish apex.

Ecology and phenology.—Rocky slopes, talus, and ledges, in metamorphic, granitic, and volcanic substrates, 3200–3900 m elev. Flowering Jul–Aug.

The distinctiveness of this taxon was initially discussed in letters between Frank W. Peirson and Ethel Crum in the 1930's (archives of University Herbarium, University of California, Berkeley). Peirson, an avid collector, had sent specimens of *Potentilla* from Rock Creek Lake Basin in the eastern Sierra Nevada to the University of California at Berkeley for identification by Ethel K. Crum. Crum helped with *Potentilleae* for Jepson's *Flora of California* (1936), where she is described as "a scholarly assistant" who "became ardently attached to Potentilla, wherefore certain new varieties bearing her name" (p. 174). According to Mason (1943), Crum "assisted in the organization of the material for many of the larger genera in [vol. 2 of *Flora of California*], but adopted as her own, the genus *Potentilla*, the manuscript of which was accepted with some revisions." Crum maintained this interest during her tenure as Assistant Curator of the University Herbarium (1933–1943), during which time she was also Secretary to the Editorial Board of Madroño (Mason 1943).

In both of two drafts of her letter to Peirson of 15 November 1934, Crum identified his No. *11272* as "Potentilla sp. nov. This very interesting specimen of the Potentilla glandulosa aggregate with reddish tinged flowers differs in certain particulars from all segregates known to me … . I believe that in the present state of knowledge [of the] P. glandulosa aggregate it will be best to give this form a distinct binomial. If you wish, therefore, I shall be glad to prepare a description for publication, making your specimen the type of a new species." One draft of this letter (presumably the one sent) then adds the caveat that she first needs to examine the recently published *Potentilla brevifolia* var. *perserverans* A. Nelson. Crum never followed through on describing Peirson's collection, even when supplemented with additional collections, evidently deferring to David Keck and the contemporaneous biosystematics studies on the *Potentilla glandulosa* complex (letter of 5 May 1938). Peirson gave her his support, noting that "You have probably put more work and thought on Potentilla than anyone else in the state and it is only just and fitting that you proceed with a synopsis of the genus in spite of publications by others" (letter of 5 Oct 1940). In response, Crum (letter of 8 Oct 1940) indicated that she did not feel prepared to revise the genus, but agreed to return to *Peirson 11272,* "which I examined several years ago and then laid aside." She apologized for holding it up so long, and promised to send a "definite opinion" within the next two weeks.

Instead, Crum sent the specimen to Keck, "who was very much interested considering it was quite aberrant" (letter of 29 Oct 1940). Keck, who had just published his revision of the *P. glandulosa* complex (in Clausen et al. 1940), proposed to name the new taxon after Crum, which Peirson heartily endorsed (letter of 14 Dec 1940). Crum, however, urged Keck not to do so "not only because I don't deserve the honor but because my name is not euphonious" (letter of 20 Dec 1940). She hoped instead that Keck would use some variant of Peirson's name, though there already was a *P. peirsonii* Munz (= *Drymocallis cuneifolia* Rydb.). Following Crum's untimely death in January 1943, her colleague Annetta Carter wrote to Peirson about a letter received from Keck, in which he indicated his intent to use the epithet *crumiana*: "Miss Crum always objected to any publicity, but Dave feels that considering all the work that she did on Potentilla, she certainly deserves to have her name commemorated" (letter of 26 Oct 1944).

For whatever reason, Keck likewise never followed through on his intent to describe this distinctive taxon. I take great pleasure in adopting the suggestion of Keck, Peirson, and Carter in giving much-deserved recognition to one of my predecessors in *Potentilla* research, and finally giving a name to Peirson's discovery over 70 years after its original collection. Subsequent collections show the taxon to be both more widespread and perhaps less distinctive than initially believed. The red-tinged petals that first caught Crum's attention are not reliably present, but the leaflet characters provide a distinctive gestalt not found elsewhere in *Drymocallis,* though approaching *D. fissa* in Colorado.

OTHER SPECIMENS EXAMINED: **UNITED STATES. CALIFORNIA. Fresno Co.:** Kings Canyon National Park, Glenn's Pass Trail, 10,580–11,900 ft, 29 Jul 1948, *H. & V. Bailey 2736a* (UC); Kearsarge Pass, 11,500 ft, 15 July 1900, *W.L. Jepson 859* (JEPS); SE corner of Mt. Goddard, very steep stair-step climb, 12,350–12,750 ft, 15 Aug 1957, *C.H. Quibell 6933* (JEPS, RM); W toe of peak facing Goddard Canyon, 12,438 ft, 17 Aug 1957, *C.F. Quibell & A. McCallum 7047* (UC). **Inyo Co.:** Kearsarge Pass trail, 10,500 ft, 7 Aug. 1942, *A.M. Alexander & L. Kellogg 3272* (DS, NY, UC); Seventh Lake, Big Pine Lakes, 11,200 ft, 9 Aug 1947, *J.T. Howell 23963* (CAS); Inconsolable Range above Big Pine Lakes, 12,400 ft, 14 Aug 1947, *J.T. Howell 24093* (CAS, DS, UC); E side of Kearsarge Pass, 11,500 ft, 20 Jul 1948, *J.T. Howell 24790* (CAS); slope above N Fork of Oak Creek between Pk. 12606 and Pk. 10643, 11,500 ft, 6 Aug 1948, *F.L. Jones s.n.* (DS); head of Thibaut Creek, vicinity of Mt. Baxter, 10,600 ft, 16 Oct 1948, *F.L. Jones s.n.* (DS); Kearsarge Trail, 11,000 ft, 16 Aug 1936, *M. Kerr s.n.* (SBBG); Rock Creek Lake basin, cirque on east slope, 11,000 ft, 19 Jul 1931, *F.W. Peirson 9515* (UC); Rock Creek Lake Basin, rocky slopes above East Recess, 11,400 ft, 11 Aug 1937, *F.W. Peirson 12195* (JEPS); Taboose Pass trail, 11,200 ft, 16 Jul 1977, *D.W. Taylor 6604* (JEPS). **Mono Co.:** White Mountains, cirque heading N Fork of Perry Aiken Creek, 0.75 mi due E of White Mt. Peak, 11,900 ft, 25 Jul 1987, *J.D. Morefield & T.S. Ross 4701* (MO, NY, UC). **Tulare Co.:** near summit Arroyo-Kern Divide, region of Kaweah Peaks, 4 Aug 1897, *W.R. Dudley 2417* (DS); Nine Lakes Basin, head of Big Arroyo, cirque just north of Black Kaweah, 11,500 ft, 18 Aug 1938, *C.W. Sharsmith 3792* (DS, MO, NY, UC); W slope Kaweah Peaks Ridge above Nine Lakes Basin, head of Big Arroyo, 12,100 ft, 20 Aug 1938, *C.W. Sharsmith 3805* (CAS, UC).

10. Drymocallis glabrata Rydb., Mem. Dept. Bot. Columbia Coll. 2:201. 1898. = *Potentilla glandulosa* Lindl. subsp. *glabrata* (Rydb.) D.D. Keck; *P. glandulosa* Lindl. var. *intermedia* (Rydb.) C.L. Hitchc.

Potentilla glandulosa β *incisa* Lindl. (Bot. Reg. t. 1973. 1837) is in all likelihood another synonym for *D. glabrata*, although Keck (in Clausen et al. 1940: 48) concluded that var. *incisa* "is beclouded with doubt, and does not stand for any of the preceding natural units [of *P. glandulosa*]." In his earlier revision of *Horkelia* and *Ivesia,* Keck (1938, p. 83) stated that *P. glandulosa* β *incisa* was "surrounded by confusion and should doubtless be rejected." Keck's conclusions at first seem justified: most collections labeled as corresponding to Tab. 1973 in Edward's Botanical Register, including that annotated by Keck as holotype of *P. glandulosa* β *incisa* in the

Lindley Herbarium at Cambridge (CGE), consist of *Horkelia californica* subsp. *frondosa* (Greene) Ertter. This taxon, which grows in central California, is superficially similar to the image in Tab. 1973 but differs in significant regards, including petal color (white, not yellow). During my visit to Cambridge in 2002, however, I found a different collection of "*B.R. 1973*," also from the Lindley Herbarium, filed as an unidentified *Potentilla*. This sheet, which is an excellent match for the illustration and description of *P. glandulosa* β *incisa*, has the diagnostic features of *D. glabrata:* i.e., leafy spreading inflorescence, large yellow petals, and septate glandular hairs as the dominant vestiture. The purported California origin of *P. glandulosa* β *incisa* remains a problem, but Douglas also collected within the range of *D. glabrata* in eastern Oregon. Given the potential for mix-ups in collections and data following Douglas's death in 1834, as evident in the confusion with *H. californica* subsp. *frondosa,* it is realistic to suspect that the specimens on which Tab. 1873 were based may have originated in eastern Oregon, within the range of *D. glabrata*.

11. Drymocallis deseretica Ertter, sp. nov. (**Fig. 2**). Type: UNITED STATES. Utah: Summit Co.: Uinta Mts., in the notch of Notch Mt., 28 km (17.5 mi) airline distance E (75°) of Kamas, T1S R9E S30 (NE1/4), 3250 m (10,650 ft) elev.; locally common on rocky W slope of notch, 22 Aug 1984, *N.H. Holmgren & P.K. Holmgren 10750* (holotype: UC 1583251; isotypes: BRY 342384, NY, RM).

A *D. glabrata* inflorescentiis contractioribus, sepalis elongatis, pedicellis velutinis differt.

Herbaceous perennial from ± branched caudex. **Stems** few, erect, (1.5–)2.5–6(–6.5) dm, the base 2–3(–4) mm diam., with sparse to abundant septate glandular hairs to 2(–3) mm long, inconspicuous short eglandular hairs sparse or lacking. **Basal leaves** (5–)7–20 cm long with (2–)3 pairs of lateral leaflets, sometimes with a much-reduced fourth pair; sheathing leaf-bases glabrous or ± glandular, rarely sparsely strigose; vestiture of rachis similar to that of stem; terminal leaflet ± petiolulate, the blade obovate to rhombic with an acute to obtuse apex, (1.5–)7–20 cm long, (1–)1.5–3 cm wide, both surfaces with a sparse mixture of subsessile glands, short glandular trichomes, and simple hairs ± 0.5 mm long, the margins single- to ± double-toothed with 5–9 teeth per side. **Cauline leaves** 1–2, sometimes equaling or exceeding basal leaves, 3–15 cm long with 2–3 pairs of lateral leaflets. **Inflorescence** relatively compact, comprising (⅙–)⅓–½ of plant height, relatively leafy; subtending bract trilobed, rarely pinnate, 2–7 cm long; branches diverging at a 10–20° angle; pedicels 2–15(–20) mm long, with abundant short spreading hairs ± 0.2 mm long and sparse to moderately abundant septate glandular hairs. **Flowers** 3–15(–20); hypanthium shallowly saucer-shaped, 4–7 mm diam., with abundant short simple hairs ± 0.2 mm long and ± sparse glandular trichomes; epicalyx bractlets linear to lanceolate or narrowly elliptic, (2.5–)3–8 mm long, 0.5–2(–3) mm wide, rarely notched; sepals (5–)6–12(–15) mm long, the vestiture like that of hypanthium or more sparse, the apex acute (to obtuse); petals cream to pale yellow, narrowly to broadly obovate, (4–)6–10 mm long, (2.5–)3.5–6(–7) mm wide, equaling or more often shorter than mature sepals, the apex rounded; stamens 20–25, the filaments 1–3 mm long, the anthers ± elliptic; styles very thickly fusiform, slightly > 1 mm long, golden-brown, attached just below middle of achene. **Achenes** ± obliquely pyriform with a slight beak, 1.2–1.5 mm long, light brown.

Ecology and phenology.—Openings among sagebrush, aspen, fir, and/or spruce, often where moist or rocky, and below cliffs, 2000–3250 m elev. Flowering (May) Jun–Sep.

Drymocallis deseretica is common in the northern Wasatch and western Uintah mountains of Utah, where it has generally been treated as *Potentilla glandulosa* var. *intermedia* (= *D. glabrata*) or *P. glandulosa* var. *pseudorupestris* (= *D. pseudorupestris* var. *saxicola*). It differs from both species in its more compact inflorescence, velutinous pedicels, and conspicuously enlarged acute sepals, which create a very distinctive gestalt. Plants with a comparable gestalt, but shorter obtuse sepals, occur in the Raft River Mountains of Utah. The species intergrades with *D. glabrata* to the north and *D. arizonica* to the south, with the exact range not yet determined. Petal color is rarely recorded on labels and needs to be confirmed.

Representative specimens: **UNITED STATES. UTAH: Cache Co.:** Intervale, 1 mi from mouth of Pine Canyon, Wellsville Range, 19 Jun 1932, *B. Maguire 2991* (UC). **Duchesne Co.:** W fork of Duchesne River, 44 mi E of Heber, T1N R7E S33, 27 Jul 1978, *D. Atwood 7018* (BRY); Uinta Mts., head of Duchesne River near Mirror Lake, 4 Aug 1980, *S. Goodrich 14717* (BRY). **Juab Co.:** Mt. Nebo, jct. Willow Creek and Cottonwood Campground trails, 23 Jul 1976, *F. Peabody 645* (BRY). **Salt Lake Co.:** Bells Canyon, near reservoir, 20 Jul 1959, *W.P. Cottam et al. 15802* (WIS); Alta Pass above Twin Lake, 7 Aug 1939, *B. Maguire 17363* (UC); above Salamander Lake, Lamb's Canyon, 10

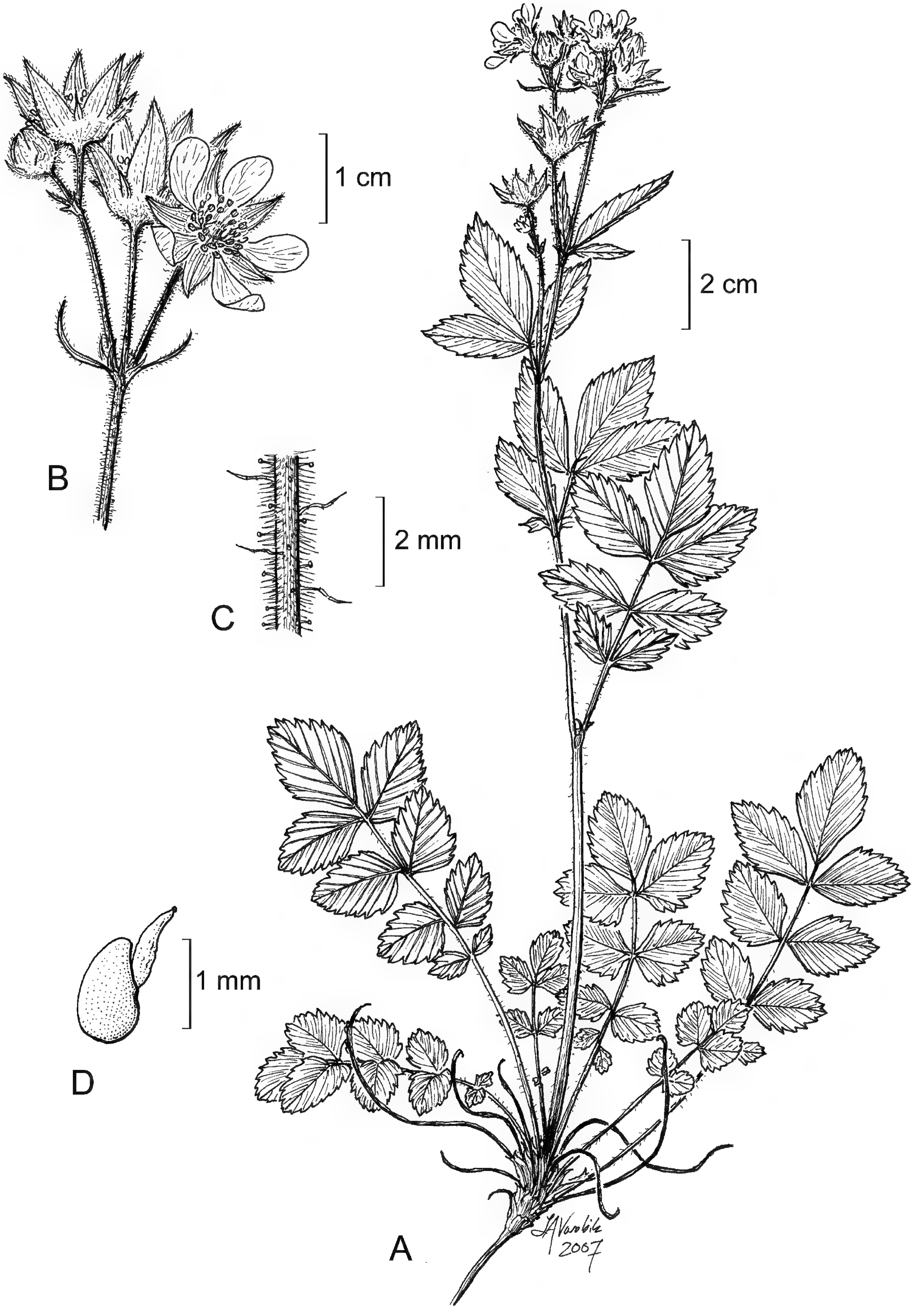

Fig. 2. *Drymocallis deseretica*. A: habit. B: inflorescence. C: vestiture of pedicel. D: achene and style.

May 1958, *R.K. Vickery 2073* (UC). **Sanpete Co.:** top of Log Hollow Canyon, San Pitch Mts., 3 Jul 1979, *R. Collins 301* (BRY); 13 km air distance ENE of Fairview, Hwy 30, upper Gooseberry Creek drainage, 19 Jun 1985, *N.H. Holmgren et al. 10880* (UC); Upper Horseshoe Flat, 28 Jul 1962, *H. Johnson s.n.* (BRY). **Summit Co.:** Stillwater Basin, head Bear River, Uinta Mts., 18 Aug 1933, *B. Maguire et al. 4172* (UC); due W of parking lot at head of Bald Mt. Trail, summit of Mirror Lake Pass, 1 Aug 1970, *P.A. Replogle 200* (BRY). **Tooele Co.:** Mill Fork of South Willow Canyon, Stansbury Mts., T4S R7W S14, 4 Jul 1980, *A. Taye 990* (BRY). **Utah Co.:** Pika Cirque, Mt. Timpanogos, 12 Jul 1974, *K. Allred* 1027 (BRY); along Timpanogos trail between 1st and 2nd falls, 30 Jun 1964, *A. C. Blauer & J. Brotherson* 44 (BRY); Little Cottonwood Canyon, Albion Basin campground, 20 Aug 1984, *N.H. Holmgren & P,K. Holmgren 10721* (UC); Provo, 8000 ft., 3 Jul 1894, *M.E. Jones 5575* (UC); 1 mi NE of Springville Crossing on Diamond Fork Creek, T7S R6E S31, 21 Jun 1969, *J.W. Thomas 155* (BRY). **Wasatch Co.:** Strawberry Valley, T3S R12W, 16 Jul 1964, *V.B. Matthews 89* (BRY).

12. Drymocallis glandulosa (Lindl.) Rydb., Mem. Dept. Bot. Columbia Coll. 2:198. 1898. = *Potentilla glandulosa* Lindl.

The original illustration of *Potentilla glandulosa* in Edwards's Botanical Register (19: pl. 1583. 1833), drawn from living material "in the Chiswick Garden in August last," has bright yellow petals. It is therefore probable that David Douglas collected the seeds from which the specimen was grown somewhere in Oregon, since coastal populations in California (treated here as var. *wrangelliana*) are predominantly white-petaled. Variation in *D. glandulosa* s.s. outside of California is unclear, with no evident pattern to differences in petal size and color; as default, these have largely been assigned to var. *glandulosa*. Sporadic collections have been made in Idaho, Montana, Nevada, and Utah; disjunct populations in Arizona south of the Mogollon rim may represent an undescribed variety.

12a. Drymocallis glandulosa var. **glandulosa**

12b. Drymocallis glandulosa var. **wrangelliana** (Fisch. & Avé-Lall.) Ertter, comb. nov. Basionym: *Potentilla wrangelliana* Fisch. & Avé-Lall., Ind. Seminum Hort. Petrop. 7:54. 1841.

12c. Drymocallis glandulosa var. **reflexa** (Greene) Ertter, comb. nov. Basionym: *Potentilla glandulosa* Lindl. var. *reflexa* Greene, Flora Francisc. 65. 1891. = *P. glandulosa* subsp. *reflexa* (Greene) D.D. Keck.

A disjunct collection from a major mining area in central Idaho (Boise Co., Clear Creek–Grimes Creek, 28 Jun 1959, *L. Maydale s.n.*, CIC) most likely results from dispersal via the transport of mining equipment from California, parallel to a comparable speculation for *Eriogonum inerme* (S. Watson) Jeps. (Ertter & Moseley 1993). The variety, with its small reflexed yellow petals, is otherwise known only from the mountains of California and southern Oregon.

12d. Drymocallis glandulosa var. **viscida** (Parish) Ertter, stat. et comb. nov. Basionym: *Drymocallis viscida* Parish, Bot. Gaz. 38:460. 1904.

This overlooked variety combines the flower and vestiture of *Drymocallis glandulosa* var. *reflexa* with the narrow inflorescence and predominately single-toothed leaflets of *D. lactea* var. *lactea*.

13. Drymocallis campanulata (C.L. Hitchc.) Ertter, stat. et comb. nov. Basionym: *Potentilla glandulosa* var. *campanulata* C.L. Hitchc., Vasc. Pl. Pacific NorthW. 1:861. 1969.

The epithet "campanulata" was used provisionally as a species of *Potentilla* in the treatment of Rosaceae (Hitchcock & Cronquist 1961) in volume 3 of *Vascular Plants of the Pacific Northwest,* "in anticipation of its publication by Dr. Keck," but the validating publication in "Additions and Corrections" in volume 1 (Hitchcock et al. 1969) treated the new taxon as a variety of *P. glandulosa*. This entity was referred to as the John Day race in Clausen and Hiesey (1958).

14. Drymocallis rhomboidea (Rydb.) Rydb., Mem. Dept. Bot. Columbia Coll. 2: 203. 1898. = *Potentilla rhomboidea* Rydb.; *P. glandulosa* Lindl. subsp. *globosa* D.D. Keck.

Keck (in Clausen et al. 1940) identified the type of *P. rhomboidea* as *P. glandulosa* subsp. *glandulosa* and therefore described *P. glandulosa* subsp. *globosa* to accommodate this distinctive taxon.

15. Drymocallis cuneifolia Rydb., Mem. Dept. Bot. Columbia Coll. 2:204. 1898. = *Potentilla cuneifolia* (Rydb.) Th. Wolf, not *P. cuneifolia* Bertol.; *P. peirsonii Munz.*

Rydberg (1898) described *Drymocallis cuneifolia* on the basis of a collection by Samuel B. Parish in the San Bernardino Mountains of San Bernardino County, California, "probably near Green Lead Mines," in June 1886 (F, GH, NY). The collection, distributed as *Potentilla glandulosa* var. *nevadensis,* was numbered and cited as *Parish 1818* (which is also the number given to a collection of *Phlox dolichantha* A. Gray, another rare plant endemic to the San Bernardino Mountains). Rydberg noted that the species "differs from the others in the small flowers with erect petals and the cuneate-flabelliform leaflets"; it also had filiform styles that are very unusual in *Drymocallis.* When comparable (though much smaller) specimens were found in 1919 by F. W. Peirson in the San Gabriel Mountains in Los Angeles County, Munz and Johnston (1925) adopted *Potentilla cuneifolia* (Rydb.) Th. Wolf for both forms. Since this name was a later homonym of *P. cuneifolia* Bertol., however, Munz (1932) renamed the species *P. peirsonii,* noting that Peirson had "rediscovered a plant that had not been collected for many years."

The continued lack of comparable new collections from the San Bernardino Mountains led Keck (in Clausen et al. 1940) to conclude that the type of *Drymocallis cuneifolia* was merely an immature specimen of *Potentilla glandulosa* subsp. *nevadensis* (= *D. lactea* var. *lactea*). As a result, he described *P. glandulosa* subsp. *ewanii* to accommodate populations in the San Gabriel Mountains. He did, however, note that "the type of *D. cuneifolia* is fragmentary, and since neither *Ewanii* nor *cuneifolia* is well represented in herbaria as yet, the possibility exists that the differences which now appear impressive may eventually loose importance."

Serendipitously, a small population of plants comparable to the type of *Drymocallis cuneifolia* has recently been discovered in the San Bernardino Mountains, not far from Parish's original collection: San Bernardino Co., San Bernardino Mts., Grout Creek, NE of Butler Peak, 200 m W of creek crossing along FS road 2N13, 0.3 mi W of FS road 2N70, 34°16'08"N, 116°58'40"W, 2195 m/7200 ft, 30 June 2004, *Mark A. Elvin 3555* (IRVC, UCR). These plants were identified as *P. glandulosa* subsp. *ewanii* and have the diagnostic small narrow corollas and elongate styles of this taxon. These features, however, also characterize the type of *D. cuneifolia,* which was collected in the same general area. Both *Elvin 3555* and the type of *D. cuneifolia* are larger plants than is the norm in the San Gabriel Mountains, with more elongate leaflets. As a result, I am treating the San Bernardino Mountain and San Gabriel Mountain populations as varieties of a single species, *D. cuneifolia.*

15a. Drymocallis cuneifolia var. **cuneifolia**

As indicated above, this variety is currently known from a single extant population and must therefore be considered extremely rare and potentially threatened. Although not known from limestone substrates, its occurrence on alluvial benches in an area known for a cohort of federally listed carbonate endemics (e.g., *Erigeron parishii* A. Gray, *Astragalus albens* Greene) opens the possibility that *D cuneifolia* var. *cuneifolia* might have similar limitations.

15b. Drymocallis cuneifolia var. **ewanii** (D.D. Keck) Ertter, stat. et comb. nov. Basionym: *Potentilla glandulosa* Lindl. subsp. *ewanii* D.D. Keck, Carnegie Inst. Wash. Publ. 520:47. 1940.

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Note added in proof.—In a recently published paper, Soják (2006) provides new combinations in *Drymocallis* of all subspecies of the *Potentilla glandulosa* complex as recognized by Keck (in Clausen et al. 1940), with no change in rank or taxonomic arrangement.

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LECTOTYPIFICATIONS AND NEW TAXA IN *POTENTILLA* SECT. *SUBVISCOSAE* (ROSACEAE) IN ARIZONA

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ABSTRACT

Potentilla sect. *Subviscosae* (Rydb.) B.C. Johnston exemplifies evolutionary radiation in the montane Madrean Archipelago of Mexico and the American Southwest, with multiple localized taxa endemic to different mountains ranges. Lectotypification of *Potentilla ramulosa* Rydb. maintains usage as the variety of *P. subviscosa* Greene in the Santa Catalina and Rincon mountains, Arizona. *Potentilla wheeleri* var. *viscidula* Rydb. is lectotypified on the hybrid between *P. ramulosa* and a trifoliate species in the Huachuca and Santa Rita mountains of Arizona, with the latter species newly described as **P. rhyolitica** Ertter. Closely related plants from the Chiricahua Mountains are recognized as **P. rhyolitica** var. **chiricahuensis** Ertter. An extremely localized *Potentilla* from the Hualapai Mountains, Arizona, is described as **P. demotica** Ertter. The range of *P. albiflora* (which has yellow flowers, not white) is extended to the the nearby Mogollon Rim. *Potentilla cottamii* is moved to *P.* sect. *Subviscosae* from *P.* sect. *Aureae*. *Potentilla wheeleri* is restricted to southern California, excluding *P. luteosericea* (= *P. pinetorum*) as a separate species in Baja California, Mexico. A key to the non-Mexican species is provided and vernacular names are suggested.

Key Words: *Potentilla* sect. *Subviscosae*, Madrean Archipelago, Huachuca Mountains, Hualapai Mountains, lectotypifications, new species, *Potentilla subviscosa, Potentilla ramulosa, Potentilla viscidula, Potentilla albiflora, Potentilla wheeleri, Potentilla cottamii, Potentilla luteosericea*

RESUMEN

La sección *Subviscosae* (Rydb.) B.C. Johnston de *Potentilla* ejemplifica una radiación evolutiva en el Archipiélago montañoso Madrense de México y el suroeste de Estados Unidos, representado con múltiples taxa locales y endémicos en los diferentes sistemas montañosos. La lectotipificación de *Potentilla ramulosa* Rydb. mantiene su uso como variedad de *P. subviscosa* Greene de las montañas Santa Catalina y Rincon en Arizona. Se lectotipifica *Potentilla wheeleri* var. *viscidula* Rydb. como un híbrido entre *P. ramulosa* y una especie trifoliolada en las montañas Huachuca y Santa Rita de Arizona, la cual ha sido descrita recientemente como **P. rhyolitica** Ertter. Plantas cercanamente relacionadas de las Montañas Chiricahua son reconocidas como **P. rhyolitica** var. **chiricahuensis** Ertter. Una *Potentilla* de distribución limitada en las Montañas Hualapai, Arizona se describe como **P. demotica** Ertter. La distribución de *P. albiflora* (que tiene flores amarillas y no blancas) se extiende al cercano Mogollon Rim. *Potentilla cottamii* se transfiere de la sect. *Subviscosae* a la sect. *Aureae*. *Potentilla wheeleri* circunscribe su distribución al sur de California, excluyendo a *P. luteosericea* (= *P. pinetorum*) como una especie aparte en Baja California, México. Se provee con una clave para identificar las especies que no están en México y se sugieren sus nombres comunes.

INTRODUCTION

In his 1898 monograph of *Potentilla* L. (Rosaceae), Rydberg divided the genus into multiple "groups," many of which were adopted and established at formal taxonomic ranks by later workers (e.g., Johnston 1985). Among the more intriguing is *P.* sect. *Subviscosae* (Rydb.) B.C. Johnst., initially comprised of *Potentilla wheeleri* S. Watson, *P. wheeleri* var. *viscidula* Rydb., *P. subviscosa* Greene, and *P. ramulosa* Rydb. (Rydberg 1896, 1898). These taxa and their subsequently described relatives, all endemic to the southwestern United States and Mexico, share the following characters: 1) stems prostrate to decumbent, or even pendant on vertical rock faces, relatively short and lax; 2) vestiture of entire plant consisting of various proportions of short glandular trichomes, short eglandular hairs ca 0.2 mm long, and long straight eglandular hairs 1–3 mm long; 3) stipules narrowly triangular to linear, ± herbaceous; 4) leaves 3–7-digitate, the leaflets neither tomentose beneath nor notably bicolored, few-toothed; 5) pedicels relatively lax, often becoming recurved; 6) styles (0.7–)1.5–3 mm long, usually somewhat rough-thickened basally; 7) achenes relatively few (4–25) and large (± 1–2 mm long), smooth to lightly ribbed.

What makes *Potentilla* sect. *Subviscosae* intriguing is the extent to which it exemplifies evolutionary radiation in an island setting, with the "islands" in this case consisting of scattered mountain ranges isolated by arid lowlands. The center of radiation for *P.* sect. *Subviscosae,* at least in the United States, is the isolated mountains extending north from Mexico's Sierra Madre Occidentale, dubbed the Southwestern Sky Island Ecosystem or the Madrean Archipelago (e.g., McLaughlin 1995). As a result, different unique and highly endemic members of the section occur on the Pinaleno, Santa Catalina/Rincon, Huachuca/Santa Rita, and Chiricahua ranges in southeastern Arizona, including taxa described in the present paper. This radiation presumably also characterizes the more extensive Mexican portion of the "archipelago," but collections and taxonomic analysis of *Potentilla* from this region are too preliminary for a proper evaluation. *Potentilla mexiae* Standl. is unquestionably a member of this section in Chihuahua and Durango, and there is evidence of additional undescribed variation deserving taxonomic recognition.

A full-scale revision of the entire section is strongly called for, with special attention paid to species in Mexico including those currently placed in *Potentilla* sections *Aureae* (Lehm.) Juz. and *Ranunculoides* (Th. Wolf) Juz. However, the current paper focuses on those lectotypifications and new descriptions needed for the pending treatment of *Potentilla* for *Flora of North America North of Mexico,* with some additional notes on several species of interest in the United States.

LECTOTYPIFICATIONS

In his initial review of *Potentilla* "group" *Subviscosae* in 1896, Rydberg described *Potentilla wheeleri* var. *viscidula* (p. 429) and *P. ramulosa* (p. 430 and plate 276). The former was based on four syntypes, with two from Arizona ("C.G. Pringle, 1881; J.G. Lemmon, no. 158. 1881") and two from California ("W.G. Wright, 1879; Coville & Funston, no. 1672. 1891"). Two syntypes were given for *P. ramulosa*, both from Arizona: "J.G. Lemmon, no. 399, 1881; H.H. Rusby, 1883." The corresponding herbarium specimens currently known to me are:

Syntypes of *Potentilla wheeleri* var. *viscidula*

- *C.G. Pringle, s.n.,* Arizona [Santa Cruz Co. or Pima Co.], Santa Rita Mountains, alt. 8,000 ft, 3 May 1881 (distributed as *Potentilla subviscosa* Greene "near *P. wheeleri,* Watson.")
  - GH 26877, mounted on same sheet as *Lemmon 158* syntype (GH 26878), both annotated by Rydberg ("P.A.R.") as "*P. wheeleri* var."
  - 3 sheets at NY, all annotated in Rydberg's hand as *P. viscidula*, plus an unannotated fourth duplicate (NY 39334) mounted with an isotype of *P. subviscosa* Greene (NY 39333)
  - 2 sheets at US, only one annotated by Rydberg
  - 1 sheet at MO, not annotated by Rydberg
- *J.G. Lemmon 158,* Arizona [Pima Co.], summit of Santa Catalina Mountains, Apr 1888
  - GH 26878, mounted on same sheet with Pringle syntype (GH 26877)
- *W.G. Wright, s.n.,* California [San Bernardino Co.], Mt. San Bernardino, 12,000 ft alt., Jun 1879
  - GH 26880, in packet mounted on same sheet with holotype of *P. wheeleri* (*Rothrock 324,* California, southern Sierras, 8200 ft, Sept 1875) and 3 non-type collections of *P. wheeleri* s.s. (*Parry & Lemmon 100; Parish & Parish 1498*)
- *F.V. Coville & F. Funston 1672,* California [Tulare Co.], Whitney Meadows, Sierra Nevada, 21 Aug 1891
  - GH 26879, not annotated by Rydberg

Syntypes of *Potentilla ramulosa*

- *J.G. Lemmon 399*, Arizona [Cochise Co.], Rucker Valley [in southeastern Chiricahua Mountains], 1881
  - GH 244121, annotated as *P. ramulosa* by Rydberg, originally determined as *P. gracilis* var. *rigida*, on mounted half-sheet
- *H.H. Rusby 591* (on 3 of 4 sheets). Arizona, Flagstaff, 1883
  - 3 sheets at NY with a date of Jun 7, one annotated by Rydberg
  - 1 sheet at NY with a date of September

An unnumbered Lemmon collection from the north slopes of the Santa Catalina Mountains, April and May 1881 (MO, UC), is not syntype material, even though Rydberg annotated the MO specimen as *P. wheeleri viscidula n.v.*

In the upcoming treatment of *Potentilla* for *Flora of North America,* both *Lemmon 158* (syntype of *P. wheeleri* var. *viscidula*) and *Lemmon 399* (syntype of *P. ramulosa*) fall within *P. subviscosa* var. *ramulosa* (Rydb.) Kearney & Peebles. The Pringle syntype is a mixed collection, with *P. subviscosa* var. *ramulosa* being the largest component. Among the multiple exsiccatae, at least one plant (i.e., on the sheet at MO) is the trifoliate species described below as *P. rhyolitica* Ertter, and some others are probable hybrids between the two species. The other syntype of *P. ramulosa, Rusby 5191,* consists of both early-season (June) and late-season (September) forms of *P. subviscosa* var. *subviscosa,* which exhibits a pronounced seasonal leaf dimorphism. Both of the remaining syntypes of *P. wheeleri* var. *viscidula, Coville & Funston 1672* and *Wright s.n,*. fall within *Potentilla wheeleri* s.s., which is restricted to California as currently circumscribed (and as discussed later). *Wright s.n.* represents the high-elevation extreme in the San Bernardino Mountains that Jepson (1925) named *P. wheeleri* var. *paupercula*.

From the preceding, it is clear that application of the names *Potentilla wheeleri* var. *viscidula* and *P. ramulosa* is highly dependent on which syntype is chosen as lectotype for each taxon. As it happens, first-stage lectotypification has already been done by Kearney and Peebles (1942), who cited *Pringle s.n,* 1881*,* as the type of *P. viscidula* (Rydb.) Rydb. and *Lemmon 399* as the type of *P. ramulosa.* In that Kearney and Peebles explicitly state that "In order to save indexers the labor of reviewing so large a work, no new names or combinations are published here" (p. 5), it may very well be that they likewise did not intend any new lectotypications, but this is nevertheless what they effectively accomplished (J. McNeill, pers. comm. 2006).

Fortunately, the selection of *Lemmon 399* as the type of *Potentilla ramulosa* preserves current usage of the epithet for the sole, commonly encountered representative of *P.* sect. *Subviscosae* in the heavily-visited Santa Catalina Mountains, here treated as *P. subviscosa* var. *ramulosa*. In contrast, if *Rusby 591* had been selected a new name would be needed for plants in the Santa Catalina Mountains, now that the marked seasonal dimorphism of leaf shape in the widespread *P. subviscosa* var. *subviscosa* is better understood, as discussed later.

Potentilla ramulosa Rydb., Bull. Torrey Bot. Club 23:430. 1896. Type: U.S.A. ARIZONA. Cochise Co.: Chiricahua Mountains, Rucker Valley, 1881, *Lemmon 399* (lectotype, designated by Kearney & Peebles, Fl. pl. ferns Ariz. 403. 1942: GH 244121!; the only specimen known) = *P. subviscosa* var. *ramulosa*.

Potentilla wheeleri var. *viscidula* presents a more complicated situation. The name was applied broadly at its inception (Rydberg 1896), encompassing a diversity of specimens from southern Arizona and southern California. In his subsequent treatment of the genus for *North American Flora,* Rydberg (1908) added Chihuahua, Mexico, to the distribution of the taxon, possibly based on specimens which would now be identified as *P. mexiae*. He also raised the taxon to species rank as *P. viscidula* (Rydb.) Rydb., a status and circumscription followed by Tidestrom and Kittell (1941). In contrast, Kearney and Peebles (1942) initially treated *P. viscidula* as a synonym of *P. wheeleri,* but in their subsequent flora (1951) they likewise accepted *P. viscidula* as a distinct species (with the caveat, however, that it was "Perhaps too nearly related to *P. Wheeleri* Wats."). Although these Arizona and New Mexico floras continued to include California in the distribution of *P. viscidula,* California floras consistently recognized only *P. wheeleri*, sometimes citing *P. viscidula* in synonymy (e.g., Jepson 1936; Abrams 1944; Munz 1959).

In spite of incompatibility problems with published distributions and descriptions, *Potentilla viscidula* has in practice been increasingly applied to a notably sericeous, trifoliate member of *P.* sect. *Subviscosae* that occurs on rock outcrops along popular trails near the summit of the Huachuca and Santa Rita mountains of southeastern Arizona, corresponding to the distribution in Arizona as given in Kearney and Peebles (1942, 1951). This species is clearly distinct from the 5-foliate species *P. wheeleri* and *P. subviscosa,* with the latter also having a very different vestiture. My initial understanding, based on herbarium studies and personal fieldwork, was that this trifoliate species was the only member of the section in these two mountain ranges, with a less hairy variant occurring in the Chiricahua Mountains. It was only in the process of lectotypification that I realized that *P. subviscosa* var. *ramulosa* also occurs in the Santa Rita Mountains (as the primary element in the existing lectotype of *P. wheeleri* var. *viscidula*), the Huachuca Mountains (*Goodding 1300*, May 1912, ARIZ, NY, RM), and the Chiricahua Mountains (the lectotype of *P. ramulosa* itself). This odd situation, whereby most historical collections differ from more recent collections from the same mountain ranges, may reflect the fact that early collectors worked from existing bases at lower elevations (e.g., McCleary's Ranch, now headquarters for the Santa Rita Experimental Range), whereas more recent botanists tend to collect along a newer network of well-constructed trails that lead to the highest peaks. Both *P. viscidula* and *P. subviscosa* are listed in a recent flora of the Huachuca Mountains (Bowers & McLaughlin 1996).

As it happens, the lectotype of *Potentilla wheeleri* var. *viscidula* designated by Kearney and Peebles, or for that matter any of the syntypes, is not compatible with continued use of the name *P. viscidula* for the trifoliate species. Although the *International Code of Botanical Nomenclature* (McNeill et al. 2006) now provides multiple options to conserve established nomenclature in order to avoid "disadvantageous nomenclatural changes" (Art. 14.1), including the conservation of a name using a different type (Art. 14.9), I do not believe that usage of *P. viscidula* for the highly localized trifoliate species is well enough established to justify conservation. The historical conflation with *P. wheeleri* has never ceased, with several recent publications treating *P. viscidula* as synonymous with *P. wheeleri* (e.g., Medina 2003; Kartesz & Meacham 1999; PLANTS database at http://plants.usda.gov/). Furthermore, the initial protologue only allows for plants with 5–7 leaflets in sect. *Subviscosae*, and the epithet "*viscidula*" itself is incompatible with the sericeous vestiture of the trifoliate species. For these reasons a fresh slate seems preferable, with the Kearney and Peebles lectotypification retained and the trifoliate plants described below as *P. rhyolitica*.

One further complication is that the dominant element in the Pringle lectotype is the same taxon as the lectotype of *P. ramulosa,* with the epithet *viscidula* having priority at the varietal level. To preserve established usage of *P. subviscosa* var. *ramulosa,* I am therefore selecting one of the minor elements in Pringle's collection as a second-stage lectotypification, specifically the largest of three plants on GH 26877. From its intermediate vestiture this plant is evidently a hybrid between *P. subviscosa* var. *ramulosa* and the sympatric trifoliate species. The selected plant, on a sheet annotated by Rydberg, is an excellent match for Rydberg's protologue, and its designation as lectotype removes the epithet *viscidula* from contention with the established epithet *ramulosa* at varietal rank.

Potentilla wheeleri S. Watson var. **viscidula** Rydb., Bull. Torrey Bot. Club 23:429. 1896. Type: U.S.A. ARIZONA. Santa Cruz Co. or Pima Co.: Santa Rita Mountains, Alt. 8000 ft, 3 May 1881, *C.G. Pringle s.n.* (lectotype (first stage designated by Kearney & Peebles, Fl. pl. ferns Ariz. 402. 1942; second stage herein): largest of three plants on GH 26877!) = hybrid between *P. subviscosa* var. *ramulosa* and *P. rhyolitica* var. *rhyolitica*.

DESCRIPTION OF *POTENTILLA RHYOLITICA* AND VARIETIES

The drawback with the preceding lectotypification of *Potentilla wheeleri* var. *viscidula* is that the trifoliate species is left without a name, a situation that is here rectified.

Potentilla rhyolitica Ertter, sp. nov. (**Fig. 1**). Type: U.S.A. ARIZONA: Cochise Co.: Carr Peak in Huachuca Mts., rhyolite outcrops near junction of Carr Peak and Miller Canyon trails, open forest of ponderosa pine, limber pine, Douglas-fir, oak, & *Holodiscus,* ca. 9000 ft elev., T23S R20E Sec. 22, 3 Jun 1993, *B. Ertter 11872* (holotype: UC; isotypes: ALA, ASC, ASU, ARIZ, GH, MEXU, MO, NY, PR, US).

Potentilla albiflora maxime simile, sed petioli pilis longioribus (1–3 mm vs. ± 1 mm) et foliolorum dentibus paucioribus.

Plants tufted to rosetted, green to grayish, abundantly glandular. **Stems** prostrate, 0.2–2 dm long, with abundant glandular trichomes and fine spreading hairs ± 1 mm long. **Leaves** generally ternate, 2–8(–11) cm long; petiole 1–6(–8) cm long with abundant glandular trichomes, short hairs, and spreading longer hairs 1–2(–3) mm long; leaflets 3(–5), obovate, often petiolulate, the central one 1–3 cm long, toothed ⅓ to midvein with 2–3(–4) teeth per side, moderately to densely sericeous on both sides. **Inflorescences** 1–10-flowered; pedicels 0.5–1(–2) cm long, becoming recurved in fruit, with abundant short glandular trichomes, short hairs ± 0.2 mm long, and scattered longer hairs ca. 1 mm long. **Flowers**: hypanthium 3–5 mm diam.; epicalyx bractlets lanceolate-elliptic, 2–4 mm long; sepals 3–5 mm long, acute; petals yellow, ± broadly elliptic-obovate to obcordate, 4–7 mm long, the apex rounded to shallowly emarginate; stamens 15–20, the filaments 1.5–3 mm long, the anthers 0.6–1 mm long; styles 5–15, slender, scarcely rough-thickened basally, 2–3 mm long. **Achenes** light brown to reddish brown, 1.5–2.2 mm long, smooth to lightly ribbed.

Although previously associated with *Potentilla wheeleri,* that strictly Californian species has 5–7 leaflets. A closer affinity exists with *P. albiflora* L. O. Williams, another trifoliate member of *P.* sect. *Subviscosae* endemic to southeastern Arizona. Indeed, the differences between *P. rhyolitica* and *P. albiflora* are fairly subtle, consisting primarily of differences in vestiture, number of leaflet teeth, and carpel number. Populations of *P.*

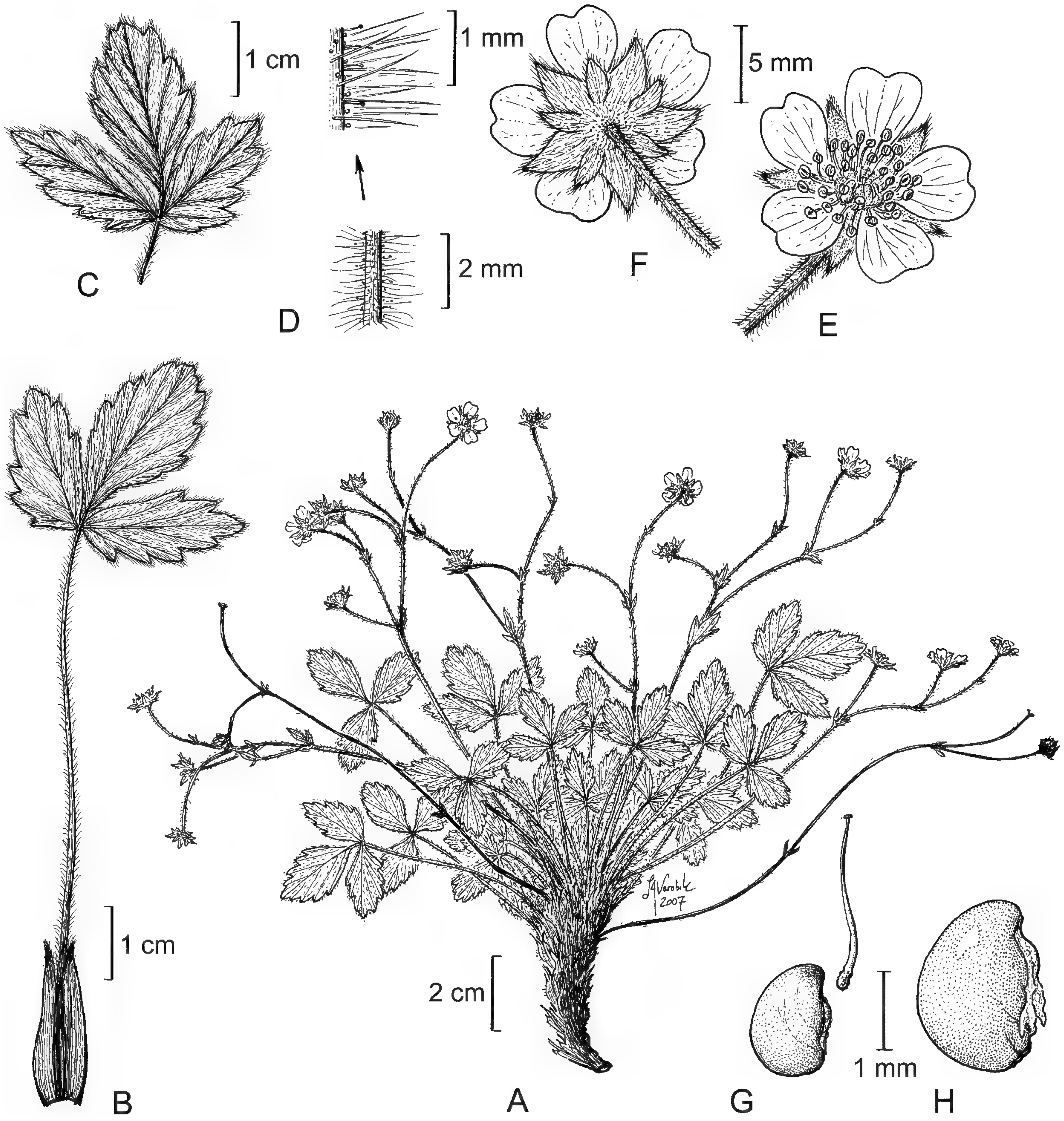

Fig. 1. Potentilla rhyolitica Ertter. A–G. *P. rhyolitica* var. *rhyolitica* (drawn from *Ertter 11872*). A. Habit. B. Basal leaf. C. Underside of leaf. D. Vestiture of petiole. E. Flower, top view. F. Flower, bottom view. G. Achene and style. H. Achene of *P. rhyolitica* var. *chiricahuensis* Ertter (drawn from *Blumer 2023*).

rhyolitica in the Chiricahua Mountains are somewhat intermediate between the two species and sufficiently distinct so as to warrant the recognition of two varieties within *P. rhyolitica*, as presented here.

Potentilla rhyolitica var. **rhyolitica**

Stems 0.3–2 dm long. **Leaves:** long hairs of petiole ± 1(–2) mm long; leaflets (moderately to) densely sericeous, gray-green. **Flowers** 2–10; filaments 1.5–2.5 mm long; styles 5–15, 2–2.5 mm long. **Achenes** ± 1.5 mm long, smooth to lightly ribbed.

Distribution and phenology.—Endemic to the summit areas of the Santa Rita and Huachuca mountains in Santa Cruz and Cochise counties, southeastern Arizona, mostly forming dense tufts in crevices of rhyolitic and quartzitic outcrops in open pine forests, 2600–2900 m elev. Flowering Apr–Jun. An anomalous collection from desert grasslands in the San Rafael Valley southwest of the Huachuca Range (*Fritts & Fritts 83-143,* COLO, and reported as *P. wheeleri* by McLaughlin [2006]) may also belong here, though in a significantly different ecological setting and with more oblanceolate leaflets.

As already noted, the name *Potentilla viscidula* has frequently been applied to existing collections of this entity, with *P. subviscosa, P. dissecta* Pursh, *P. concinna* Richardson, and *P. albiflora* serving as alternate identifications. John J. Thornber, botanist at University of Arizona and the Santa Rita Experimental Range in the early 1900's, was the first to notice the distinctiveness of this taxon. However, although Thornber annotated the ARIZ sheet of *Goodding 110* as "Type!" of a new species, with the epithet "trifoliolata" replaced with "pinetorum," he did not follow through with formal publication.

The variety is sufficiently localized to warrant conservation attention, especially given its proximity to well-used trails in popular hiking areas. "Huachuca cinquefoil" is recommended as a vernacular name.

Additional collections examined: **U.S.A. Arizona: Cochise Co.:** Huachuca Mts., mountain tops, 8 May 1909, *L.N. Goodding 102* (ARIZ); Miller's Canyon, moist slopes, Huachuca Mts., 8 May 1909, *L.N. Goodding 102a* (RM); Miller's Canyon, Huachuca Mts., dry rocky places, usually clinging to rocks, 8 Jun 1909, *L.N. Goodding 110* (ARIZ, RM); Huachuca Mts., rock crevices on summits, May 1912, *L.N. Goodding 1300* p.p. (BKL, RM p.p. [mixed collection with *P. subviscosa* var. *ramulosa*]); Miller Canyon, top of saddle, Huachuca Mts., 8500 ft, 23 Apr 1955, *H. S. Haskell & C. F. Deaver 5177* (ASC, RSA); Huachuca Mts., Carr Peak Pass along trail to Peak, rhyolite crevices, T23S R20E S22, ca. 8900 ft, 11 May 1984, *Soreng & Muldaven 2386* (COLO). **Santa Cruz Co.:** Mt. Wrightson Peak along Old Baldy Trail, 100 ft below summit, in rock crevices, 18 May 1986, *D. Bertelsen s.n.* (ARIZ); Mt. Baldy, Santa Rita Mts., 9400 ft, 9 May 1937, *R. Darrow s.n.* (ARIZ); Mt. Wrightson (Old Mt. Baldy) in Santa Rita Mts., solid rhyolite outcrops along trail on NE side of peak, 9000 ft, T20S R15E Sec 18, 4 Jun 1993, *B. Ertter 11881* (UC; to be distributed); Santa Rita Mts., 8000 ft, 3 May 1881, *C.G. Pringle 13677 p.p.* (MO).

Potentilla rhyolitica var. **chiricahuensis** Ertter, var. nov. (**Fig. 1H**). Type: U.S.A. ARIZONA: Cochise Co.: Flys Peak in Chiricahua Mts. ca. 40 air mi SE of Willcox, local on summit and along trail in open forest, rocky openings in forest of limber pine, Douglas-fir, ponderosa pine, and aspen, T18S R30E, 9660 ft, 2 Jun 1993, *B. Ertter 11872* (holotype: UC; isotypes: ARIZ, GH, MEXU, MO, NY, US).

A *Potentilla rhyolitica* var. *rhyolitica* foliolis viridioribus et acheniis grandioribus (± 2 mm vs. ± 1.5 mm) differt.

Stems 0.2–1(–1.5) dm long. **Leaves:** long hairs of petiole 1–2(–3) mm long; leaflets moderately (to densely) hairy, green. **Flowers** 1–7; filaments 2–3 mm long; styles 5–10, (2–)2.5–3 mm long. **Achenes** ± 2 mm long, smooth.

Distribution and phenology.—Endemic to upper elevations of the Chiricahua Mountains, Cochise Co., Arizona, in rocky openings in mixed conifer forests, 2700–2900 m. Flowering May–Jun.

Potentilla rhyolitica var. *chiricahuensis* differs from the typical variety in being greener and less sericeous, with somewhat longer and coarser hairs and larger seeds. It is also less likely to be rooted in outcrops, favoring rocky flats. "Chiricahua cinquefoil" is a suitable vernacular name for this localized taxon, which merits some level of conservation attention.

As with *P. rhyolitica* var. *rhyolitica,* Thornber was evidently the first to recognize that the trifoliate Chiricahua plants represented a distinct taxon. He annotated *Blumer 2023* (US) as the type of a new species, using the epithet "substrigosa," but this combination was never published.

Additional collections examined: **U.S.A. Arizona: Cochise Co.:** Fly Park, Chiricahua Mts., 8900 ft, 7 Jul 1907, *J. C. Blumer 2023* (US); Rustler's Park, moist slope, 9000 ft, 18–19 Jun 1930, *G. J. Goodman & C. L. Hitchcock 1173* (MO, RM, UC); Chiricahua Wilderness Area, Crest Trail, ¼ mi N of turnoff to Anita Park, 9480 ft, 29 May 1975, *J. & A. Leithliter 7* (ASU); Chiricahua Wilderness Area, intersection of Crest Trail and Tub Spring Trail, ¾ mi S of Long Park, 9070 ft, 10 Jun 1975, *J. & A. Leithliter 52* (ASU); Flys Peak – Cima Cabin Trail junction, Chiricahua Mts., 9200 ft, 29 May 1959, *J. McCormick & Assoc. 82* (ARIZ).

DESCRIPTION OF *POTENTILLA DEMOTICA*

In the opposite corner of Arizona, the rarest member of *Potentilla* sect. *Subviscosae* was discovered in 1979 as part of a floristic study in the Hualapai Mountains (Butterwick et al. 1991). It was reported as a western range extension of *P. subviscosa* but differs in rock-dwelling habit, petal color, and epicalyx, among other characters. Although the Hualapai Mountains are not considered part of the Madrean Archipelago, they continue the theme of montane "islands" scattered across the arid Southwest.

Potentilla demotica Ertter, sp. nov. (**Fig. 2**). Type: U.S.A. ARIZONA: Mohave Co.: Hualapai Mts. ca. 12 air mi SE of Kingman, pink granite knoll SE of Hualapai Peak, in open ponderosa pine forest, with *Antennaria, Heuchera, Cheilanthes, Poa,* T20N R15W, ca 7500 ft, 30 May 1993, *B. Ertter 11864* (holotype: UC; isotypes: ARIZ, GH, MO, NY, RSA, US).

Potentilla rimicola aemulans, differt foliolis brevioribus et epicalyces bracteolis late ellipticis.

Plants perennial, rooted in rock crevices, rosetted to tufted, the caudex simple to few-branched on a thickened taproot. **Stems** spreading, 0.2–1.5(–2) dm long, with abundant short septate glandular trichomes, short simple hairs ca. 0.2 mm long (sparse proximally, more abundant distally), and scattered slender spreading hairs 1–2 mm long. **Leaves** primarily basal, palmate, 2–8 cm long; stipules very narrowly triangular; petiole 1–7 cm long, with abundant glandular trichomes and slender spreading hairs 1.5–2.5 mm long; leaflets (3–)5, oblanceolate, the central one 0.5–1.5(–2) cm long, sparsely hairy on both sides, toothed ½–¾ to midvein on distal ¾ of blade, the rounded teeth 2–3(–4) per side; cauline leaves 1–2, highly reduced. **Inflorescences** lax, 1–7-flowered; pedicels 0.5–1(–2) cm long, slender, sometimes recurved, with short glandular trichomes, short hairs ± 0.2 mm long, and longer hairs ± 1 mm long. **Flowers:** hypanthium shallow, 2–3 mm diam.; epicalyx bractlets ovate-elliptic, 1–2.5 mm long, 1–1.5 mm wide; sepals 2.5–4 mm long, obtuse; petals yellow with darker base, ± obcordate with a short claw, shallowly emarginate, 3–7 mm long, exceeding sepals; stamens 20, the filaments 1.3–2 mm long, the anthers 0.5 mm; styles 5–12, slender, scarcely rough-thickened basally, 2–2.5 mm long. **Achenes** light brown with reddish apices, 1.5–1.8 mm, smooth to lightly ribbed.

Distribution and phenology.—eastern extension of Hualapai Peak in the Hualapai Mountains of Mohave Co., Arizona, crevices of granite outcrop in ponderosa pine woodland, ca. 2300–2400 m. Flowering May–Jun.

Although initially identified as *Potentilla subviscosa* (Butterwick et al. 1991), *P. demotica* is probably more closely related to *P. rimicola* (Munz & I.M. Johnst.) Ertter, which grows in rock crevices in the mountains of southern California and northern Baja California. The new species is apparently extremely rare and localized, currently known from a single granite knoll in Hualapai Mountain Park, part of the Mohave County park system. The label for *Butterwick & Hillyard 6757* indicates that about 100 clusters of one to fifteen plants each were present in 1980, which is compatible with my observations in 1993. Conservation attention is obviously called for, though the knoll is a long hike from the nearest trailhead and not directly on any trail.

The epithet *demotica* (from "demotikos," Greek for "of the people," suggested by J. Reveal) alludes to the tradition among the Hualapai that they arose from the "Pai" or "the people." "Hualapai Cinquefoil" is an appropriate vernacular name.

Additional collections examined: U.S.A. Arizona: Mohave Co.: eastern extension of Hualapai Peak, Hualapai Mts., T20N R15W Sec. 32 NW1/4, scattered in rock crevices, Ponderosa Pine Woodland, 8000 ft, 10 Aug 1979, *M. Butterwick & B. Parfitt 5407* (ASU, COLO); E portion of Hualapai Peak system, T20N R15W Sec. 32 NW1/4, granitic substrate, Ponderosa Pine Forest, 8000 ft, 6 Jun 1980, *M. Butterwick & D. Hillyard 6757* (ASU, COLO).

NOTES ON SOME OTHER SPECIES IN *POTENTILLA* SECT. *SUBVISCOSAE*

Potentilla albiflora L.O. Williams

Contrary to the specific epithet, petals of living plants are yellow, not white, though (like many *Potentilla*) they tend to fade in pressed material. "Whiteflowered cinquefoil" is accordingly misleading as a common name, with "Pinaleno cinquefoil" a recommended alternative. Although previously known only from the Pinaleno (Graham) Mountains in Graham Co., Arizona, the following collection (distributed as *P. diversifolia* Lehm.) extends the range to the Mogollon Rim and opens up the possibility of further discoveries in this relatively sparsely botanized corner of Arizona.

Arizona: Greenlee Co.: Cienega Camp on Hwy 666, Blue Range, Apache National Forest, 20 mi SW of Alpine, mesic headwaters of the Blue River in mixed coniferous forest, elev. ca. 2600 m, 17 Jul 1964, *M. Baad 657* (MICH, WTU).

Potentilla cottamii N. Holmgren

Holmgren (1987) described *Potentilla cottamii* from isolated quartzite outcrops in the Pilot Range and Raft

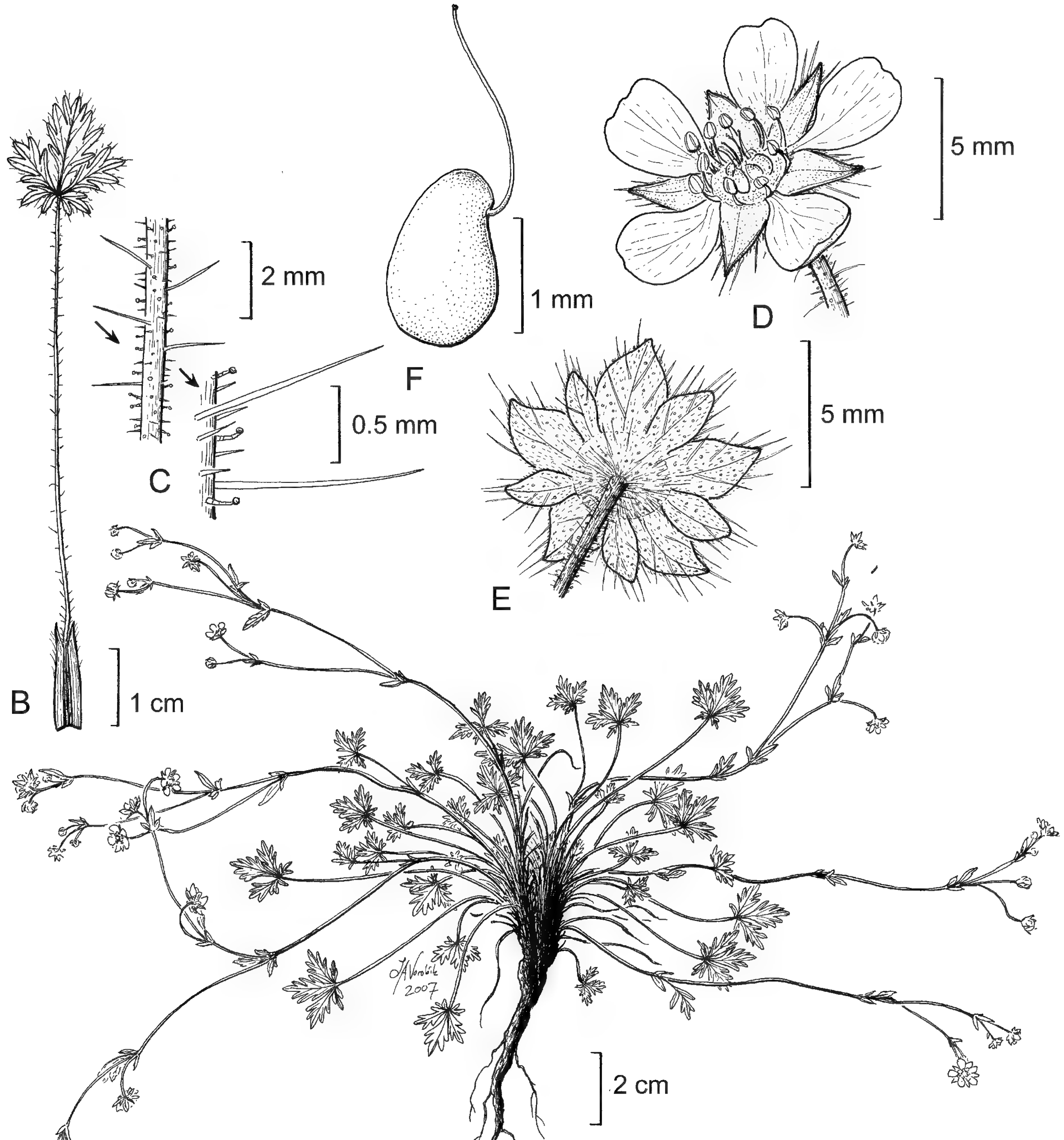

Fig. 2. ***Potentilla demotica*** **Ertter (drawn from** ***Ertter 11864*****). A. Habit. B. Basal leaf. C. Enlargement of petiole vestiture. D. Flower. E. Hypanthium, epicalyx, calyx. F. Achene and style.**

River mountains of northwestern Utah and adjacent Nevada; it has since been found in Utah's Stansbury and Deep Creek mountains. Holmgren speculated that his new species was most comparable to *P. hyparctica* Malte and *P. robbinsiana* Oakes, members of *P.* sect. *Aureae* occurring in arctic and alpine regions in North America. In contrast, R. Elven (pers. comm. 2006) confirms that any resemblance with these species is superficial, with *P. cottamii* having very different vestiture and stipule types. In my understanding *P. cottamii* fits readily into *P.* sect. *Subviscosae*, sharing the distinctive combination of simple and glandular vestiture types but with unusually small flowers and accordingly short styles. The trifoliate leaves, stipules, petrophytic habit, and biogeographic distribution as a montane "island endemic" are likewise compatible with membership in *P.* sect. *Subviscosae*.

Potentilla subviscosa Greene

The two varieties of *Potentilla subviscosa* have generally been based on extremes of leaflet margins, with var. *subviscosa* having deeply lobed leaflets and var. *ramulosa* having more shallowly and regularly toothed leaflets, which are also significantly larger overall. As so defined, the varieties were largely sympatric and questionably distinct. Multiple examples of collections from the same general area, and even variation on a single plant, indicate that these extremes can occur as striking seasonal differences in leaf shape and petiole vestiture, perhaps as an adaptation to the monsoonal rainfall pattern in the American Southwest. Leaves formed early in the season and coinciding with peak flowering have deeply divided leaflets, and the petiole vestiture often consists almost exclusively of short glandular trichomes. Later-formed leaves have progressively less deeply divided leaflets and an increasing percentage of both short and long non-glandular hairs; the leaves are sometimes significantly larger as well. This dimorphism is best developed in Arizona populations of *P. subviscosa*, including the *Rusby 591* syntype of *P. ramulosa*, which consists of both early-season plants with deeply lobed leaflets and late-season plants with significantly larger, less deeply toothed leaflets. A pencil annotation on one of the latter specimens at NY indicates "status autumnalis" in the handwriting of Jiři Soják, a Czech expert in *Potentilla* based at the National Museum in Prague (PR).

Within this new context of seasonal leaf dimorphism, *P. subviscosa* var. *ramulosa* can still be distinguished by the absence of deeply divided leaflets even on early-formed leaves. As so defined, this variety is the only representative of *P.* sect. *Subviscosae* that occurs in the Santa Catalina and Rincon ranges in Pima Co., Arizona. Comparable plants have been collected on Aztec Peak in the Sierra Ancha Range of Gila Co., Arizona, where they overlap the range of and possibly intergrade with *P. subviscosa* var. *subviscosa*. The typical variety itself is widespread in the mountains of New Mexico and north of the Mogollon Rim in Arizona, barely entering Colorado in the Sangre de Cristo Range of Las Animas County.

Potentilla wheeleri S. Watson.

As here circumscribed, *Potentilla wheeleri* is restricted to the southern Sierra Nevada, San Bernardino Mountains, and San Jacinto Mountains in southern California. Compact plants from the alpine summit of Mount San Gorgonio in the San Bernardino Mountains were described by Jepson (1925) as *P. wheeleri* var. *paupercula*, but I have not found sufficient consistent differences to maintain this as a distinct variety. In contrast, petrophytic plants from Tahquitz Peak (San Jacinto Mountains, Riverside Co., California) and the Sierra San Pedro Mártir (Baja California, Mexico) originally described as *P. wheeleri* var. *rimicola* Munz & I.M. Johnst. are now recognized as a distinct species, *P. rimicola* (Ertter 1991). Other plants of *Potentilla wheeleri* s.l. from the Sierra San Pedro Mártir in Baja California Norte have more open inflorescences, leaves that are sometimes subpalmate, and less hairy leaflets that are only shallowly and apically toothed; these populations can probably also stand as a distinct species, *P. luteosericea* Rydb. (= *P. pinetorum* Wiggins).

KEY TO *POTENTILLA* SECT. *SUBVISCOSAE* NORTH OF MEXICO

1\. Leaflets mostly 3, rarely 5.
  2\. Petals < 2 mm long; styles < 2 mm long; NW Utah and adjacent Nevada **P. cottamii**
  2\. Petals 3–8 mm long; styles 2–3 mm long; SE Arizona.
    3\. Longest hairs on petiole ± 1 mm long; central leaflet with 3–5(–6) teeth per side; Pinaleno Mountains and nearby Mogollon Rim **P. albiflora**
    3\. Longest hairs on petiole 1–2(–3) mm long; central leaflet with 2–3(–4) teeth per side **P. rhyolitica**
      4\. Leaves gray-green, ± densely sericeous; styles 2–2.5 mm long; achenes ± 1.5 mm long, smooth to lightly ribbed; Santa Rita and Huachuca mts. var. **rhyolitica**
      4\. Leaves green, ± moderately hairy; styles 2.5–3 mm long; achenes ± 2 mm long, smooth; Chiricahua Mts. var. **chiricahuensis**
1\. Leaflets mostly 5, rarely 3 or 7.

5. Petals pale yellow adaxially, white abaxially, narrowly obcordate; leaflets with 2–9 teeth or lobes per side ________ **P. subviscosa**
    6. Leaflets often strongly dimorphic, at least those formed early in season divided ½–¾ to midvein into 3–7 lobes per side, late-season leaflets often coarsely toothed less than ¼ to midvein with 6–9 teeth per side; long hairs on petioles 1–1.5(–3) mm long; widespread in n Arizona and New Mexico, barely entering Colorado ________ var. **subviscosa**
    6. Leaflets scarcely dimorphic, those formed early in season toothed ¼–½ to midvein with 2–4 teeth per side, late-season leaflets similarly toothed with up to 6 six teeth per side; long hairs on petioles 2–3(–4) mm long; Santa Catalina and Rincon mts. and Sierra Ancha in SE Arizona ________ var. **ramulosa**
5. Petals bright yellow adaxially, somewhat paler abaxially, narrowly to broadly obcordate; leaflets with 2–4(–5) teeth per side.
    7. Plants rooted in ground; leaflets densely hairy; styles ca. 20, 1.2–2 mm long; southern Sierra Nevada and San Bernardino Mts. of Calif. ________ **P. wheeleri**
    7. Plants rooted in rock crevices, often on vertical surfaces; leaflets sparsely to moderately hairy; styles 5–15(–20), 1.5–2.5 mm long.
        8. Leaflets 1–3 cm long, oblanceolate to obovate-cuneate, toothed in distal ⅓; epicalyx bractlets lanceolate-elliptic; San Jacinto Mts., California, & Baja California, Mexico ________ **P. rimicola**
        8. Leaflets 0.5–1.5(–2) cm long, oblanceolate, toothed in distal ¾; epicalyx bractlets ovate-elliptic; Hualapai Mts., Arizona ________ **P. demotica**

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BOOK REVIEWS

ERNEST SMALL and GRACE DEUTSCH. 2002. **Culinary Herbs for Short-Season Gardeners.** (ISBN 0-87842-453-9, pbk.), Mountain Press Publishing Company, Box 2399, Missoula, MT 59806, U.S.A. $20.00. (**Orders:** www.mountain-press.com, info@mtnpress.com, 406-728-1900, 406-728-1635 fax). $20.00, 182 pp., 14 color photographs, 14 b/w illustrations, 128 full color illustrations, and one full color map of plant hardiness zones of North America.

Growing up in semi-tropical Australia, writer/publisher Grace Deutsch knew she had her hands full after immigrating to Southern Ontario, Canada with desires of having a culinary herb garden. She admired and was curious as to how her gardening friends in Montana, the Adirondacks and northern Alberta managed to have persistently beautiful and productive flower, vegetable and herb gardens in such a relatively short warm-weather season. Fortunately, she met co-author Dr. Ernie Small by chance at a summer herb fair. Dr. Small was raised in the Ottawa Valley and is an international authority on agriculturally important plants. He has written over 200 scientific publications and 7 books, including *Culinary Herbs*, the professional herb-growers bible. Together they collaborated to create this very useful book for the novice or experienced short-season gardener who enjoys a culinary garden just outside their kitchen door. It is concise, practical, and easy-to-use.

A full color map of Canada and the USA helps you interpret your plant hardiness zone for growing perennial herbs that will survive your particular winters. Chapter: *Making the Most of the Short Growing Season* is full of practical advice. Chapter: *Growing and Caring for Your Herbs* is a gardening primer for herb growers. Chapter: *The Culinary Herb Compendium* includes 50 species, with 100 cultivars. Herbs are arranged alphabetically by common name along with scientific name and the plant family name. Icons clearly mark annuals from perennials along with a colored "Coldest Tolerated" zone box. These boxes enable you to quickly see the coldest zone in which the herb may overwinter successfully. These individual herb listings include the following elements:

Description of herb's origin; life cycle; size; leaf shape, color, taste and fragrance; stem and root formation; flowering habit; suitability for growing in pots or containers; which parts are edible; plus any additionally desirable features, for example, if the flowers are very alluring to honeybees or butterflies. **Cultivation Notes:** everything you need to know about plant's soil, light, and moisture requirements; propagation techniques; pest and disease problems; growing indoors; outdoor overwintering survival strategies. **Harvesting Notes:** for maximum flavor and how best to preserve. **Culinary Uses:** both domestic and commercial; when herb should be added in the cooking process; if the herb makes a tea and brewing instructions. **Craft Uses:** to enjoy the natural beauty of herbs. **Medicinal Uses:** traditional herbal medicine uses and its value in modern medicine; nutritional information. **Cautions:** information on existing known problems that susceptible individuals may have from consumption of or contact with the herbs. **Cultivars and Relatives:** descriptive listing of other useful plants related to herbs and outstanding cultivars. **Herbal Trivia:** snippets of the myths, legends, and folklore surrounding each herb.

I particularly enjoyed the use of the beautifully modified botanical illustration masterpieces produced in the 18th and 19th centuries.—*Linny Heagy, Linny/Designer, Illustrator, email: a0005835@airmail.net.*

MAGGIE CAMPBELL-CULVER. 2007. **A Passion for Trees: The Legacy of John Evelyn**. (ISBN 1-903-91947-9, hbk.). Eden Project Books, Eden Project Online Shop Bodelva Par, Cornwall PL24 2SG United Kingdom (**Orders:** http://shop.edenproject.com/khxc/gbu0-display/splash.html). $45.00, 288 pp., color and b/w photos and illustrations throughout.

This copiously illustrated book marks the tercentenary of the death of English horticulturist and founding father of modern conservation, John Evelyn (1620-1706). It explores the legacy of John Evelyn through illustrated portraits of 30 of Britain's best-loved trees.

Described by Samuel Pepys as *'a man so much above others…a most excellent, humoured man and very knowing.'* Evelyn, like Pepys is well known as a diarist, whose writing tells us much about the life and times of the 17th century, but it is in his interest in nature, gardens, horticulture and trees that is of concern in this book. Not only a gardener, Evelyn was a royal advisor, and precursor of the modern environmental movement, but he was also the author of exceptional works on horticulture. The greatest of these is *Sylva: A Discourse of Forest Trees,* published in 1664.

Unlike other European countries, Britain became unique in the way it used trees in the landscape. British designers of the 18th century found aesthetic considerations of prime importance over the more utilitarian aspects of silviculture. It was an idea based on creating landscapes by consulting the 'Genius of the Place'. Evelyn's *Sylva* is among the first books in English to show an appreciation of the aesthetic value of trees and the benefits of planting them to shape the landscape, as an artist might achieve with a painting.

From the beloved English Oaks to the Acacia, Arbutus, Bay, Box, Yew, Holly, Juniper and Laurel trees, author Maggie Campbell-Culver walks hand in hand with Evelyn to paint loving portraits of his well-loved trees. She ends with the following:

"The management and planting of trees are exactly the same as they were in 1664. What better, therefore, could we do than follow the advice of Sylva*? The planting of trees is an essential element of life, and conservation is as necessary as it was when John Evelyn argued for it over 300 years ago."—Linny Heagy, Linny/Designer, Illustrator, email: a0005835@airmail.net.*

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A NEW VARIETY OF *FESTUCA ROEMERI* (POACEAE) FROM THE CALIFORNIA FLORISTIC PROVINCE OF NORTH AMERICA

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ABSTRACT

The grass *Festuca roemeri* is a community dominant in grasslands and savannas from southwest British Columbia through central California. Inland plants in southern Oregon and California differ from more northern *F. roemeri* in isozyme profiles, leaf pubescence, some inflorescence measurements, and perhaps physiology. These populations are here described as **F. roemeri** var. **klamathensis.**

RESUMEN

Festuca roemeri es una gramínea dominante en la comunidad de pastizales y savanas del suroeste de Columbia Británica hasta el centro de California. Plantas distribuidas desde el interior del suroeste de Oregón hasta el noroeste de California difieren de *F. roemeri* por la pubescencia foliar, los perfiles de isoenzimas, algunas medidas de la inflorescencia y quizás en su fisiología. Estas poblaciones son descritas en el presente trabajo como **F. roemeri** var. **klamathensis.**

A dominant bunchgrass of savannas in the Klamath Region of Oregon and California has been identified variously as *Festuca idahoensis* Elmer, *Festuca idahoensis* × *F. occidentalis* Hook. hybrids, *F. idahoensis* var. *oregana* (Hack.) C.L. Hitchc., *F. ovina* L., and *F. rubra* L. In despair, some botanists simply report *Festuca* sp. The grass is *F. roemeri* (Pavlick) E.B. Alexeev (Alexeev 1985; Pavlick 1983; Wilson 1999), but differs slightly from typical, more northern *F. roemeri*. It is described here as a variety of *F. roemeri*.

Festuca roemeri var. **klamathensis** B.L. Wilson, var. nov. (**Figs. 1–2**). Type: U.S.A. Oregon. Jackson Co.: Rogue River National Forest, Baldy Peak Trail, T40S R3W S22, 2 Jul 1996, *B.L. Wilson 8199* (holotype: OSC; isotypes: DAV, MO, NY, RSA, UC, UTC)

A *Festuca roemeri* var. *roemeri* foliorum tricomatibus adaxialibus longioribus et numerosioribus differt.

Cespitose, the old plants sometimes dying in the center, leaving a ring of living shoots; leaf sheaths open (sheath margins overlapping) to the base; leaves glaucous, occasionally green; leaf blades erect, somewhat stiff, conduplicate, 5–30(–50) cm long, 0.55–1.2(–1.5) mm wide, the abaxial (outer) surface glabrous or pubescent, the adaxial (inner) surface with numerous hairs 0.06–0.3 mm long (the longer hairs often about as long as the leaf is thick), adaxial ribs 5–9; veins 5–7(–9). Abaxial sclerenchyma bands >2× as wide as thick, usually forming large bands at margins and midrib, often with smaller bands opposite veins, usually lacking adaxial sclerenchyma; flag leaf 1.5–7 cm long; culm nodes becoming exposed 1; flowering shoots (20–)30–95 cm long, panicle 7–15(–20) cm long. Inflorescence branches at lowest node 1–2, appressed (usually) or spreading after anthesis; spikelets 2–6 on longest branches, 7–16 mm long. Florets 3–5; glumes unequal, the lower 3.2–5.1(–5.7) mm, the upper 4.4–6(–7.2) mm long; lemma (6–)6.2–8.5 mm long, glabrous, with lemma awn (1–)1.5–4.6 mm long, shorter than the lemma body; anthers 3–4.2 mm long; ovary apex glabrous. Tetraploid.

Distribution.—inland sites from southern Douglas County in southwest Oregon to northwest California, east of the coastal mountains (Fig. 3).

Habitat.—community dominant in mesic to dry pine or oak savanna, grasslands, and edges of grassy balds, on a variety of substrates including serpentine.

Festuca roemeri was originally described as *F. idahoensis* var. *roemeri* Pavlick, based on populations found in upland sites in the moist, maritime climate of southwest British Columbia and northwest Washington

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Fig. 1. *Festuca roemeri* var. *klamathensis,* habit. **Left:** *Wilson 8199,* from *Pinus ponderosa* savannah on non-serpentine soils, Jackson County, Oregon. **Right:** *White & Lillico 210,* from serpentine grassland in Josephine County, Oregon.

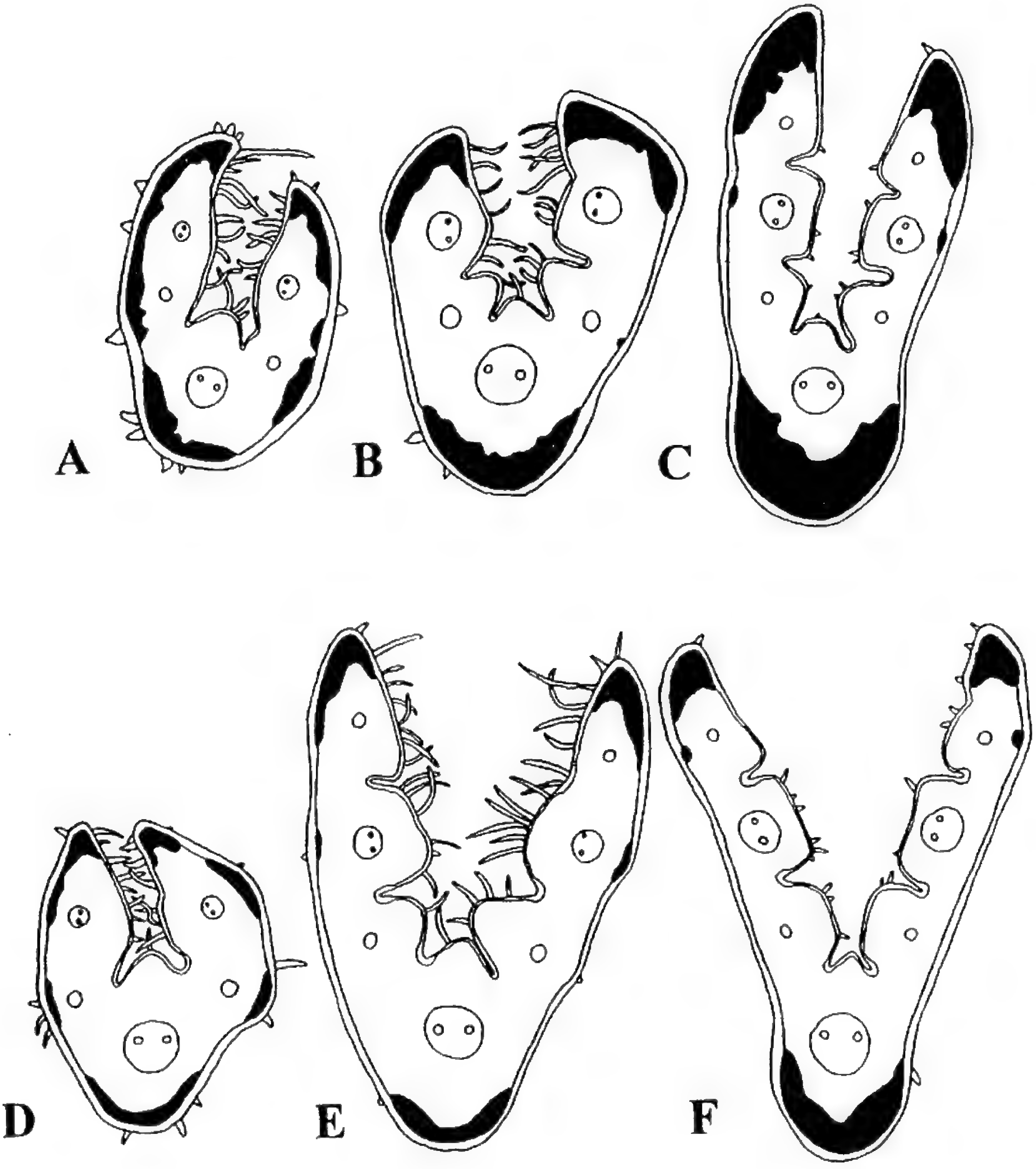

Fig. 2. Leaf cross-sections of field-collected plants (top row) and plants from a common greenhouse environment (bottom row). **A** and **D:** *Festuca idahoensis*. **B** and **E:** *F. roemeri* var. *klamathensis*. **C** and **F:** *Festuca roemeri* var. *roemeri.*

(Pavlick 1983). It was soon recognized at the species level (Alexeev 1985). *Festuca idahoensis* sensu stricto is widespread east of the Cascade Range and Sierra Nevada through the western Great Plains. The narrow conduplicate leaves with dense hairs on the inner surface (where the stomata are located) are adaptive for the dry to xeric continental climate in which it grows. *Festuca roemeri* differs from *F. idahoensis* sensu stricto in its ovate to obovate-pyriform leaves that have few hairs on the inner surface. *Festuca roemeri* is more widely distributed than was initially realized, growing at least as far south as Santa Cruz County, California.

At inland sites in southwestern Oregon and northwestern California, F. *roemeri* grows in dry, continental

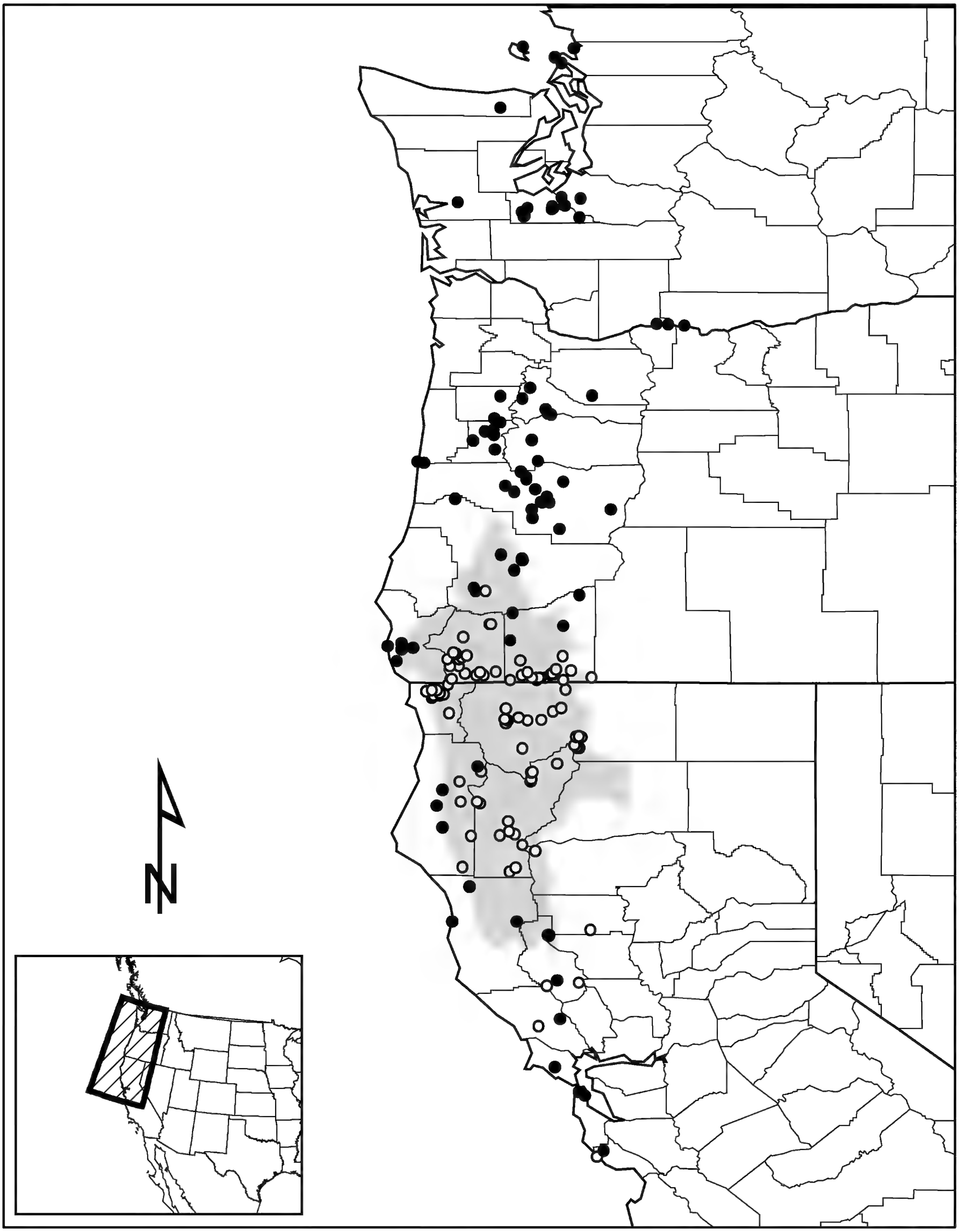

Fig. 3. Distribution of *Festuca roemeri* var. *klamathensis* (open circles) and *F. roemeri* var. *roemeri* (shaded circles) in the U.S.A. Shaded area is the Klamath ecoregion.

environments similar to those inhabited by *F. idahoensis*. These inland populations differ from *F. roemeri* var. *roemeri* in having long hairs on the inner surface, like *F. idahoensis* (Fig. 2). Even in a common greenhouse environment, *F. roemeri* var. *klamathensis* had more and longer hairs than *F. roemeri* var. *roemeri* (Table 1). The difference in leaf hairs can be detected in the field by bending the opened leaf over a finger and viewing the adaxial surface with a hand lens: leaves of *F. roemeri* var. *roemeri* appear glabrous whereas those of *F. roemeri* var. *klamathensis* appear distinctly pubescent. In *Festuca*, the extent of abaxial pubescence is greater at high temperatures (Aiken et al. 1994), but adaxial hair characters may be more stable that other leaf anatomical traits, and the adaxial hair traits are species specific (Aiken et al. 1994; Dubé & Morisset 1996; Ramesar-Fortner et al. 1995; Wilson 1999).

A combination of other traits distinguishes *F. roemeri* var. *klamathensis* from *F. roemeri* var. *roemeri* and from *F. idahoensis. Festuca roemeri* var. *klamathensis* often has leaves with a shape more typical of *F. roemeri* var. *roemeri,* although plants growing on serpentine substrates have leaves nearly as narrow as those of *F. idahoensis* (but with better defined ribs and grooves). Glumes and lemmas average slightly longer in *F. roemeri* var. *klamathensis* than in *F. roemeri* var. *roemeri* (Table 2). In *F. roemeri* var. *klamathensis*, isozyme band patterns as revealed on gels stained for malate dehydrogenase (following the methods of Wendel & Weeden 1989) match those of *F. idahoensis,* not *F. roemeri* var. *roemeri* (Wilson 1999).

Festuca roemeri var. *klamathensis* is phenotypically plastic. Plants of fertile soils have lush, dense bunches of 30 cm long, moderately glaucous leaves, and lemmas up to 8 mm long. They do not resemble the intensely glaucous, depauperate individuals of serpentine barrens, which may have leaves up to 7 mm long, gnarled bases, dead centers, and lemmas up to 6.5 mm long. When brought into the greenhouse the depauperate plants produce broader leaves (Fig. 2; Wilson 1999). Plants of intermediate stature exist in the wild, but extensive populations usually have only large or only depauperate individuals, leading biologists to treat these variations as different taxa. A similar range of variation is observed in *F. roemeri* var. *roemeri,* but in that variety depauperate plants are usually found on rock outcrops within populations of more lush plants.

From Lake County, California, southwards, plants of *F. roemeri* are intermediate and cannot always be classified into either variety. *Festuca roemeri* var. *klamathensis* is named as a variety, rather than a subspecies, because of these intermediates. On the north and west edges of its range, the transition zone is narrower.

The name *Festuca idahoensis* var. *oregana* (Hack.) C.L. Hitchcock has been applied dwarfed fescues of western Washington and Oregon, including those referred to here as *F. roemeri* var. *klamathensis* (Hitchcock et al. 1969), but its type specimen (*Cusick 753,* Oregon, 1884; US!), is *F. idahoensis* (Pavlick 1983), which can also be dwarfed when growing extremely stressful microhabitats. The type of *F. ovina* var. *columbiana* Beal (1886; US!) is *Lake s.n.* June 1882 (labeled as collected near Pullman, Washington, but apparently really collected near the head of Tukanon River, Blue Mountains, Washington, according to an annotation by Piper). It appears to be *F. idahoensis* as well, and was collected well outside the known range of *F. roemeri*.

Conservation concerns

Application of the names *Festuca idahoensis* and *F. ovina* to populations of *F. roemeri* var. *klamathensis* has led land managers to mistakenly plant commercial cultivars of *F. idahoensis* and "Sheep Fescue" as native species in habitat restoration projects within the range of *F. roemeri* var. *klamathensis*. *Festuca idahoensis* plantings within the range of *F. roemeri* var. *roemeri* usually die because *F. idahoensis* is adapted to be winter dormant in a drier climate with less pressure from fungal pathogens, but *F. idahoensis* may survive in the environment of *F. roemeri* var. *klamathensis*. Hybridization between the two tetraploid taxa might well occur and could result in the loss of genetic traits typical of *F. roemeri* var. *klamathensis,* including its adaptive phenotypic plasticity. Planting Sheep Fescue as a native grass is erroneous because *F. ovina* and the other taxa sold under this name, such as *F. trachyphylla* (Hack.) Krajina and *F. valesiaca* Gaudin, are not native to North America. A second concern is that demand for *F. roemeri* var. *roemeri* seed has grown faster than the supply of seed. Unlike *F. roemeri* var. *roemeri* (Wilson 1997), *Festuca roemeri* var. *klamathensis* is common and rarely grows with other fine-leaved fescue species. This simplifies collection of uncontaminated seed and establishment of pure cultivated seed sources. Nomenclatural clarification may reduce pressure to use

Table 1. Traits of *F. roemeri* leaf anatomy. **N** = number of individuals measured. **Max** = maximum value. **Min** = minimum value. s = standard deviation. Probability (**p**) is the probability that the measurements for *F. roemeri* var. *roemeri* and *F. roemeri* var. *klamathensis* are the same.

	F. roemeri* var. *roemeri					***F. roemeri* var. *klamathensis***					**Probability**
	N	**Mean**	**s**	**Max.**	**Min.**	**N**	**Mean**	**s**	**Max.**	**Min.**	**p <**
Plants from the field											
Number of vascular bundles	15	6.61	0.62	7.33	5.00	11	5.45	0.60	6.33	5.00	9.77×10^{-5}
Number of fibers (sclerenchyma strands)	15	5.27	1.27	8.00	3.00	11	4.10	0.82	5.67	3.00	0.008843
Adaxial hair length (mm)	15	0.031	0.026	0.117	0.014	11	0.094	0.044	0.216	0.061	0.000629
Adaxial hairs/side	15	4.57	1.81	8.75	2.00	11	10.39	1.97	14.50	8.12	1.53×10^{-7}
Adaxial grooves	15	5.34	0.69	6.00	4.00	11	4.20	0.36	5.00	4.00	1.84×10^{-5}
Plants from greenhouse											
Number of vascular bundles	16	6.59	0.73	7.5	5.00	11	5.98	0.98	7.50	5.00	0.9308
Number of fibers sclerenchyma strands)	16	5.40	1.78	8.0	3.00	11	4.04	0.91	5.25	3.00	0.01591
Adaxial hair length (mm)	16	0.013	0.005	0.020	0.006	11	0.077	0.078	0.304	0.017	0.02144
Adaxial hairs/side	16	1.83	1.41	6.00	0.50	11	8.93	4.27	14.00	0.00	0.00018
Adaxial grooves	16	5.34	0.73	6.50	4.00	11	4.43	0.79	6.00	3.70	0.006039

F. roemeri var. *klamathensis* seed at inappropriate locations. Third, *F. roemeri* var. *roemeri* is uncommon to rare in much of its range, with most Oregon populations varying from 13 to approximately a thousand individuals. The fate of this taxon is not tracked when it is treated as taxonomically identical to *F. roemeri* var. *klamathensis*.

Etymology.—The name *klamathensis* is appropriate for this fescue variety because the ancient, varied, and botanically complex Klamath Range (Whitaker 1960) is the center of its distribution. This region is named after the Klamath people who live there and once used fires to manage the *F. roemeri* var. *klamathensis* grasslands.

The following key distinguishes the native and the more common introduced fine-leaved fescues growing at low to moderate elevations in and near the range of *F. roemeri*.

KEY TO FINE-LEAF FESCUES OF PACIFIC COASTAL STATES AND PROVINCE

1a. Longer awns longer than the lemma bodies; ovary apices densely pubescent; plants growing in the shade ____ **F. occidentalis**
1b. Longer awns none or up to as long as the lemma bodies; ovary apices glabrous (rarely with <10 hairs); plants growing in the sun or in partial shade.
2a. Plant rhizomatous ____ **F. rubra**, sensu lato
2b. Plant cespitose.
3a. Lemmas >(5.8–)6 mm long.
4a. Leaves very narrow, smoothly rolling between the fingers, round to hexagonal in cross section; ribs on adaxial surface usually 3(–5); native range east of the Cascade Range and Sierra Nevada (in California wholly east of Interstate Highway 5) but occasionally planted to the west ____ **F. idahoensis**
4b. Leaves wider, not rolling between the fingers or doing so with angles that can readily be felt, V-shaped or obovate to elliptic in cross section; ribs on adaxial surface 5 or more; native range west of the Cascade Range and Sierra Nevada (in northern California, near or west of Interstate Highway 5) ____ **F. roemeri**
5a. Hairs on the adaxial surface of leaves short (<< thickness of leaf) and usually sparse (except in some south coastal and Columbia Gorge populations) ____ **F. roemeri** var. **roemeri**
5b. Hairs on the adaxial surface of leaves long (½ to about = thickness of leaf) and dense ____ **F. roemeri** var. **klamathensis**
3b. Lemmas <5.8, usually 4–5.5 mm long.
6a. Leaf sheaths with margins fused to near the top (but readily splitting as the plant grows); leaf

TABLE 2. Selected measurements of *F. roemeri* inflorescences. **N** = number of individuals measured. **Max** = maximum value. **Min** = minimum value. **s** = standard deviation. Probability (**p**) is the probability that the measurements for *F. roemeri* var. *roemeri* and *F. roemeri* var. *klamathensis* are the same.

	F. roemeri* var. *roemeri					***F. roemeri* var. *klamathensis***					**Probability**
	N	**Mean**	**s**	**Max.**	**Min.**	**N**	**Mean**	**s**	**Max.**	**Min.**	**p <**
Panicle length (cm)	21	13.28	2.39	19.5	9.5	19	11.39	3.31	18.0	5.6	0.0485*
Lower glume length (mm)	21	3.42	0.66	4.9	2.0	19	3.89	0.69	5.7	3.2	0.0341*
Upper glume length (mm)	21	5.04	0.59	6.2	4.2	19	5.52	1.14	7.2	4.4	0.1135
Lemma length (mm)	21	6.95	0.42	7.9	6.5	19	7.47	0.72	8.5	6.3	0.0097*
Longest awn length (mm)	21	3.94	0.89	5.3	2.3	18	3.40	0.90	4.6	1.8	0.0692

sclerenchyma bundles < 2× as broad as thick (but sometimes fused into broader groups); leaf sheaths brown and shredding to reveal whitish veins. Native and introduced taxa ____ **F. rubra,** sensu lato

6b. Leaf sheaths with overlapping margins; leaf sclerenchyma bundles generally > 2× as broad as thick; leaf sheaths paler, not shredding ____ introduced Sheep and Hard Fescues

7a. Leaves thinner (0.4–0.6 mm wide); leaf sheaths not conspicuously broader than blades; leaves always with at least 5 ribs on adaxial surface; adaxial hairs many and long; leaf sclerenchyma interrupted and sometimes consisting of three discrete bands ____ **F. valesiaca**

7b. Leaves often broader (0.5–1.2 mm wide); leaf sheaths in some cultivars conspicuously broader than blades; leaves with 3 - many ribs on adaxial surface; adaxial hairs many and short; leaf sclerenchyma various, sometimes forming a continuous band under the abaxial epidermis ____ **F. trachyphylla**

APPENDIX

SPECIMENS OF *FESTUCA ROEMERI* VAR. *KLAMATHENSIS* EXAMINED

In Oregon, all legal descriptions (TRS) are based on the Willamette Meridian.

CALIFORNIA: Alameda Co.: Upper end of Corral Hollow, 18 Apr 1941, *Hoover 4847* (UC); W of Corral Hollow, on road to Livermore, 21 May 1939, *Stebbins 2710* (DAV). **Del Norte Co.:** Stoney Creek Bog, T17N R2E S16 (H meridian), 26 May 1978, *Alcasas 103* (HSC); T18N R1E S35 (H meridian), 20 Jun 1979, *Baker 868* (HSC); Old Gasquet Road, T17N R2E S13& S24 (H meridian), 25 Jun 1975, *Barker 1006* (HSC); near Gasquet, 22 May 1979, *Clinton & Overton 3084* (HSC); Gasquet, Jun 1902, *Davy s.n.* (UC); French Hill Road, T17N R2E S29 (H meridian), 14 Jun 1978, *Nelson 4152* (HSC); Smith River, Elk Camp Ridge, May 1937, *Parks & Tracy 5833* (HSC); state line N of Monumental, at head of Shelly Creek, 17 Jun 1936, *Parks & Tracy 11386* (UC); Stony Cr. Bog near Gasquet, T17N R2E S16 (MD meridian), 13 May 1973, *Smith 6749* (OSC); 1 mi SW of Patrick Creek, 19 Jun 1936, *Yates 5770* (DAV); 41°59′9″N, 123°58′16″W, 2 Jun 1980, *York 928* (HSC); near High Plateau Mt., 31 May 1980, *York s.n.* (HSC). **Humboldt Co.:** Trinity Summit, 31 Jul 1901, *Goddard 134* (UC); Brannan Mountain, 10 Jul 1930, *Tracy 8867* (OSC); Mail Ridge, 7 mi N of Harris, 15 Jun 1950, *Tracy 18803* (UC). **Lake:** Snow Mountain, 15 Jun 1979, *Heckard & Hickman 5040* (JEPS); Reiff, Knoxville Ridge, 11 Jun 1938, *Jepson 19012* (JEPS); between Cobb Mt. & Adams Spring on the Binkley Ranch, 4 Jul 1933, *Jussel 360* (UC). **Mendocino Co.:** Grouse Moutain, 25 Jul 1933, *Tracy 12890* (UC). **Santa Cruz Co.:** N end of Swanson Road, overlooking Greyhound Rock, 10 km NW of Davenport, 13 May 1983, *Buck & West 265* (JEPS). **Shasta Co.:** T28N R10W S6 (MD meridian), 22 Jun 1980, *Nelson & Nelson 5820* (HSC). **Siskiyou Co.:** Paradise Lake, Marble Mountains, trail to Kings Castle, 22 Jul 1949, *Alexander & Kellogg 58844* (UC); Rainbow Ridge above Sulloway Cr. about 1.5 mi W of Mt. Shasta City, 11 Jun 1936, *Babcock & Stebbins 1894* (UC); Rainbow Ridge above Sulloway Cr. about 1.5 mi W of Mt. Shasta City, 13 Jun 1936, *Babcock & Stebbins 2008* (UC); Big Flat Campound, 2 Jul 1959, *Bacigalupi 7232* (JEPS); headwaters of S Fork of Salmon River near N base of Caribou Mt., just S of low divide (Trinity Co. boundary) separating Coffie Creek drainage from that of Salmon River, 2 Jul 1959, *Bacigalupi 7234* (DAV); 40°24′20″N, 123°34′00″W, 20 Jun 1980, *Baker 2220* (HSC); 13 mi E of Hamburg, banks of Klamath River, 31 May 1942, *Beetle 3431* (DAV); Moffitt Creek, 13 Jun 1909, *Butler 833* (UC); Moffet Creek NW of Fort Jones, 6 Jun 1922, *Dunning s.n.* (JEPS); Big Flat, T37N R9W S18 (MD meridian), 3 Aug 1966, *Ferlatte 251* (HSC); Eastern Flank of Mt. Eddy, just below summit fell field, 13 Aug 1967, *Heckard 1709* (JEPS); Eastern Flank of Mt. Eddy, just below summit fell field, 13 Aug 1967, *Heckard 1711* (JEPS); toward the head of Wagon Creek, Mt. Eddy, 17 Jul 1920, *Heller 13680* (DAV); ½ mi SE of Kings Castle, Marble Mts., 6000 ft, 9 Jul 1939, *Hitchcock & Martin 5321* (UC); NE face of Marble Mountain, T43N R12W S15 (MD meridian), 4 Sep 1966, *Major s.n.* (DAV); Summit between Beach Creek & Toad Lake, 22 Jul 1959, *Murphy 591* (DAV); 0.2 mi E of Butcher Gulch on the Cecilville-Forks of Salmon

Road, 28 May 1972, *Smith & Sawyer 5384* (HSC); junction of French Creek and Sugar Creek Road, 1/2 mi W of Parrott Mill Road, 30 Jun 1972, *Smith & Sawyer 5641* (HSC); E of Cook and Green Pass, T18N R4W S8 (MD meridian), 3 Jul 1972, *Smith & Sawyer 5660* (HSC); T43N R12W S2 (MD meridian), 7 Jul 1976, *Stillman 161* (HSC); T43N R12W S15 (MD meridian), 7 Aug 1976, *Stillman s.n.* (HSC); Soap Creek Ridge between Yreka and Fort Jones, 3 Aug 1949, *Tofsud s.n.* (DAV); Mt. Eddy, T40N R5W S7& S 18 (MD meridian), 20 Aug 1976, *Whipple 1706* (HSC); Intersection Hwys 263 & 96, T47N R6W S18SW 1/4 of SW 1/4 (MD meridian), 30 May 1996, *Wilson 8094* (OSC); Highway 263 bridge over the Klamath River, at intersection with Highway 96, SE corner of bridge, T74N R6W S18SW 1/4 of SW 1/4 (MD meridian), 30 May 1996, *Wilson 8095* (OSC); Indian Scotty Campground, T44N R11W S26SW 1/4 of NE 1/4 (MD meridian), 1 Jun 1996, *Wilson 8112* (OSC); Quartz Valley Road, S of the Charity Mission, N of bridge over river (and N of Forest Service Road 43N21), T43N R10W S3SW 1/4 of NE 1/4 (MD meridian), 1 Jun 1996, *Wilson 8115* (OSC); Idlewild Campground on the Salmon River at the intersection of Forest Service roads 41N37 and 1CO1., T40N R10W S18SW 1/4 of SW 1/4 (MD meridian), 1 Jun 1996, *Wilson 8117* (OSC); Old Edgewood-Weed road, which parallels the I-5 on the E, 2.2 mi by road more or less W of N. Weed Blvd., and 2 mi more or less W of where a road crosses the railroad tracks and intersects with this one from the NE, T41N R5W S4 (MD meridian), 21 Jun 1996, *Wilson 8162* (OSC); Stewart Springs Road, T42N R5W S32SW 1/4 (MD meridian), 22 Jun 1996, *Wilson 8168* (OSC); 0.9 mi from the Gazelle Road on the Stewart Springs Road (Forest Service Road 17), at the first bend in the road, ca. 3.5 mi W and 1 mi N of Weed, T42N R5W S32SW 1/4 (MD meridian), 22 Jun 1996, *Wilson 8173* (OSC). **Sonoma Co.:** 3 mi NW of Graton, 30 May 1937, *Yates 6544* (DAV). **Tehama Co.:** Tedoc Mountain, T28N R8W S29 (MD meridian), 22 Jul 1978, *Smith & Nelson 10032* (HSC, JEPS); Tedoc Mountain, T28N R9W S29 (MD meridian), 23 Jun 1979, *Smith & Nelson 10162* (HSC). **Trinity Co.:** Morris Meadow, Stuart Fork of Trinity River, 21 Aug 1948, *Alexander & Kellogg 5526* (UC); ridge road on South Fork Mtn. ca. 10 mi N of its junction with Highway 36, 16 Jun 1972, *Anderson 5887* (HSC); South Fork Mt., along 1 SO 2, the road to Pickett Peak, 0.4 mi from its junction with Highway 36, 15 Jul 1971, *Anderson s.n.* (HSC); near Castle Rock, 25 Jun 1980, Baker 2250 (HSC); Indian Valley near Hayfork, 16 Jul 1965, *Bordon s.n.* (DAV); T30N R12W S31SW 1/4 of NW 1/4 (MD meridian), 16 Jun 1980, *Nelson & Nelson 5446* (HSC); T30N R12W S13 (MD meridian), 18 Jun 1980, *Nelson & Nelson 5544* (HSC); Red Mountain, T26N R12W S20 (MD meridian), 9 Jun 1978, *Nelson & Sawyer 4135* (HSC); Eagle Creek Campground, Shasta-Trinity National Forest, T38N R7W S16NE 1/4 (MD meridian), 15 Jun 1979, *Smith 10009* (HSC); T30N R11W S28 (MD meridian), 22 Jul 1980, *Smith 10307* (HSC); Underwood Mountain Pass, 12 Jun 1965, *Spellenberg 1104* (HSC, OSC); T25N R12W S11 (MD meridian), 28 Jun 1997, *Sprecht 1105* (HSC); Mt. Eddy, T40N R6W S12 (MD meridian), 23 Jul 1976, *Whipple 1506* (HSC).

OREGON: Douglas Co.: Beatty Creek ACEC/RNA, T30S R6W S21and/or T30S R7W S25, 2 Jun 1994, *Brainerd & Kuykendall BLW9856* (OSC). **Jackson Co.:** Siskiyou Pass, junction old Hwy 99 w/ I-5 just N of Hilt, T41S R2E S8SE 1/4, 16 Jun 1998, *Chambers 6130* (OSC); Mount Ashland, T40S R1E S, 6 Jul 1958, *Dennis 1085* (OSC); Rogue River near Elk Creek, 9 Jun 1930, *Henderson 13344* (ORE); Dutchman's Peak, summit area, 7400 ft, 6 Aug 1961, *Hutchison 985* (JEPS); T40S R2W S7 E half of section, 23 Jun 1955, *Jeffers 61* (OSC); Lower Applegate Creek, 18 Jul 1899, *Leiberg 4096* (ORE); Grizzly Peak, 17 Jul 1913, *Peck 4470* (WILLU); Dry Summit of Mt. Ashland, 19 Jul 1913, *Peck 9307* (WILLU); Long John Creek, T40S R1W S35, *Wheeler 2987* (US); Collings Mt. near Steamboat, T40S R4W S35, 13 Jul 1950, *Whitaker 169* (WS); Observation Peak, T41S R2W S12, 14 Jul 1950, *Whitaker 271 & 248* (WS); Emigrant Creek, T40S R2E S1, 20 Aug 1949, *Whitaker 349* (WS); Deadman Pt. near Dutchman's Peak, T40S R2W S33, 13 Jul 1950, *Whitaker 222, 224, 227* (WS); Big Red Mountain (summit), T40S R1W S31, 15 Jul 1950, *Whitaker 330,* 326 (WS); Ashland Peak, Siskiyou Mts., T39S R1E S34, 21 Aug 1949, *Whitaker SS355* (WS); near Canberry Campground, T41S R4W S10, 28 May 1994, *Wilson 6936* (OSC); Cantrall-Buckley County Park, 1.5 mi SW of Ruch, T38S R3W S33, 20 Jun 1996, *Wilson 8137* (OSC); Baldy Peak Trail, T40S R3W S22, 2 Jul 1996, *Wilson 8197* (OSC); South-facing slope E of the summit of Mount Ashland, T40S R1E S17, 6 Aug 1993, *Wilson, Kuykendall, Otting & Zika 6339* (OSC); Private inholding between the Klamath and Rogue River National Forests, 0.2 mi (by road) E of Siskiyou Gap and 0.4 mi (by road) W of the intersection of forest service roads 20 and 22, where the road crosses a small seep, T40S R1W S34, 6 Aug 1993, *Wilson, Kuykendall, Otting & Zika 6381* (OSC). **Josephine Co.:** Woodcock Mountain, T39S R8W S19, 20 Jun 1995, *Brock 560* (OSC); Fiddler Mountain, 11 May 1974, *Chambers 3947* (OSC); Illinois River Valley, Rockydale Rd. 2 mi. N of junction with Waldo Road, T40S R8W S15NE, 15 Jun 1998, *Chambers 6117* (OSC); Kalmiopsis Wilderness Road, T38S R8W S30, 11 Jun 1984, *Fredricks 285* (OSC); Deer Creek, 4 mi from Selma, 11 Apr 1926, *Henderson 5949* (ORE); Grayback Mountain, 13 Jul 1930, *Henderson 13339* (ORE); Eight Dollar Mountain, near Selma, Illinois River Valley, The Nature Conservacy Preserve, E base of the mountain, 11 May 1983, *Kagan 5118301-2* (OSC); 22 mi W of Gasquet Trail on O'Brien-Sourdough Road, *Kruckeberg 1861* (WS, WTU); Siskiyou N.F., junction roads 4402 & 4402-19, 4 mi SW of O'Brien, T41S R9W S4NE 1/4, 9 May 1984, *Shelly 696* (OSC); Illinois River Valley, W of Selma, 0.5 mi up Oregonite Trail from Store Gulch GS, T37S R9W S34SW 1/4 of SW1/4, 7 Jun 1969, *White & Lillico 187* (ORE); Illinois River Valley, W of Selma, hill E of Sixmile Creek, T38S R9W S2NW 1/4 of SE 1/4, 8 Jun 1969, *White & Lillico 210* (ORE); Onion Mountain Road, ca. 3 mi NW of Lookout junction, T36S R8W S4, 20 Jun 1969, *White & Lillico 289* (ORE); Hoover Gulch Trail, T38S R9W S30, 21 Jul 1969, *White & Lillico 319* (OSC); Hoover Gulch Trail, T38S R9W S30, 21 Jul 1969, *White & Lillico 322* (ORE); Whetstone Butte, T38S R9W S30, 25 Jun 1969, *White & Lillico 336* (ORE); Limestone Trail, Grayback, T40S R6W S20, 10 Jul 1950, *Whitaker 84* (WS); Murphy Creek, T29S R6W S2, 12 Jul 1950, *Whitaker 166* (WS); Josephine Mountain, T39S R9W S20, 20 Jul 1950, *Whitaker 410* (WS); No. 8 Gulch Trail, Browntown near Holland, T40S R7W S22, 11 Jul 1950, *Whitaker 119 & 136* (WS); Holland-Browntown Road, T40S R7W S4, *Whitaker 145 & 147* (WS); Sucker Creek, Grayback area, T40S R7W S12, 2 Jul 1949, *Whitaker SS83* (WS); Big Red Mountain, Ashland Area, Siskiyou Mountains, T40S R1W S32, 22 Aug 1949, *Whitaker s.n.* (WS); Sexton Moutain, T34S R6W S23, 15 May 1994, *Wilson 6834* (OSC);

Near fen on Fiddler Mountain, 1.7 mi by road from bridge over the Illinois River, 0.7 mi from Forest Service Road 4201 on a dirt road that intersections with 4201, 1 mi from (S of) the bridge, T38S R8W S30, 14 May 1994, *Wilson, Camacho & Otting 6786* (OSC); Slope above and NE of Illinois River bridge, Eight Dollar Mountain, 24 May 1996, *Zika 12866* (OSC).

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BOOK REVIEWS

Lester Rowntree. 2006. **Hardy Californians: A Woman's Life with Native Plants. New Expanded Edition.** (ISBN 0-520-25051-6, pbk.). The University of California Press, Berkeley, CA 94704, U.S.A. (**Orders:** California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A., www.ucpress.edu, 609-883-1759, 609-883-7413 fax). $19.95, 391 pp., 81 b/w photographs.

Like the very native California flora she sought out to find, 52 year old Lester Rowntree was tenacious. A self-proclaimed "lady-gypsy," who traveled California's backroads and walked its mountain trails, often alone, sometimes with a pack animal to carry her camera and collecting equipment. Lester carved out a unique and soul nurturing authentic life—the life of a field botanist, writer, lecturer, and gardener. In her book *Hardy Californians*, she describes landscapes and places that would soon disappear, a rural and pastoral California that would fall victim to postwar "progress."

The original *Hardy Californians* published in 1936 became a classic over the years. Unfortunately, it also became a rare book after the bookplates were sacrificed to the 1940s war effort. In 1980, a year after Lester's death at age 100, *Hardy Californians* was reprinted as a paperback, yet this edition also is now scarce.

This new and expanded edition is a reprint of Lester's original version as well as new material: a biographical sketch of Lester by her grandchildren, Lester B. Rowntree and Rowan A. Rowntree. Also included is an essay by Judith Lowrey, an award-winning writer and native plant horticulturist who, despite never having met Lester, captures much of Lester's essence by illuminating her prolific writings and professional contributions with added photographs of Lester at different stages of her life. The sixty-four photographs of native plants have been reproduced anew from Lester's original negatives, taken in the early 1930s with a large-format camera. Also included in the back of the book is an updated species list of plants referenced by Lester in the original 1936 edition of *Hardy Californians*.

Often described as a female John Muir, she was both a free spirit and a recluse living for months in the mountains on beans and bread. In her words:

"The best places of all were in the high mountains, where I knew no one was camping above me. I used to love sleeping at the edge of snow banks during thaw time to watch the alpines open with the rising sun.

Up in the Sierra, after the flora and fauna and the silva—the forest trees—have accepted you, you climb to the top of a peak in a thunderstorm, take off your clothes and dance in the rain. Soon you know that the elements have accepted you, too."—Linny Heagy, Linny/Designer, Illustrator, email: a0005835@airmail.net.

William W. Dunmire. 2004. **Gardens of New Spain: How Mediterranean Plants and Foods Changed America.** (ISBN 0-292-70564-6, pbk). University of Texas Press, P.O. Box 7819, Austin, TX 78713-7819, U.S.A. (**Orders:** http://www.utexas.edu/utpress, 512-471-4032). $24.95, 375 pp., illustrated, 6" × 9".

William Dunmire discusses how plants and animals from the Mediterranean world arrived in the Americas, and how they were cultivated in this new setting. It is a fascinating story, for it involves the many cultures and geographic regions (the Middle East, Asia, and Africa) that gave so much to Spain. The story also involves the many people who brought these crops and animals to the Americas. The introduction of these new plants and animals forever changed the face, and taste, of the land.

Written in the tradition of historical and cultural geography, the reader will learn about each new crop and animal, its use and habitat in the Old World and the challenges facing its introduction into the New World. Many crops were first introduced into Mexico, and then later spread to New Mexico, Arizona, California, and Texas. When the Spanish left for the New World, they brought along the plants and animals of their homeland— wheat, melons, grapes, vegetables and a cornucopia of Mediterranean fruit. Watermelon and cantaloupe seeds were among Pueblo Indian trade items imported from Mexico, which means a European presence was felt here long before the Spanish themselves appeared. Some of their offerings thrived and became staple crops alongside the corn, beans and squash that had traditionally sustained the original Americans. Other imports couldn't adapt or didn't please local palates. This intermingling of Old and New World plants gave rise to many of the culinary dishes and foods we enjoy today.

His earlier works include: *Wild Plants of the Pueblo Province* (1995), *A Readable Guide to Southwestern Native American Ethnobotany* (1997), and *Wild Plants and Native Peoples of the Four Corners* (1997).

Gardens is recommended for anyone interested in plants and their uses. It is a good read and well organized with an index, glossary, and extensive bibliography.—*Gary Jennings, Library, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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DESCRIPTION OF *CAREX KLAMATHENSIS* (CYPERACEAE), A RARE SEDGE OF THE KLAMATH REGION OF OREGON AND CALIFORNIA, U.S.A.

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ABSTRACT

A previously undescribed sedge of serpentine fens in southwest Oregon and three California sites is described here as globally rare *Carex klamathensis*. This species is rhizomatous, with glaucous foliage and pale, more or less papillose, obovate perigynia with bent beaks. It resembles and may be most closely related to the midwest North American taxa *Carex meadii* and *Carex tetanica*. It differs from both of these in its achene surface morphology. In addition, it has smaller perigynia than *C. meadii* and wider staminate spikes than *C. tetanica*. It is most easily confused with a form of *C. hassei* that grows in serpentine fens in northwest California. That taxon usually has a mix of flowers with two or three stigmas in the same plant. *Carex klamathensis* consistently has flowers with three stigmas and is a taller, more robust plant with wider staminate spikes.

Key Words: *Carex klamathensis*, *Carex hassei*, serpentine endemic, Paniceae

RESUMEN

Se describe en este trabajo una ciperácea previamente no descrita de ciénegas serpentinícolas del suroeste de Oregón y de tres sitios en California como una endémica restringida, *Carex klamathensis*. La especie es rizomatosa con hojas glaucas y pálidas, más o menos papilosas, periginio obovado con picos doblados. Parece estar más estrechamente relacionada a los taxa del medio oeste de América del Norte, *Carex meadii* y *Carex tetanica*. Difiere de esas dos especies por la morfología de la superficie del aquenio. Además, posee un periginio más pequeño que *C. meadii* y espigas estaminadas más anchas que *C. tetanica*. Se puede confundir más fácilmente con una forma de *C. hassei* que ocurre en ciénegas serpentinícolas del noroeste de California. Ese taxón usualmente tiene una mezcla de flores con dos o tres estigmas en la misma planta. *Carex klamathensis* consistentemente tiene flores con tres estigmas y es una planta más alta, más robusta, con espigas estaminadas más anchas.

INTRODUCTION

A strongly glaucous sedge in *Carex* section *Paniceae* has long confused botanists studying serpentine fens in southwest Oregon. Its long rhizomes, three stigmas, and pale, papillose, perigynia initially led to its misidentification as *Carex californica* L.H. Bailey, a widespread but local plant of disturbed meadows and roadsides west of the Cascade Range. As botanists became more familiar with the serpentine species in the late 1980s, they realized that its indistinct perigynium beaks and pale shoot bases differentiated it from *C. californica,* which has tubular perigynium beaks and red-brown shoot bases, rhizomes, and scales. Then the species was identified as *Carex livida* (Wahlenb.) Willd., a species of northern bogs and known from a few Oregon sites and one California wetland (*Bolander 4745,* Mendocino County, California; specimen at UC). In the late 1990s Oregon botanists found that the serpentine plants differed from *C. livida* not only in habitat but also in inconspicuous but consistent morphological traits of the leaves, inflorescence, and perigynia.

At the same time Lawrence Janeway, working independently in California, discovered *Carex livida*-like sedges at three isolated springs on serpentine substrates (Fig. 1). This plant matched no other described species, although it resembled the Midwestern species *C. meadii* Dewey and *C. tetanica* Schkuhr (A.A. Reznicek, pers. comm.).

Further study revealed that the new species can be difficult to distinguish from a form of *C. hassei* L.H.

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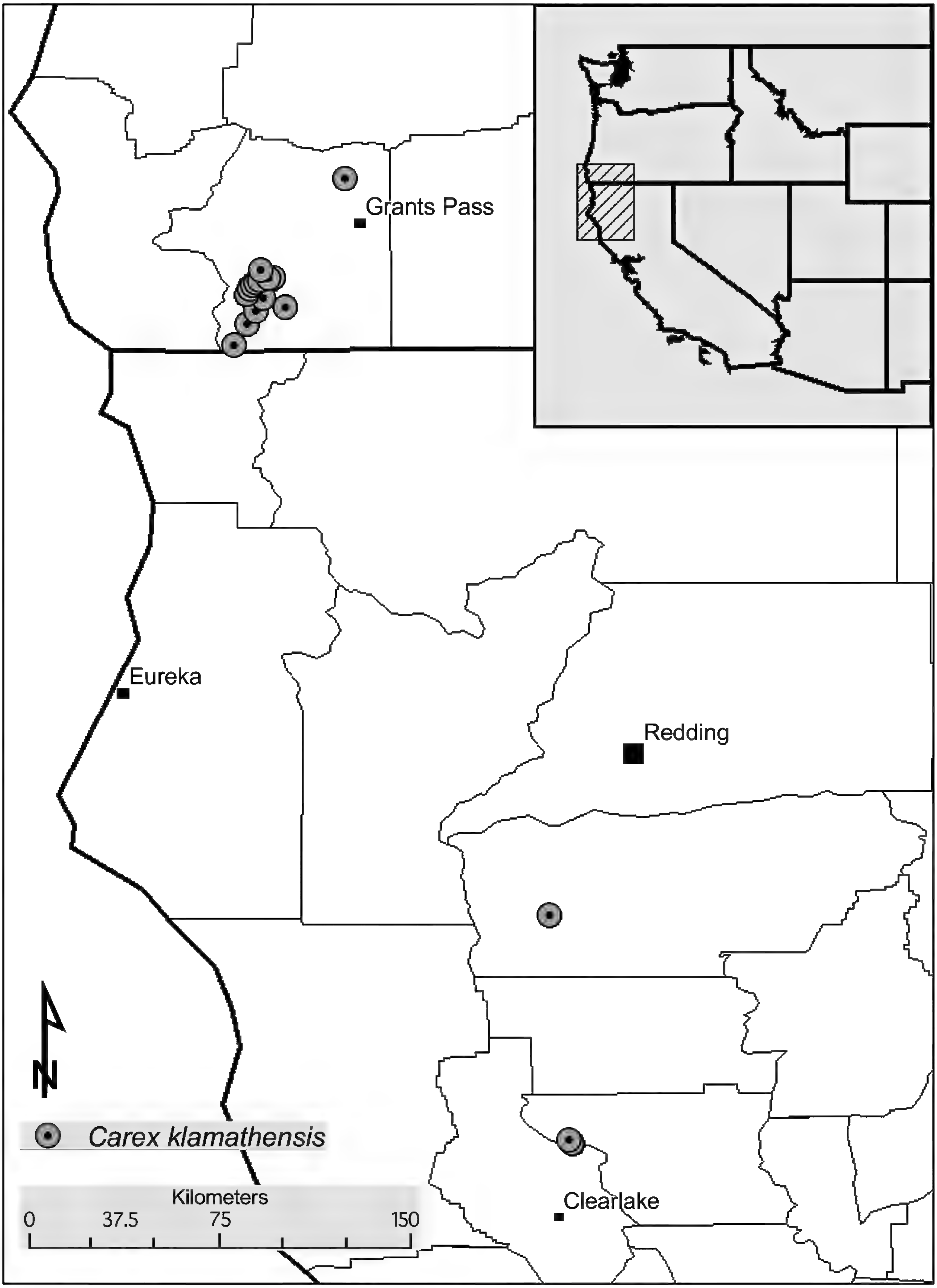

Fig. 1. Distribution of *Carex klamathensis* in southwest Oregon and northwest California. Inset map: western United States.

Bailey which lives in serpentine fens in northwest California and has a mix of 2-stigma and 3-stigma flowers in the same plant (Wilson et al. in preparation).

TAXONOMY

Carex klamathensis B.L. Wilson & L.P. Janeway, sp. nov. (**Figs. 2–3**). Type: U.S.A.: Oregon: Josephine Co.: BLM *Darlingtonia* fen along Eight Dollar Road, on S base of Eight Dollar Mountain, 0.9 mi from Route 199, full sun, peaty wet ground over serpentine, elev. 420m, 42°14' N, 123°40' W, 18 May 2004, *Peter F. Zika 19642* (holotype: OSC; isotypes: CHSC, MICH, MO, UC, WTU).

Carex klamathensis a *Carex livida* differt foliis latioribus, perigyniis obovatis brevioribus. Species haec *Carex meadii* affinis sed differt perigyniis brevioribus, acheniis paginis reticulatis minute. Species haec *Carex tetanica* affinis sed differt spicis terminalibus staminatis latioribus, acheniis paginis reticulatis minute. A *Carex hassei* differt perigynibus stigmatibus 3.

Description: Plant rhizomatous, the rhizomes whitish to medium brown, occasionally dull orange brown, paler than the dark to medium brown (rarely straw-colored) scales, slender, 1–2(–2.5) mm wide exclusive of sheathing scales. Shoot bases medium to dark brown, phyllopodic. Leaves glaucous with the sheaths basally white, with lower surface densely papillose between and sometimes over the veins, 18 to 50 cm long, the wider leaves 2–6 mm wide (average 3.8 mm). Ventral surface of leaf sheath hyaline, the mouth shallowly U-shaped. Culms 30–100 cm long, scabrous or not, longer than the leaves, erect at anthesis but sometimes bending over by the time the perigynia ripen. Inflorescence 5–23 cm long (average 14.5 cm), with 1–2(–4) lateral spikes. Bract of lowest spike 3–14 cm long (average 9.1 cm) including a sheath (0.8–)1.5–4(–8) mm long, 0.33 to 1.5 (average 0.67) times as long as the inflorescence. Lateral spikes pistillate, usually one per node, (0.6–)1.5–2.5 cm long, 4–7 mm wide, the uppermost usually 1.5–6 cm or more below the terminal spike, but sometimes as close as 0.3 cm below the terminal spike. Perigynia moderately crowded in the spike but the lowermost sometimes remote, the internodes in the middle of the spike 0.1–1.2 mm (average 0.5 mm) long. Terminal spikes all staminate in most populations, but in some populations, including those in California and on Sexton Mountain, Oregon, these may be gynecandrous or, less often pistillate, androgynous, or with staminate and pistillate flowers mixed. Staminate terminal spikes 1.3–2.7 cm (average 1.8 cm) long, 2–5 mm (average 3.6 mm) wide, 3.7–9.5 (average 5.3) times as long as wide, with 50–190 (average 112) flowers. Lowest staminate scale yellowish to reddish brown, paler near the midrib, acute to obtuse, often awned, 2.2–5.1 mm (average 2.3 mm) long excluding awn, the awn if present 0.3–3 mm (average 1.1 mm) long. Other staminate scales similar in color to the lowest, with the apex rounded and sometimes mucronate. Pistillate scales 3-nerved (the lateral nerves sometimes faint), reddish brown, dark brown, or rarely gold, the midrib and surrounding area green, white, or light brown, the edges sometimes pale, 1.9–2.8 mm long excluding awn, the apex rounded or obtuse, less often acute, sometimes mucronate to awned, the awn, if present, up to 1.5 mm long. Perigynia obovate to elliptic, 1.7–3.6 mm (average 2.9 mm) long, (0.8–)1.2–1.6(–1.8) mm (average 1.4 mm) wide, 1.6–2.4 (average 2.1) times as long as wide, light green, tan, or whitish, sometimes marked with dark brown distally, papillose particularly toward the beak or rarely smooth, the base succulent when fresh and drying withered, the beak usually curved, the distance from beak tip to top of achene (0.1–)0.4–0.7(–1) mm. Stigmas 3, or occasionally 2 on 0–5%(–15%) of flowers that have viable achenes. Achene greenish yellow when young, ripening dark brown, trigonous, or lenticular if stigmas 2, 1.6–2.7 mm (average 2.2 mm) long including stub at persistent base of deciduous style, 0.7–1.7 mm (average 1.2 mm) wide. Achene width/length ratio 0.67(0.44–0.88). Anthers 2.5–3.5 mm long when dry.

Habitat.—Fens on ultramafic (serpentine) soils, often with *Darlingtonia californica,* in Oregon at 400–950 m elevation in *Pinus jeffreyi* savannah; in California at 1000–1140 m elevation in chaparral.

Range.—Several populations in Josephine County, southwest Oregon, and also found at isolated sites in Colusa, Lake, and Tehama counties, California (Fig. 1).

KEY TO THE NORTH AMERICAN TAXA OF *CAREX* SECTIONS *BICOLORES* AND *PANICEAE*

The key for section *Paniceae* is modified from Rothrock and Reznicek (2002). Percents of pistillate flowers with various stigma numbers refer to perigynia that produce hard, dark, apparently viable achenes. In all *Carex,* aborted ovaries may have only two stigmas.

1. Stigmas prevailingly 2: 0–10%(–67% in *C. hassei*) of pistillate flowers with 3 stigmas **Carex** section **Bicolores**
2. Perigynia at maturity succulent throughout, orange to whitish, drying dark brown **C. aurea**
2. Perigynia at maturity dry throughout or succulent only at base, green, whitish, or tan.
3. Pistillate scales black with green midrib **C. bicolor**
3. Pistillate scales gold to dark brown.
4. Lateral spikes crowded, overlapping; terminal spike usually gynecandrous, perigynia usually crowded with internodes between them 0.2–0.7 mm; proximal staminate scales (2–)2.5–3.7 mm, awnless; scales rounded or obtuse; 90–100% of pistillate flowers with two stigmas each **C. garberi**
4. Lateral spikes often less crowded; terminal spike usually staminate; perigynia crowded or more distant with internodes between them 0.2–1.5 mm; proximal staminate scales 3–6(–15) mm, acute to awned; scales obtuse to acute, often awned; 33–100% of pistillate flowers with two stigmas each **C. hassei**
1. Stigmas prevailingly 3; (80%–)90–100% of pistillate flowers with 3 stigmas **Carex** section **Paniceae**
5. Perigynium apex contracted to a cylindrical beak (0.4–)0.6–1.8(–2.2) mm long.
6. Bladeless basal sheaths and proximal leaf sheaths pale brown; columns, leaves, and perigynia not or very sparsely papillose **C. vaginata**
6. Bladeless basal sheaths and proximal leaf sheaths strongly tinged with reddish purple; culms, leaves, and perigynia heavily papillose.
7. Perigynia 4.2–6.8 mm long; beak 0.8–1.8(–2.2) mm long; range eastern **C. polymorpha**
7. Perigynia 3.4–4.2 mm long; beak 0.5–1 mm long; range western **C. californica**
5. Perigynium apex tapering and beakless, indistinctly beaked, or contracted to a beak less than 0.5 mm long.
8. Lateral spikes nodding on flexible peduncles **C. laxa**
8. Lateral spikes erect or ascending on stiff peduncles.
9. Perigynia beak straight, cuneately tapering; leaves channeled, glaucous **C. livida**
9. Perigynia beak curved, concavely tapering (at least on one side); leaves flat or folded, glaucous or not.
10. Bladeless basal sheaths and proximal leaf sheaths strongly tinged with reddish purple plants forming loose clumps to extensive closed colonies of vegetative shoots from superficial rhizomes.
11. Widest leaves 1.8–3(–4) mm wide; plants colonial with longest rhizomes 2.5–18 cm; habitat woodlands **C. woodii**
11. Widest leaves 3.5–6 mm wide; leaves loosely cespitose with longest rhizomes to 2 cm; habitat granite balds and cliffs **C. biltmoreana**
10. Bladeless basal sheaths and proximal leaf sheaths brownish or faintly, irregularly tinged with reddish purple; plants usually with vegetative shoots widely scattered and inconspicuous from deep rhizomes.
12. Inflorescences usually 1.7–3.5(–4.3) times as long as bract (measured from node of proximal nonbasal spike).
13. Perigynia 0.6–1.4(–1.8) mm wide; achenes 0.7–1.7 mm wide; range Oregon and California **C. klamathensis**
13. Perigynia 1.4–2.4 mm wide; achenes 1.8–2.9 mm wide; range Eurasia, introduced to northeastern North America **C. panicea**
12. Inflorescence usually 0.9–1.6 times as long as bract (measured from node of proximal nonbasal spike).
14. Achenes (1.5–)1.7–2.2(–2.5) mm wide **C. meadii**
14. Achenes 0.7–1.7(–1.9) mm wide.
15. Achene surface reticulate with a papilla filling each compartment outlined by the ridges; terminal spike narrow (1.8–3 mm wide); range east of the Rocky Mountains **C. tetanica**
15. Achene surface reticulate but flat between ridges (or with a tiny papilla in the center of each compartment); terminal spike wide, (2–5 mm wide); range in Oregon and California **C. klamathensis**

DISCUSSION

Carex klamathensis is easily confused with other rhizomatous sedges that have glaucous foliage, pale brown or whitish (not red-brown) plant bases, and pale, more or less papillose perigynia. Compared to *C. livida*, *C. klamathensis* has wider leaves, more staminate flowers, and shorter, obovate (not fusiform) perigynia (Table 1; Fig. 3 and 4).

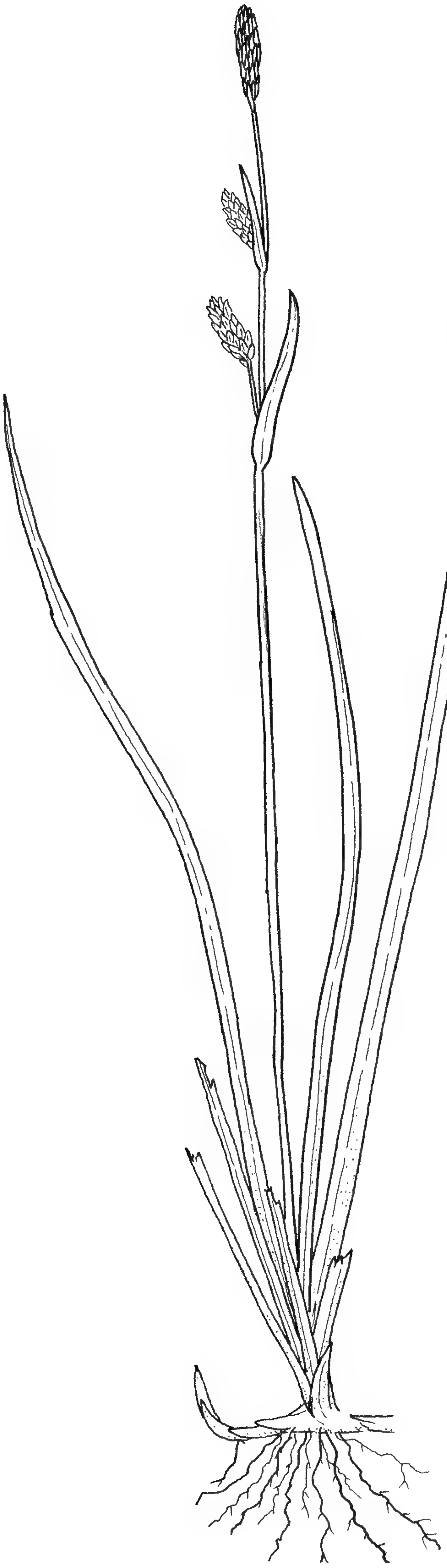

Fig. 2. *Carex klamathensis*, habit.

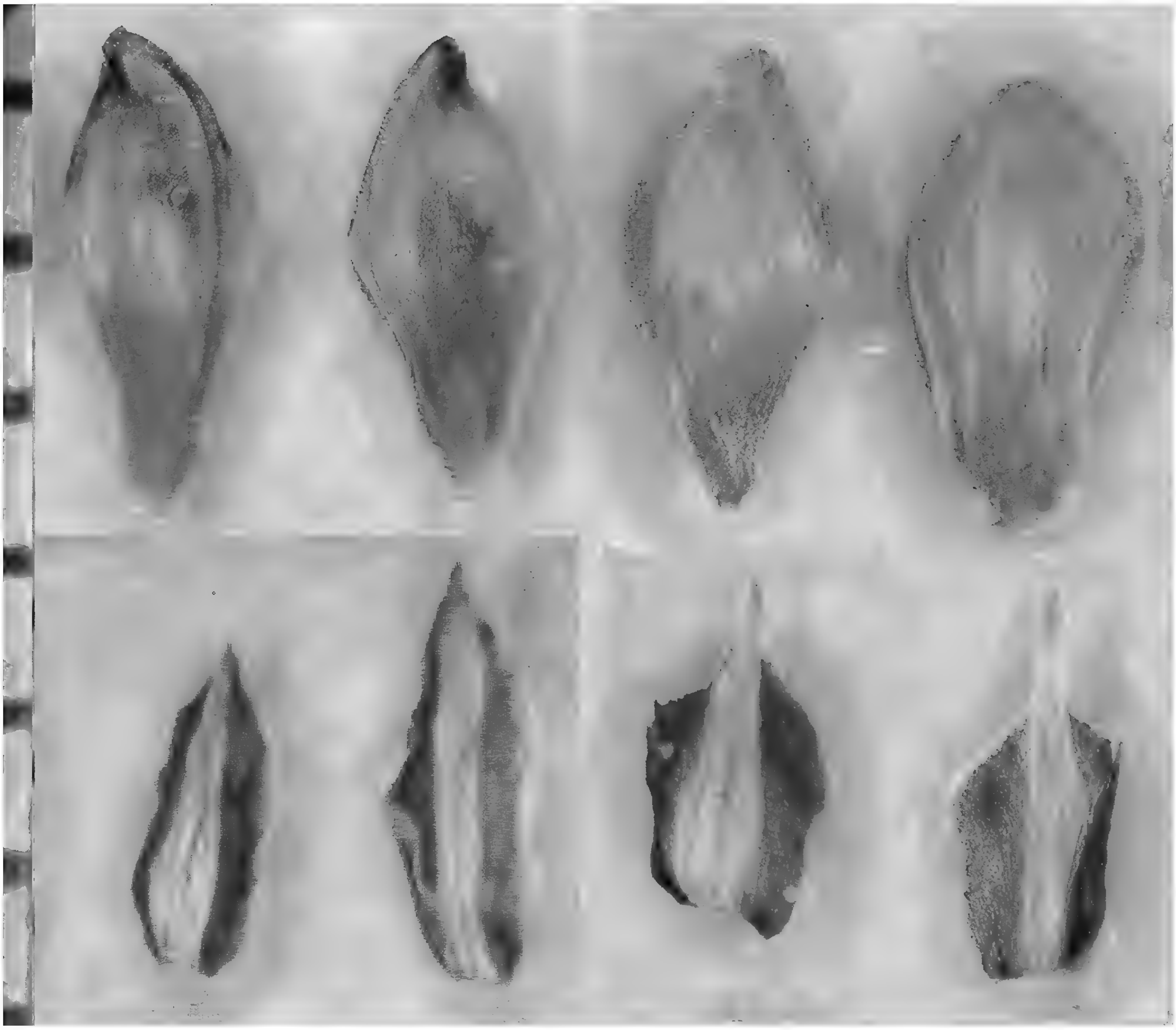

Fig. 3. Perigynia and pistillate scales of *Carex klamathensis.*

Carex klamathensis differs from *C. meadii* and *C. tetanica* of midwestern North America not only in range, but also by its wider leaves and different achene surface. In *C. klamathensis,* the achene surface is reticulate with low ridges and a flat space between the ridges, or with a minute central papilla in that flat space. In the Midwestern taxa, the achene surface is papillate with a large papilla occupying virtually all of the surface between the low ridges. In addition, *C. klamathensis* has smaller perigynia and narrower achenes than *C. meadii,* and lives in a wetter habitat (Table 2; Fig. 4). *Carex klamathensis* has more staminate flowers and therefore a wider staminate spike than *C. tetanica* (Table 2).

Carex klamathensis can be difficult to distinguish from a form of *C. hassei* that lives in serpentine fens in the mountains of northwest California (Table 3). In general, *C. hassei* has two stigmas per pistillate flower and *C. klamathensis* has three, although any three-stigma flowers that abort may have two stigmas. This results in variation in achene shape; two-stigma flowers produce lenticular achenes and three-stigma flowers produce trigonous achenes. In *C. klamathensis,* although most individuals have only 3-stigma flowers, some plants have a few (less than 15%, usually less than 10%) flowers that have two stigmas and produce hard, lenticular achenes. In the *C. hassei* from serpentine fens, few populations have only plants with 2-stigma flowers. In most populations, the proportion of 2-stigma perigynia varies from (33–)40–90%. Two-stigma and three-stigma flowers occur on the same plant, mixed in the same spike, and they are all capable of

Table 1. Traits distinguishing *C. klamathensis* from *C. livida.*

Trait	***Carex klamathensis***	***Carex livida***
Substrate	serpentine	non-serpentine
Leaf width (mm)	wider; average 3.7, (range 1.9–6 mm)	narrower; average 2.2 (range 1.5–3.2)
Terminal staminate spike width (mm)	wider; average 3.5 mm (range 2–5)	narrower; average 2.2 (range 1.4–4.8)
Flowers, terminal staminate spike	average 112 (range 40–190)	average 50 (range 8–71)
Number of lateral spikes 3 or more)	average 2.2 (range 1–4, 40% with	average 1.7 (range 1–3 but only 1% with 3)
Perigynium length (mm)	average 2.9 (range 1.7–3.6)	average 3.8 (range 3.1–4.8)
Perigynium shape some perigynia)	obovate to elliptic (rarely fusiform on	fusiform
Perigynium beak the perigynia)	bent (rarely straight on some of	straight

Table 2. Traits distinguishing *C. klamathensis* from *C. meadii* and *C. tetanica*. Measurements are average and, in parentheses, range.

Trait	***Carex klamathensis***	***Carex meadii***	***Carex tetanica***
Range	Pacific coast states	Midwest	Midwest and east
Substrate	serpentine	not serpentine	not serpentine
Habitat	fens	mesic meadows	wet sites
Leaf width (mm)	3.8(2–6)	2.8(2.4–3.3)	2.5(1.8–3.3)
Terminal spike width (mm)	3.6(2–5)	3.5(2.2–5.7)	2.4(1.8–3.1)
Staminate flowers	112(40–190)	112(48–174)	70(40–120)
Height (cm)	57(30–100)	32(23–47)	26(12–34)
Perigynium length (mm)	2.9(1.7–3.6)	3.6(3.3–4)	2.9(2.4–3.6)
Perigynium width (mm)	1.4(1.2–1.6)	2.0(1.6–2.5)	1.6(1.2–1.9)
Achene surface	reticulate	papillose	papillose

Table 3. Selected statistically significant ($p < 0.05$) traits distinguishing *C. klamathensis* from the form of *C. hassei* that grows in serpentine fens in northwest California. Measurements are average and, in parentheses, range.

Trait	***C. klamathensis*** **Average (range)**	***C. hassei*** **Average (range)**
Culm length (cm)	57(30–100)	33.3(15.2–45.3)
Leaf width (mm)	3.8(2–6)	2.8(1.8–3.7)
Inflorescence length (cm)	14.4(5.1–23.3)	10.0(3.9–17.8)
Inflorescence bract length (cm)	9.1(3.3–14.0)	6.9(3.2–15.2)
Terminal Spike Length (cm)	1.8(1.3–2.7)	1.4(1.1–2.3)
Terminal Spike Width (mm)	3.6(2–5)	2.8(1.4–4.5)
Staminate flowers in terminal spike	112(40–186)	81(57–152)
Lowest staminate scale, length (mm)	4.3(2.2–5.1)	3.2(1.9–5.7)
Perigynia (% with 3 stigmas)	97%(85–100%)	37%(0–62%)
Perigynium length (mm)	2.9(1.9–3.5)	2.5(2.2–2.9)
Perigynium length/width ratio	0.48(0.37–0.58)	0.54(0.46–0.63)
Achene width/length ratio	0.67(0.44–0.88)	0.74(0.48–0.93)

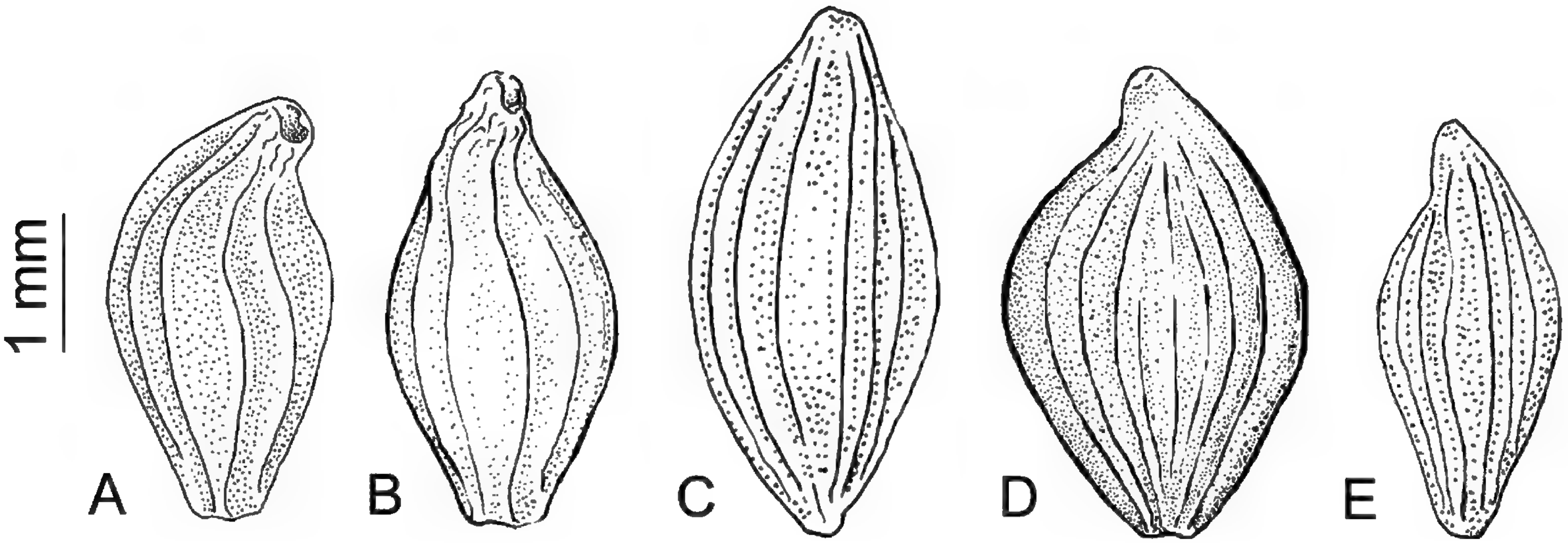

Fig. 4. Perigynia of *C. klamathensis* and similar taxa. A. *Carex hassei*. B. *Carex klamathensis*. C. *Carex livida*. D. *Carex meadii*. E. *Carex tetanica*. Scale at left is 1 mm.

producing hard, dark, apparently viable achenes. In general, *C. klamathensis* is a more robust plant, taller, with longer and wider terminal spikes, longer inflorescence nodes, wider leaves, and slightly longer perigynia. However, populations of delicate *C. hassei* may produce occasional robust plants. (The robust *C. hassei* plants observed were identified as *C. hassei* because they had 50–91% two-stigma flowers.) Because of this variation in *C. hassei*, ranges for most measured traits overlap greatly, even though average dimensions of most traits differ significantly (Table 3). The two taxa also differ in traits such as the color and stiffness of the foliage, which are hard to quantify.

Carex klamathensis is a globally rare species of fens and springs, endemic (Safford et al. 2005) to serpentine substrates. Although 35 specimens were examined (Appendix), these represent only 3 California and 12–15 Oregon populations. Four of the sites (10 collections) were on Eight Dollar Mountain, Josephine County, California, and two more sites were within 3 km south of that mountain.

Populations are probably stable where habitats are stable, but habitats are threatened by road building, recreational use of serpentine wetlands (particularly the effects of off-road vehicles), and mining. These activities can harm *C. klamathensis* populations directly by killing plants or indirectly by altering water flow. The sedge probably survives fire well, both because its rhizomes are protected underground in moist soil and because its microhabitat does not carry intense ground fire well. However, it is vulnerable to those fire suppression activities that involve bulldozers. The three California populations, which are somewhat genetically distinct from the Oregon populations (Wilson et al. in preparation), are all small and isolated. More than half of one has been destroyed in recent years by bulldozing associated with mining. We hope that clarifying *C. klamathensis* taxonomy and morphology will aid in its preservation.

APPENDIX

CAREX KLAMATHENSIS SPECIMENS EXAMINED

[1] = from Day's Gulch, the site of most collections, reported under various names

U.S.A. **CALIFORNIA. Colusa Co.:** Bear Wallow Spring; on N side of Lovelady Ridge about 0.5 mi NE of Pacific Point, T16N R07W S23 S1/2, 5 Jul 1999, *Janeway & Castro 6497* (CHSC); Lovelady Ridge, Bear Wallow Springs, 28 Jun 2002, *Wilson et al. 10702* (OSC). **Lake Co.:** Kanaka Glade, a spring at the head of Spanish Creek East Fork, near the top of Pacific Ridge, T16N R6W S30 SW ¼ of NW ¼, 7 Jul 1999, *Janeway & Isle 6492* (CHSC); Kanaka Glade, a spring at the head of Spanish Creek East Fork, near top of Pacific Ridge, 3 Jul 1998, *Janeway & Castro 5714* (CHSC, OSC); Kanaka Glade, 19 May 1985, *Stebbins C532* (DAV); Kanaka Glade, 28 Jun 2002, *Wilson et al. 10704* (OSC[1]). **Tehama Co.:** Pepperwood Springs, near top of Raglin Ridge, T25N R07W S21 SE ¼ of NW ¼, 11 Jun 2000, *Janeway & Isle 6785* (CHSC, OSC); Pepperwood Springs, 20 Jun 2003, *Wilson & Brainerd 10951* (CAS, DAV, MICH, OSC); Pepperwood Springs, 28 Jun 2002, *Wilson et al. 10708* (OSC, WTU). **OREGON. Josephine Co.:** Frank's Fen, 18

Jun 2000, *Brainerd & Newhouse BLW10403* (OSC, UC); Fiddler Mtn. Road, above Josephine Creek, 1.8 mi S of bridge over Illinois River by Eight Dollar Mtn., 11 May 1974, *Chambers 3958*[1] (OSC+); BLM fen, less than 1 mile down Eight Dollar Mtn. Rod., W of Rte. 199, 23 Mar 1996, *Clery 56* (OSC); West bank of Josephine Creek, about 150 m upstream from ford, 19 Jul 1981, *Greenleaf 1186* (OSC); Whiskey Creek, 17 Jun 1999, *Kuykendall et al. BLW10021* (OSC); Josephine Creek, 25 Jun 1930, Leach 2836 (ORE); TNC Bog/$8 Mtn., 13 Jun 2003, Newhouse & Kuykendall 2003-001 (WTU), 2003-002 (CHSC), 2003-003 (MO), 2003-004 (DAV, OSC); Star Flat, 14 Jun 2003, *Newhouse & Kuykendall 2003-006* (OSC) & 2003-007 (CHSC); Days Gulch Botanical Area, 14 Jun 2003, *Newhouse & Kuykendall 2003-008*[1] (OSC) and 2003-009[1] (NY); Mars Fen/Rough & Ready Creek, 14 Jun 2003, *Newhouse & Kuykendall 2003-010* (OSC), 2003-11 (CHSC, UC, WTU), and 2003-012 (MICH, SOC); south base of Sexton Mountain, 20 May 1948, Peck 24796 (WILLU); Eight Dollar, 18 Jun 1999, *Wilson & Kuykendall 10041* (DAV, RSA, UC); Fiddler Mtn., 18 Jun 1999, *Wilson & Kuykendall 10042*[1] (MICH, WTU) and 10044[1] (OSC, UC); Mike's Gulch, 2 Jul 2003, *Wilson & Kuykendall 10960* (OSC); Siskiyou NF, near fen on Fiddler Mountain, 1.7 mi by road from bridge over the Illinois River, 0.7 mi from Forest Service Road 4201 on a dirt road, 14 May 1994, *Wilson et al. 6782*[1] (OSC); Woodcock Bog, 17 Jun 1999, *Wilson et al. 10013* (CHSC, OSC, WTU); Woodcock Bog, 18 Jun 1999, *Wilson et al. 10053* (OSC); Fens on East side of Eight Dollar Mtn., 18 Jun 2000, *Wilson et al. 10400* (MO, NY) and 10401 (CAS, MICH); Siskiyou National Forest, 19 May 1997, *Zika 13081* (WTU); BLM fen on $8 Mountain Road, 18 May 2004, *Zika 19642* (CHSC, MICH, MO, OSC, UC, WTU).

ACKNOWLEDGMENTS

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BOOK REVIEWS

Audrey Eagle. 2006. **Eagle's Complete Trees and Shrubs of New Zealand.** (ISBN 0-909010-08-0, hbk., slipcase). Te Papa Press, Museum of New Zealand, Te Papa Tongarewa, PO Box 467, Wellington, NEW ZEALAND. (**Orders:** Museum of New Zealand, Cable St., PO Box 467, Wellington, New Zealand, www.tepapa.govt.nz). NZ $200.00, Vol. 1, 544 pages; Vol. 2, 592 pages, richly illustrated, 9" × 11".

This beautiful two-volume set brings together Eagle's botanical artworks from her award winning and best selling 1975 and 1983 publications. The new edition includes over one hundred and seventy new paintings to depict every presently known native tree and shrub in New Zealand. The total number of plants illustrated, in color and life-size, is more than 800.

These long-awaited volumes are the result of decades of skilled draughtsmanship and loving, painstaking observation, as well as many years of field and laboratory research by New Zealand scientists. Audrey Eagle has been painting New Zealand's flora since 1954. She began painting the specimens she collected with the sole purpose of learning their botanical names. In 1968 she was contacted by William Collins Publishers to write and illustrate a book about native plants. With the aim of including examples of every genus of New Zealand tree and shrub, she began completing the required illustrations. After 27 years of work, her first book was published in 1975 with 228 species illustrated. Her second book followed in 1982 with a further 405 species illustrated. The current work has 173 additional species illustrated for a total of 806 species. With one exception every plant has been illustrated from live specimens. She is probably the only person in the world who has had the privilege of seeing live material of all the presently know New Zealand woody flora.

Painted from live specimens, every plant is depicted at life-size in technically superb detail, and many include detailed enlargements showing all aspects of the leaves, flowers and fruit. As many of the native plants have small flowers, these and other details helpful to the recognition of a species are shown enlarged. In the case of leaves that are too large to fit on the page, reductions of the complete plants are shown. Each painting is accompanied with comprehensive notes on a facing page. Written in consultation with expert botanists, these provide accurate and up-to-date descriptions of each plant, including notes on its habitat, distribution, nomenclature and more. Her 1983 work included short biographies of many botanists and others after whom plants have been named. In curtailed form, this information is included with the botanical information for each species.

The botanical names of plants follow the Plant Names Database of Landcare Research, Lincoln, New Zealand. If a plant is commonly recognized by another name in the New Zealand Plant Conservation Network database it is noted in the text. As many formally recognized plant species names have changed since her earlier works, the currently recognized name of each plant is indicated in the botanical description and reference is made to the relevant publication. Common and Māori names have been included whenever possible. The editorial style follows the *New Zealand Journal of Botany.*

Passionately involved in New Zealand's botanical community, Eagle was a founding member of the Royal Forest and Bird Protection Society of New Zealand. She has also served on the Nature Conservation Council. Her illustrations have been cited in numerous published studies of New Zealand's flora. In 2001, Audrey Eagle was appointed a Companion of the New Zealand Order of Merit for her services to botanical art. Her latest work was short-listed for the New Zealand Booksellers Choice Award for 2007. The award is given to the book that New Zealand booksellers most enjoyed reading, selling and promoting in the previous year. This set is the accumulation of Audrey Eagle's life's work. It is an outstanding contribution to botany in New Zealand and an essential addition to any botanical library concerned with the flora of the Pacific Rim.—*Gary Jennings, Library, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

David Yetman. 2006. **The Organ Pipe Cactus.** (ISBN 0-8165-2541-2, pbk.). The University of Arizona Press, 355 S. Euclid Avenue, Suite 103, Tucson, AZ 85719, U.S.A. **(Orders:** www.uapress.arizona.edu, orders@uapress.arizona.edu). $ 9.95, 80 pp., 36 color photos, 1 drawing, 1 map, 8" × 10".

When you first see one, it is obvious how the organ pipe cactus got its name. Its slender vertical branches, reaching for the heavens and perhaps 30 feet tall, bring to mind the tubes of a pipe organ. Whether standing alone or growing in a grove, these spectacular and intriguing plants are found exclusively in the United States in a small area of the Sonoran Desert in the southwestern corner of Arizona.

David Yetman provides an in-depth and comprehensive look at these intriguing and picturesque plants that most Americans will never have the opportunity to see in person. Seven chapters explore where they grow; the special conditions required for their germination, growth, and survival; their position in a genus with more than twenty species; discovery by western Europeans; early history in the Mayan civilization; uses as a commercial crop; and the future of the organ pipe cactus. Although it is the most common columnar cactus worldwide, it is so unusual in the United States that it is only one of two cacti (the saguaro) and the Joshua tree, to have a national preserve established to protect it.

This is a beautifully illustrated book, well written and is a handsome addition to his other two works. He is the co-editor of *Gentry's Río Mayo Plants: The Tropical Deciduous Forest and Environs of Northwest Mexico*, also published by the University of Arizona Press, and the author of *Mayo Ethnobotany: Land, History, and Traditional Knowledge in Northwest Mexico.*—*Gary Jennings, Library, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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UNA NUEVA ESPECIE DE *AGAVE*, SUBGENERO *LITTAEA* (AGAVACEAE) DE TAMAULIPAS, MÉXICO

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RESUMEN

Se describe e ilustra **Agave montium-sancticaroli** como una nueva especie de la región de la Sierra de San Carlos, Tamaulipas, México. Esta especie pertenece al grupo Marginatae y muestra similitudes con *Agave* ×*glomeruliflora* (Engelm.) A. Berger.

ABSTRACT

Agave montium-sancticaroli is described and illustrated as a new species from the Sierra de San Carlos Region, Tamaulipas, Mexico. The new species belongs to the Marginatae group, and is similar to *Agave* ×*glomeruliflora* (Engelm.) A. Berger.

La identificación de las especies de *Agave* utilizadas para la obtención de mezcal (bebida destilada) en Tamaulipas, México, llevó al descubrimiento de una nueva especie, que se describe a continuación.

Agave montium-sancticaroli García-Mend., sp. nov. (**Figs. 1–3**). Tipo: MÉXICO. Tamaulipas: Municipio de San Carlos, 6 km al NE de Los Magueyes, carretera Ciudad Victoria a San Carlos, matorral submontano de Acacia rigidula, Cordia boissieri, Havardia pallens, Helietta parvifolia y Mimosa monancistra, 307 m, 27 May 2004, *A. García-Mendoza, C. Jacques, A. Mora & A. Salazar 7605* (holotipo: MEXU; isotipos: ENCB, TEX, UAT).

Planta perennis, 1.5–2 m alta; folia 50–80(–100) per rosulam, 100–120 cm longa, 9–12 cm ad medium lata, lanceolata, concava, viridi-flavida, basem versus glauscescentia, margine dentato cum fascia cornea angusta, dentibus 4–6 mm longis, 1.5–3 mm ad basem latis, rectis vel retrorsis, 1–3(–4.5) cm inter se distantibus, inter grandibus uno vel aliquibus dentibus minimis; spina terminali 2.5–3.5 cm longa, per 12–16 cm decurrenti. Inflorescentia racemoso-paniculata, 5.5–7 m alta, plus minusve fusiformis, (60–)80–140 ramis lateralibus 8–13 cm. Flores 10–20 per umbellam, 4.5–5(–5.5) cm longi, viridi-flavidi; perianthii tubus 5–6(–8) mm longus; tepala 1.5–2.2 cm longa, 3–4(–7) mm lata; filamenta 3.5–4(–5.5) cm longa, ad apicem tubi inserta. Capsulae 3.5–4.5 cm longae, 1.7–2 cm latae, oblongae.

Plantas perennes, surculosas, rosetas compactas, 1.5–2 m de alto, 2–2.5 m de diámetro. Hojas 50–80(–100) por planta, 100–120 cm de largo, 9–12 cm de ancho en la parte media, lanceoladas, erectas, rígidas, fibrosas, cóncavas, verde-amarillentas, glaucescentes hacia la base, en ocasiones con bandas transversales glaucas; margen dentado, con una delgada banda córnea; dientes 4–6 mm de largo, 1.5–3 mm de ancho en la base, rectos a retrorsos, grisáceos, separados por 1–3(–4.5) cm, más cercanos entre sí cerca de la base, con uno a varios dientecillos muy pequeños entre los grandes; espina terminal de 2.5–3.5 cm de largo, decurrente por 12–16 cm, acanalada en el dorso. Inflorescencia racemoso-paniculada de 5.5–7 m de alto, más o menos fusiforme, pedúnculo de 3–4 m, con (60–)80–140 ramas laterales, de 8–13 cm las inferiores, reduciéndose gradualmente hacia el ápice hasta 2–4 cm; brácteas del pedúnculo de 11–16 cm de largo, 2.5–5.5 cm de ancho en la base, deltoides, cartáceas, margen entero, espina terminal 7–9 mm de largo. Flores en grupos de 10–20 por umbela, de 4.5–5(–5.5) cm de largo, verde-amarillentas; pedicelos(0.5–)1–1.5 cm de largo, elongándose hasta 2 cm durante la fructificación; ovario de 2–2.5(–3) cm de largo, 4–6 mm de ancho, cilíndrico, cuello del perianto de 4–5(–6) mm, tubo del perianto de 5–6(–8) mm de largo, 7–10(–12) mm de ancho en el ápice; tépalos de 1.5–2.2 cm de largo, 3–4(–7) mm de ancho en la base, ápice cuculado; filamentos

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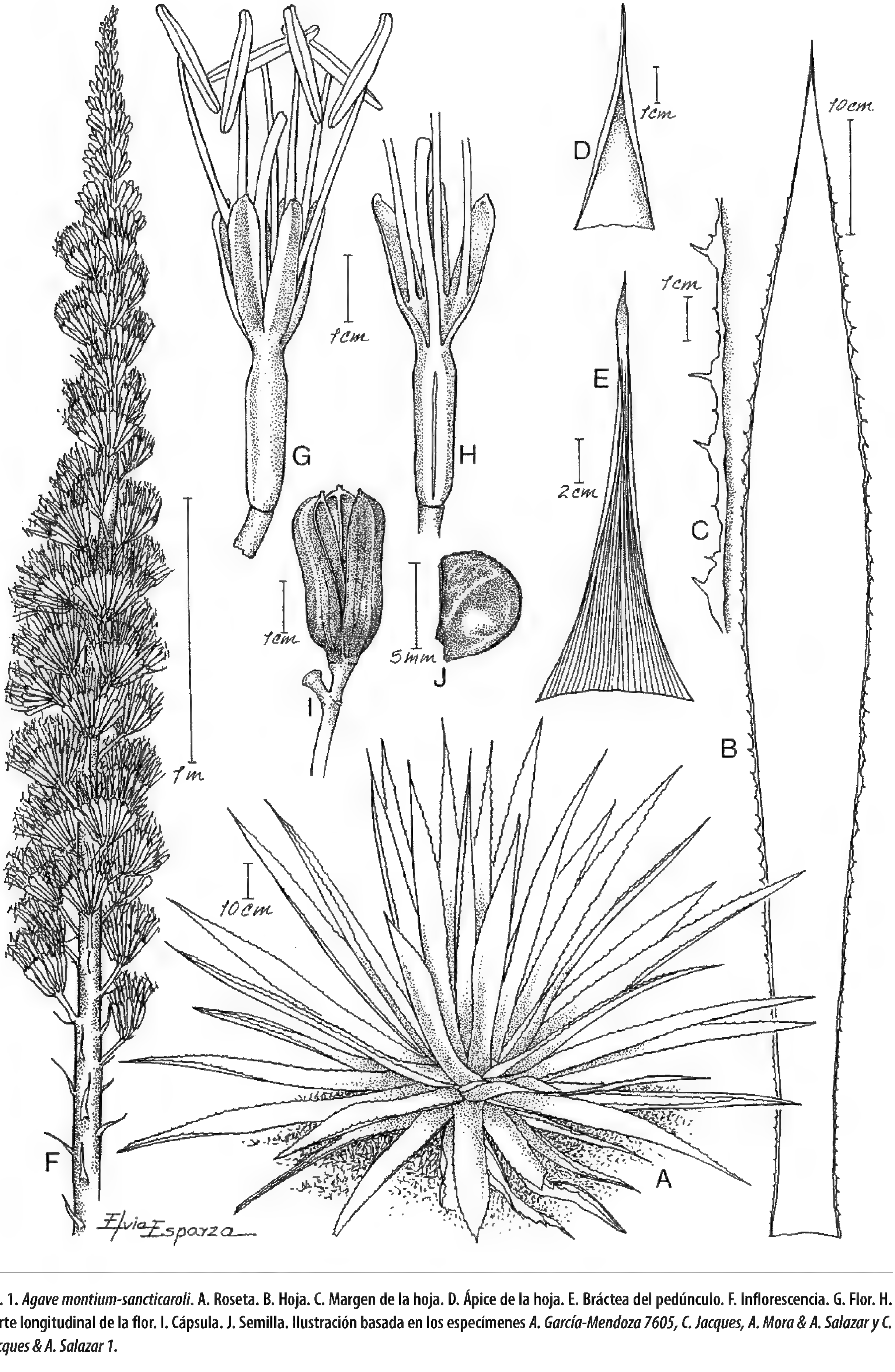

Fig. 1. *Agave montium-sancticaroli*. A. Roseta. B. Hoja. C. Margen de la hoja. D. Ápice de la hoja. E. Bráctea del pedúnculo. F. Inflorescencia. G. Flor. H. Corte longitudinal de la flor. I. Cápsula. J. Semilla. Ilustración basada en los especímenes *A. García-Mendoza 7605, C. Jacques, A. Mora & A. Salazar y C. Jacques & A. Salazar 1.*

Fig. 2. *Agave montium-sancticaroli.* Planta en su hábitat.

de 3.5–4(–5.5) cm de largo, insertados en el ápice del tubo, verdes con tintes púrpura, anteras 1.3–1.5(–2) cm de largo, 1–2 mm de ancho, amarillas; estilo 5–5.5 cm, estigma trilobado. Cápsulas de 3.5–4.5 cm de largo, 1.7–2 cm de ancho, oblongas. Semillas de 4–6 mm de largo, 3–4 mm de ancho, con una ala hasta de 0.5 mm, aplanadas, negras.

Especímenes adicionales examinados: **MÉXICO. Tamaulipas:** Municipio de San Carlos, 12 km al NE de Los Magueyes, carretera Ciudad Victoria a San Carlos, 318 m, 27 May 2004, *A. García-Mendoza, C. Jacques, A. Mora & A. Salazar 7608* (ENCB, MEXU, UAT); Km 31 de la brecha "la chepina," que une la carretera Ciudad Victoria-Matamoros a San Carlos, 289 m, 13 Abr 2003, *C. Jacques & A. Salazar 1* (MEXU).

Agave montium-sancticaroli se desarrolla en planicies y lomeríos sobre rocas calizas y suelos arenosos o de rendzina, entre los 150 y los 800 m, en el matorral submontano y su transición hacia el bosque de *Quercus*; algunas especies asociadas son: *Acacia rigidula* (gavia), *Celtis pallida* (granjeno), *Cordia boissieri* (anacahuita), *Ebenopsis ebano* (ébano), *Havardia pallens* (tenaza), *Helietta parvifolia* (barreta), *Leucophyllum frutescens* (cenizo), *Opuntia engelmannii* (nopal cuijo) y *Prosopis glandulosa* (mezquite). Su distribución se restringe a la región centro de Tamaulipas, en el pie de monte, entre la Llanura Costera del Golfo de México y la Sierra de San Carlos, en los municipios de Burgos, Cruillas, Jiménez, Padilla, San Carlos y San Nicolás y posiblemente en Méndez y San Fernando. Las poblaciones se encuentran dispersas y cada planta llega a producir de dos a ocho hijuelos estoloníferos. El epíteto específico alude al municipio y Sierra de San Carlos, donde habita de manera natural y preponderante.

Agave montium-sancticaroli recibe el nombre común de "jarcia" y se utiliza para la elaboración de mezcal (nombre genérico para las bebidas destiladas de *Agave*). En la Sierra de San Carlos, para la elaboración

Fig. 3. *Agave montium-sancticaroli*. Ejemplar en floración.

de esta bebida (llamada localmente "vino" o "vino-mezcal"), se emplea preferentemente *Agave americana* L. subsp. *protamericana* Gentry ("mezcal" o "maguey cenizo") y, en menor proporción, *Agave univittata* Haw. y *Agave funkiana* K. Koch & Bouché, ambas conocidas como "lechuguilla" o "amole," especies que por su alto contenido de azúcares son agregadas como saborizantes.

Por sus hojas con el margen córneo continuo, espina terminal decurrente, inflorescencia racemosa, flores con tubos muy cortos con los tépalos proporcionalmente más largos y filamentos insertados en la orilla del tubo, *Agave montium-sancticaroli* se ubica en el grupo Marginatae, delimitado por Gentry (1982). Morfológicamente se relaciona con *Agave ×glomeruliflora* (Engelm.) A. Berger, de la que se diferencia por tener rosetas más grandes, con mayor número de hojas, proporcionalmente mucho más largas, hojas lanceoladas, dientes del margen más pequeños, espina apical no aquillada en el envés, inflorescencia robusta con mayor número de ramas y flores por umbela, flores con pedicelos más largos y cápsulas más grandes no rostradas. Ambas especies comparten el tamaño de las flores, fenómeno conservador, común entre las especies del grupo y que se utiliza poco para separar a las especies; en cambio, Gentry (1982) considera que los caracteres de las hojas, como forma, tamaño, color y tipo de armadura, están muy diversificados y proveen los caracteres taxonómicos suficientes para diferenciar a los taxa.

Gentry (1982) aplicó el nombre de *Agave glomeruliflora* a una serie de híbridos entre *A. lechuguilla* (subg. *Littaea*) con *A. gracilipes*, *A. havardiana* y *A. neomexicana* (subg. *Agave*), los cuales tienen inflorescencias racemosas y hojas intermedias en ancho entre las especies mencionadas y *A. lechuguilla* (fotos de estas plantas se aprecian en Muller, 1883, como *Agave chisosensis* y Breitung 1968). Por su parte, Reveal y Hodgson (2002) consideran que el nombre de *Agave ×glomeruliflora* "should probably be more appropiately applied only to crosses and back-crosses between *Agave lechuguilla* and *A. havardiana*." *Agave ×glomeruliflora* es un taxón propio del Desierto Chihuahuense. Crece en la Sierra del Carmen, al norte de Coahuila (México) y en las montañas Big Bend, Texas (USA); habita laderas con pastizal y bosque de *Quercus-Juniperus*, en altitudes entre los 600 y los 1600 m (Gentry 1982; Reveal y Hodgson 2002).

Agave montium-sancticaroli se desarrolla a menor altitud y se localiza a más de 400 km en línea recta de la población más cercana de *Agave ×glomeruliflora*, en Cuatro Ciénegas, Coahuila. De manera natural, se observó que *Agave montium-sancticaroli* llega a formar híbridos con *Agave funkiana* y *A. univitatta*, especies con las que convive en su área de distribución, tales híbridos se reconocen por presentar caracteres vegetativos intermedios; tales como el tamaño de la roseta, tamaño, forma y dentición de las hojas e inflorescencias de menor talla, con menor número de ramas florales. Algunas recolectas con estas características morfológicas se reconocen en los ejemplares de *A. García-Mendoza, C. Jacques, A. Mora & A. Salazar 7607 y 7610* (MEXU y UAT).

Consideramos que *Agave montium-sancticaroli* debe ser considerada una especie bajo riesgo de extinción, ya que por su alto contenido de azúcares, superior al de *Agave americana* subsp. *protamericana* (Jacques-Hernández 2005), es altamente apreciada por los mezcaleros y se extrae en buenas cantidades de su hábitat; así mismo, la baja densidad de sus poblaciones silvestres, el bajo número de hijuelos vegetativos que produce y la apertura de nuevas tierras agrícolas, están disminuyendo sus poblaciones naturales, ante lo cual, es necesario realizar los estudios biológicos pertinentes, promover su cultivo mediante semillas e hijuelos asexuales y su propagación *in vitro* por cultivo de tejidos, con el objetivo de conservar las poblaciones silvestres y asegurar la materia prima suficiente para las próximas décadas, que permitan continuar elaborando el apreciado vino-mezcal "San Carlos" de Tamaulipas.

AGRADECIMIENTOS

A Fernando Chiang, Arturo Mora y Raquel Galván, por leer de manera crítica el manuscrito; el primero hizo además la descripción latina. La ilustración es obra de Elvia Esparza. La Fundación Produce Tamaulipas y la Secretaría de Investigación y Posgrado, del Instituto Politécnico Nacional proveyeron los fondos económicos necesarios para el presente estudio.

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RE-EXAMINATION OF *MUHLENBERGIA CAPILLARIS*, *M. EXPANSA*, AND *M. SERICEA* (POACEAE: MUHLENBERGIINAE)

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ABSTRACT

Molecular genetic data [intersimple sequence repeats (ISSR)] and morphological data support the recognition of *Muhlenbergia capillaris, M. expansa,* and *M. sericea* as separate species. Multi-response permutation analysis show significant differences (T = -9.03, A = 0.20, $P < 0.01$) among these three species indicating that individuals within a species were more genetically similar to one another than they were to individuals of another species. Apparently, *Muhlenbergia sericea* and *M. capillaris* are derived from a recent common ancestor, and are sister to *M. expansa.* A key to separate *Muhlenbergia capillaris, M. expansa*, and *M. sericea* is provided.

RESUMEN

Los datos genéticos moleculares [secuencias entre repeticiones simples (ISSR)] y los datos morfológicos apoyan el reconocimiento de *Muhlenbergia capillaris, M. expansa* y *M. sericea* como especies separadas. El análisis de permutación de respuesta múltiple (T = -9.03, A = 0.20, $P< 0.01$) entre estas tres especies que indican que los individuos dentro de una misma especie son genéticamente más similares entre si que entre los individuos de otras especies. Al parecer, *Muhlenbergia sericea* y *M. capillaris* son derivadas de un ancestro común reciente, y *M. expanda* es su especie hermana. Se proporciona una clave para separar *Muhlenbergia capillaris, M. expansa* y *M. sericea.*

Muhlenbergia Schreb. is primarily a Western Hemisphere genus of 152 species, with 69 species native to North America, north of México (Peterson 2003; Peterson et al. 2007). Members of this genus can be annual or perennial, rhizomatous to cespitose, and can occur in a variety of ecological settings. The genus is characterized by having solitary or rarely paired spikelets that are usually one-flowered; awned, mucronate or unawned lemmas that are three-veined; and a base chromosome number of $x = 10$ (Peterson et al. 1997). In recent years there has been some debate regarding the taxonomic status of *Muhlenbergia capillaris* (Lam.) Trin., *M. expansa* (Poir.) Trin., and *M. sericea* (Michx.) P.M. Peterson, three perennial cespitose species native to the southeastern and gulf coast of the United States, with the outcome potentially effecting cultural traditions and economic aspects of the Gullah peoples who have traditionally used *M. sericea* [synonyms: *Muhlenbergia filipes* M.A. Curtis; *Muhlenbergia capillaris* var. *filipes* (M.A. Curtis) Chapm. ex Beal] as the primary plant material to make sweetgrass baskets (Burke et al. 2003; Rosengarten 1986).

Muhlenbergia capillaris, M. expansa and *M. sericea* are all members of *Muhlenbergia* subgenus *Trichochloa* section *Podosemum* (Soderstrom 1967; Peterson & Herrera 2001). *Muhlenbergia sericea* is a perennial cespitose species that occurs in marginal maritime habitat along coastal barrier islands and woodlands of the southeastern and gulf coasts (TX to NC) and is characterized by long involute leaf blades (35–100 cm long), long-awned lemmas (8–35 mm long) and upper glumes (2–25 mm long), and lemmas with long setaceous teeth (1–5 mm long) near the apex. *Muhlenbergia capillaris* has a much wider ecological and geographical range (TX to KS to MA to FL) and superficially resembles *M. sericea*. However, *M. capillaris* has shorter-awned lemmas (2–18 mm long), unawned or shorter awned upper glumes (1–5 mm long), and usually lacks setaceous teeth or, if present, these are less than 1 mm long. *Muhlenbergia expansa* grows in wet pine savannas and pitcher plant flatwoods inland from the coastal plain (*M. sericea*) habitat and lacks awned upper glumes (sometimes these can be mucronate, i.e., with a mucro less than 1 mm long) or setaceous teeth. The lemmas of *M. expansa* are unawned, mucronate or have awns 1–3 mm long.

Morden and Hatch (1989) conducted a morphological study of *Muhlenbergia sericea, M. capillaris,* and

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M. expansa specimens from 25 herbaria across the southeastern United States and suggested that these taxa are three varieties of *M. capillaris* rather than three distinct species. In our study, we use molecular genetic data [intersimple sequence repeats (ISSR)] to address the hypothesis that *Muhlenbergia sericea, M. capillaris,* and *M. expansa* are three distinct species. In addition, we offer a different interpretation of Morden and Hatch (1989) published data in support of our hypothesis that these are three distinct species.

METHODS

Plant genomic DNA was extracted from approximately 0.1 g of silica-dried leaves from field-collected plants, herbarium sheets, and 0.5 g fresh leaf material using E.Z.N.A.® plant DNA miniprep kit (Omega Bio-Tek, Doraville, Georgia, U.S.A.). *Muhlenbergia sericea* was collected from the eastern ($n = 8$, collected by K. Olandt in Charleston County, South Carolina) and western ($n = 4$, collected by P. Maywald in Kennedy County, Texas) range of the species in the fall of 2004. *Muhlenbergia expansa* DNA was extracted from two South Carolina herbarium sheets (*Townsend 2341 & 1123*) from the Clemson University Herbarium. *Muhlenbergia capillaris* extractions consisted of two individuals from Alabama (MacDonald 12080 & Allison 7225, University of Alabama Herbarium) and three individuals from South Carolina (collected in 2005 by DJG from Apron Island in Charleston County, South Carolina). Two individuals were extracted of *Muhlenbergia wrightii* Vasey ex J.M. Coult. and *M. montana* (Nutt.) Hitchc. grown from seeds that were purchased from Western Native Seed, Coaldale, Colorado.

Muhlenbergia montana and *M. wrightii* (outgroup) are perennial cespitose species native to the southwestern United States and occur on rocky slopes at elevations of 1100 to 3500 m. The former species has been included in the *Muhlenbergia montana* complex (Herrera 1998) and the later species is probably aligned with other genera in the Muhlenbergiinae (Peterson et al. 2004; Peterson et al. 2007).

Twenty five intersimple sequence repeat (ISSR) primers were surveyed, with six primers selected for this study (sequence, number of bands; $(GT)_6$-RG, 8 bands; $(CA)_8$-RG, 8 bands; $(CA)_6$-RY, 5 bands; $(GA)_8$-YC, 8 bands; $(CT)_9$-G, 3 bands; $(CA)_6$-RG, 4 bands). ISSR polymerase chain reaction (PCR) protocol followed that of Wolfe et al. (1998); 94° C for 1min 50sec, 40 cycles of 94° C for 40 sec, 43° C for 45 sec, and 72° C for 1min 50 sec, followed by a final extension at 72° C for 5 min. PCR profiles were visualized in 1.5% agarose gels and stained with ethidium bormide. Images were captured using a digital camera (Olympus C-4000 Zoom, Melville, NY), converted to a negative image, and fragment size was estimated based on a DNA marker (Benchtop pGEM, #G7521, Promega, Madison, WI). Fragment sizes were used to assign loci for each primer and bands were scored as diallelic for each locus (1=band present, 0= band absent). Individual ISSR profiles were used to calculate a priori species assignment using multi-response permutation procedure (MRPP) (PC-Ord, ver. 4.2, MjM Software Design, Gleneden Beach, Oregon, U.S.A.). Nei's genetic distance (1972) was calculated among taxa based on band frequency data and Neighbor-Joining cluster analysis (Saitou and Nei, 1987) using NTSYSpc 2.2d (NTSYSpc Numerical Taxonomy and Multivariate Analysis System, Applied Biostatistics Inc., New York, NY).

RESULTS AND DISCUSSION

ISSR analysis clearly supports *Muhlenbergia sericea* as a separate species that shares a common ancestor with *M. capillaris* and *M. expansa*, which is in agreement with Peterson's (2003) recent treatment of *Muhlenbergia*. MRPP analysis indicated significant differences ($T = -9.03$, $A = 0.20$, $P < 0.01$) among the a priori species designation, meaning that individuals within a species were more genetically similar to one another than they were to members of another species. If *Muhlenbergia sericea* and *M. expansa* were varieties of *M. capillaris*, then we would have expected to find members of all three a priori species forming one genetically similar grouping.

Phylogenetic relationships among these five *Muhlenbergia* species revealed predictable associations, with the more eastern *Muhlenbergia* species (*M. expansa, M. capillaris, M. sericea*) forming a monophyletic group (Fig. 1). *Muhlenbergia wrightii* (outgroup) and *M. montana* are native to the mountain and southwestern regions

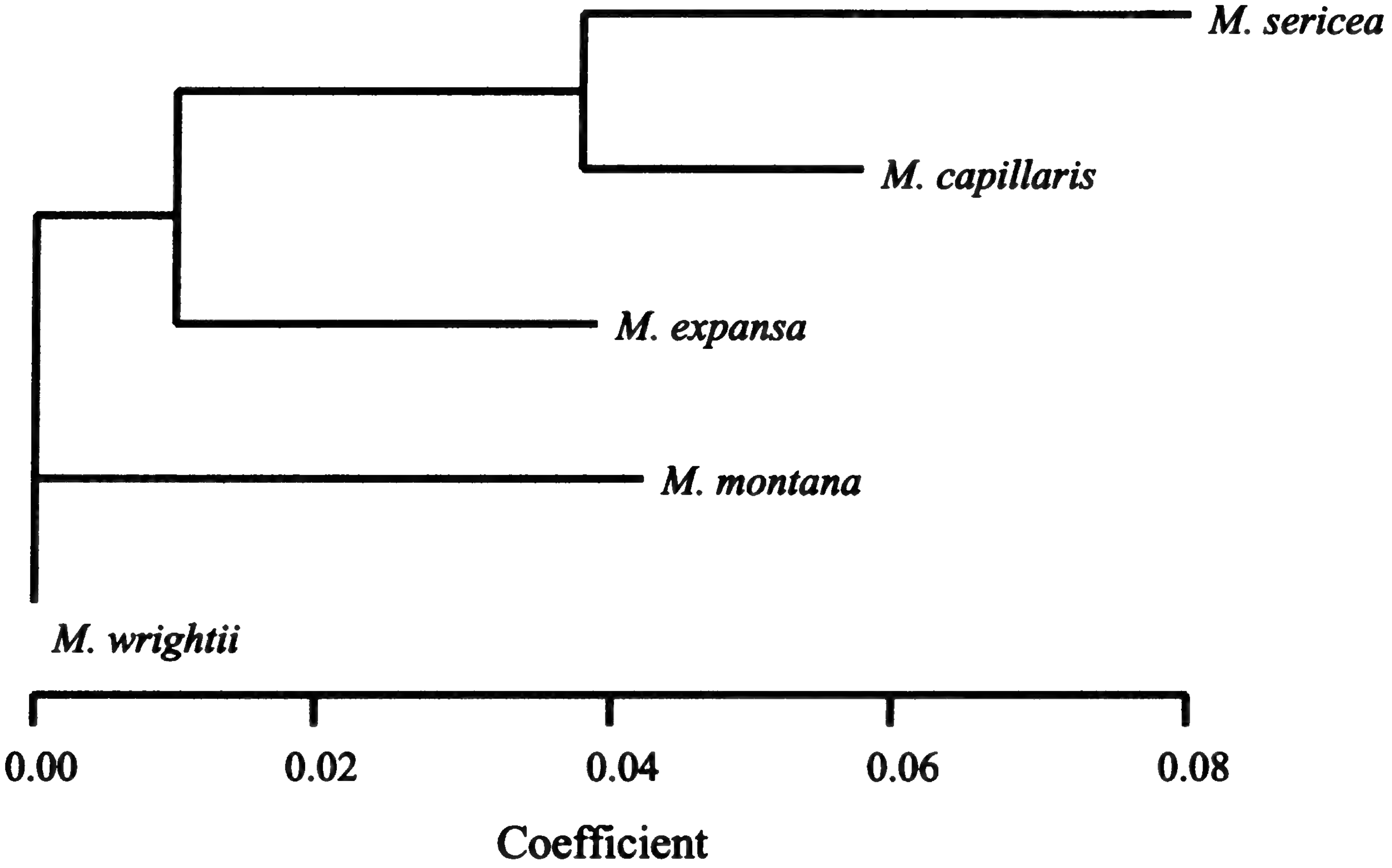

Fig. 1. Neighbor-Joining cluster analysis based on Nei's genetic distance among five *Muhlenbergia* species. The three southeastern *Muhlenbergia* species (*M. sericea, M. capillaris, M. expansa*) were more similar to one another than they were to the southwestern *M. montana* and mountain *M. wrightii* species.

of the United States and were clearly different from the three eastern species. Much of the taxonomic confusion surrounding *Muhlenbergia sericea, M. capillaris,* and *M. expansa* extends from the potential geographic and ecological overlap of these taxa and the limited number of diagnostic characters. Based on our ISSR molecular markers, *Muhlenbergia sericea* and *M. capillaris* are more similar to one another than they are to *M. expansa* (Fig. 1).

Morden and Hatch (1989) conducted a taxonomic study of *Muhlenbergia sericea*, *M. capillaris*, and *M. expansa* based on morphological characters and recommended that these three taxa should be a single species consisting of three varieties. We respectfully disagree with their conclusions and offer a different interpretation of their results. The taxonomic, geographic, and morphological sampling was sufficient and appropriate for the stated objectives of their study; however, they failed to use summary statistics to assess differences among taxa. An analysis of variance or non-parametric analysis should have yielded statistically significant differences among the three taxa for morphological characters which have been used historically to separate these species. Plotting the means ± 1 standard error (Fig. 2) for blade, upper glume awn, lemma awn, and setaceous teeth lengths are a good indication that significant differences would have been found if the authors tested for difference among taxa. Morden and Hatch's PCA analysis does not present key multivariate statistics, such as eigenvalues for each axis or parallel analysis indicating which axes are appropriate for interpretation. In addition, a graph of individuals on the first two PCA axes clearly show *Muhlenbergia sericea* and *M. expansa* as separate clusters with *M. capillaris* intermediate (Fig. 1; Morden and Hatch 1989). Discriminate analysis statistics were also not presented in their manuscript; however, we would suggest that a misclassification rate of 3.7% (13 out of 350) is not strong support for realigning these three taxa as varieties of *Muhlenbergia capillaris.* In a draft (9 Aug 2006) of the Flora of the Carolinas, Georgia,

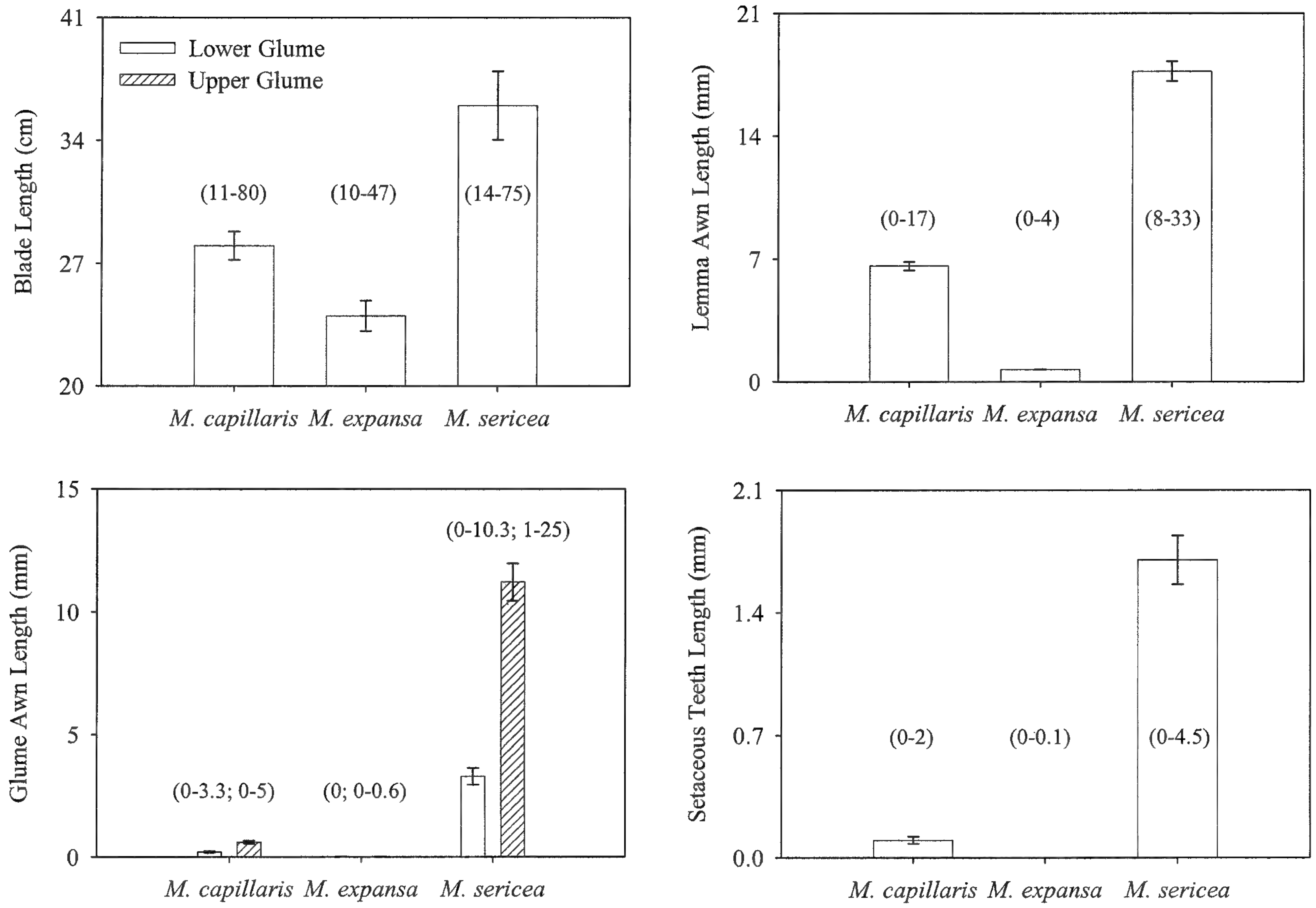

Fig. 2. These data represent the mean (± 1 SE), with range in parentheses, of key morphological characters used to distinguish *Muhlenbergia capillaris, M. expansa,* and *M. sericea*. Compiled from table 1 in Morden and Hatch 1989.

and Virginia, A.S. Weakley (in prep.) also comments in regards to Morden and Hatch (1989) and states that these three taxa are undoubtedly biological species.

Based on our molecular genetic data and a more rigorous statistical interpretation of Morden and Hatch (1989) morphological study, we conclude that *Muhlenbergia sericea* and *M. capillaris* are two closely related species that have limited ecological and morphological overlap, but these taxa should remain as distinct species. Morphological and ISSR analysis indicate that *Muhlenbergia sericea* and *M. capillaris* are more similar to one another than either is to *M. expansa*. While proper identification of *Muhlenbergia sericea*, *M. capillaris*, and *M. expansa* in the field is sometimes difficult, we recommend using a combination of ecological setting, blade length and mature floret characters (glume awn, lemma awn, and setaceous teeth length) to distinguish among these three closely related species. We provide a key to separate these three species below.

A KEY TO *MUHLENBERGIA CAPILLARIS*, *M. EXPANSA*, AND *M. SERICEA* IN NORTH AMERICA

1. Body of the glumes more than 1/2 as long as the lemmas; lemmas unawned, mucronate, or with awns only 1–3 mm long; upper glumes never awned but sometimes mucronate ____ **Muhlenbergia expansa**
1. Body of the glumes less than 1/2 as long as the lemmas; lemmas usually awned 2–35 mm long; upper glumes often awned, the awns 1–25 mm long.
  2. Upper glumes unawned or with awns to 5 mm long; lemmas without setaceous teeth or with teeth no more than 1 mm long; lemma awns 2–13(–18) mm long ____ **Muhlenbergia capillaris**
  2. Upper glumes awned, the awns 2–25 mm long; lemmas with setaceous teeth 1–5 mm long; lemma awns 8–35 mm long ____ **Muhlenbergia sericea**

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BOOK REVIEWS

PATRICK GASS, edited and annotated by CAROL LYNN MACGREGOR. 1997. **The Journals of Patrick Gass: Member of the Lewis and Clark Expedition.** (ISBN 0-87842351-6). Mountain Press Publishing Company, Box 2399, Missoula, MT 59806, U.S.A. $20.00. (**Orders:** www.mountain-press.com, info@mtnpress.com, 406-728-1900, 406-728-1635 fax). $20.00, 445 pp., illustrated, 6" × 9".

Captain Lewis asked the men who could write to keep journals. Patrick Gass was one of the seven known journal keepers whose journals have survived. Patrick had only 19 days of formal education and by his own admission "never learned to read, write, and cipher till he had come of age." His journal provides us with more details about some activities of the Expedition than do the other journals and is more readable. Gass' journal is full of descriptions of the surrounding country and the wildlife, including a list of animals killed for food by the expedition. He was a keen observer, and since he was a carpenter, he provided details not included in other journals on the construction of earth lodges and canoes of the native people. Gass was almost certainly responsible for supervising the building of Forts Mandan and Clatsop; his records of those forts are particularly detailed and useful.

His journal was subsequently published in 1807 and proved quite popular: it went through six editions in six years. It was published just six months after the Corps returned to St. Louis and seven years before Lewis's and Clark's were published. The inclusion of Gass' previously unknown account book from later in his life lend new insight into Gass's work and his life. He lived until 1870 and died when he was ninety-nine. The previous year the Pacific railroad had been completed and Patrick Gass, one of the first Americans to cross the continent and the last survivor of the Corps of Discovery, had lived to see it.

The University of Nebraska Press edition of the Journals of Lewis and Clark, vol. 10, contains the journal of expedition member Sergeant Patrick Gass. The journal is to be found only in printed form; the original has been lost since its first publication. This edition is a valuable supplement to it and should be purchased by libraries holding the original.—*Gary Jennings, Library, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

RONALD D. QUINN and STERLING C. KEELEY. 2006. **Introduction to California Chaparral.** (ISBN 0-520-24566-0, pbk.).The University of California Press, Berkeley, CA 94704, U.S.A. (**Orders:** California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A., www.ucpress.edu, 609-883-1759, 609-883-7413 fax). $19.95, 322 pp., illustrated, 4½" × 7¼".

The California chaparral is well known to us. We have seen it hundreds, if not thousands, of times as a backdrop in movie and television productions from early westerns to MASH to the present day. But it is not just a feature of the Hollywood Hills. It is an essential part of the entire California landscape from the Mexican border to the Oregon border. The chaparral is a wonderfully resilient ecological community which has adapted to recurring fires and droughts. The book's authors, both chaparral researchers and scientists, were interested in writing a book for a wider audience. They were brought together by the Press and have produced a concise, engaging, and beautifully illustrated book. They describe an ecosystem which contains awesome and spectacular plants and animals: Fire Beetles that mate only on burning branches, lizards that shoot blood from their eyes when threatened, Kangaroo Rats that never drink water, and seeds that germinate only after a fire, even if that means waiting in the soil for a 100 years or more.

Part of the University of California Natural History Guide, the book follows the typical pattern for their guides. The contents include: **1.** The California chaparral. Discusses where it is found and what is the composition of vegetational communities. **2.** Mediterranean climate. How rainfall is affected by the unpredictable wind and the influence of temperature and microclimates. **3.** Fire. The cycle of fire and the influence of historical fire patterns. Natural responses to the effect of fire by plants and animals. **4.** Plants. Discusses the common evergreen shrubby vegetation as well as other plant families and introduced weeds. **5.** Animals. Enumerates the mammals, rodents, birds, and insects that inhabit the chaparral. 6.Living with the chaparral. Addresses prescribed fire, threats to the chaparral, and options for wise (human) growth. A glossary and supplemental readings and references complete the book.

Chaparral will introduce general readers to the plants and animals associated with chaparral and will be a review for biologists and land managers its natural history, ecology, and management challenges. It is useful both as a field guide and as an introductory overview of the ecology of chaparral. It also provides a better understanding of how we might live in harmony, safety, and appreciation of this unique ecological community.—*Gary Jennings, Library, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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EOËPIGYNIA BURMENSIS GEN. AND SP. NOV., AN EARLY CRETACEOUS EUDICOT FLOWER (ANGIOSPERMAE) IN BURMESE AMBER

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ABSTRACT

Eoëpigynia burmensis gen. & sp. nov. is described from Early Cretaceous Burmese amber. The genus is characterized by small, perfect, actinomorphic flowers possessing a perianth with a single series of basally connate sepals, four distinct equal petals, four included stamens alternate with the petals, an inferior ovary, a single style with a bilobed stigma, and triaperturate pollen. Flowers with similar morphology occur in the family Cornaceae.

KEY WORDS: Burma, amber, eudicot flower, Early Cretaceous, Cornaceae

RESUMEN

Eoëpigynia burmensis gen. & sp. nov. se describe del ámbar birmano del Cretácico temprano. El género se caracteriza por tener flores pequeñas, perfectas, actinomórficas que tienen un perianto con una serie sencilla de sépalos connados en la base, cuatro pétalos independientes iguales, cuatro estambres inclusos alternando con los pétalos, un ovario ínfero, un estilo simple con estigma bilobulado, y polen triaperturado. Existen flores con una morfología semejante en la familia Cornaceae.

INTRODUCTION

Burmese amber has an interesting past dating back to AD 100 when an amber trade route was established with China. The first Europeans visited the mines in 1836 but it was not until 1896 that the amber was noted to contain insect remains. From AD 100 until 1936, the Burmese amber mines supplied amber to various parts of the world (Chhibber 1934). In 2001, a new amber mine was excavated in the Hukawng Valley, southwest of Maingkhwan in the state of Kachin (26°20'N, 96°36'E) (Poinar et al. 2005). This new amber site, known as the Noije Bum 2001 Summit Site, was dated to the Upper Albian (100 to 105 mybp) of the Early Cretaceous (Cruickshank & Ko 2003).

The Early Cretaceous age of amber from the Noije Bum 2001 Summit Site as determined by Cruickshank and Ko (2003) is supported by primitive insects from this deposit. For example, a bee was discovered still possessing characters of sphecid wasps, the group considered ancestral to bees (Poinar & Danforth 2006). An elcanid grasshopper was also found at this site, representing a group (Elcanoidea) that first appeared in the Early Permian and continued only to the mid-Cretaceous (Poinar et al. 2007). Thus, both paleontological data and inclusions in the amber support an Early Cretaceous age for deposits from the Noije Bum 2001 Summit Site.

Nuclear magnetic resonance (NMR) spectra of amber samples taken from that locality indicate an araucarian (possibly *Agathis*) source of the amber (Lambert & Wu, unpublished data 2002). While insects are dominant, the deposits have revealed some very interesting plant fossils, including a unisexual flower with affinities to the family Monimiaceae (Poinar & Chambers 2005) and two early bambusoid grasses (Poinar 2004). In the present paper, we describe a bisexual flower, provisionally assigned to the family Cornaceae, from the Noije Bum 2001 Summit Site.

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MATERIALS AND METHODS

The flower is complete and well-preserved. One of the petals shows some evidence of insect damage, and fungal hyphae are associated with one of the anthers. The flower was in anthesis at entombment, and pollen grains occur on and adjacent to the anthers as well as on the stigma. The piece of amber containing the flower is square, measuring 5 mm in length by 5 mm in width by 1.5 mm deep. Examination and photographs were made with a Nikon stereoscopic microscope SMZ-10 R at 80 × and a Nikon Optiphot microscope at 800×.

DESCRIPTION

Eoëpigynia Poinar, Chambers & Buckley, gen. nov. TYPE SPECIES: *Eoëpigynia burmensis* Poinar, Chambers & Buckley, sp. nov.

Diagnosis.—Flowers small, bisexual, regular, epigynous; perianth tetramerous; calyx comprising a short crown (gamosepalous) at summit of ovary, sepal lobes incised, number uncertain; petals 4, separate, valvate, regular; stamens 4, free to base, in a single whorl, alternating with the petals, filaments linear, anthers introse, dorsifixed; pollen shed singly, pollen grains triaperturate (possibly tricolporate with thickened exine adjacent to colpi); gynoecium syncarpous, ovary inferior, style 1, stigma bilobed, pericarp wall thick-textured at anthesis, fruit type unknown; presence of floral disc not determinable.

Eoëpigynia burmensis Poinar, Chambers & Buckley, sp. nov. (**Figs. 1–2**). TYPE: MYANMAR (BURMA): KACHIN: northern Myanmar, amber mine in the Hukawng Valley, SW of Maingkhwan, (26°20´N, 96°36´E), Aug 2005, *Buckley s.n.* (HOLOTYPE: perfect flower (accession # ab 214) deposited in the collection of Ron Buckley, Florence, Kentucky 41042-8355, U.S.A.).

Description.—**Flower** bisexual, glabrous, length 1.5 mm; no free hypanthium evident; calyx lobes with incised margins, greatest length of calyx 0.34 mm; petals lanceolate-ovate, margins abaxially recurved, up to 0.95 mm long, 0.34 mm wide; stamens with ovoid anthers up to 0.15 mm long, filaments 0.54–0.61 mm long; stigma at level of anthers, estimated length of style 0.55 mm; length of ovary 0.54 mm; width of ovary 0.39 mm; diameter of pollen grains, 12–14 µm.

Etymology.—Genus name from the Greek "eos" dawn, "epi-" upon, and "gyne" female, from the age and the relation of the floral perianth to the ovary. Species named for the country of origin of the fossil.

DISCUSSION

Certain structures that would be helpful in the placement of *Eoëpigynia*, for example the presence of a floral disc, could not be observed due to the fossil's orientation in the amber. However, it was possible to view the flower from both sides to verify the characteristics described here. Based on its floral features, *Eoëpigynia* (Figs. 1, 2) represents a core eudicot that can provisionally be assigned to the family Cornaceae *sensu lato*, in the basal asterid order Cornales. The phylogenetic position of Cornales as sister to all the remaining asterids (perhaps excluding Ericales) is well confirmed by molecular studies (Stevens 2001 onwards; Hilu et al. 2003; Judd & Olmstead 2004; Bremer et al. 2004). The perfect flower, inferior ovary, compound style, 4-merous perianth and androecium, and possibly tricolporate pollen of our fossil are most similar to the modern genus *Cornus* (see illustrations in Wangerin 1910; Judd et al. 1999). The pollen of the fossil may be of particular importance in this placement. In an equatorial optical section (Fig. 1D) three distinct paired thickenings are seen in the exine marking what we assume are the three colpi (we could not focus our instrument clearly on a pore at this spot). This pattern is strongly reminiscent of SEM equatorial transections of *Cornus* pollen illustrated by Ferguson (1977), e.g. his figure 2c of thickened endexine in this area in *C. volkensii*, as well as his figures 4d of *C. disciflora* and 6c of *Curtisia dentata*. Because of the pollen orientation in the amber, we were unable to observe a pore face-on, where the characteristic H-shaped endoaperture thinning pattern of Cornaceae/Nyssaceae might be seen (Erdtman 1966; Ferguson 1977). The pollen grains of *Eoëpigynia* are smaller than in most of the types defined by Ferguson (1977) but are within the range of his *Curtisia*-type, described as 12–20 × 12–17 µm (p. 6). One might speculate that small pollen are related adaptively to the small size of pollinating insects of that period, for example the 2 mm-long bee recently described from Burmese amber by Poinar and Danforth (2006).

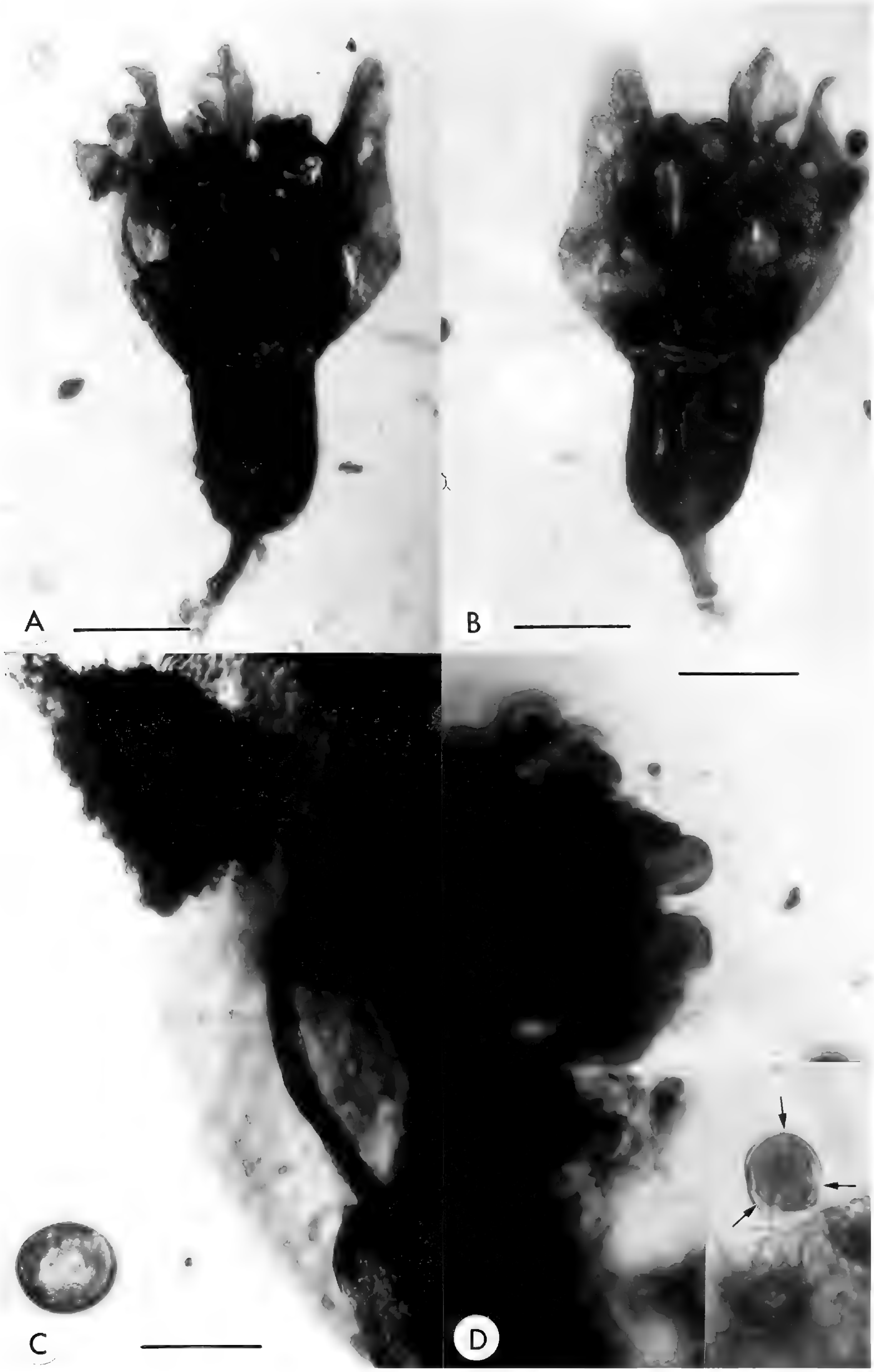

Fig. 1. *Eoëpigynia burmensis* in Burmese amber. A. One side of flower. Scale bar = 0.34 mm. B. Opposite side of flower. Scale bar = 0.34 mm. C. Stamen: anther covered with triangular pollen mass held together by fungal hyphae. Scale bar = 0.17 mm. D. Pollen grains on anther. Insert shows individual pollen grain (arrows indicate aperture areas surrounded by thickened exine. Scale bar = 18 µm.

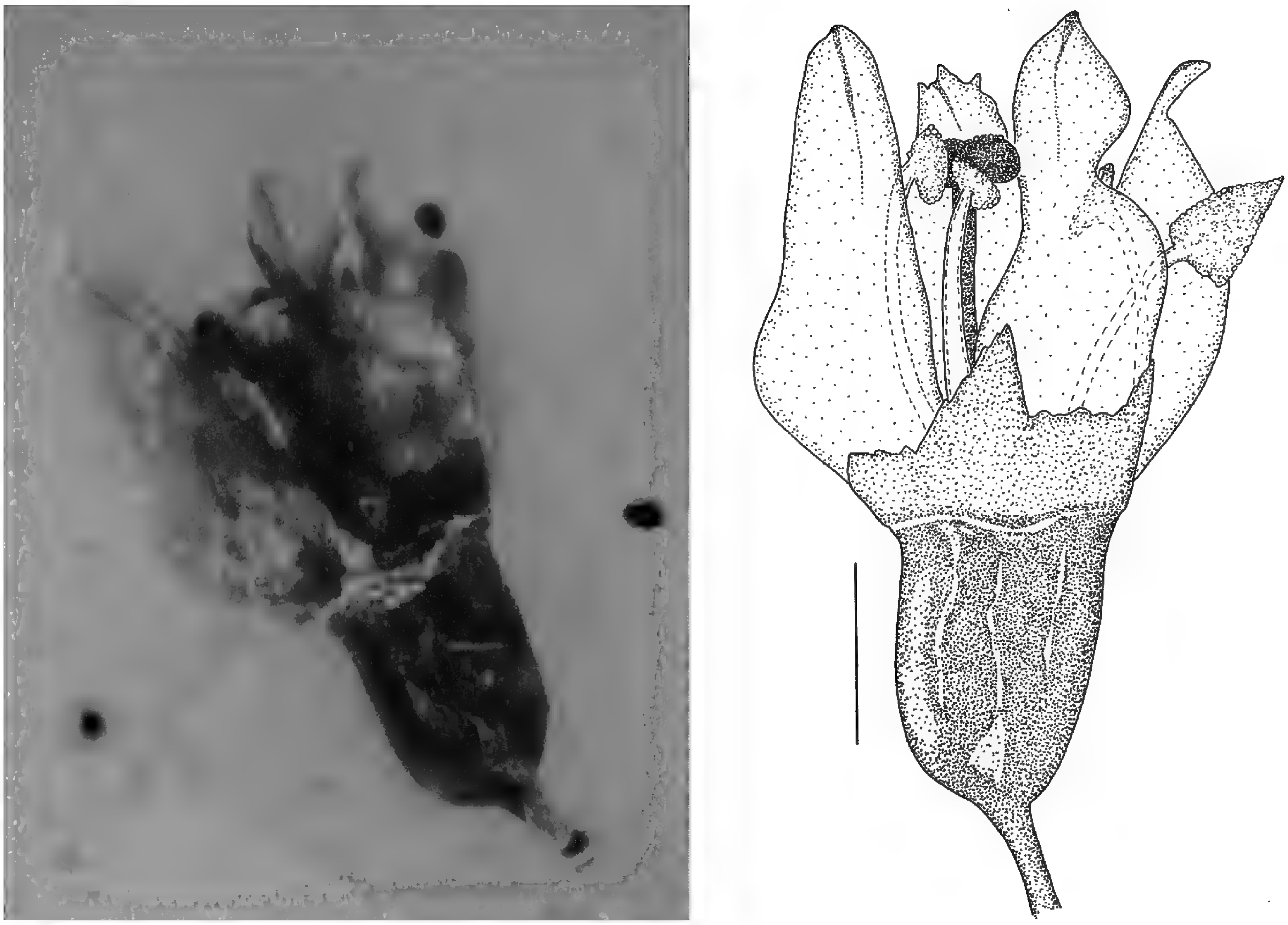

Fig. 2. Flower of *Eoëpigynia burmensis* in Burmese amber. Anther on right as described in Fig. 1C. Scale bar = 0.34 mm.

The generic makeup of Cornales, as well as family Cornaceae, has been reexamined in recent molecular phylogenetic studies (Xiang et al. 1998; Fan & Xiang 2003; Hilu et al. 2003; Judd & Olmstead 2004). It is proposed that Cornaceae be limited to two genera, *Cornus* and *Alangium*, and that other genera formerly assigned here be segregated to families Nyssaceae, Mastixiaceae, and Grubbiaceae. At the ordinal level, the once widely separated families Loasaceae and Hydrangeaceae are to be included in Cornales. If *Eoëpigynia* is placed in the larger context of this basal asterid clade, it shows that a simplified epigynous flower, with a single style, 4-merous perianth parts, and four stamens, arose early in the differentiation of this evolutionary line.

As pointed out by Gustafsson and Albert (1999), epigyny is not a recent phenomenon. Examples were found by Friis et al. (1994) in Early Cretaceous sediments in Portugal, originally dated as Valanginian or Hauterivian but now reassigned to the early Albian (Heimhofer et al. 2005). A probable relationship to Chloranthaceae has been established (Eklund et al. 2004). Phylogenetic studies have also shown that the evolution of ovary position has been dynamic, with at least 64 changes from hypogyny to epigyny but only 24 changes in the opposite direction (Gustafsson & Albert 1999; Soltis et al. 2003). In neither of these papers are Cornales specifically discussed, however. Modern Cornales are well represented in the Southeast Asian flora, with *Cornus* itself having a circumpolar Northern Hemisphere distribution (Wangerin 1910; Xiang et al. 2005). Reference fossils (fruit stones) attributed to the Cornelian-Cherry line of *Cornus* in the latter paper are taken from the careful review by Eyde (1988) and are Eocene or younger in age.

In studies using molecular phylogenetic dating methods with known fossil reference points (Bremer et al. 2004; Anderson et al. 2005), the Early Coniacian (88 mybp) cornalean genus *Hironoia* (Takahashi et al. 2002) has been used. Based on these papers, the age of the stem group asterids may be ca. 128 mybp, the Cornales and Ericales diverging soon afterwards (Stevens 2001 onwards). Anderson et al. (2005) place the separation of Cornales from remaining asterids at ca. 109 mybp. The reference fossil *Hironoia* consists of three-dimensionally preserved drupes, with characters of the endocarp wall and dehiscence valves synapomorphic with the genera *Nyssa* and *Mastixia*. However, it could not be placed with certainty in one or the other genus. Another known cornalean fossil is *Tylerianthus* from the Upper Cretaceous Turonian Period, ca. 90 mybp (Gandolfo et al. 1998; Crepet et al. 2004), with affinities to the Hydrangeaceae. The putative cornacean fossil *Eoëpigynia* would extend the age of the clade, if used in similar dating studies. It would be well to note, however, that its generalized floral morphology would allow possible placement of this fossil in other epigynous clades of core eudicots as well, including Saxifragales, Myrtales and Asterales. Its similarity to Cornaceae, although highly suggestive, is not fully diagnostic of the proposed relationship. We know of no other fossil flower from the Cretaceous with the floral syndrome of this specimen.

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LECTOTYPIFICATION OF *GAULTHERIA PYROLIFOLIA* AND *G. PYROLOIDES* (ERICACEAE)

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ABSTRACT

Different names have been used for two eastern Asian and Alaskan species of *Gaultheria* in various taxonomic treatments. To resolve this problem, a lectotype for the name *G. pyroloides* is selected. The name *G. miqueliana*, employed in most taxonomic works for the species from Japan, Russia, and Alaska since its publication in 1918, must be relegated to synonymy under *G. pyroloides*. A lectotype is also selected for the Himalayan species *G. pyrolifolia*. Several morphological characters are identified that differentiate the two species.

RESUMEN

Se han usado diferentes nombres para dos especies, del este de Asia Alaska, de *Gaultheria* en varios tratamientos taxonómicos. Para resolver este problema, se ha seleccionado un lectotipo para el nombre *G. pyroloides*. El nombre *G. miqueliana*, empleado en la mayoría de los trabajos taxonómicos para la especie de Japón, Rusia, y Alaska desde su publicación in 1918, debe ser relegado a la sinonimia de *G. pyroloides*. Se ha seleccionado también un lectotipo para la especie del Himalaya *G. pyrolifolia*. Se han identificado varios caracteres morfológicos que diferencian las dos especies.

During preparation of manuscripts on the taxonomy of *Gaultheria* for a treatment of the genus in Gaoligong Shan, western Yunnan Province, China (Fritsch) and for Flora of North America (Trock), the authors detected inconsistency in the application of the names *G. miqueliana* Takeda, *G. pyrolifolia* J.D. Hooker ex C.B. Clarke, and *G. pyroloides* Miquel to two species from eastern Asia and the Aleutian Islands. Here we clarify the nomenclature of these species by designating lectotypes for *G. pyrolifolia* and *G. pyroloides*.

Nomenclatural Background of *Gaultheria pyroloides* and *G. pyrolifolia*

Gaultheria pyroloides was described on the basis of several gatherings from Sikkim by John Dalton Hooker (*s.n.*), two of which are now on the same sheet at K but were possibly separate when Miquel saw the material (Fig. 1), and one from Japan (collector not determined; Fig. 2). In the protologue, Miquel (1863) indicated that he considered these specimens to represent one and the same species, as evidenced by the following statement: "Specimina nostra capsulifera ab indices, quae in regione alpina 12–13,000 alt. Himalayae Sikkimensis detecta et e Museo Kewensi mihi concessa, floribusque instructa sunt, nullo modo differunt," which in English translates roughly to "Our [Japanese] capsuliferous specimen in no way differs from that from the index, which, found in the alpine region of the Sikkim Himalaya between 12,000 and 13,000 feet elevation and given to me from the Museum at Kew, is provided with flowers." The description seems to be based solely or in large part on the Japanese specimen, because only the fruiting condition is described and flower characters are not included. This suggests that Miquel did not have direct access to the Sikkim specimens at the time of description and was relying at least in part on memory in his decision to include the Sikkim and Japanese plants under the same species. Perhaps a memory lapse, then, explains why Miquel ascribed the name *G. pyroloides* to "Hook. *fil.* et Th. *herb. Ind. or.*" (i.e., J.D. Hooker and T. Thomson) when "*G. pyrolaefolia* H f & T" in Hooker's handwriting [as confirmed with the examples in Burdet (1975)] is written on the Hooker and Thomson sheet, and not "*G. pyroloides*."

Subsequently, C.B. Clarke [in Hooker (1882)] described *Gaultheria pyrolifolia* (as *G.* "*pyrolaefolia*") based on several gatherings of Hooker (ascribing the name to "*Hook. f. ms.*"), including those seen by Miquel. Clarke appears to have been unaware that *G. pyroloides* was already published or at least that it was based on a

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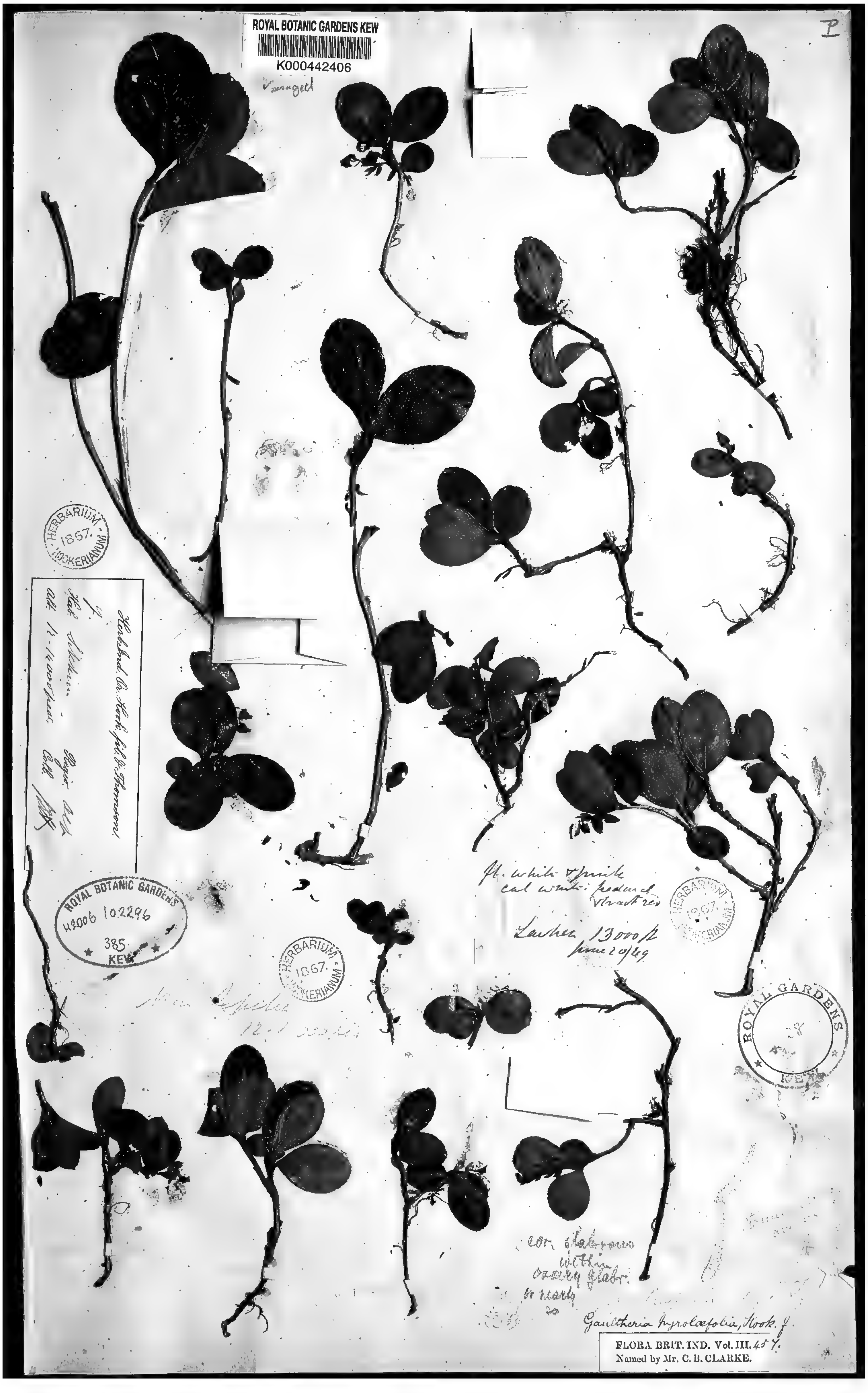

Fig. 1. Image of the lectotype (K) of *Gaultheria pyrolifolia* J.D. Hooker ex C.B. Clarke from Sikkim. The specimens from Lachen constitute the lectotype, although it is unclear precisely which individual fragments were collected from there versus Mt. Lepcha.

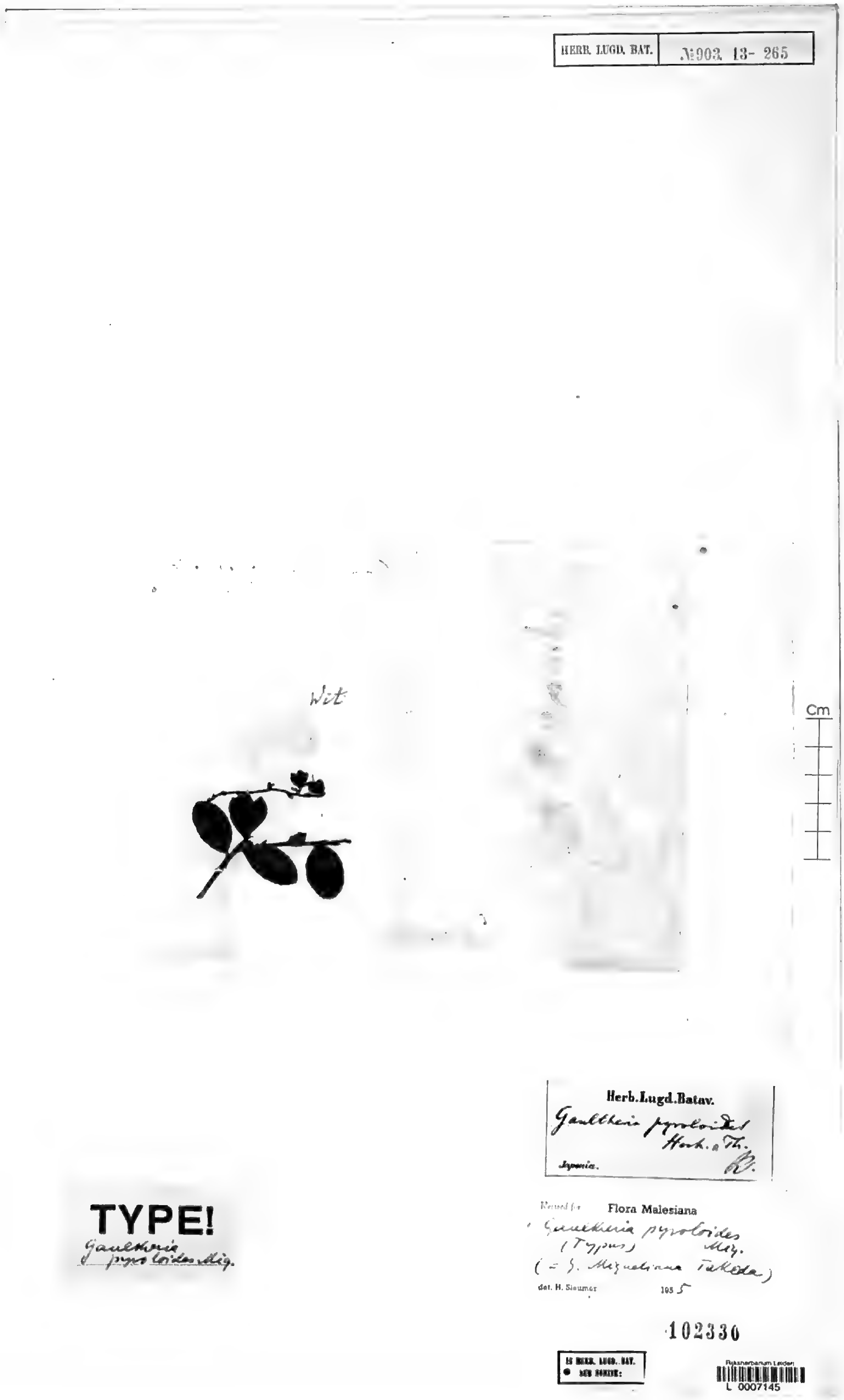

Fig. 2. Image of the lectotype (L) of *Gaultheria pyroloides* Miquel from Hokkaido, Japan.

Himalayan specimen in addition to one from Japan, because mention is made neither of it nor any other potentially confounding nomenclatural issues in the protologue.

If the specimens under consideration were one and the same species, then one might argue that the only nomenclatural issue of consequence involves the orthographic similarity between the epithets "*pyrolifolia*" and "*pyroloides*." Article 60.3 of the International Code of Botanical Nomenclature (ICBN; McNeill et al. 2006) states, however, that "The liberty of correcting a name is to be used with reserve…." Because the meanings of the epithets "*pyrolifolia*" and "*pyroloides*" are distinctly different ["*Pyrola*-leaved" versus "resembling *Pyrola*" (the whole plant), respectively], the names are not justifiably considered as orthographic variants.

Morphological Distinctness of the Himalayan and Japanese Plants

The most recent comprehensive treatments of eastern Asian *Gaultheria* [i.e., those of Airy Shaw (1941) and Middleton (1991)] have followed Takeda (1918) in recognizing two species constituting the type material of *G. pyroloides*, as justified by the bluish black versus white fruiting calyx observed in Himalayan and Japanese specimens, respectively (Takeda 1918). The other difference between the two species cited by Takeda ("2-aristate anther" versus "4-aristate anther") is incorrect and undoubtedly resulted from a misreading of the original description of *G. pyrolifolia*, which states "anther-cells 2-horned at apex." In fact both species of *Gaultheria* have 4-aristate anthers when these are functional (i.e., as opposed to the highly reduced anthers of female flowers, as observed by us on specimens from the Himalaya). The use of a single character to distinguish species should be questioned, and to our knowledge the differences between these species have not been documented since Takeda (1918). By examining herbarium material of both species from A, BM, E, GH, K, KUN, and S, we have observed other features that further distinguish the bluish black-fruited species from the white-fruited species: leaves adaxially glabrous versus densely puberulent along midvein, bracteoles ovate versus oblanceolate, flowers 4–5 mm versus 5–6 mm long, and style 2–2.5 mm versus 3–3.5 mm long. The bluish black-fruited species is distributed in the eastern Himalaya from Sikkim (India) to northwestern Yunnan (China); the white-fruited species is distributed from central Honshu (Japan) to Sakhalin Island and Kunashir Island, Siberia (Russia) with an isolated population on Kiska Island, Alaska (U.S.A.).

Nomenclatural Resolution

In an apparent attempt to solve the nomenclatural problem of two species comprising the original material of the same name, Takeda (1918) gave the new name *G. miqueliana* Takeda to the Japanese plant (as he saw it, the epithets "pyrolifolia" and "pyroloides" were equivalent). Inexplicably, however, *G. pyroloides* was cited in synonymy, and Takeda did not designate a type for *G. miqueliana*. The only reference to the original material seen by Miquel was implied by the exclusion of the Hooker material from *G. pyroloides* ["Syn. *Gaultheria pyroloides* Miq. in Ann. Mus. Lug.-Bat. i, p. 30 (1863–64)….nec Hook. f. et Thoms."]. Because *G. pyroloides* was included in the synonymy of *G. miqueliana* and the type of *G. pyroloides* (at that time undesignated) neither explicitly nor implicitly excluded, *G. miqueliana* was nomenclaturally superfluous when published and is therefore illegitimate.

Airy Shaw (1941) later attempted to solve the problem. He asserted that the name *Gaultheria pyroloides* should be credited to Miquel and can legitimately be used for the Japanese species, and he thereby used the name "*G. pyrolaefolia* Hook. et Thoms. [sic]" for the blue-fruited species and *G. pyroloides* Miq. for the white-fruited species. Because Airy Shaw did not clearly indicate the lectotype with the word "type" or equivalent in accordance with Article 7.11 of the ICBN (McNeill et al. 2006), he did not lectotypify the names. Neither apparently did Hermann Sleumer, who annotated the specimen during a revision of the genus for *Flora Malesiana* in accordance with Airy Shaw's opinion (Fig. 2), but whose treatment (Sleumer 1967) makes no mention of the issue. This is not surprising in that neither species occurs in Malesia.

Authors of major taxonomic treatments of *Gaultheria* that include Japan, Russia, or Alaska have not taken up Airy Shaw's opinion; rather, they have consistently treated the white-fruited species as *G. miqueliana* (e.g., Ohwi 1965; Bush 1967; Hultén 1968; Middleton 1991;Yamazaki 1993). Most authors of treatments of

Gaultheria that include the Himalayan region have treated the bluish black-fruited species as *G. pyroloides* (e.g., Hara 1966, 1982; Fang et al. 1986; Hsu 1991; Long & Rae 1991; Middleton 1991), the only exception being Fang & Stevens (2005), who follow Airy Shaw (1941) by using *G. pyrolifolia*. Lectotypification is required to clarify the application of names regarding these two species.

1\. **Gaultheria pyroloides** Miquel, Ann. Mus. Bot. Lugduno-Batavi 1:30. 1863. (**Fig. 2**). *Gaultheria miqueliana* TAKEDA, BOT. MAG. (TOKYO) 32:195. 1918 (NOM. ILLEG. SUPERFL.). TYPE: JAPAN. "In insula Ieso" (Hokkaido) [protologue], collector undetermined [LECTOTYPE designated here: L 102330 (Herb. Lugd. Bat. No. 903, 13-265; image)].

We have lectotypified *Gaultheria pyroloides* on the Japanese specimen because 1) *G. pyrolifolia* was described by Clarke on the basis of the Sikkim specimens (Hooker 1882) and thus there is a legitimately published name clearly available for it; 2) the original description of *G. pyroloides* is based mainly or entirely on the Japanese specimen and published as part of a treatise on the flora of Japan; and 3) the alternative of lectotypifying *G. pyroloides* on the Sikkim specimen (with *G. pyrolifolia* as a taxonomic synonym) would prompt the need for a new name for the Japanese species.

2\. **Gaultheria pyrolifolia** J.D. Hooker ex C.B. Clarke in J.D. Hooker, Fl. Brit. India 3:457. 1882 ["*pyrolaefolia*"]. (**Fig. 1**). TYPE: INDIA. SIKKIM: Lachen, 13,000 ft elev., 20 Jun 1849, *J.D. Hooker s.n.* (LECTOTYPE designated here: K image catalogue number K000442406; probable duplicates: E, GH, NY-image, P).

The protologue of *Gaultheria pyrolifolia* cites the following gatherings, the specimens of which must be considered syntypes: "Lachen, *J.D.H.*; Mon Lepcha and Jongri, *J.D.H.*, *Clarke*." Because we have not been able to examine Clarke's material (probably at BM), we have chosen to lectotypify on the Hooker material. We specifically have lectotypified on the K sheet, on which Hooker's handwriting is apparent, as follows. Two localities are indicated on this sheet: "Lachen, 13000 ft", on what appears to be a field label, and "Mon Lepcha 12–14000 ft", handwritten directly on the sheet. Even though the material is now placed on the same sheet (we consider a third label on which is printed and handwritten "Herb. Ind. Or. Hook. fil. & Thomson" / "G." [*Gaultheria*] / "Hab. Sikkim" "Regio. Alp" / "Alt. 12–14000 ped" "Coll. JDH" to be a general label that refers to the whole sheet), from Hooker's journals (1854) it is clear that it represents two gatherings, made at different times (January 1849 versus June 1849) from distinct places (about 60 km apart).

In accordance with Article 8.2 of the ICBN (McNeill et al. 2006) requiring a type to comprise a single gathering, we have chosen the Lachen specimens on the sheet as the lectotype. The Lachen specimens were chosen over those from Mt. Lepcha because they are in closest proximity to both Hooker's handwritten note "*G. pyrolaefolia* H f & T" and an illustration accompanied by Hooker's initials of an abortive stamen, the flowers from which are placed among the specimens nearest the Lachen label. We do so with the caveat that it is unclear precisely which specimens on the sheet correspond to the Lachen gathering; we assume that at least some of the specimens directly adjacent to the label belong to this gathering and thus constitute the lectotype. Accordingly, the E, GH, NY, and P specimens must be treated as only probable duplicates, because there appears to be no way of knowing whether the material on those sheets is from Lachen, Mt. Lepcha, or both.

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A NEW NAME FOR THE WELL-KNOWN *ASPLENIUM* (ASPLENIACEAE) FROM HALE COUNTY, ALABAMA

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ABSTRACT

The name of the hybrid fern *Asplenium* × *ebenoides* R.R. Scott pro sp. [= × *Asplenosorus ebenoides* (R.R. Scott) Wherry] has long been misapplied to the well-known *Asplenium* species of reticulate origin from Hale County, Alabama. A new name, **Asplenium tutwilerae**, and description are provided.

RESUMEN

Se ha aplicado mal el nombre del helecho híbrido *Asplenium* × *ebenoides* R.R. Scott pro sp. [= × *Asplenosorus ebenoides* (R.R. Scott) Wherry] al bien conocido *Asplenium* de origen reticulado de Hale County, Alabama. Damos un nombre nuevo, **Asplenium tutwilerae**, y su descripción.

INTRODUCTION

The fern name *Asplenium ebenoides* was originally published by R.R. Scott (Scott 1865). He based his description on a single plant, collected in 1862, from near Philadelphia, PA on the west bank of the Schuylkill River.

As an editorial note appended to that article, Thomas Meehan suggested that the discovery might represent a fern hybrid, since only a single specimen had been found: "Is it a hybrid or variation? or, is it a species? Is it the last individual of a declining race, or is it the first creation of a new one?" The next year, Berkeley (1866) declared the plant to be a hybrid and correctly identified its parents: *Asplenium platyneuron* (L.) B.S.P. and *A. rhizophyllum* L. [=*Camptosorus rhizophyllus* (L.) Link].

Seven years later, in a list of significant collections including "Asplenium eb[e]noides R.R. Scott," D.C. Eaton (1873) announced, "A new locality for this very rare species has been found by Miss Julia S. Tutwiler near Havana, in Central Alabama. … As every fact connected with *this singular and disputed form* [emphasis added] will interest botanists in general and fernists in particular, we extract freely from Miss Tutwiler's letter, which is beside[s] brimful of botanical spirit:

> I found it in a little magic spot, a Fairy-glen, about five miles from my home. You must know that we live in Central Alabama … in a hilly country of sand and red clay, with long red gullies washed everywhere into the hills, but no rocks except pudding-stones [a type of conglomerate]. One day I happened to hear of beautiful mossy crags and cliffs some miles away, and went to seek them. To my delight and surprise, I found a little narrow glen, which seemed to have been picked up somewhere in the Blue Ridge and carried bodily through the air to be dropped down in this odd place. … There seemed a separate soil and climate to this little freak of nature. I found there five ferns which I had never seen in any other spot around us.

Most importantly, Tutwiler's list of ferns in the "Havana Glen" included *Asplenium ebenoides* and its purported parents, *A. platyneuron* ["Asplenium ebeneum"] and *A. rhizophyllum* ["Camptosorus"].

A quarter century later, in a paper on the habitats of rare ferns in Alabama, Underwood (1896) reported on his own visit to Havana Glen and raised doubts about the hybrid origin of *Asplenium ebenoides*:

> The glen is a deep gorge cut in a conglomerate rock, well wooded and shaded. [Several fern species are present.] But the object of our search is here in considerable quantity, in fact the commonest fern of the glen, *Asplenium ebenoides*. … Many have regarded it a hybrid, but the display of the species at Havana clearly demonstrates that it is not a hybrid at all. … It appears to be multiplying, as many young

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> plants were seen in the rock crevices. This myth of hybridity may be put aside, for *Asplenium ebenoides* is as clearly defined a species as we possess in the genus *Asplenium*. …

Soon after, Maxon (1900) reported on his own visit to "the somewhat famous locality" of Havana Glen. His conclusions contrasted markedly with Underwood's. He found *Asplenium ebenoides* to be quite abundant and *A. platyneuron* to be "common in the near vicinity," but its other supposed parent, *A. rhizophyllum*, was "not in great evidence, … though it had previously been found here in small quantity." The sheer number of individuals of *A. ebenoides*, despite the lack of one parent, raised the question in Maxon's mind "as to whether the fact of the fern's fertility effectually disposes of the supposition of its hybridity. May it not be a *fertile* hybrid?" And, "To my mind the supposition of hybridity for *A. ebenoides* is not weakened by the discovery of its evident fertility."

Slosson (1902) tested the origin of *Asplenium ebenoides* by forcing the hybridization of gametophytes of *A. platyneuron* and *A. rhizophyllum*, then comparing the characteristics of the resulting crosses to plants collected in various parts of the eastern United States and from Havana Glen (the latter collections by Underwood and Maxon). Her succinct conclusion: "Surely we have here convincing proof of the origin of *A. ebenoides*."

Wherry and Trudell (1930) reported on their 1929 expedition to Havana Glen, "the famous station where this hybrid spleenwort reproduces itself." They found *Asplenium ebenoides* to be "less abundant than in former years, [with] only about 25 adult plants being seen during an hour's search. It is, however, definitely reproducing itself by spores …" They also noted, "One of the parent ferns, *Asplenium platyneuron*, occurs sparingly on the same rocks, but no *Camptosorus* could be found in the vicinity."

Wagner (1954) determined the cytological reason behind the fertility of the Havana Glen population—and the unimportance of the lack of one parent. His studies of sterile *Asplenium ebenoides* from a Maryland population revealed "72 univalents, 36 from each of the parents." By contrast, the fertile Alabama population had "72 normal-appearing chromosome pairs," or 144 total chromosomes. Thus, the Havana Glen population is a natural and self-reproducing allotetraploid.

Finally, Wagner and Whitmire (1957) produced an allotetraploid by culturing the few unreduced, viable spores from a diploid *Asplenium* × *ebenoides* originally collected in Maryland. In their words, "The culture allopolyploid contrasts with the Alabama wild type in an ensemble of characters, both sporophytic and gametophytic"; these differences include blade texture, blade color, frond outline, width of pinnae, number of dwarf or abortive pinnae, form of pinnae margins, and the outline of gametophytic wings. As explanation, "Even seemingly trivial genetic differences where the parents are as distantly related as *Asplenium platyneuron* and *A. rhizophyllum* might be magnified in new combinations between them, and produce unexpectedly strong differences in the allopolyploids formed from different parental varieties in different localities."

Despite the above noted differences in chromosome complement, fertility, and morphology, "the sterile hybrid *Asplenium platyneuron* × *rhizophyllum* and its allopolyploid derivative" were treated together as *Asplenium ebenoides* in the recent *Flora of North America* treatment (Wagner et al. 1993).

DESCRIPTION

The description below is based on specimens from the only locality from which *Asplenium tutwilerae* has been collected to date—the well-published location near Havana in Hale County, Alabama. Generally referred to as "Havana Glen" (Walter et al. 1982), this north-south oriented ravine contains a maturing deciduous forest of various red oaks (*Quercus* spp.), beeches (*Fagus grandifolia* Ehrh.), and hickories (*Carya* spp.). The sides of the ravine are rather steep, encompassing roughly 30 m of elevation. An intermittent stream in the ravine bottom is surrounded by dense stands of *Illicium floridanum* Ellis. Along the upper third of the west-facing slope occur outcroppings of ferruginous conglomerate rocks that contain pebbles of quartz and chert (Fig. 1A). It is in the crevices of these rocks that *A. tutwilerae* can be found.

Asplenium tutwilerae B.R. Keener & L.J. Davenport, sp. nov. **(Figs. 1B, 2)**. TYPE: U.S.A. ALABAMA: Hale Co.: Havana, growing in shaded crevices along the upper portions of sandstone conglomerate cliffs, 28 Jul 1900, *C.J. Pollard & W.R. Maxon 335* (HOLOTYPE: US; ISOTYPES: MO, NY [2], PH [2], US).

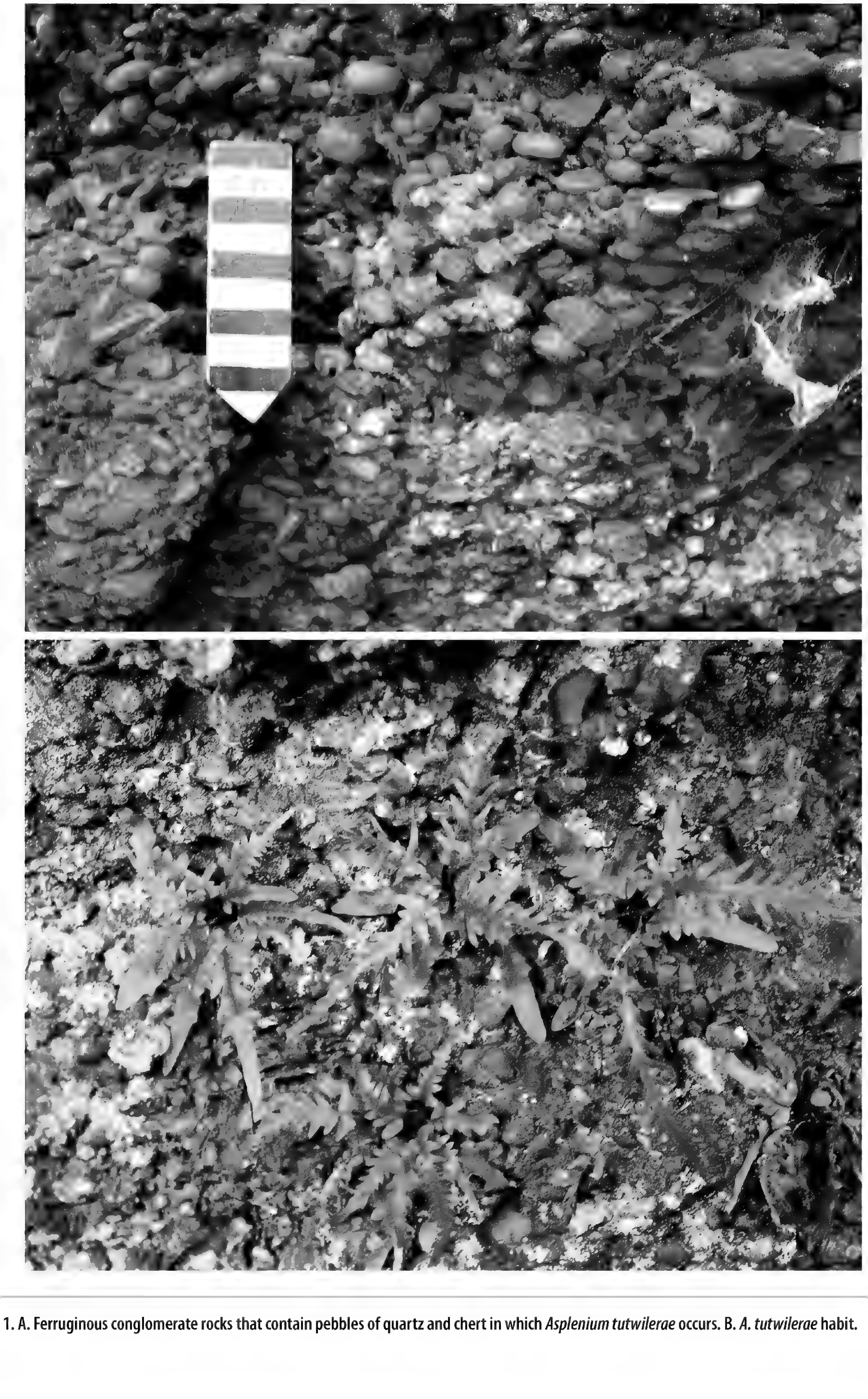

Fig. 1. A. Ferruginous conglomerate rocks that contain pebbles of quartz and chert in which *Asplenium tutwilerae* occurs. B. *A. tutwilerae* habit.

Fig. 2. Holotype (*C.L. Pollard & W.R. Maxon 335,* US) of *Asplenium tutwilerae.*

Planta inter *A. rhizophyllo* L. et *A. platyneurone* (L.) B.S.P., species e America boreali orientali; differt a *A. rhizophyllo* frondibus latioribus ad maturitatem basi pinnatis vel pinnatifidis; differt a *A. platyneurone* frondibus ad maturitatem dimidio distali pinnatifido vel integro-subintegro.

Plants epipetric. **Roots** numerous, filiform, to 6 cm long, monopodially branching. **Rhizomes** horizontal to erect, 0.5–2 cm × 0.3–0.5 cm, imbedded by adventitious roots and bases of old and current stipes, scaly near apices; scales narrowly triangular, 1–4 mm × 0.2–0.5 mm, pellucid, essentially one cell thick, with thicker brownish black secondary walls forming areolate reticulum. **Fronds** dimorphic; smaller, mostly sterile blades usually appressed to the substrate; larger, fertile blades, ascending to erect. **Stipes** castaneous to purplish brown, lustrous, proximal 1/4 scaly, distal 1/2 pubescent; scales similar to those of rhizome, reduced to linear-triangular to linear, reticulum also reduced to consist of midvein and/or cross hatchings; pubescence of clavate, orange reddish hairs; stipes of smaller fronds 0.5–2.5 cm long, recurved; stipes of larger fronds 2.0–9 cm long, ascending to erect. **Blades** extremely variable; herbage green, opaque, not leathery, pubescent; pubescence of clavate, orange reddish hairs; smaller fronds lanceolate, 2–11 cm × 1–2 cm, pinnatifid in proximal 1/2–2/3, apices long attenuated in distal 1/3–1/2, with margins irregularly lobed or entire-serrulate, occasionally pinnately compound in proximal 1/4; larger fronds lanceolate, 7–18 cm × 2–8 cm, pinnately compound in proximal 1/4–1/3, pinnatifid for middle 1/2, apices long attenuated in distal 1/4–1/3 with margins irregularly lobed or entire-serrulate, occasionally producing viable plantlets at apex. **Rachises** castaneous to purplish brown, lustrous proximally, green, dull distally, pubescent; pubescence of clavate, orange reddish hairs. **Pinnae** of smaller fronds 0–1 pairs, ovate, 0.5–0.9 cm × 0.4–0.5 cm, bases truncate, apices obtuse, margins entire; pinnae of larger fronds 1–2 pairs, lanceolate, 0.7–2 cm × 0.4–1 cm, bases truncate to auriculate, apices obtuse to acute, margins entire to crenulate-serrulate. **Segments** of smaller fronds ovate, 0.3–1 cm × 0.2–0.4 cm, apices obtuse, margins entire to crenate-serrulate; segments of larger fronds lanceolate, 0.3–5 cm × 0.3–1 cm, apices acute to obtuse, margins entire to crenulate-serrulate. **Sori** of smaller fronds when fertile, 1–3 per pinna or segment in proximal and middle portion of frond, 1 on each side of the midrib corresponding with each lobe or tooth on distal attenuated apices; sori of larger fronds, 1–18 per pinna or segment in proximal and middle portion of frond, 1 on each side of midrib corresponding with each lobe or tooth on distal attenuated apices. **Indusia** present, membraneous, attached along one margin. **Spores** 64 per sporangium. $2n = 144$.

Additional specimens examined: **UNITED STATES. ALABAMA. Hale Co.:** near Green Springs, 31 Jan 1874, *Prof. Tutwiler s.n.* (NY); northern Alabama, 1877, *Miss Tutwiler s.n.* (MO); near Havana, 20 Mar 1878, *E.A. Smith 20* (UNA [2], US [2]); Havana, 1884, *J.W.A. Wright s.n.* (NY); Aug 1890, *J.W.A. Wright s.n.* (PH); Near Havana, 16 May 1896, *L.M. Underwood s.n.* (MO [2], NY [3], US); rocky glen, Havana, 21 Dec 1898, *W. Trelease 326798* (MO); Havana, Jan 1905, *Whatley s.n.* (UNA); near Havana, Mar 1907, *J.W. Moreland s.n.* (PH); one mi N of Havana, 9 May 1929, *E.T. Wherry s.n.* (US); Havana, 11 Jul 1953, *C. O'Kelley & R. Chermock s.n.* (UNA); Havana Fern Glen, ca. 1 air mi N of Havana, 26 Jul 2006, *B.R. Keener 3023 with L.J. Davenport, R. Cobb, & N. Cobb* (UNA).

DISCUSSION

The name *Asplenium* × *ebenoides* has been misapplied to the Havana Glen population since its discovery in the latter half of the 19th century. In a summary paper published 15 years after his determination of the allotetraploid nature of that population, Wagner (1969) argued for a "single, simple approach" to the naming of hybrids, "such as using the hybrid binomial. … *The question of whether a given hybrid is 'fertile' or 'sterile,' diploid or polyploid, is not pertinent* [emphasis added]." We, however, argue just the opposite: The Havana Glen population of *Asplenium tutwilerae* is sexually viable and on its own evolutionary track; therefore, it should be recognized as a distinct species separate from *A.* × *ebenoides*.

Asplenium tutwilerae qualifies as a distinct species under the Biological Species Concept (Mayr 1963) due to its being a sexually reproducing population that is reproductively isolated. It also qualifies under various phylogenetic species concepts in that it represents a distinct and unique monophyletic lineage (Baum & Donoghue 1995; Mayden 1997).

Reticulate evolution by means of a hybridization event has been well documented in the genus *Asplenium* (Smith & Levin 1963; Wagner 1954; Werth et al. 1985b). Two other Aspleniums that have arisen in a fashion similar to *Asplenium tutwilerae* are currently designated as distinct species, *A. pinnatifidum* Nuttall and *A. bradleyi* D.C. Eaton (Wagner et al. 1993). It is worth noting that both of these are believed to have originated in more than one location (Werth et al. 1985a) while *A. tutwilerae* is known currently to have a single origin.

With a single origin and a single population, *Asplenium tutwilerae* immediately assumes its place as one of the rarest fern species in the world. Efforts must begin to insure its preservation.

ACKNOWLEDGMENTS

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RELATIONSHIPS OF *HOUSTONIA PROSTRATA* (RUBIACEAE) OF MEXICO AND ARIZONA AND A REVIEW OF *HOUSTONIA* SUBGENERA AND SECTIONS

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ABSTRACT

Houstonia prostrata, a species discovered in 1899, has been collected in Baja California, Sinaloa, Sonora, Mexico and Cochise Co., Arizona. Its relationships have been problematical for many years. Comparisons of seed and pollen morphology in *Houstonia* and *Hedyotis* species and in *Lucya tetrandra* support recognition of *Houstonia prostrata* as the type species of a new monotypic subgenus, *Houstonia* subgenus *Porotis,* named for the unique numerous and regularly-arranged pores in the seed testa. Review of previously named subgenera and sections in *Houstonia* indicates that the subgenus *Chamisme* should be restricted to the *Houstonia purpurea* L. group of four species. The group of ten Mexican and southwestern United States species is recognized as *Houstonia* subgenus *Ericotis*.

RESUMEN

Houstonia prostrata, una especie descubierta en 1899, se ha recogido en Baja California, Sinaloa, Sonora, México y Cochise Co., Arizona. Sus relaciones han sido problemáticas durante muchos años. Basados en comparaciones de la morfología de la semilla y del polen en especies de *Houstonia* y de *Hedyotis* y en *Lucya tetrandra* se concluye que merece el reconocimiento como especie tipo de un nuevo subgénero monotípico, *Houstonia* subgénero *Porotis*, nombrado así por los únicos poros testales numerosos y regularmente dispuestos de la semilla. La revisión de subgéneros y de secciones previamente nombrados en *Houstonia* indica que el subgénero *Chamisme* se debe restringir al grupo de *Houstonia purpurea* L. de cuatro especies. El grupo de diez especies mexicanas y del sudoeste de Estados Unidos se reconoce como *Houstonia* subgénero *Ericotis*.

INTRODUCTION

Houstonia prostrata Brandegee is an annual herb native to Baja California Sur, Sinaloa, and Sonora, México, and Cochise County, Arizona. It was first collected by T.S. Brandegee in Baja California Sur in 1899, and no other new collections from Baja are known to the present writer. In 1904 Brandegee collected and described another new species, *Houstonia parvula*, in Sinaloa. Standley (1918), in treating the North American flora, placed *Houstonia parvula* in synonymy under *Houstonia prostrata*. Shreve and Wiggins (1964) in their Sonoran Desert flora treated the two species as varieties: *Houstonia prostrata* var. *prostrata* with branches prostrate, internodes shorter than leaves, leaves mostly sessile, and var. *parvula* with branches erect, internodes mostly equaling or exceeding leaves, leaves mostly short-petiolate. My study of the types (Figs. 1, 2) and other collections indicates that these differences are minor and overlap greatly, consequently, I have not recognized varieties and have treated the two species as one under the older species name. *Houstonia prostrata* has also been found in Sonora, and was collected in 1971 in the United States by Mason, Canfield, and Gilbertson who found it in Guadeloupe Canyon, Cochise Co., Arizona.

MORPHOLOGY AND TAXONOMY

In recent years *Houstonia prostrata* has been treated as *Hedyotis vegrandis* W.H. Lewis, a new name under *Hedyotis* necessitated by a prior use of the name *Hedyotis prostrata* (see nomenclature below).

The question of the circumscription of *Hedyotis* has been a knotty problem for many years (reviewed by Terrell 1996:16). Seed and capsule characters along with chromosome numbers and pollen morphology are important in the classification of the tribe Hedyotideae and were used in several papers by Terrell and

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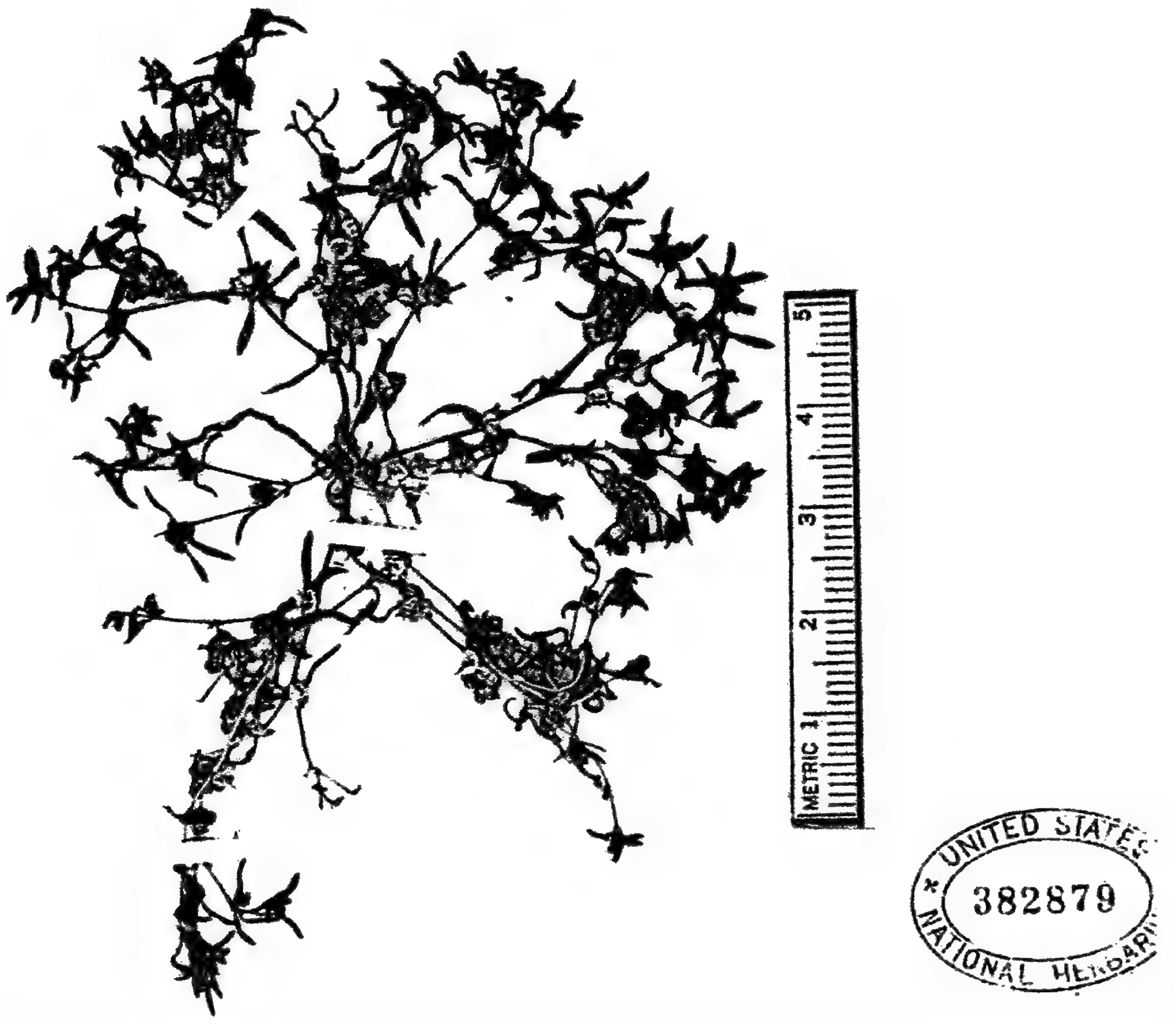

Fig. 1. Isotype of *Houstonia prostrata* Brandegee (US-382879).

collaborators.The seed and capsule characters proved valuable in establishing tribal (Terrell and Wunderlin 2002) and other taxonomic limits (Robbrecht 1989; Terrell et al. 2005) in the Hedyotideae. Extensive variation in seed structure adds to the impression that the genus *Hedyotis* has been too broadly circumscribed in the past. *Hedyotis* subgenus *Hedyotis* includes its type species, *H. fruticosa* L., native to Sri Lanka and southern India. This species and a number of similar Asian and Pacific species are recognized by their capsule and seed morphology (Terrell and Robinson 2003). Twenty-one Hawaiian species formerly in *Hedyotis* were placed in the resurrected genus *Kadua* (Terrell et al. 2005). I now recognize *Hedyotis* species as having seeds without ventral depressions and with a prominent hilar ridge on an otherwise level or convex ventral face. In contrast, *Houstonia prostrata* has a large ventral depression containing a hilar ridge, consequently, it is here excluded from the genus *Hedyotis*.

In a molecular study of *Houstonia* Church (2003) grouped *Houstonia prostrata* with *Stenotis*, a genus with seven species in Baja California (Terrell 2001, formerly in *Hedyotis*), and the monotypic genus *Carterella* (Terrell 1987). The molecular data disagree with the current morphological data on *Stenotis* and *Carterella*, which are so different in morphology from *H. prostrata* that I do not mention them in the present study. Church concluded that the phylogenetic placement and taxonomic status of *Houstonia prostrata* “should be reviewed more thoroughly before including it in *Hedyotis* or *Stenotis*.” I am in agreement with this statement

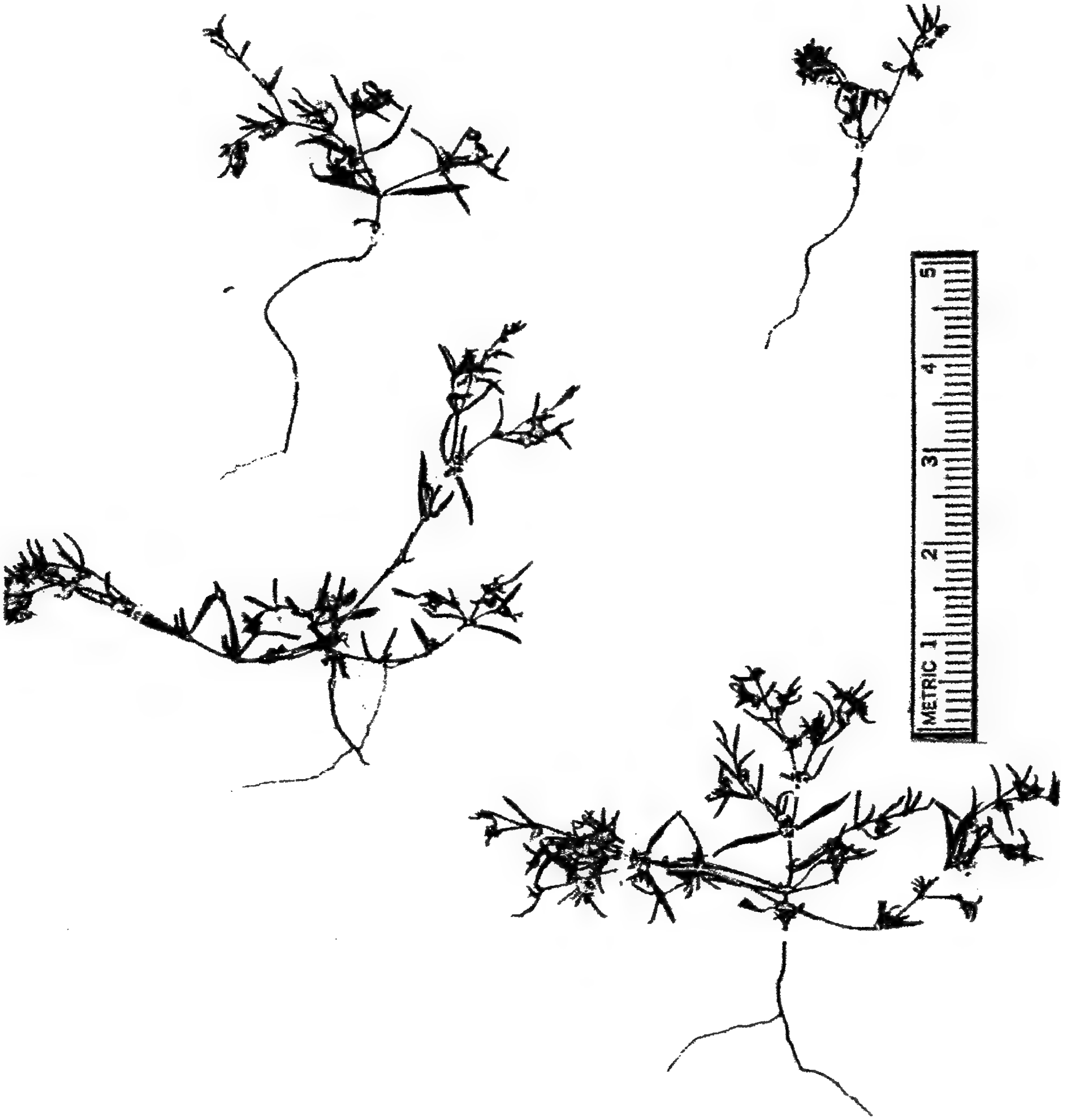

Fig. 2. Isotype of *Houstonia parvula* Brandegee (US-571999).

and believe that both morphology and molecular data are important and should be utilized in taxonomic studies.

Comparison of *Houstonia prostrata* seeds with seeds of previously examined Hedyotideae revealed only three genera having hilar ridges in ventral depressions. These are the following: (1) the Asian genus *Neanotis*, (2) *Lucya*, a monotypic genus of the West Indies, (3) *Houstonia*, a genus of 20 species occurring only in North America (Terrell 1996).

Neanotis was compared with *Hedyotis* (sens. lat. incl. *Houstonia*) by Lewis (1966). He found that *Neanotis* pollen was 5–12 aperturate, whereas *Hedyotis* pollen was 3 or 4 aperturate. He also listed five other differences in the pollen of the two genera and concluded that *Neanotis* was fully distinct from *Hedyotis*. His conclusions are accepted here.

The second genus for comparison with *Houstonia prostrata* is the monotypic genus *Lucya* (Table 1). *Lucya tetrandra* occurs on rock outcrops and similar habitats in Puerto Rico, Cuba, Dominican Republic, Haiti, and Jamaica. It is readily distinct from *Houstonia prostrata* in habit and aspect, and in being perennial, 4–25 cm tall, with tubers and ovate or elliptic leaves, compared with *H. prostrata*, a low inconspicuous annual with oblanceolate or linear leaves (Table 1). The seeds of *Houstonia prostrata* (Fig. 3) and *Lucya* (Fig. 4) are similar in having thickened involute (rolled) margins, in being longitudinally bowed, and in having a large ventral depression. They differ in the following: *Lucya* has (1) only a scar in the ventral depression instead of a hilar ridge, (2) a testa lacking pores, whereas *H. prostrata* has numerous pores, (3)6–8 calyx lobes, a marked departure from the usual 4 lobes in all other studied taxa of this tribe, (4)6-colporate pollen compared to 3 or 4 in *Houstonia* species (based on recent data supplied by the palynologists Walter H. Lewis and Joan Nowicke). These significant basic differences lead to the conclusion that *Lucya* should be maintained as a genus distinct from *Houstonia prostrata*. The seed similarities suggest, however, that the two taxa are rather closely related.

A brief description of *Lucya* and its nomenclatural data are added below in the taxonomic treatment.

Houstonia, the third genus with seeds similar to those of *Houstonia prostrata* was monographed by Terrell (1996). A full comparison of *H. prostrata* with *Houstonia* is presented in the following review of the infrageneric taxa in *Houstonia.*

INFRAGENERIC TAXA OF *HOUSTONIA*

This genus has two subgenera and four sections as follows: *Houstonia* subgenus *Houstonia* with sections *Houstonia* and *Mullera* and subgenus *Chamisme* with sections *Amphiotis* (=*Chamisme*) and *Ericotis*. A diagnostic key to these taxa was provided by Terrell (1996: 20–21). The seeds of several of the species mentioned here are illustrated in Terrell (1996: Figs. 1–4). The infrageneric taxa are considered below in their order.

Houstonia subg. *Houstonia* includes six species that are distributed throughout much of the eastern United States, southeastern Canada, and southeastern U. S. south to Florida and eastern Texas. The type species is *H. caerulea* L., the traditional Bluets. They all have a similar aspect or habit, and are small herbs, soft-stemmed, spring-flowering, and with salverform corollas. Section *Houstonia* with five species has (1) subglobose seeds each with a circular orifice opening into a subglobose hilar cavity lacking a hilar ridge, (2) pollen 3-aperturate, (3) chromosome x = 8, except 7 in *H. procumbens* (J.F. Gmel.) Standl.. A sixth species, *H. rosea* (Raf.) Terrell in section *Mullera*, differs in having (1) seeds with a hilar ridge in a shallow depression (2) pollen 4-aperturate, (3) chromosome number x = 7 (the chromosome and pollen data from Lewis 1962, 1965). *Houstonia procumbens* differs from other species in section *Houstonia* in having a chromosome number of x = 7 and capsules widely dehiscing and sometimes separating into two halves and deflexed to the base of the capsule. Church and Taylor (2005) in molecular studies found that *H. procumbens* and *H. rosea* were genetically quite distinct from other species and are more closely related to each other than previously known. *Houstonia procumbens* is tetraploid, *H. rosea* diploid. The data suggest that it would be more accurate to include *H. procumbens* with *H. rosea* in the section *Mullera*, and this is done in the following taxonomic treatment. The subgenus *Houstonia* with its two sections hybridizes somewhat within its own subgenus (Church & Taylor 2005), but is quite distinct from all other *Houstonia* subgenera and sections.

Houstonia subg. *Chamisme* section *Amphiotis* (= section *Chamisme*) is typified by *H. purpurea* L., one of four perennial spring- and summer-flowering species with fibrous stems, funnelform corollas, and a chromosome number of x = 6. All species have seeds with a low hilar ridge in a shallow depression, entire margins, and a reticulate testa. Pollen is 3-aperturate and colpororate (Lewis in Terrell et al. 1986). The distribution of the species includes much of the eastern U. S. and a small part of southeastern Canada. This group is discrete and genetically distinct from other *Houstonia* species. Church and Taylor (2005) have provided helpful molecular evidence about hybridization within this group.

Houstonia subg. *Chamisme* section *Ericotis* includes ten species distributed in southwestern U. S. and Mexico. They are annual or perennial with corollas salverform, funnelform, or subrotate, and a chromosome

TABLE 1. Characters of *Houstonia prostrata, Lucya,* and two species of *Houstonia* subg. *Ericotis.*

	Houstonia prostrata	***Lucya tetrandra***	***Houstonia parviflora***	***Houstonia subviscosa***
Habit	annual herb	perennial with tubers	annual herb	annual herb
Stem height cm	2–9	4–25	3–20	3–30
Leaves length mm	5–14 mm	5–32 mm	5–30 mm	5–25
shape	oblanc., linear, narr.ellip.	ovate, brdly. ellip	narr. elliptic, oblanceolate	linear/oblanceolate
Styly	apparently homostylous	apparently homostylous	homostylous	homostylous
Inflor., flowers	one per node	one per node	few-flowered cymes	one per node
Pedicels length mm	sessile or to 2	1–7	to 12 or more	2–7
pedicels when fruiting	recurved	recurved	erect	recurved
Calyx lobes number	four	six to eight	four	four
Corollas length mm	1–2 mm	2.0–2.3 mm	0.8–2.5 mm	1.5–3 mm
shape	tubular	tubular	short-funnelform	short-funnelform
tubes/lobes	tubes 1–3 times longer	subequal	subequal	subequal
Anthers length mm	0.2 mm	0.2 mm	0.2–0.5 mm	0.2–0.4 mm
Capsules L/W	1.5–3.0 × 3–4	ca. 2.5 × 3–5	2–4.5 × 2.5–4.5	1.8–3.5 × 2.5–5.0
Seeds length mm	0.8–1.2	1.4–1.7	0.9–1.4	0.7–1.1
longitudinally bowed	yes	yes	no	no
shape	boat-shaped	boat-shaped	boat-shaped	saucer-shaped
depression	moderately deep	moderately deep	shallow	shallow
margins involute, thick	yes	yes	no	no
hilar ridge present	yes	no; hilar scar only	yes	yes
testa type	reticulate	reticulate	reticulate	coalescent
testa pores present	yes	none	none	none
areoles shape	polygonal	polygonal	polygonal or rounded	none
areole walls	straight, indistinct	sinuous, indistinct	straight/sinuous, distinct	coalescent

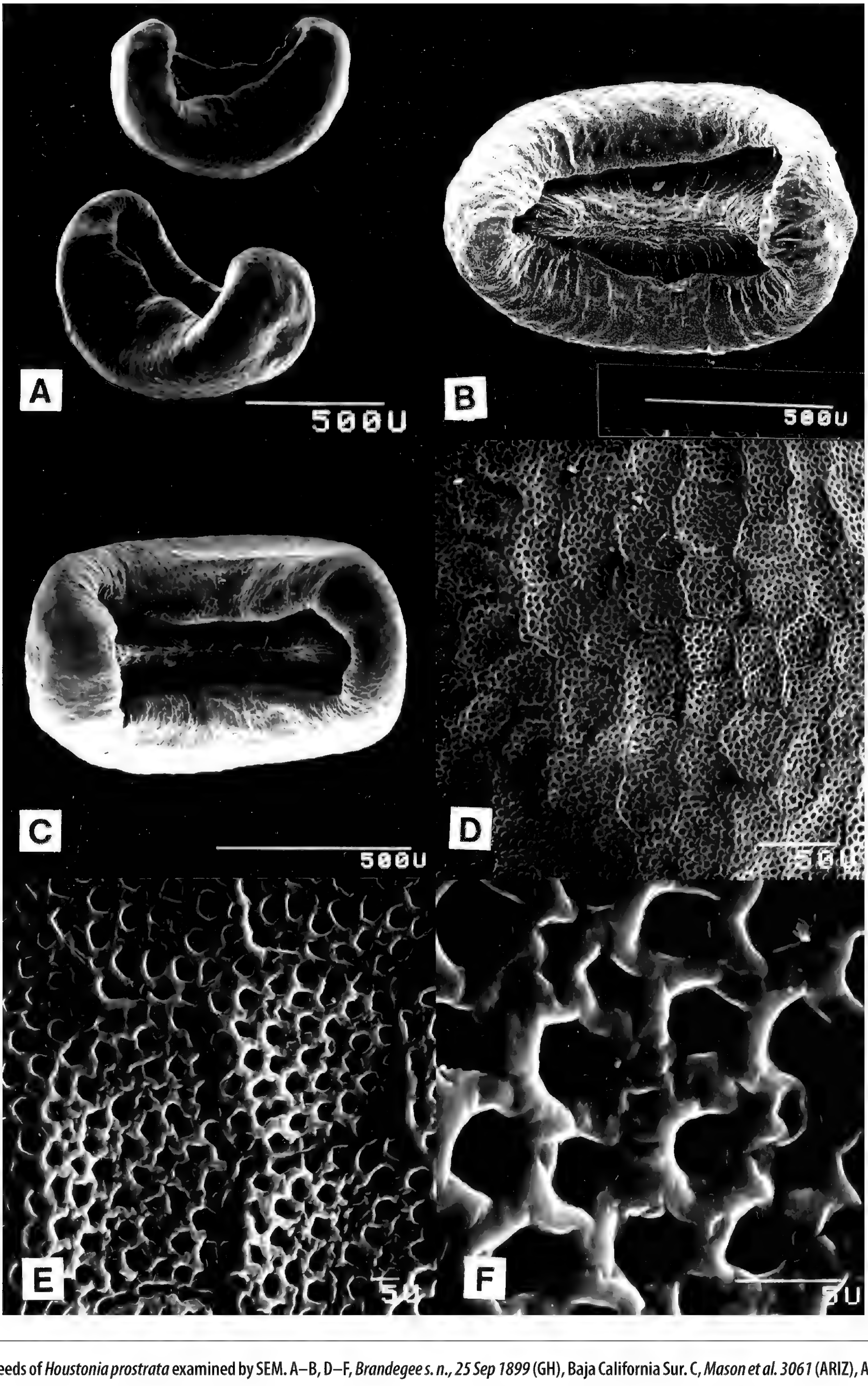

Fig. 3. Seeds of *Houstonia prostrata* examined by SEM. A–B, D–F, *Brandegee s. n., 25 Sep 1899* (GH), Baja California Sur. C, *Mason et al. 3061* (ARIZ), Arizona. A, seeds strongly longitudinally bowed. B, C, ventral face showing hilar ridge in depression and thickened rolled margin. D–F, enlargements of testa showing numerous regularly-arranged pores and areoles with low, indistinct walls. Bar scales in microns.

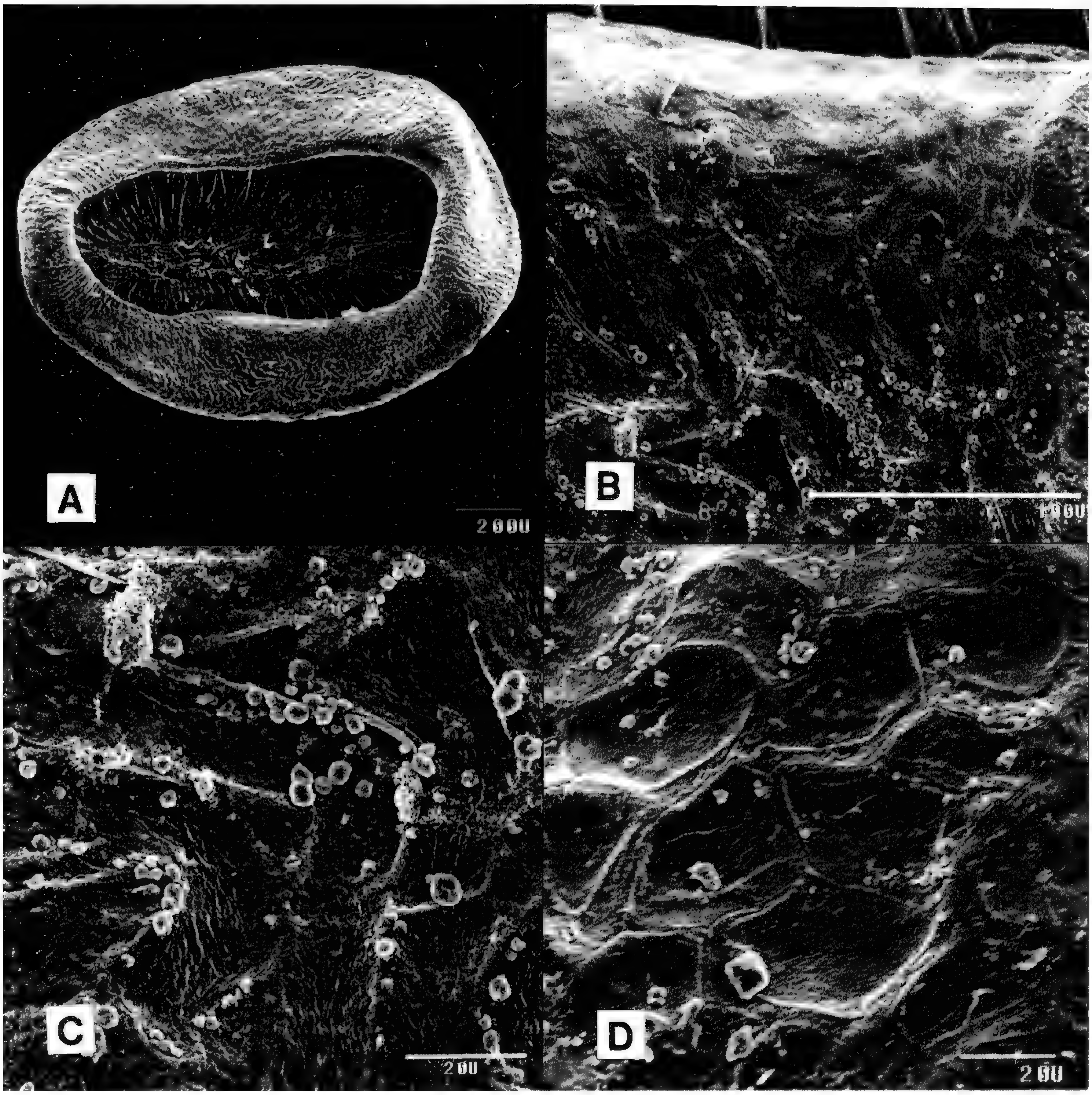

Fig. 4. Seeds of *Lucya tetrandra* examined by SEM. A–D, *Leonard & Leonard 12702* (US), Haiti. A, seed showing hilar scar and thickened rolled margin. B, zigzag areoles below rim on side of seed. C, same, enlarged. D, polygonal areoles on dorsal face of seed. Bar scales in microns.

number of x = 11 (unknown for two species). *Houstonia rubra* Cav. is the type species, noteworthy for its long (8–41 mm) corollas. Nine of the species have seeds with coalescent areoles that appear as a jumbled mass of intermixed areole walls (Terrell 1996, Figs 3d, 4d). These seeds are more complex than other *Houstonia* seeds, and have the following characters: (1) boat- or cup-shaped seeds with shallow to deep depressions, (2) margins entire or lobed and varying from thin and open to somewhat rolled and covering the edges of the depressions, (3) hilar ridges sometimes fused with margins at one end of the seed, (4) some species have a bilobed sinus at one end of the seed. Seven selected species are shown in Table 2. Church and Taylor (2005) noted the genetic distinctness among these species. The first three species headed by *H. rubra* in Table 2, have generally similar seed morphology. *Houstonia humifusa* (A. Gray) A. Gray is noteworthy for its symmetrically lobed seed margins. *Houstonia acerosa* (A. Gray) Benth. & Hook. f. and *H. wrightii* A. Gray have cupulate seeds, but otherwise are rather distinct from each other. The seventh species, *H. parviflora*

TABLE 2. Characters of seven species of *Houstonia* subgenus *Ericotis*.

	rubra	***croftiae***	***subviscosa***	***humifusa***	***acerosa***	***wrightii***	***parviflora***
Leaves fasciculote	no	no	no	no	yes	no	no
acerose	no	no	no	no	yes	no	no
Inflor. styly	heterostylous	homostylous	homostylous	heterostylous	heterostylous	heterostylous	homostylous
frtg. pedicels recurved	yes	yes	yes	yes	erect	yes	erect
fls. sessile and grouped	no	no	no	no	yes	no	no
bract-like leaves	no	no	no	no	yes	no	no
Corollas length mm	8–41	1.5–3.1	1.5–3	3.5–10	4.5–17	3.5–9.5	0.8–2.5
shape	salverform	short-funnelform	short-funnelform	funnelform	salv./subfunn.	funn./subsalv.	short-funnelform
tube longer than lobes	2–4 times	subequal	subequal	1–2 times	1–3 times	subequal	subequal
Anthers length mm	1–2.5	0.25–0.4	0.2–0.4	0.7–1.3	0.8–2.0	0.6–1.2	0.2–0.5
Stigmas lobes length	0.3–1.0	0.3–0.5	0.3–0.7	0.3–0.8	0.4–1.6	0.1–0.6	0.2–0.3
shape	oblong/subglob.	linear	linear	ellip./oblong	linear/narr. obl.	oblong/subglob.	broadly elliptic
Capsules extent inferior	1/8–1/3	1/6–1/2	½–4/5	1/5–1/2	1/2–4/5	1/8–1/2	2/5–4/5
Seeds length mm	0.8–2.1	0.9–1.4	0.7–1.1	0.9–1.6	0.5–1.5	0.7–1.7	0.9–1.4
shape	saucer-shaped	saucer	saucer	boat-shaped	cup-shaped	boat/cup	boat
contorted?	no	no	no	no	strong	moderate	no
depression	shallow	shallow	shallow	medium deep	deep	medium.deep	shallow
margins upturned	slight	slight	slight	moderate	strong	strong	moderate
margins lobed	no	no	no	yes	irregularly	no	no
bilobed sinus at ridge end	yes	yes	yes	yes	none	yes?	none
testa	coalesced	coalesced	coalesced	coalesced	coalesced	coalesced	reticulate

Holz. ex Greenm., endemic to southeastern Texas, differs from the others in having reticulate testas and polygonal areoles, however, its other characteristics, including chromosome number, resemble the other nine species. Pollen in section *Ericotis* is 3-colporate and colpororate (Lewis in Terrell et al. 1986). The group includes considerable variation among species but is fully distinct morphologically and genetically from the other subgenera and sections.

The previous discussion of *Lucya* compared to *H. prostrata* (Table 1) concluded that the two taxa are similar in two unusual seed characters, but have basic differences in pollen and calyx lobes; consequently, *Lucya* remains a distinct monotypic genus.

Two of the section *Ericotis* species, *H. subviscosa* (A. Gray) A. Gray and *H. parviflora*, differing in their seed morphology, are included in Table 1 for direct comparison with *Houstonia prostrata* and *Lucya tetrandra*. Several morphological characters are rather similar among these species (see also Table 2). Nine of the section *Ericotis* species have seeds with coalescent areoles, a character absent in *H. prostrata*. The tenth species, *H. parviflora*, does not have seeds like *H. prostrata*.

It is concluded that the general resemblances of *Houstonia prostrata* are to *Houstonia*, e.g., it has a seed with a ventral depression containing a hilar ridge and 3-colporate pollen. It has other resemblances as documented in the tables. The specialized characters peculiar to *H. prostrata* are the following: (1) seeds longitudinally bent, (2) margins conspicuously thickened and involute, (3) testa with numerous conspicuous regularly-arranged pores. (The first two of these characters also occur in *Lucya tetrandra*). The presence of numerous pores in *Houstonia prostrata* is considered especially significant, as pores have never been found in any other hedyotoid genus studied thus far. *Houstonia prostrata* is a clearly marked and distinctive new subgenus of *Houstonia*, here termed as subgenus *Porotis* emphasizing its unique testal pores. The following paragraphs document its nomenclatural and taxonomic characters.

TAXONOMIC TREATMENT

The preceding outline of the subgenera and sections follows the classification devised previously (Terrell 1996), however, it has become apparent that the sections *Amphiotis* (*Chamisme*) and *Ericotis* are fully distinct and do not belong in the same subgenus. I had in 1991 treated *Ericotis* as a subgenus, and this combination appears below as a restoration of an earlier combination. The four subgenera are listed below. Sections are recognized only in *Houstonia* subg. *Houstonia*.

1. **Houstonia** L. subgenus **Houstonia**, Sp. Pl. 1:105. 1753. Lectotype: *Houstonia caerulea* L. Six species. Section *Houstonia* with four species, Section *Mullera* Terrell with two species.
2. **Houstonia** subgenus **Chamisme** Rafinesque, Ann. Gen. Sci. Phys. 5:227.1820. Lectotype: *Houstonia purpurea* L. Four species.
3. **Houstonia** subgenus **Ericotis** Terrell, Phytologia 71:219.1991. Type: *Houstonia rubra* Cav. Ten species.
4. **Houstonia** subgenus **Porotis** Terrell, subg. nov. Basionym: *Houstonia prostrata* Brandegee, Zoe 5:105.1901. Type: *Houstonia prostrata.*

Plantae parvae herbaceae annuae; corollae 1–2 mm longae tubulares; capsulae 3/4 inferiores longitudinaliter dehiscentes; semina longitudinaliter curvata cymbiformia margine involuta, hilis linearibus in cavis prominentibus; testa in parietibus cellularum minute multe porifera.

Plants small annual herbs, corollas 1–2 mm long, tubular, capsules 3/4 inferior, dehiscing loculicidally, seeds longitudinally bent, cymbiform, margin involute, linear hilar ridge in a ventral depression, testa with numerous minute pores.

Etymology.—*Porotis* is a name derived from poro, pore, and -otis, ear.

HOUSTONIA PROSTRATA

Houstonia prostrata Brandegee, Zoe 5:105.1901. *Hedyotis vegrandis* W.H. Lewis, Rhodora 63:222.1961, nom. nov., non *Hedyotis prostrata* Korthals, Nederl. Kruidk. Arch. 2, 2:160.1851. *Houstonia prostrata* var. *prostrata* Wiggins in Shreve & Wiggins, Veg. Fl. Sonoran Desert 2:1399.1964. Type: MEXICO. Baja California Sur: on clean sand of dry stream, resembling a prostrate *Euphorbia*, La Palma, Cape Region, 25 Sep 1899, *T.S.Brandegee s.n*, (lectotype: UC!; isotypes: GH!, NY! US-2!). (Fig. 1 isotype US-382879).

Houstonia parvula Brandegee, Zoe 5:221.1905, non ***Hedyotis parvula*** (A. Gray) Fosb., Bishop Mus. Bull. Bot. 174:54.1943. ***Hedyotis sinaloae*** W.H. Lewis, Rhodora 63:222. 1961, nom. nov. ***Houstonia prostrata*** var. ***parvula*** (Brandegee) Wiggins, in Shreve & Wiggins, Veg. Fl. Sonoran Desert 2:1399.1964. TYPE: MEXICO. SINALOA: Gravel deposits of Tamazula River near Culiacan, 12 Oct 1904, ***T.S. Brandegee s.n.*** (LECTOTYPE: UC!; ISOTYPES: GH-2!, MO!, NY!, US-2!). (Fig. 2 isotype US-571999).

Small annual herb (Table 1). Stems 2–9 cm tall, slender, erect or prostrate and matted, minutely whitish papillose-puberulent to glabrate. Leaves 5–14 × 0.5–2.5 mm, sessile or short-petiolate, narrowly oblanceolate, linear, narrowly elliptic, or narrowly oblong, minutely papillose above, glabrous or minutely papillose beneath, margins often revolute, apices obtuse or acute. Stipules to ca. 1 mm × ca. 2 mm, scarious, deltate, margins with 1–few sometimes gland-tipped teeth. Flowers apparently homostylous, one per node, subsessile or on pedicels to 2 mm long, becoming recurved at fruiting stage. Hypanthium (calyx cup) puberulent or scaberulous; calyx lobes numbering 4, to ca.1 × ca. 0.6 mm, lanceolate or deltate. Corollas 1–2 mm long, tubular, white or apices of lobes tinged with purple; tubes 0.5–1.5 mm long; lobes ca. 0.5 mm long, usually shorter than tube; anthers ca. 0.2 mm long, elliptic, inserted at mouth of tube; stigmas included in tube, not seen. Capsules 1.5–3.0 × 3–4 mm, wider than long, 3/4 inferior, thin-walled, fragile, 2-locular, glabrous or minutely papillose, dehiscing widely loculicidally and splitting the septum. Seeds (Fig. 3) 4–10 or more per capsule, 0.8–1.2 × 0.5–0.7 mm, black, somewhat compressed dorsiventrally, longitudinally bowed, cymbiform, in outline broadly elliptic, elliptic, or oblong, dorsal face rounded, ventral face with a moderately deep elliptic depression, margin entire or slightly wavy, thickened, involute or inrolled, linear hilar ridge centered in depression and 2/3–4/5 as long as seed, ridge ends sometimes slightly enlarged, areoles polygonal, with low, indistinct walls, testa with numerous minute pores (Fig. 3D-F). Terrell (1986 et al., Figs. 7, 8) illustrated the pollen of *Houstonia prostrata* with the numerous pores (the contribution of Joan Nowicke), and data supplied by Lewis in that paper noted that *H. prostrata* pollen has colporate type A, the most common type in the Rubiaceae and a generalized type from which species with more specialized pollen may have evolved. The chromosome number for *Houstonia prostrata* is not known. Flowering August to October.

Distribution.—Stream beds, gravel deposits, llanos; México: Baja California Sur (Cape Region), Sinaloa, and western Sonora; United States: Cochise Co., Arizona.

Additional collections. **MEXICO. SONORA:** *Olneya-Prosopis-Cercidium* llano, 27 mi W of Hermosillo on road to Kino Bay, 28 Aug 1941, *I.L. Wiggins & R.C. Rollins 135* (ARIZ! CAS! DS! GH!, MICH!, MO!, NY!). **UNITED STATES. ARIZONA. Cochise Co.;** in gravel-filled depression on rock outcrop above stream, Guadeloupe Canyon, in southeasternmost corner of county and state, 25 Aug 1971, *C.T. Mason, E.Canfield, R.Gilbertson 3061* (ARIZ!).

LUCYA

Lucya DC., Prodr. 4:343.1830, nom. cons. (ICBN 2000). TYPE SPECIES: *Lucya tetrandra* (L.) K.Schumann, in Engl. & Prantl, Nat. Pflanzenf. 4(4):27.1891. *Peplis tetrandra* L., Amoen. Acad. 5:413.1759. *Lucya tuberosa* DC., Prodr. 4:434.1830, nom. illeg. (fide ICBN 2000).

This limited description is based on 25 collections loaned from herbaria and descriptions in floras.

Small perennial herb (Table 1) with tubers to ca. 7 mm wide. Stems 4–25 cm tall, slender, erect, spreading, or prostrate, glabrous or pubescent. Leaves with petioles to ca. 5 mm long, blades 5–32 × 4–17 mm, ovate, broadly ovate, or broadly elliptic, tapering or broadly rounded at base, glabrous or pubescent to densely hirsute, sometimes with flattened hairs, apices usually obtuse. Stipules to ca. 1–2 mm long and wide, apices sometimes with short teeth. Flowers apparently homostylous, usually one per node, on filiform pedicels 1–7 mm long, erect, spreading or in fruit recurved. Hypanthium (calyx cup) glabrous to densely hirsute; calyx lobes numbering 6–8, to ca. 1 mm long, linear or shortly lanceolate, glabrous or ciliate. Corollas 2.0–2.3 mm long, tubular, white; tubes ca.1 mm long; lobes ca.1 mm long, ovate, glabrous; anthers 0.2 mm long, elliptic, inserted at mouth of tube; stigmas included in tube, not seen. Capsules 2.5 × 3–5 mm, wider than long, 3/4 inferior, thin-walled, 2-locular, glabrous, sparsely pubescent, or hirsute, dehiscing widely loculicidally and halves becoming completely deflexed. Seeds (Fig. 4) usually ca. 5–8 per capsule, 1.4–1.7 × 0.9–1.4 mm, black or dark brown, somewhat compressed dorsiventrally, longitudinally bowed, cymbiform, in outline broadly elliptic, elliptic, oblong, or suborbicular, dorsal face rounded, ventral face with a rather deep elliptic depression, margin thickened, involute or inrolled, hilar scar centered in depression, dorsal face and ventral rim with areole walls polygonal, sinuous or zigzag, low and distinct or indistinct, testa surface irregularly rough, lacking pores.

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BOOK REVIEWS

John O. Sawyer. 2006. **Northwest California: A Natural History.** (ISBN 0-520-23286-0, hbk.). The University of California Press, Berkeley, CA 94704, U.S.A. (**Orders:** California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A., www.ucpress.edu, 609-883-1759, 609-883-7413 fax). $75.00, 247 pp., 26 color illustrations, 17 maps, 23 tables, 6" × 9".

John Sawyer has been interested in the mountains of northwest California since before he arrived at Humboldt State College in 1966 and has studied them ever since. This book is an answer to his question "Why does this area look that way?" As a plant ecologist his interests extended those of the conifers and the vegetation pattern.

The first two chapters cover the craggy Klamath Mountains and the rolling hills of the North Coast and highlight many specific places, especially the national and state parks and wilderness areas, well worth visiting. A cautionary theme regarding visiting these areas resounds through the book. Private (and public) lands may hide marijuana gardens. Stay on the roads, respect owners rights, and heed the "No Trespassing" signs. The following chapters deal with geological history and the changing roles of fire and land use. He illustrates how the region, in many ways the least modified portion of the state, is a place where many plants and animals have been shielded from extinction. The last chapter concerns the biological future of northwest California. Nearly all of the plant and animal species remain, as do the original vegetation patterns. Saving the wildlands that have been degraded and restoring them by setting them aside can be done. The fragments of natural tapestries can be made complete again.

His selected readings are divided by chapter, sub-divided by subject or topic within each chapter and cites the literature mentioned in the text. Of interest is his inclusion of internet sources and unpublished works. The unpublished works, theses and dissertations, are the fruit of the labors of many of his graduate students.

An index to plant names follows the bibliography. The names follow *A Checklist of the Vascular Plants of Northwestern California*, John O. Sawyer and James P. Smith. The latest edition is available at the Humboldt State University Herbarium web site. His list includes many recent nomenclatural and taxonomic changes, so the scientific names may differ from those in *The Jepson Manual*.

This remarkable volume is informative and engaging. It is a comprehensive natural history of the area and is recommended for all libraries interested in the region. John O. Sawyer is Professor of Botany, Emeritus, at Humboldt State University. Among his previous books are *Trees and Shrubs of California*, from University of California Press (2001), *Ecology and Restoration of Northern California Coastal Dunes* (1998), *Manual of California Vegetation* (1995), and numerous ecological surveys of northwestern California.—*Gary Jennings, Library, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

Neil G. Sugihara, Jan W. van Wagtendonk, Kevin E. Shaffer, Jo Kauman, and Andrea E. Thode (eds.). **Fire in California's Ecosystems.** (ISBN 978-0-520-24605-5, hbk.). The University of California Press, Berkeley, CA 94704, U.S.A. (**Orders:** California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A., www.ucpress.edu, 609-883-1759, 609-883-7413 fax). $75.00, 612 pp., 100 b/w photographs, 100 line illustrations, 8½" × 11".

Pyrodiversity promotes biological diversity. Pyrodiversity is important in ecosystems where variation of fire severity provides much of the fine-scale habitat variability. Fire is both an integral natural process in the California landscape and a growing threat to its urban and suburban developments as they encroach on wildlands. Managing the balance between fire suppression, prevention, and use is critical. This book provides an overview of the tools needed to manage that balance.

This text is laid out with the meat of the book in three parts. Part I introduces the basics of fire ecology. It includes an historical overview of fire, vegetation, and climate in California; overviews of fire as a physical and ecological process; and reviews the interactions between fire and the physical, plant, and animal components of the environment. Part II explores the history and ecology of fire in each of California's nine bioregions. Each has its own unique situation. Part III examines fire management in California, including both Native American and post-European settlement; discusses current issues related to fire policy and management, including air quality, watershed management, invasive plant species, native species, and fuel management; and considers the future of fire management. Three appendices follow covering: Plant common and scientific names; Animal common and scientific names; and, Bioregions, ecological zones, and plant alliances of California that occur is this text. A glossary and index complete the work.

This comprehensive volume, both a text and an authoritative reference tool, is the first to synthesize our knowledge of the science, ecology, and management of fire in California. It will be a useful tool for biologists seeking to develop effective management measures to maintain fire-dependent ecosystems. It will be equally useful to resource managers who are concerned with the appropriate application of fire ecology management and with intelligent, cost-effective fire suppression.—*Gary Jennings, Library, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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A NEW VARIETY OF *HUMBOLDTIA* (FABACEAE: CAESALPINIOIDEAE) FROM THE WESTERN GHATS OF INDIA

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ABSTRACT

A new variety **Humboldtia brunonis** Wall. var. **raktapushpa** P.S. Udayan, K.V. Tushar & Satheesh George is described and illustrated from India.

RESUMEN

Se describe y se ilustra una nueva variedad, **Humboldtia brunonis** Wall. var. **raktapushpa** P.S. Udayan, K.V. Tushar & Satheesh George de la India.

The genus *Humboldtia* Vahl is known to have six species and one variety (Sanjappa 1986) mostly confined to the Western Ghats of India with one species (*Humboldtia laurifolia* Vahl) extending to Sri Lanka. During the course of floristic exploration along the Western Ghats of Kerala in South India, the authors collected interesting specimens of *H. brunonis* Wall. On closer examination it turned out to be an undescribed taxon which is described here as a new variety.

DESCRIPTION OF THE SPECIES

Humboldtia brunonis Wall. var. **raktapushpa** P.S. Udayan, K.V. Tushar & Satheesh George, var. nov. (**Figs. 1–3**). Type: INDIA. Kerala. Kozhikode District: Kakkayam, 11° 33' N 75° 55' E ± 750 m elev., 08 Jan 2003 (fl), *P.S. Udayan, K.V. Tushar & Satheesh George 01067* (holotype: BRIT; isotypes: CAL, CALI, L, MH).

Differt a *H. brunonis* var. *brunonis* inflorescentiae late caramesinus rubra, sepalis erectis, petalis anguste obovatis, staminum filamentis crasso 11 mm longis, staminodiis 3, globosis brevis alternalibus.

Differs from *H. brunonis* var. *brunonis* by its much congested, bright crimson-red inflorescence, erect sepals, narrowly obovate petals; staminal filaments 11 mm long, stout, alternating with 5, short, globose staminodes.

Shrubs to small trees, 4–6 m high and to 40 cm gbh, bark grayish-black, coarsely fissured; branchlets light brown, glabrous solid, sometimes swollen; stipules lanceolate, 2–4 × 0.5–1.5 cm, prominently parallel veined, glabrous; appendages 2, similar, 1 × 0.5 cm, reniform, prominently veined, glabrous, persistent; leaves alternate, pinnately 4-foliolate, subsessile, up to 25 cm long; rachis up to 5.5 cm long, obscurely winged, shallowly canaliculated above, glabrous, young rachis brown tomentose; leaflets bijugate; lamina 8.5–16 × 2.5–5 cm, chartaceous to thinly coriaceous, elliptic-lanceolate, obtusely acuminate at apex, inequilateral at base; lateral veins 6–8 pairs, prominently reticulate below, dark green above and pale beneath, the margins entire, grayish when dry, glabrous, young leaves drooping, coppery brown, brownish pubescent beneath, glabrous above; inflorescence erect, 3–7 cm long, axillary racemes; peduncles 1–3 cm, brown pubescent, up to 50-flowered, floriferous axis up to 6 cm; flowers ca 2 cm long, pedicels 5–7 mm long, pilose, bracts ovate, acute, 3 × 2 mm, with a gland at the middle, light brown pubescent; bracteoles 2, 4 × 3 mm, ovate-obovate, with a gland at the middle, obtuse at apex, with a pinkish midvein, brown pubescent, ciliate along margin; calyx tube ca 1–2 mm long, brownish tomentose; lobes 4, 5 × 3 mm, ovate, concave, imbricate, obtuse at

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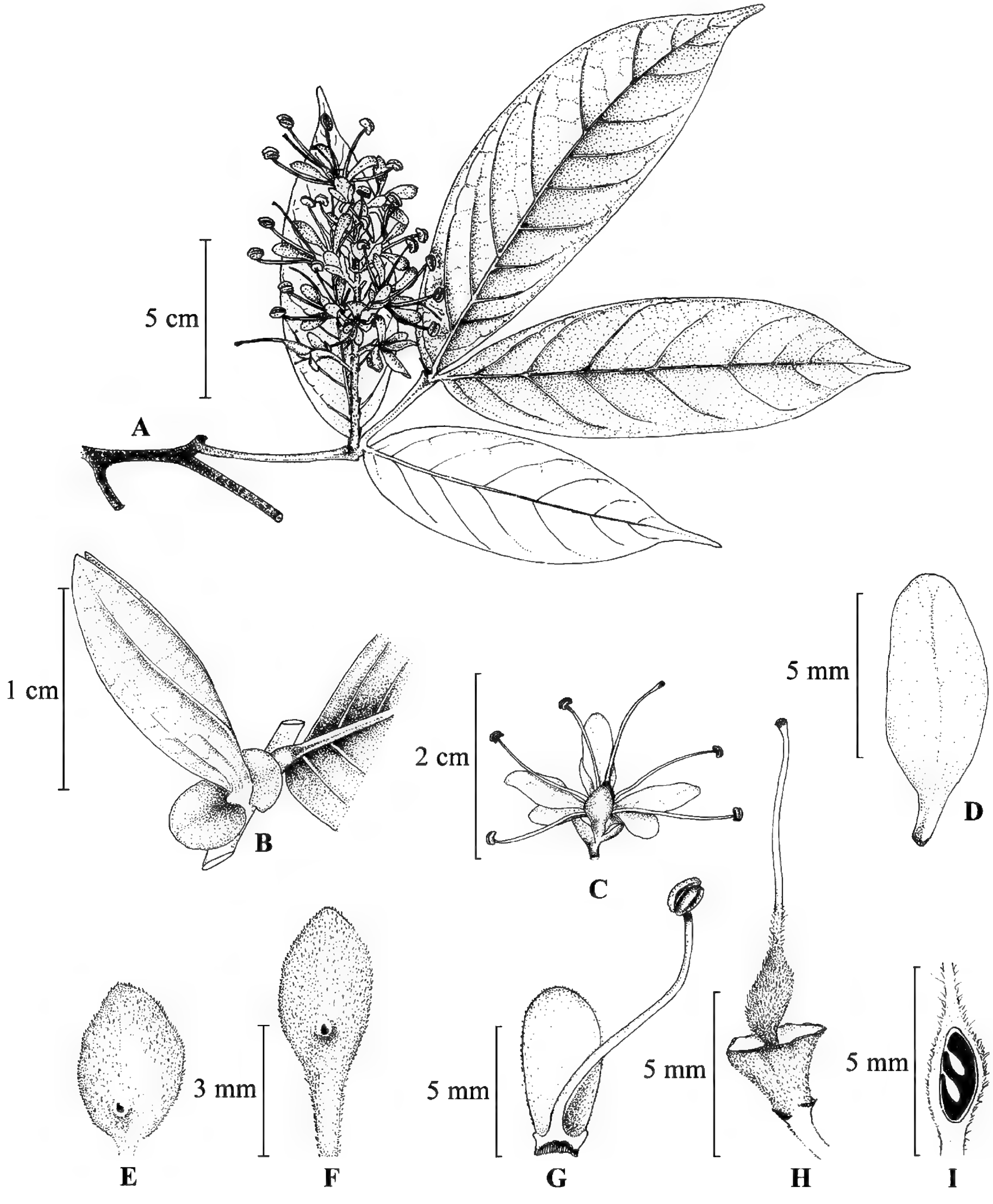

Fig. 1. *Humboldtia burnonis* var. *raktapushpa*. A. Flowering branch. B. A portion of young stem showing stipule. C. Flower. D. Petal. E. Bract. F. Bracteole. G. Sepal with a stamen. H. Pistil. I. Longitudinal section of ovary.

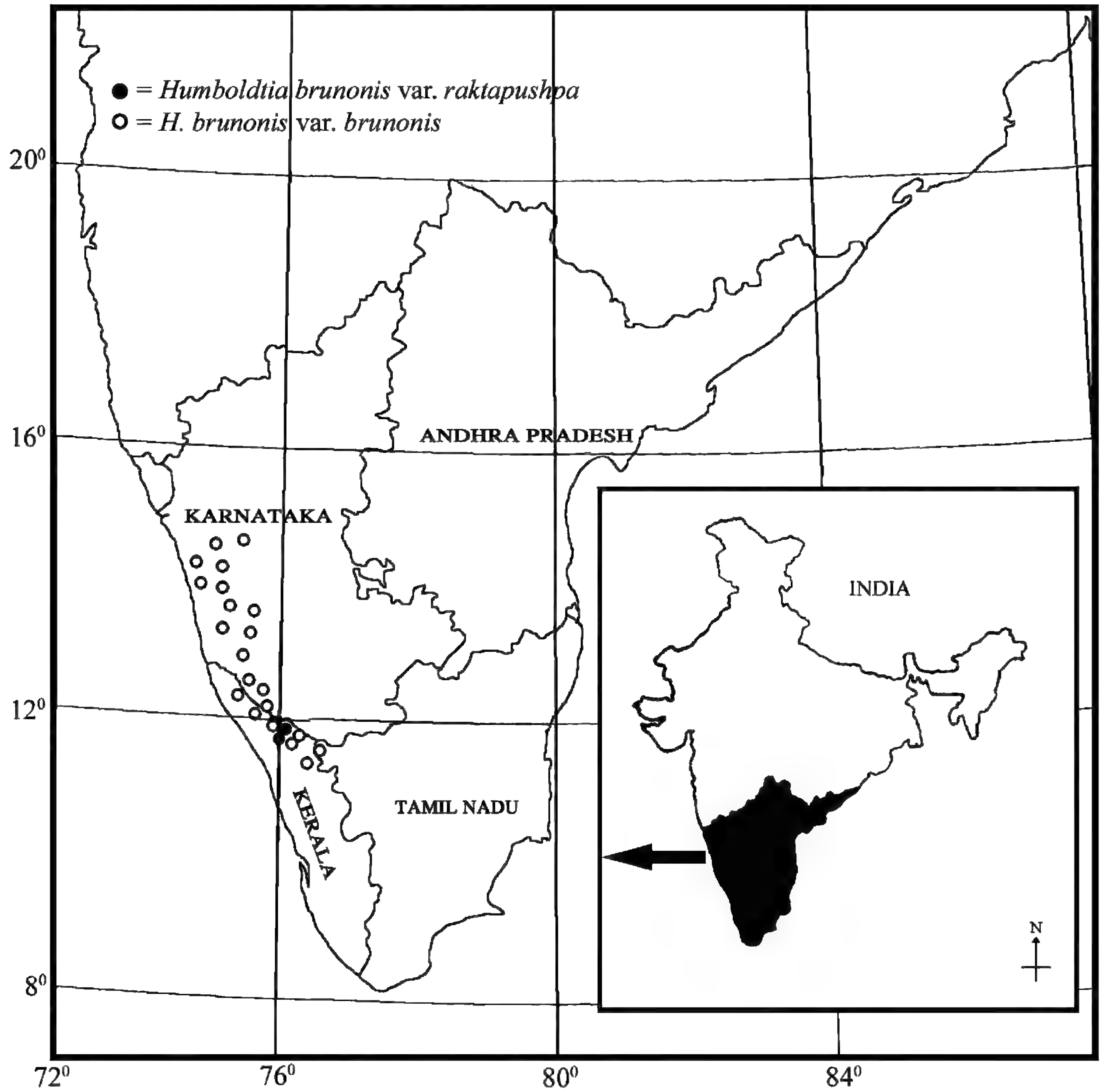

Fig. 2. Distribution of *Humboldtia brunonis* var. *raktapushpa* (= ●) and *H. brunonis* var. *brunonis* (= ○).

tip, brown pubescent, reddish; petals 3, bright crimson-red, obovate, 0.6–0.8 cm long, clawed, claws ca 1.5 mm long, prominently nerved, glabrous; stamens 5, fertile, alternating with 5 short, globose staminodes, the staminal filaments ca 11 mm long, crimson red, stout, glabrous; anthers versatile, 2 × 1.25 mm, oblong; ovary 5 mm long, stipitate, stipe 2 mm long, obliquely ellipsoid, densely pubescent, 2-ovuled; style 1 cm long, slender, pilose towards base; stigma capitate; pods 3.5–4 × 1.5–2 cm, dolabriform, brown pubescent when young, 1–2 seeded, 0.5 × 0.5 cm, brownish.

Distribution, habitat, and phenology.—Humboldtia brunonis var. *raktapushpa* is so far known only from the type locality, Kakkayam along the foothills of the Western Ghats of Kerala (Fig. 2). This species grows in the semi-evergreen forests at an elevation of about 750 m in moist shady locations along with tree species such as *Vateria indica* L., *Elaeocarpus tuberculatus* Roxb., *Euodia lunu-ankenda* (Gaertn.) Merr., and *Syzygium laetum* (Buch.-Ham.) Gandhi. Flowering from January to April, and occasionally at other seasons.

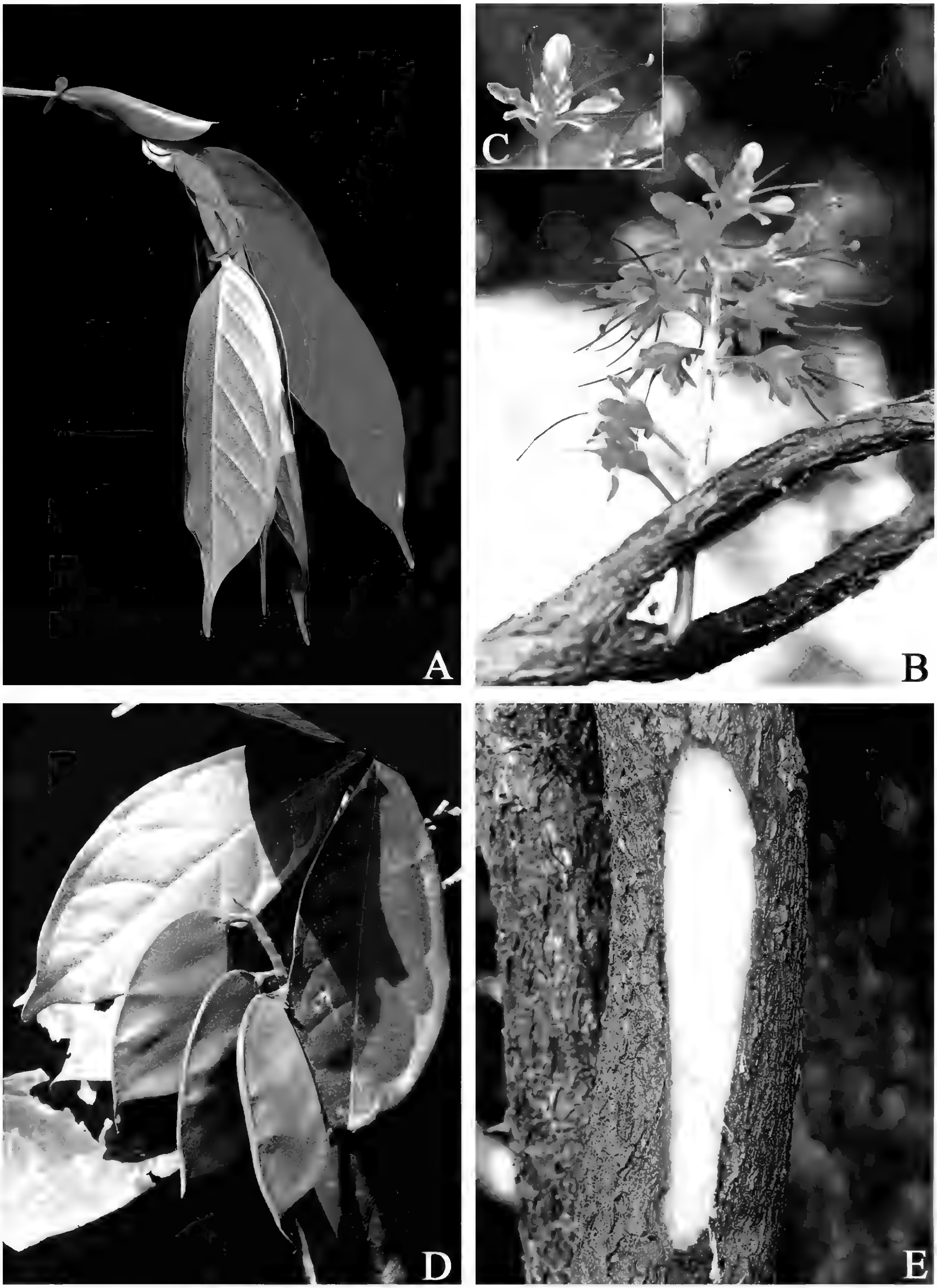

Fig. 3. *Humboldtia brunonis* var. *raktapushpa*. A. Young shoot. B. Inflorescence arising from the stem. C. Single flower. D. Infructescence. E. A portion of the trunk showing bark characters.

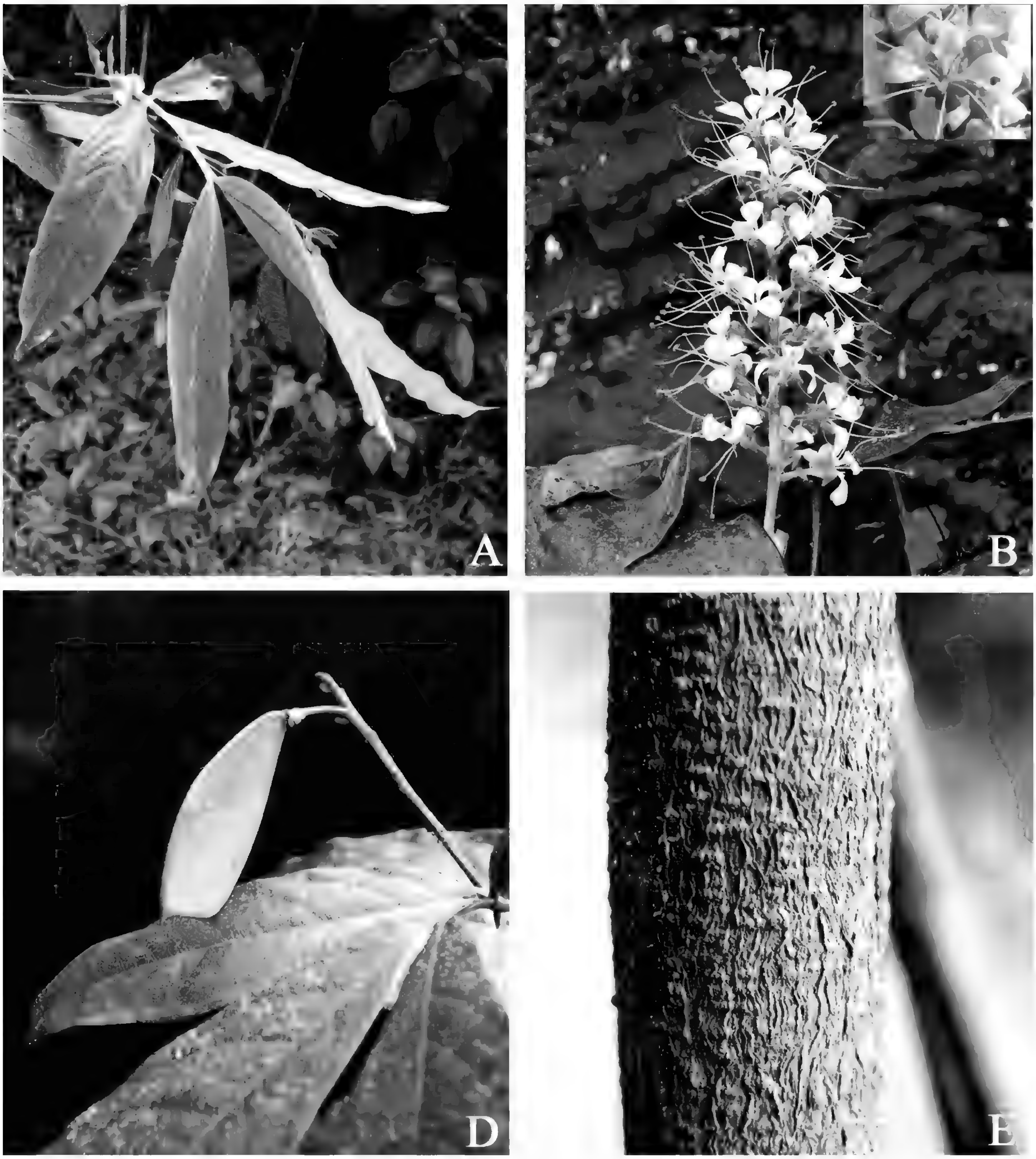

Fig. 4. ***Humboldtia brunonis* var. *brunonis*. A. Young shoot. B. Inflorescence. C. Single flower. D. Infructescence. E. A portion of the trunk showing bark characters.**

Conservation significance.—Because of the very restricted distribution and no other known collections of this species, a more detailed assessment of its distribution and biology would be valuable.

Etymology.—The varietal name '*raktapushpa*' is derived from the Sanskrit, *rakta* meaning 'red' and '*pushpa*' meaning 'flower' referring to the flower color.

Paratype: INDIA. Kerala. Kozhikode Dist.: Kakkayam, 11° 33' N 75° 55' E ca 780 m, 7 Jan 2005 (fl & fr), *P.S. Udayan et al. 03348* (CMPR, MH)

Table 1. Comparison of two varieties of *Humboldtia brunonis.*

Characters	var. *raktapushpa*	var. *brunonis*
Bark	Coarsely fissured and thinly flaky bark	Not fissured, mottled gray
Inflorescence	Dense, 3–7 cm long	Lax, 10–15 cm long
Flowers	Bright crimson-red	White tinged with pink
Stamens & Staminodes	Filaments stout, crimson red, to 11 mm long; staminodes globose	Filaments slender, white, to 15 mm long; staminodes filiform
Calyx	Tube 1–2 mm long, brownish tomentose	Tube 8–10 mm long, glabrescent
Petals	Narrowly obovate, 6–8 mm long	Broadly obovate, 10–15 mm long
Pod	1 or 2-seeded	3–4-seeded

DISCUSSION

Humboldtia brunonis Wall. var. *raktapushpa* P.S. Udayan, K.V. Tushar & Satheesh George is known only by a small population in the type locality. It resembles the typical form of *H. brunonis* in the vegetative form. The most striking feature of the new variety is the short, bright crimson-red inflorescence with flowers borne in dense spiral clusters. The vegetative feature that distinguishes var. *raktapushpa* is its coarsely fissured and thinly flaky bark (Table 1).

The flower colour of *Humboldtia brunonis* Wall. had been interpreted variously by different authors. Wallich (1832) while describing the flower states "flores magnitudine circiter illorum Tamarindi, coloris forsan laeti aurantiaci Jonesiae….", from this it appears that he was not sure whether the flowers are slightly orange. However, the excellent plate (t. 233) drawn by Griffith in Wallich's *Plant Asiatic Rarioris* (1832) accompanying the description undoubtedly agrees with what is currently understood as *H. brunonis* Wall. Brandis (1906) and Gamble (1919) probably following Wallich (1832) also described the flower as 'orange'. Sanjappa (1986) while revising the genus *Humboldtia* seems to be little confused. He described the flowers of *H. brunonis* as 'white' and the petals of which as "white, pink or orange". We had studied living populations of the typical variety of *H. brunonis* throughout its entire range of distribution and found that the flowers are always white with slight pinkish tinge (Fig. 4). This is in corroboration with the observations made by various other authors (Beddome 1871; Gandhi 1976; Saldanha & Singh 1984; Keshavamurthy & Yoganarasimhan 1990). The reason for this different interpretation could be due to its deep pink sepals. It is likely that many of the collectors mistook the sepals for the petals particularly when the tree is in a late flowering stage with all its petals shed.

ACKNOWLEDGMENTS

Authors are thankful to M. Sanjappa and G.V.S. Murthy, Botanical Survey of India (BSI) and N. Sasidharan, Kerala Forest Research Institute (KFRI), for their comments on our specimens; curators of CAL, CALI, FRLH and MH herbaria. The study was supported by grants from Department of Biotechnology (DBT), Government of India. We are also thankful to the authorities of Arya Vaidya Sala, Kottakkal for providing facilities; Indira Balachandran for helpful suggestions and encouragement; A.K. Pradeep for the review of an earlier version of the manuscript and illustration; N.K. Janardhanan, for assisting during field visits; P. Subramanian and V.V. Mohanan, Kerala State Forest Department, Kozhikkode for granting permission for the field visits.

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BOOK REVIEWS

Dennis W. Schlicht, John A. Downey, and Jeffrey A. Nikola. 2007. **The Butterflies of Iowa.** (ISBN 1-59829-533-4, pbk.). University of Iowa Press, 100 Kuhl House, Iowa City, IA 52242, U.S.A. (**Orders:** http://www.uipress.uiowa.edu/). $29.95, 233 pp., color photographs, 7" × 10".

By definition as well as size, this book is not intended as a field guide but rather as a manual to accompany comprehensive guides used in identifying and studying the butterflies of Iowa. Through the maps it is also a finding guide. Essential information is provided for each species: status (breeding or otherwise), flight period, description, and habitat. Under the heading Natural History the authors note the larval host plants (though often not specifically), larval and imago (adult form) behavior and other pertinent and interesting facts. A most innovative feature is the "Questions" rubric, questions about each species, which indicate how much there is yet to learn about butterflies in general and the potential research that even an amateur lepidopterist could undertake through careful observation and study.

Since the photographic plates are of pinned specimens, they lack brilliance. However, the views of dorsal and ventral surfaces of male and female (sexually dimorphic species) will facilitate identification.

A well-executed study of the subject, this book should be helpful and stimulating to all levels of butterfly watchers and collectors in Iowa and neighboring states.—*Joann Karges, (TCU Library, retired), Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

Jonathan Silverton. 2005. **Demons in Eden: The Paradox of Plant Diversity.** (ISBN 0-226-75771-4, hbk.). University of Chicago Press, 1427 East 60th Street, Chicago, IL 60637-2954, U.S.A. (**Orders:** www.press.uchicago.edu, 773-702-9756 fax). $25.00, 169 pp., 8 color plates, 5½" × 8½".

In this book the author, a professor and researcher at the Open University, Milton Keynes, asks and answers some important and intriguing questions regarding alien, invasive plants and their past and future potential for the development of new species. He poses a fundamental question "how to reconcile the evolution of diversity with the fact that natural selection favors individuals with demon traits and dominating proclivities." (p.34)

He then takes the reader around the world to illustrate demon plants which he has studied intensely. With a first stop to show the extraordinary diversity in the plants of the Kew Gardens he proceeds to the Kew Laboratories where major molecular work is establishing a new evolutionary tree of knowledge. This Darwinian tree is the metaphor the reader follows in the book, as the author leads us to the Canary Islands, to the chalk grass lands of England, to Mount Shimagare of Japan with its demon bamboo (*Sasa*) and the fir forests there and in the Adirondacks, to southern Mexico, to Barro Colorado, to Guanacaste, to the Florida Everglades.

In these areas the author discusses the evolution of plants, the colonizing tendencies of naturally or intentionally introduced aliens, the importance of niches and gaps, soils and other environmental conditions, the costs of reproduction in some plants (the bloom-and-die syndrome), competition among similar species, dispersal limitations, and transplanted ecosystems. An important chapter ("New Demons?") concerns the development and use of transgenic crops, the realized and potential effects.

While the situation for biodiversity seems dire (the most dangerous demon is actually mankind), the author presents the restoration of parts of Guanacaste as "good news," which should of course be emulated, and conservation efforts should expand around the globe.

Thoroughly scientific, stimulating, and provocative, the book offers significant insights into invasive plants (alien or endemic) and biodiversity. Chapter notes include bibliography and suggestions for further reading.—*Joann Karges, (TCU Library, retired), Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

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AGASTHIYAMALAIA (CLUSIACEAE), A NEW GENUS FOR *POECILONEURON PAUCIFLORUM*, AN ENDEMIC AND ENDANGERED TREE OF WESTERN GHATS, INDIA

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ABSTRACT

The taxonomic position of the Indian endemic tree genus *Poeciloneuron* was reassessed using morphological and anatomical data. *Poeciloneuron pauciflorum* differs from *P. indicum*, the only other species of the genus, in its solitary axillary flowers, inconspicuous parallel leaf venation and apotracheal banded wood parenchyma. Because of these differences we propose to place *P. pauciflorum* into a new monotypic genus **Agasthiyamalaia**, gen. nov. **Agasthiyamalaia pauciflora,** comb. nov., is proposed with the support from morphological and anatomical characters.

ABSTRACT

La posición taxonómica del género arbóreo endémico de la India *Poeciloneuron* se ha reevaluado usando datos morfológicos y anatómicos. *Poeciloneuron pauciflorum* difiere de *P. indicum*, la otra especie del género, por sus flores axilares solitarias, venación foliar paralela inconspicua y parénquima del xilema apotraqueal bandeado. Por todas estas diferencias proponemos colocar a *P. pauciflorum* en un nuevo género monotípico **Agasthiyamalaia**, gen. nov. Se propone la nueva combinación **Agasthiyamalaia pauciflora,** comb. nov., con el soporte de caracteres morfológicos y anatómicos.

INTRODUCTION

Poeciloneuron Bedd. is an endemic tree genus with two species belonging to the family Clusiaceae. It was described by Beddome (1865) under the family Ternstroemiaceae as a monotypic genus. Bentham and Hooker (1862–67) also included *Poeciloneuron* in Ternstroemiaceae. Beddome (1871) later added another species viz. *Poeciloneuron pauciflorum* to the genus. Beddome (1871) included this species under *Poeciloneuron,* with the comment, "if this species remains in the genus, the generic character must be considerably altered." Even though *Poeciloneuron* has anatomical similarities with the family Bonnetiaceae, because of its entire opposite leaves (Seetharam 1985), and presence of secretary canals (Metcalfe & Chalk 1950; Dickson & Weitzman 1996), it was included in Clusiaceae (see also Engler 1888). Floral morphological and palynological studies also fixed its position in the family Clusiaceae (Seetharam & Pocock 1978; Seetharam 1985). Detailed floral morphological work suggested that *Poeciloneuron* belongs to the tribe Calophylleae, which also includes the genera *Calophyllum*, *Kayea*, *Mesua* and *Mammea* (Seetharam 1985). However, a critical comparative study of these two endemic species of *Poeciloneuron* is still needed.

METHODS

Plant Materials

Twigs with flowers and fruits were collected for morphological studies from southern Western Ghats in evergreen forests. Fresh flowers, fruits and leaves were preserved in FAA solution for laboratory studies. The wood samples were collected from mature branches for anatomical studies. The identify was confirmed in the regional herbarium of BSI (MH) and voucher specimens are deposited in the Herbarium, Department of Botany, Goa University, Goa, India.

Wood anatomical studies

Free hand sections (T.S., T.L.S. and R.L.S.) of wood were made. The sections were stained in safranin for

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1–2 minutes and washed and processed for permanent mount following Johansen (1940). All the stained sections were observed under Leica MPS 32 microscope. The terminology of IAWA Committee on Nomenclature (1964) was followed in describing the wood anatomical characters.

RESULTS AND DISCUSSION

Morphology

The conspicuous reticulate veins of the leaves of *Poeciloneuron indicum* differ from distant parallel veins of *P. pauciflorum*. In *P. pauciflorum* the flowers are axillary and solitary (or paired) whereas in *P. indicum* they are in terminal or axillary panicles. The sepals are in two whorls in *P. pauciflorum* whereas they are in single whorl of five in *P. indicum* (Table 1).

Wood anatomy

The wood of both species can be described as follows: Wood diffuse porous; vessels solitary, rounded in outline, ca. 56 µm in diameter, mean member length 745 µm (580–910 µm) tailed, ca. 16 per mm^2, perforation simple; vessels to ray pits simple or bordered, alternate. Rays uniseriate, heterogenous, type III, 5–16 cells in high, ca 280 µm high, ca 70 per mm^2. Parenchyma apotracheal, banded. Fibers thick walled, bordered pits numerous, fiber tracheids present. The major difference between these two species based on wood anatomy is wood parenchyma arrangement. In *P. paciflorum* the wood parenchyma is apotracheal banded and in *P. indicum* it is paratracheal aliform type. Other characters such as vessel length and diameter, and fiber length showed quantitative differences.

Pollen morphology

The characters of pollen morphology were adapted from Seetharam and Pocock (1978). Tricolporate isopolar, polar axis 20.8 ± 2.2 µm, Equatorial axis 22.6 ± 2.0 µm, P/E ratio 0.9, ectoaperature 7–12 × 1.5 µm, endoaperature 4–6 × 1–2 µm, tectum 11–20 µm, perforate, more or less regular, bear warty projections. The species of *Poeciloneuron* differ in the arrangement of their endoapertures. In *P. indicum* the endoaperture is perpendicular to ectoaperture, whereas in *P. pauciflorum* it is parallel. Tectal perforations are irregular in *P. indicum* and regular in *P. pauciflorum*, tectal crests are smooth in *P. indicum* whereas they are warty in *P. pauciflorum* (Table 2.)

Poeciloneuron Bedd. is represented by two species: *P. indicum* and *P. pauciflorum*. The differences between these two are substantial enough to necessitate placing *P. pauciflorum* in a separate genus.

KEY TO GENERA

Flowers in terminal or axillary panicles; sepals 5, in a single whorl; stamens 12; leaves with fine reticulation ______ **Poeciloneuron**

Flowers solitary or paired in leaf axils; sepals 4, in 2 whorls; stamens 16–22; leaves with distantly parallel venation ______ **Agasthiyamalaia** gen. nov.

Agasthiyamalaia S. Rajkumar & Janarth., gen. nov. Type: *Poeciloneuron pauciflorum* Bedd., Fl. Sylv. 1:93, t. 93. 1871. *Agasthiyamalaia pauciflora* (Bedd.) S. Rajkumar & Janarth., comb. nov. herein.

Poiciloneuro proxima, floribus solitariis vel binatis, sepalis quattuor in verticillis duobus, staminibus 16–22, foliis venatione remote parallela differt.

Agasthiyamalaia gen. nov. is very similar to *Poeciloneuron* Bedd. but differs in its solitary or paired axillary flowers, four sepals in two whorls, 16–22 stamens and leaves with distantly parallel venation. *Agasthiyamalaia* also differs from *Poeciloneuron* s. str. in certain micro-morphological characters. The apotracheal banded wood parenchyma and perpendicular arrangement of pollen endoaperature to ecotaperature of the former are distinct from paratracheal aliform wood parenchyma and parallel positioned pollen endo and ectoaperatures of the latter.

Trees with clear bole. Leaves simple, opposite, petiolate, petiole rough, channeled. Flowers solitary or paired in the axils of the fallen leaves, pedicellate; sepals 4, in two whorls, inner two larger than outer ones, puberulous; petals 6–8, imbricate, pubescent within; stamens 16–22, attached to an elevated disc below

Table 1. Morphological differences between *P. indicum* and *Agasthiyamalaia (=P. pauciflorum).*

Characters	*P. indicum*	*Agasthiyamalaia (=P. pauciflorum)*
Leaf size	Up to 25 × 6 cm	Up to 12 × 4 cm
Leaf shape	Ovate to oblong, acuminate at apex	Oblong, bluntly acuminate at apex
Leaf surface	Reticulate conspicuous venation	Parallel inconspicuous venation
Inflorescence	Axillary and terminal panicle	Solitary or paired in leaf axils
Sepals	5, ovate, all equal in size	4, in 2 whorls, inner two larger
Petals	5, contorted	6–8, imbricate
Stamens	12	16–22
Fruit	Without lobes and blunt apex	2 lobed, pointed at apex
Seed	Testa smooth	Testa wrinkled

Table 2. Differences in pollen morphology between *P. indicum* and *Agasthiyamalaia (=P. pauciflorum)* adapted from Seetharam and Pocock (1978).

Characters	*P. indicum*	*Agasthiyamalaia (=P. pauciflorum)*
Polar axis	15.6±1.5mm	20.8±2.2mm
Equatorial axis	14.6±0.9mm	22.6±2.0mm
P/E ratio	1	0.9
Ecoaperature	8–12 × 1 mm	7–12 × 1.5mm
Endoaperature Arrangement	2 × 4 mm, perpendicular to ectoaperature	4–6 × 1–2 mm, paraellel to ecoaperature
Tectum thickness	6–8 mm	11–20mm
Tectal crests	Smooth	Warty
Tectal perforation	Irregular	Regular

ovary, anthers lobulate, dehiscence longitudinal; ovary globose, 2-celled, with pair of ovules in each; style 2, divided halfway, undulate along the margins, greenish yellow. Fruit globose, pointed at the tip, dehiscent in to two valves, one seeded. Seed hard, rounded, testa loose, membranaceous, striate, easily separable from the seed; cotyledons very large, fleshy.

Distribution.—Southern parts of Western Ghats in Tamil Nadu and Kerala States of India.

Etymology.—The genus is named after Agasthiyamalai Hills in and around which it is found.

Agasthiyamalaia pauciflora (Bedd.) S. Rajkumar & Janarth., comb. nov. **(Fig. 1)**. Basionym: *Poeciloneuron pauciflorum* Bedd., Fl. Sylv. 93, t. 93. 1871; Dyer in Hook. f., Fl. Brit. India. 1:278. 1874; Gamble, Fl. Madras 1:546. 1967 (repr. ed.); Singh in Sharma et al., Fl. India 3:146. 1993. Type: Bedd., Fl. Sylv. 1:93, t. 93. 1871.

Trees up to 15 m high, clear bole, bark grayish. Leaves with petiole, petiole up to 1.5 cm long, rough, channeled; lamina coriaceous, oblong, up to 12 × 4 cm, rounded or acute at base, entire along the margin, bluntly acuminate at apex. Flowers solitary or paired in the axils of the fallen leaves, pedicellate, pedicels up to 2.5 cm long, glabrous, green in colour; sepals 4, ovate, the outer two ca 2.5 × 3 mm, the inner two up to 8 × 3 mm, apically obtuse, green, puberulous; petals ovate, ca 0.3 × 0.2 cm, apically obtuse, white, pubescent within; stamens 16–22, ca. 0.6 cm long. Ovary ca. 0.2 cm. Fruit globose, up to 2 × 1.7 cm.

Local name.—Puli-vayila, Puthangkolli.

Specimens examined: **INDIA. Tamil Nadu:** Mundanthurai to Kannikatti, 17 Mar 1917, s.l. *14647* (MH); way to Nagapothigai from Inchikuzhi, 8 Feb 1989, *R. Gopalan 90105* (MH); Etha river bank, 1000 m 24 Apr 1990, *R. Gopalan 93232* (MH); bank of Sigapparu, way to Nagapothigai, 750 m, 22 Jan 1991, *R. Gopalan 94640* (MH); Valayar River bank, 900 m, 3 Apr 1991, *R. Gopalan 96216* (MH); way to Poonkulam, 900 m, 17 Apr 1992, *R. Gopalan 99305* (MH); banks of Chittar, 8 km above Keeriparai, Kanniyakumari Dt., 23 Feb 1998, *S. Rajkumar 210* (Herbarium, Goa Univ.); 2 Nov 2000, *S. Rajkumar 680* (Herbarium, Goa Univ.); Inchikuzhi to Kannikatty, 15 Aug 2002, *S. Rajkumar s.n.* (Herbarium, Goa Univ.). **Kerala:** Travancore, s.d. & s.l. acc. No. 3224 (MH).

Distribution.—Banks of streams or rivers, in evergreen forests surrounded by grasslands. Locally dominant, associated with *Cinnamomum* spp., *Glochidion* spp., *Knema attenuate* and *Ochlandra* spp. Young leaves are mem-

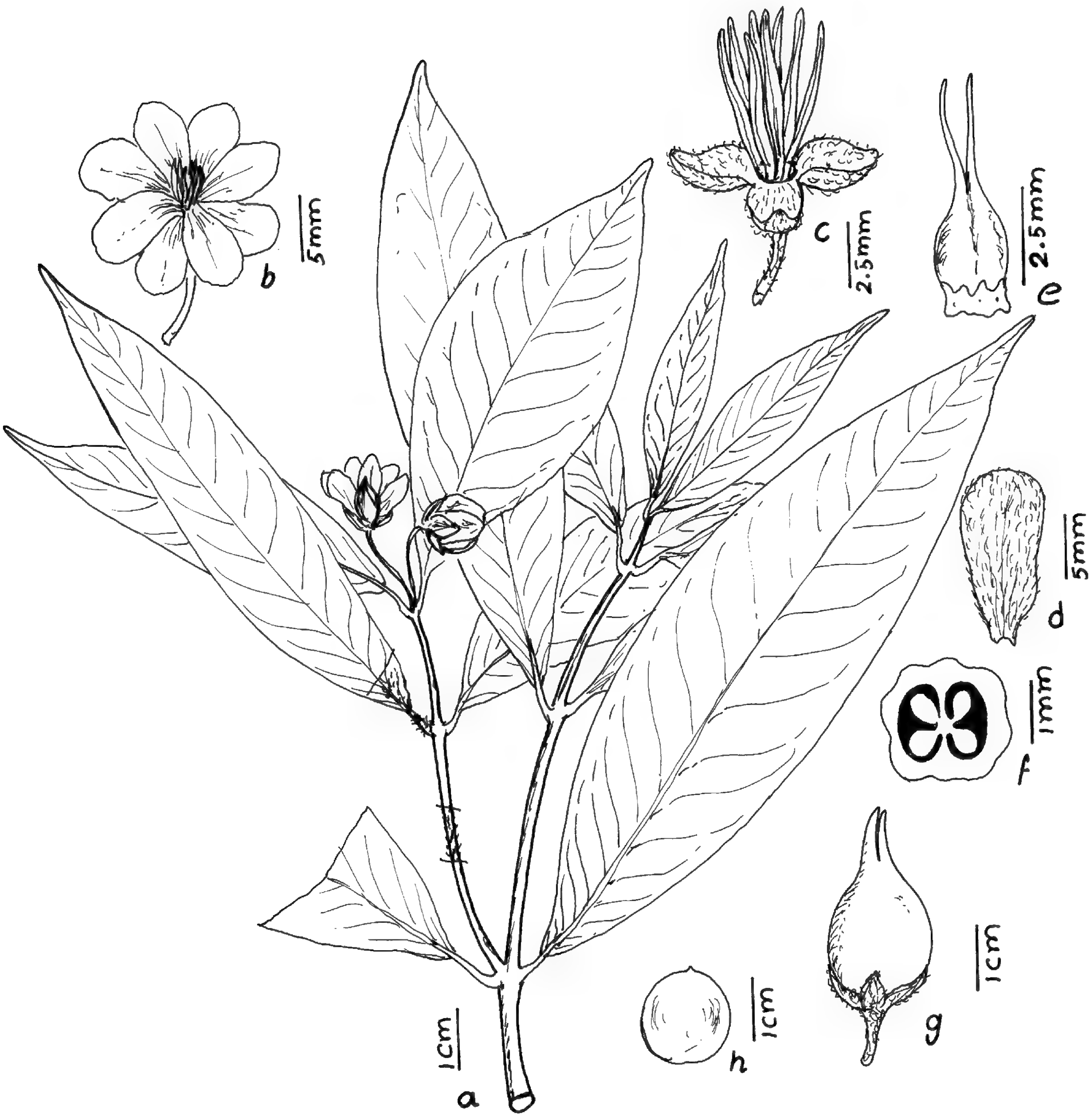

Fig. 1. *Agasthiyamalaia pauciflora* **a.** flowering shoot. **b.** flower c. calyx with stamens (corolla removed). **d.** petal. **e.** pistil. **f.** ovary. **g.** fruit. **h.** seed.

branous, white, turning pinkish. *Agasthiyamalaia* (=*P. Pauciflorum*) is a narrow endemic and was relocated by Ravikumar (pers. comm.) 70 years after its previous collections. It is listed as an endemic rare plant of Western Ghats, India (Ahmedullah & Nayar 1990; Gopalan & Henry 2000; Mohanan & Sivadasan 2002).

IUCN Conservation Assessment.—This species has been assessed as Critically Endangered (CR B1+2c ver. 2.3 (1994) by WCMC (1998) under *Poeciloneuron pauciflorum* Bedd. However, recent collections from several populations, though from a small geographic region necessitates its reassessment. Mass multiplication using tissue culture is being tested as part of a species recovery program by the Department of Biotechnology, Ministry of Science and Technology, New Delhi, India.

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We thank Peter Stevens, Missouri Botanical Garden for his critical comments on the earlier version of manuscript; Joint Director (MH, Coimbatore) for permission to consult the herbarium; K. Ravikumar (FRLHT, Bangalore) for help in locating the plant; D. Narasimhan (Madras Christian College, Chennai) for pickled specimens; and to J.F. Veldkamp (Leiden, The Netherlands) for the Latin diagnosis. We also thank reviewers John J. Pipoly III and Barney Lipscomb (BRIT) whose comments greatly helped us in revising the manuscript.

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BOOK REVIEWS

BOB PRESS (Text) and CAROL MERRYMAN (Art). 2006. **Trees: Collins Wild Guide.** (ISBN 0-00-719152-9, pbk.). HarperCollinsPublishers, Ltd., 77-85 Fulham Palace Road, London, W6 8JB, UK (**Orders:** Collins UK, Distributed by Trafalgar Square, No. Pomfret, VT 05053, U.S.A., www.trafalgarsquarebooks.com). $16.00, 191 pp., color photographs, drawings, 4" × 6¾".

This small book, with its illustrations, color photographs, and pertinent information, is an enormous help to anyone wishing to learn how to identify trees most commonly found in Britain and Ireland.

The book has a brief history of trees in Britain and Ireland. It also includes, for those unfamiliar with botanical language, a short, helpful glossary.

Every page of *Trees* has a color photograph of a species with its scientific and common names. Accompanying each photograph is an ID Fact File, which provides detailed descriptions of the tree, making it a valuable took for fast and accurate identification.

A compact range of general information covering specific characteristics such as the tree's height, crown, and pattern of branching is very helpful. The leaves, their size, shape, and texture along with fruit and flowers produced by the tree are also emphasized as important aids to correct identification.

The size of the book is a definite plus. It is small enough to fit in a picket, purse, or glove compartment, age appropriate for an adult or older child. It is a wonderful "carry along" book that imparts succinct information that both informs and educates without overwhelming the reader.

It can be safely stated that the reader will take away from this book an increased knowledge of trees and an enhanced awareness of how trees influence and enrich our environment.—*Susan Kingeter, Volunteer, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

P. DAROLD BATZER and REBECCA R. SHARITZ (eds.). 2007. **Ecology of Freshwater and Estuarine Wetlands.** (ISBN 0-250-24777-9, hbk.). The University of California Press, Berkeley, CA 94704, U.S.A. (**Orders:** California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A., www.ucpress.edu, http://www.ucpress.edu/books/pages/10296.html, 609-883-1759, 609-883-7413 fax). $59.95, 581 pp., color photos, b/w figures and photos, tables, graphs, 7" × 10".

Ecology of Freshwater and Estuarine Wetlands is designed to be a textbook and offers readers a comprehensive introduction to the ecology of wetland systems. This well illustrated book has various chapters written by professionals whom focus on their areas of expertise. This publication would be very suitable as a textbook for classes on wetland ecology and as a supplemental reading for exploring systems modeling or environmental engineering. Additionally, this title could also be a beneficial reference text for related classes, such as hydrology and/or microbiology that may have a focus on the processes and uses of wetlands.

The book chapters flow in a logical order from one to another, building on previous chapters' information. Chapter topics begin with the nuts and bolts of the physical and biological definitions of wetlands followed by wetland geomorphology, hydrology, abiotic constraints on flora and fauna, bacterial ecology, wetland plant communities, wetland ecosystem processes, U.S. wetland regulation and policy, wetland restoration, flood pulsing and biodiversity in wetlands and wetlands in the global environment.

The text is very readable and is accompanied by many supportive illustrations, graphs and photos. The information presented to readers is well balanced, providing various views and theories regarding wetlands function and definitions. Some of this text's most beneficial chapters include current research and views on bacterial ecology in wetlands as well as how these interactions control processes and diversity within wetland systems. There is also a fantastic and witty chapter on wetland restoration in which the author offers many case studies allowing reader to contemplate and learn from surprises and mistakes of others in dealing with wetland restoration. Chapter texts are thoroughly researched and the research studies presented and cited are all included in the extensive reference section. Many of the chapter authors have included issues of concern or methodological steps in evaluating various wetland topics.

Ecology of Freshwater and Estuarine Wetlands, edited by Batzer and Sharitz, provides a comprehensive and timely introduction to wetlands ecology, including well written chapters on wetland formation processes including geomorphology, soils, hydrology and bacterial ecology as well as legal policies and definitions. The text is full of supportive black and white illustrations, charts, tables and references to research studies. *Ecology of Freshwater and Estuarine Wetlands* would serve as an excellent textbook for classes focusing on wetlands, wetland ecology and related classes where system ecology and function may be of interest.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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NEW NAMES FOR BAMBOOS OF NEPAL (POACEAE: BAMBUSOIDEAE)

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ABSTRACT

The use of different generic and species concepts in Sino-Himalayan bamboos is discussed. **Himalayacalamus planatus** Stapleton is separated from *H. asper* Stapleton, both species having now flowered. Two subspecies of *Thamnocalamus spathiflorus* (Trin.) Munro are elevated to species, as **T. nepalensis** (Stapleton) Stapleton and **T. occidentalis** (Stapleton) Stapleton. *Borinda chigar* Stapleton is transferred as **Thamnocalamus chigar** (Stapleton) Stapleton. The synonymy of two species from Nepal with those from neighboring areas is discussed.

RESUMEN

Se discute el uso de diferentes conceptos genéricos y específicos en los bambúes chino-himalayos. **Himalayacalamus planatus** Stapleton se separa de *H. asper* Stapleton, habiendo florecido ahora ambas especies. Dos subespecies de *Thamnocalamus spathiflorus* (Trin.) Munro se elevan a especies, como **T. nepalensis** (Stapleton) Stapleton y **T. occidentalis** (Stapleton) Stapleton. *Borinda chigar* Stapleton se transfiere como **Thamnocalamus chigar** (Stapleton) Stapleton. Se discute la sinonimia de dos especies de Nepal con las áreas próximas.

Many Sino-Himalayan bamboos are of economic or ecological importance in their natural range, but their forest habitats are decreasing and their conservation status is of concern. Several are becoming more widely cultivated in the US and Europe as ornamentals, which has allowed more study of their systematics and identification. The bamboos of Nepal were first enumerated (Hara et al. 1980) according to available literature and earlier, tentative identifications in the national herbarium of Nepal, the British Museum (Natural History), and institutions in Japan, to give a total of 10 species from 5 genera. They were studied further in the 1980s (Stapleton 1982, 1987) and enumerated more comprehensively (Stapleton 1991, 1994a–c), to give a total of 30 species from 11 genera, but 56% of Himalayan bamboo taxa had no name at all at that time, and a substantial number of new names were duly published (Stapleton 1994a–c).

At the same time, Chinese taxonomists were actively collecting and describing Sino-Himalayan bamboos, including those from Tibet, and a revised classification was being developed, with several new genera (Keng 1982–84, 1987), as well as many new species, several collected in Tibet (Yi 1983, 1983a). However, a western generic classification of the grass family was also being produced (Clayton & Renvoize 1986), and that pre-eminent global grass account applied a much broader generic concept to bamboos. Several authorities consequently dismissed many of the new Chinese genera altogether, notably Chao and Renvoize (1989), who relegated *Pleioblastus*, *Oligostachyum*, *Bashania*, *Oreocalamus*, *Chimonocalamus*, *Yushania*, *Drepanostachyum* and *Himalayacalamus* on the grounds that they lead to confusion. Tewari (1993), Li (1997) and Seethalakshmi and Kumar (1998) followed suit. They adopted instead a few, much larger genera, such as *Sinarundinaria* Nakai. Most of the new Chinese genera were recognized by a few others (Soderstrom & Ellis 1988; Majumdar 1989; Stapleton 1987, 1994b–c). This led to two very different approaches to bamboo classification, especially for the subtropical to temperate clade of Asian and North American bamboos.

Along with a narrower generic concept, the new Chinese classification system (Keng 1982–84) also applied a narrower species concept than that used in western grass taxonomy. This utilized many vegetative characteristics, without the emphasis given to floral characters usually applied in more traditionally based treatments (Clayton & Renvoize 1986; Chao & Renvoize 1989). Keng's classification instead followed a different tradition (Munro 1868; Gamble 1896; Camus 1913) of using a narrower species concept in the bamboos than in other grasses, making good use of several characters of the culm sheaths, which are well

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differentiated in woody bamboos. Culm sheaths are usually simply referred to as culm leaves in other grasses, where they are very similar to the foliage leaves. In this way Keng's treatment was also to conflict with the much broader bamboo species concept applied by Chao and Renvoize (1989). In that treatment for example, *Drepanostachyum falcatum* was considered to extend from Pakistan to Meghalaya, almost into Bangladesh, and was called *Sinarundinaria falcata*. *Himalayacalamus* was treated essentially as a single species, *Thamnocalamus falconeri*, extending the entire length of the Himalayas.

When Keng's approach to bamboo classification was applied to the species found in Nepal, Sikkim and Bhutan (Majumdar 1989; Stapleton 1994a–c), a large number of new combinations and new taxa were seen to be required. Full use was made of vegetative characters, especially those of culm sheaths and the complex bud and branching characters unique to woody bamboos (Stapleton 1991, 1994a–c). However, because of the broader concepts applied in Clayton and Renvoize (1986) and Chao and Renvoize (1989), some caution was applied in the description of new species without knowledge of floral characteristics, for example in *Himalayacalamus asper* (Stapleton 1994c), in which bamboos with rather different culm sheaths from c & w Nepal were combined. In the few cases where comprehensive floral material was available, a tentative, somewhat broader species concept was applied, for example in *Thamnocalamus spathiflorus*, in which several subspecies and varieties were recognized, rather than distinct species (Stapleton 1994b).

Recent molecular investigations (Ní Chonghaile 2002; Guo et al. 2001, 2002) have shown no support at all for the larger genera, which appear to be polyphyletic. There has also been no support for emphasising floral characters over vegetative ones. The major groupings within the woody bamboos, at supertribal, tribal, or subtribal level, based mainly on differences in floral morphology, were seen to have no support whatsoever from molecular data (Ni Chonghaile 2002). As bamboos have more vegetative characters by which they can differ than other grasses, and there seems no reason why the species concepts applied to other grasses should be forced onto bamboos artificially, it would appear that the recognition of genera and species on the grounds of consistent differences in vegetative characters is now justified. Keng's classification system has gradually become accepted more widely around the world, and its application in the Chinese and English language Flora of China bamboo accounts (Keng & Wang 1996; Li et al. 2006) has increased its credibility. The recent recognition of 3 bamboo species native to the US, rather than 1, separated largely on vegetative characters including branching (Triplett et al. 2006), is further evidence of the trend to recognize smaller taxa with more emphasis on vegetative characters.

In consequence, it would appear that the classification system followed earlier (Majumdar 1989, Stapleton 1994a–c) is acceptable, while that applied elsewhere (Chao & Renvoize 1989; Tewari 1993; Seethalakshmi & Kumar 1998) is unnatural and paraphyletic. Building on this support for the smaller taxa previously established, it is realised that a few alterations are required to the names applied to the bamboos of Nepal (Stapleton 1994a–c). In addition, further collections have since been made within Nepal and adjoining areas, and several species have been introduced into western horticulture, allowing them to become better known, especially as some have recently flowered. Unfortunately, for various reasons, less new botanical fieldwork has been undertaken in Nepal than could have been hoped for, and many gaps in our knowledge still remain. Several additional species have been recorded for Nepal (Poudyal 2006), but most are only tentatively identified and others represent fairly recent introductions. Hopefully the return of peace to that country, and the aspiration of compiling a Flora of Nepal account, will no doubt allow our knowledge of Nepalese bamboos to continue to develop further.

Himalayacalamus was published as a monophyletic genus, but several new species from Nepal were later added, and species described from Tibet and Sikkim in other genera have also been included. In broader generic treatments it was treated as a synonym of *Thamnocalamus* (Clayton & Renvoize 1986; Chao & Renvoize 1989) on the basis of its compressed inflorescences, but *Himalayacalamus* can be distinguished by its usually solitary florets, and by reduced sheaths on inflorescence and culm branches (Stapleton 1994c). Molecular data (Ní Chonghaile 2002) suggests that *Himalayacalamus* is more closely related to *Drepanostachyum*, from which it differs in its fewer branches, adaxially glabrous culm sheaths, and more compressed inflorescences with dense spikelets of fewer, usually solitary florets. The stalk of the spikelet, incorrectly termed a pedicel in grasses but actually a peduncle, is short in *Himalayacalamus* and *Thamnocalamus*, which has suggested its homology with the vegetative promontory supporting culm branches (Stapleton 1997), hence use of the term promontory as an alternative to pedicel below. *Himalayacalamus* and *Thamnocalamus* have been redescribed to reflect current circumscription and terminology in Stapleton 1994b, 1994c, 2000, and in Li et al. 2006.

Himalayacalamus planatus Stapleton, sp. nov. (**Fig. 1**). Type: NEPAL. Rasuwa District: Syabru (ca. 28°12'N 85°28'E), elev. ca. 8,000 ft, 7 Oct 1984, *Stapleton 328* (holotype: K!).

Himalayacalamus asper mihi affinis, sed vaginis culmorum pilosis non asperis, auriculis et setulis oribus vaginorum foliorum absens, nodis culmorum planatis, lemmatibus glabris differt.

Clumps dense. Culms to 2–5 m, 0.5–1.5 cm in diam., nodding to pendulous; internodes to 20 cm, surface with little wax, soon becoming glossy, smooth with no ridges, initially with purple ring above nodes and streaks elsewhere, becoming burgundy-red to brown if exposed, walls to 4 mm thick; nodes level, scarcely raised, sheath scar thin, supranodal ridge absent or slightly raised; mid-culm branches 7–20, central branch to 0.15 cm in diam., aerial roots absent. Culm sheaths quickly deciduous on early shoots, height to ligule ca. 18 cm, similar to internodes in length, attenuating convexly in distal 1/3 to ca. 0.2 cm, basally tough and smooth with membranous recurved margins, distally thinner and shortly hispid, distal 1/3 of both edges densely ca. 0.1 cm white-ciliate; auricles absent; oral setae absent; ligule ca. 0.6 cm wide × 0.3 cm tall, exterior very shortly pubescent, interior glabrous, margin serrate; blade reflexed, to 4 × 0.2 cm, proximally scabrous, deciduous to persistent. Leaf sheath surface and edges glabrous, or overlapping edge distally short-ciliate; auricles absent; oral setae absent; ligule short, to 0.1 cm, rounded, densely puberulous; external ligule not pronounced, glabrous. Leaf blade to 13 × 1 cm, glabrous; petiole glabrous, often pigmented; 2ndary veins 2–3 each side; transverse veins not evident. Synflorescences fasciculated in spicate clusters of racemes. Spikelets on ca. 2–5 mm promontories (pedicels) with 1(–2) florets and a tiny <0.2 mm rudiment on a ca. 4 mm rhachilla extension. Glumes membranous, pale, glabrous, apical ca. 0.7 mm of margins with cilia to ca. 0.2 mm. Fertile lemma 7–9 mm, distally glabrous, not scabrous, green or purple-tinged, apical ca. 0.5 mm with cilia to ca. 0.2 mm. Palea glabrous, keels smooth, apex blunt or very shortly bifid to ca. 0.2 mm with tuft of ca. 0.2 mm hairs. Rhachilla basally to 0.3 mm-lanate along with lemma base, proximally scabrous, distally glabrous.

Distribution and Ecology.—This species is only known from Rasuwa District in Nepal, where it grows in mixed temperate forest. It is also in horticultural cultivation in the UK, France and the US.

Etymology.—The epithet is derived from the level culm nodes, which are scarcely raised and have a thin persistent culm sheath base.

Ethnobotany.—The culms are split and woven into a variety of baskets, trays and mats. Shoots are edible, and leaves are palatable for livestock, but small. Local name is *malinge nigalo* (Nepali). Extensively collected from forest areas.

Additional collections: **NEPAL. Kathmandu Valley:** Chalnakhel (cult.), 22 Jan 1991, *Stapleton* 918 (K). **UNITED KINGDOM. Devon:** Dartmouth, 27 May 1997, *Stapleton* 1120 (K). UK (cult.). **Sussex:** Leigh, 9 Nov 1998, *Pike s.n.* (K).

Two similar bamboo species in the genus *Himalayacalamus*, both lacking the smooth and glabrous culm sheaths normal for that genus were initially collected, without flowers. One was from the Seti Khola valley in Kaski District, w Nepal in 1983, the other from near Syabru in the lower Langtang valley of Rasuwa District, c Nepal in 1984. In the first enumeration of bamboos from Nepal (Stapleton 1991) these were presented as 2 separate species, but in the published account (Stapleton 1994c) they were conservatively combined into one species, *H. asper* Stapleton, the type being the 1983 Kaski collection. Both these bamboos are now in cultivation in the west, and both have now flowered. Better knowledge of their vegetative and floral characteristics, along with a greater degree of confidence in the application of a narrower species concept, requires a new name to be published for the species from the Langtang valley. It was introduced from the Syabru area in 1979 by Merlyn Edwards, and grown at Kew under the misapplied name *Arundinaria microphylla*, then in the US under the name *Neomicrocalamus microphyllus*. After this misidentification was discovered

Fig. 1. *Himalayacalamus planatus* with pilose culm sheath, no leaf sheath auricles or oral setae, level nodes and glabrous racemes of 1-flowered spikelets.

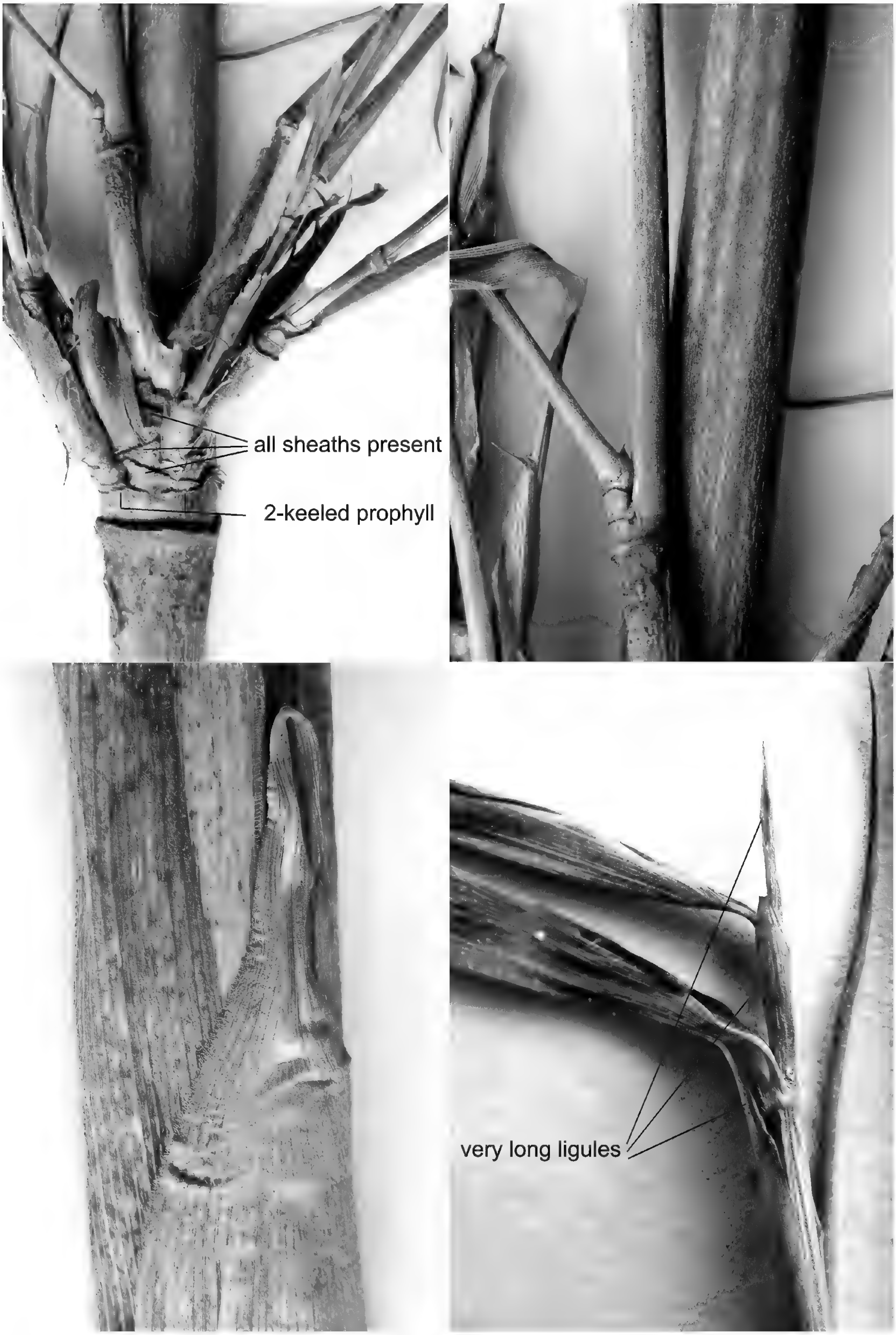

Fig. 2. *Thamnocalamus chigar* showing branch sheathing, flattened branchlet sides, sulcate culm, undifferentiated culm sheath blade and very long leaf sheath ligules.

(Stapleton 1999), it became known in cultivation as *Himalayacalamus asper*, a name that is now unfortunately also misapplied. It has flowered in the UK, as has a plant of the real *Himalayacalamus asper* from Gorapani, Kaski District, collected by Muriel Crouzet, and grown in France. The less bifid palea and shorter apical cilia on glumes, lemma and palea distinguish *H. planatus* from *H. asper*, which, in keeping with its epithet, has minutely scabrous lemmas and apically scabrous palea keels, as well as short, hard, bulbous-based spines on its culm sheaths. A more recent introduction of *H. asper* by Jean Merret, also from Kaski District of w Nepal, has been described as *Drepanostachyum merretii* by Demoly (2006). The seedlings were initially hard to identify, although they were clearly not the same as the cultivated *H. asper.* Now that they have grown larger their true identity, as the only real *H. asper* in cultivation, has been revealed.

Thamnocalamus chigar (Stapleton) Stapleton, comb. nov. *Borinda chigar* Stapleton, Edinburgh J. Bot., 51:286. 1994. TYPE: NEPAL. KASKI DISTRICT: Karuwa to Pipar (ca. 28°24'N 83°58'E), elev. ca. 3,000 m, 16 Nov 1983, *Stapleton 315* (HOLOTYPE: E).

When first collected in 1983, the generic status of this species was very uncertain. As the importance of branching and buds was not appreciated at that time, the material collected did not allow these characters to be properly assessed. New collections of this species with better branching have since been made, and they have revealed that it is not a species of *Borinda* as at first thought. It seems instead to be a rather distinct species of *Thamnocalamus*. Figure 2 shows the sheath scars on the branch complement, which are consistent with *Thamnocalamus* rather than *Borinda* (Stapleton 1994b: Fig. 1, pattern *a* rather than pattern *b*). There is a full complement of broad enclosing sheaths, initiated by a 2-keeled prophyll. In addition, the strong flattening on one side of the branchlets with substantial sulcation on a small culm, further characteristics of *Thamnocalamus*, can clearly be seen (Fig. 2).

The length of the ligules and the long, delicate culm sheaths without a well-distinguished blade are remarkable and obscure the affinity to better-known species of *Thamnocalamus*, which is however revealed in its branch complement structure. Its flowers are still not known. Partially because of the presence of this distinct species, and partially because of consistent vegetative differences between the taxa previously described as subspecies, they are elevated here to species, even though it is very hard to separate them by their flowers alone with any certainty.

Additional collection: **NEPAL. Kaski District:** Modi Khola, Deurali, elev. ca. 3000 m, Nov 1994, *M. Edwards 206* (K).

Thamnocalamus nepalensis (Stapleton) Stapleton, stat. nov. *Thamnocalamus spathiflorus* Munro subsp. *nepalensis* Stapleton, Edinburgh J. Bot. 51:283. 1994.

This subspecies was distinguished from the type by its glabrous culm sheaths and leaf sheaths without oral setae. These characters are now considered to be of importance at the species level, justifying elevation to specific rank.

Thamnocalamus occidentalis (Stapleton) Stapleton, stat. nov. *Thamnocalamus spathiflorus* Munro subsp. *occidentalis* Stapleton, Edinburgh J. Bot. 51:283. 1994.

This subspecies was distinguished from the type by its glabrous but asymmetrical culm sheaths, also with auricles and oral setae. These characters are now considered to be of importance at the species level, justifying elevation to specific rank. This is supported by the geographic disparity between this species, from the nw Himalayas, and *T. spathiflorus* from the e Himalayas. *T. nepalensis*, *T. chigar*, and *T. crassinodus*, all from c Nepal are found between the two species. Although not yet collected there, it is likely to occur in w Nepal.

Bambusa jaintiana R.B. Majumdar

Bambusa alamii Stapleton

Bambusa alamii Stapleton has been considered a synonym of *B. jaintiana* R.B. Majumdar (Alam & Hassan 1994). *B. jaintiana* was minimally diagnosed on the basis of a type collection from the Khasia Hills of Meghalaya. The type has not been seen, but an isoparatype of *B. jaintiana* at K seems identical to *B. tulda*. However, having now visited the Khasia Hills and the type locality for *B. jaintiana*, I am satisfied that a species growing there is the same as *B. alamii*, and it is assumed that they are synonymous. There is still a possibility, however, that they were introduced from s China or Indochina, where several similar species of 'Weavers' Bamboo' are cultivated.

Himalayacalamus gyirongensis (T.P. Yi) Ohrnberger & **Himalayacalamus porcatus** Stapleton

Fargesia gyirongensis T.P. Yi was described from a collection made in Gyirong Xian, Tibet at 2400 m, which suggests a location possibly less than 10 km north of the Nepalese border at Rasuwa Garhi, and possibly as close as 25 km from the type locality of the later *H. porcatus* Stapleton, from near Syabru at 2300 m. The description of *F. gyirongensis* did not mention porcate culms, and gave the culm sheath as glabrous or setose, the persistent base initially densely setose. The culm sheath of *H. porcatus* is completely glabrous, although the persistent base is lightly tomentose at first. *H. porcatus* also has distinct oral setae on symmetrical culm sheaths, while *F. gyirongensis* was described as having no oral setae, and slightly asymmetrical culm sheaths were illustrated. A suspicion still remains, however, that these two species could be the same, but without inspection of the type specimen of *F. gyirongensis* and fieldwork in Tibet, this cannot be tested properly.

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Merlyn Edwards is thanked for collecting better material of *T. chigar* in Nepal. Muriel Crouzet and Jean Merret are thanked for collecting *H. asper*, and Robert Kernin is thanked for sending a sample of Jean Merret's collection. The Keeper of the Herbarium at the Royal Botanic Gardens Kew is thanked for providing working facilities. Two anonymous reviewers are also thanked.

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FOLIA TAXONOMICA 1.
VALIDATION OF TWO TAXA FROM NORTHERN SOUTH AMERICA

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ABSTRACT

Two taxa, one species of *Aristolochia* (Aristolochiaceae) and one variety of *Passiflora* (Passifloraceae), are validated. First, *Aristolochia peltato-deltoidea,* described by Hoehne in 1942, was originally published without a Latin diagnosis and therefore the name is invalid. The species is described herein as **A. kanukuensis**. Second, Killip invalidly placed var. *orinocensis* as a variety of *Passiflora foetida* L. in 1938, as he did not mention that he had described it in 1930 at the rank of subspecies. Thus, **Passiflora foetida** var. **orinocensis** is validated here by acknowledging the new rank and providing a full citation of the basionym.

RÉSUMÉ

Deux taxa, une espèce d'*Aristolochia* (Aristolochiaceae) et une variété de *Passiflora* (Passifloraceae), sont validées. Premièrement, *Aristolochia peltato-deltoidea*, décrite par Hoehne en 1942, a été publiée sans diagnose latine, le nom est donc invalide. L'espèce est décrite ici sous le nom **A. kanukuensis**. Deuxièmement, Killip en 1938 a placé var. *orinocensis* parmi les nombreuses variétés de *Passiflora foetida* L., de façon invalide car il n'a pas signalé qu'il l'avait décrite en 1930 au rang de sous-espèce. **Passiflora foetida** var. **orinocensis** est validée par la reconnaissance du nouveau rang et la référence précise au basionyme.

During the reviewing phase of the "*Checklist of the Plants of the Guiana shield*" (Funk et al. 2007), some invalid names where found. This short paper addresses two of the names in use that need validation.

ARISTOLOCHIA KANUKUENSIS (ARISTOLOCHIACEAE)

Aristolochia peltato-deltoidea Hoehne (1942) was published with full Portuguese description and an illustration, but without a Latin diagnosis. Since the "Cambridge Rules" (Rendle 1935; Art. 38), a Latin diagnosis was mandatory and it remains so including in the last "ICBN" Art. 36 (McNeill et al. 2006), therefore the name was not validly published. When writing the treatment of the Aristolochiaceae for Flora of the Guianas (Feuillet & Poncy 1997 & 1998), the fact that the name *A. peltato-deltoidea* was invalidly published was overlooked. A name is needed for this species.

Aristolochia kanukuensis Feuillet, sp. nov. TYPE: GUYANA. UPPER TAKUTU–UPPER ESSEQUIBO: NW slopes of the Kanuku Mountains in drainage of Moku-Moku Cr. (Takutu tributary), dense forest, on exposed rocky ledges, 150–400 m, 31 Mar–16 Apr 1938, *A.C. Smith 3385* (HOLOTYPE: US; ISOTYPES: F, G, K, MO, NY, P, U).

= *Aristolochia peltato-deltoidea* Hoehne, nom. inval. (no Latin diagnosis), Flora Brasilica vol. XV, 2: 102-103; tab. 75. 1942.

Aristolochia kanukuensis a speciebus guianensibus folio deltato et basi peltato, perianthio glabro et flavovirenti, limbo perianthii fusco differt.

The validating description and a key in Portuguese are given under "79. *Aristolochia peltato-deltoidea*" in Hoehne (Flora Brasilica 15(2):102–103. 1942).

The epithet of the new species is derived from the name of the region where all the studied specimens have been collected, the Kanuku Mountains of southern Guyana. Kanuku is a name of Amerindian origin meaning "rich forest" in the Macushi language.

Other material studied: **GUYANA. Upper Takutu–Upper Essequibo:** S Kanuku Mountains, *Maas et al. 4058* (U); Kanuku Mountains, Nappi Cr., 130 m, 4 Nov 1987, *Jansen-Jacobs et al. 705* (BRG, P, U, US, US); Kanuku Mountains, Foothills at Moco-Moco Riv., *Jansen-Jacobs et al. 4592* (BRG, P, U); SE Kanuku Mountains, Makawatta Massif, 750 m, 31 May 1996, *D. Clarke & T. MacPherson 1855* (US).

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PASSIFLORA FOETIDA VAR. *ORINOCENSIS* (PASSIFLORACEAE)

Passiflora foetida subsp. *orinocensis* Killip (1930) was included in the classic "The American Species of Passifloraceae" (Killip 1938) at the rank of variety as *P. foetida* var. *orinocensis* Killip 1930, without acknowledgment of a change in rank. Therefore, the variety is not validly published. The infraspecific name is still in use (Feuillet 1989; Tillett 2003) as a variety, but not as a subspecies.

Passiflora foetida var. **orinocensis** (Killip) Feuillet, stat. nov. Basionym: *Passiflora* subsp. *orinocensis* Killip, Gentes Herb. 2:205, fig. 107. 1930. Type: VENEZUELA. Bolivar: vicinity of Ciudad Bolivar, Isla Degrero, in the Orinoco River, about 200 ft, 6 Mar 1921, *L.H. Bailey & E.Z. Bailey 1773* (holotype: US; isotype: NY).

In *Passiflora* sect. *Dysosmia* DC., the 20 species and ca. 30 varieties tend to produce natural hybrids when in contact, and the taxonomy is confused. The fruits of these species range from green, yellow, to red. Red fruits seem to represent an acquired character state and *P. foetida* var. *orinocensis* shares it with *P. ciliata* Ait., some varieties of *P. foetida* L., and several other species in the section from Central America, Mexico, and the West Indies. Further molecular research on this group, which has so far been poorly sampled, may confirm the position of var. *orinocensis* in *P. foetida* or place it in or near *P. ciliata*.

Other material studied: **VENEZUELA. Bolivar:** Bank of the lower Orinoco River, *Chaffanjon 233* (P, US); *Rusby & Squires 179* (K, MIN, NY); Orinoco River, Caicara, 95 m, 12 Jun 1940, *Ll. Williams 13283* (US). **COLOMBIA. Los Llanos:** Río Meta, Curazao, 25 Oct 1938, *J. Cuatrecasas 4094* (US).

According to Tillett (2003), *Passiflora foetida* var. *orinocensis* has also been collected in Venezuela in the territory Amazonas and the states of Apura and Barinas.

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NOTES ON THE DISARTICULATION OF *XYLOTHAMIA* (ASTERACEAE: ASTEREAE)

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ABSTRACT

The genus *Xylothamia*, primarily of the Chihuahuan and Sonoran deserts in northern Mexico, was originally described with nine species. Molecular evidence by Urbatsch et al. has subsequently shown that these species form two separate clades. Among species in each of the two groups, details of phylogenetic position vary, depending on optimality criteria used in the analysis. Four species of *Xylothamia*, including the type, are most closely related to the Caribbean genus *Gundlachia* and were transferred to *Gundlachia* by Urbatsch and Roberts. These four, however, can be interpreted as having a sister relationship with *Gundlachia* and are here maintained within *Xylothamia*. The remaining five species of *Xylothamia* are part of a clade that includes *Amphiachyris*, *Bigelowia*, *Euthamia*, *Gutierrezia*, *Gymnosperma,* and *Thurovia*. Molecular evidence indicates that two of the five species have a sister relationship but that neither this pair nor any of the other three are unambiguously closely related to any established genus. Segregates were proposed for these five species by Urbatsch and Roberts as the ditypic genus *Neonesomia* and the monotypic genera *Chihuahuana*, *Medranoa*, and *Xylovirgata*. In contrast, morphological features and geographic proximity within the Chihuahuan Desert justify congeneric treatment for these five species, which are here united in *Medranoa* (with *Chihuahuana*, *Neonesomia*, and *Xylovirgata* placed in synonymy). New combinations are **Medranoa johnstonii** (G.L. Nesom) G.L. Nesom, comb. nov., **Medranoa palmeri** (A. Gray) G.L. Nesom, comb. nov., **Medranoa purpusii** (Brandeg.) G.L. Nesom, comb. nov., and **Medranoa pseudobaccharis** (S.F. Blake) G.L. Nesom, comb. nov.

RESUMEN

El género *Xylothamia*, de distribución primaria en los desiertos de Chihuahua y Sonora del norte de México, se describió originariamente con nueve especies. Los datos moleculares de Urbatsch et al. han mostrado que estas especies forman dos clados separados. Entre las especies de cada uno de los grupos, varían los detalles de posición filogenética, dependiendo de los criterios de optimización usados en el análisis. Cuatro especies de *Xylothamia*, que incluyen el tipo, están más cercanamente relacionadas con el género caribeño *Gundlachia* y fueron transferidas a *Gundlachia* por Urbatsch y Roberts. Estas cuatro, sin embargo, pueden interpretarse como el grupo hermano de *Gundlachia* y se mantienen aquí en *Xylothamia*. Las restantes cinco especies de *Xylothamia* son parte de un clado que incluye *Amphiachyris*, *Bigelowia*, *Euthamia*, *Gutierrezia*, *Gymnosperma,* y *Thurovia*. Las pruebas moleculares indican que dos de estas cinco especies tienen una relación de grupo hermano pero que ni este par ni ninguna de las otras tres están fuertemente relacionadas con ningún otro género establecido. Se han propuesto segregaciones de estas cinco especies por Urbatsch y Roberts como género ditípico *Neonesomia* y los géneros monotípicos *Chihuahuana*, *Medranoa*, and *Xylovirgata*. En contraste, las características morfológicas y la proximidad geográfica en el desierto de Chihuahua justifica el tratamiento congenérico de estas cinco especies, dque se unen aquí en *Medranoa* (con *Chihuahuana*, *Neonesomia*, y *Xylovirgata* colocadas en la sinonimia). Las nuevas combinaciones son **Medranoa johnstonii** (G.L. Nesom) G.L. Nesom, comb. nov., **Medranoa palmeri** (A. Gray) G.L. Nesom, comb. nov., **Medranoa purpusii** (Brandeg.) G.L. Nesom, comb. nov., y **Medranoa pseudobaccharis** (S.F. Blake) G.L. Nesom, comb. nov.

The genus *Xylothamia* was proposed to include eight species (Nesom et al. 1990) traditionally associated with *Ericameria*. A ninth was added soon after (Nesom 1992). Except for *Xylothamia diffusa*, which occurs in Sonora, Baja California, and Baja California Sur, all are species of the Chihuahuan Desert. Molecular evidence by Urbatsch et al. (2003) subsequently indicated that the nine species of *Xylothamia* form two separate clades. Four species, including the type, are most closely related to the Caribbean genus *Gundlachia* (sensu Lane 1996). The remaining five species are part of a clade that includes *Amphiachyris*, *Bigelowia*, *Euthamia*, *Gutierrezia*, *Gymnosperma,* and *Thurovia*. *Gundlachia* and its related *Xylothamia* species are sister to the other group, and this larger clade is essentially what has been termed the "Gutierrezia group" (e.g., Nesom 2000).

Parsimony analyses by Urbatsch et al. were based on combined data sets of the external transcribed spacer (ETS) and internal transcribed spacer (ITS) DNA sequences, both with and without indels. A morphological data set including ten characters was added in some of the analyses. The biphyletic nature of

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Xylothamia is clear, but among species in each of the two lineages, details of phylogenetic positions vary, depending on which optimality criterion was used in the analysis.

Taxonomy proposed by Urbatsch and Roberts (2004) merged the four species of *Xylothamia* sensu stricto with *Gundlachia*. The other five *Xylothamia* species were apportioned into four new genera. The comments below propose a taxonomic alternative for the species of these two groups and the taxonomic summary shows how the original nine species of *Xylothamia* will be treated in the Astereae of Mexico (Nesom, expected 2007).

Expanded *Gundlachia*

The four species of *Xylothamia* sensu stricto and *Gundlachia* are shown by Urbatsch et al. (2003) as sister groups in analyses including indels (Figs. 1A, a ratchet analysis, and 1B, a heuristic analysis), in a Bayesian analysis (Fig. 2), and in a heuristic analysis including indel data and the morphological character matrix (Fig. 3, right side). *Xylothamia riskindii*, the other three *Xylothamia* species, and *Gundlachia* are shown as an unresolved trifurcation in a bootstrap analysis including indel data and a morphological character matrix (Fig. 3, left side). The four *Xylothamia* species are shown as a basal grade to *Gundlachia* in a tree derived from a ratchet analysis of the molecular data excluding indels (Urbatsch et al. 2003, Fig. 4). The topology shown by Urbatsch and Roberts (2004, Fig. 1) was based on the earlier-published Figure 4.

A close relationship of Caribbean *Gundlachia* to Mexican *Xylothamia* sensu stricto is supported by the molecular analyses, but the topology of the relationship is not resolved. Morphology of Caribbean *Gundlachia* is distinctive and relatively consistent among the taxa, and the geographical and morphological contrasts (noted below) with *Xylothamia* provide a rationale for recognition of these two species groups as separate genera. *Gundlachia* is paraphyletic without *Xylothamia* in only one of the various analyses by Urbatsch et al.

Urbatsch and Roberts (2004, p. 250) noted that "Flagelliform trichomes having a subterminal appendage attachment characterize the Caribbean species [of *Gundlachia*] and similar trichomes are seen in *G. riskindii*." Caribbean *Gundlachia* and "*Gundlachia*" *riskindii* also have laminar, spatulate leaves. Neither of these similarities, however, appears to have significantly influenced the parsimony analyses that included morphological data. Nesom et al. (1990, p. 103) emphasized the irregularly lobed disc corollas found in all nine of the *Xylothamia* species, unique among all their potentially close relatives, including *Gundlachia*: "The zygomorphic disc corollas of [all of the *Xylothamia*] species are even more remarkable, because to our knowledge, they do not occur in any other North American Astereae. Typically, two of the sinuses are cut nearly to the base of the throat, one is very shallow, and the other two are intermediate in depth. The two lobes on either side of the shallow sinus are erect, but the other three are sharply reflexed to coiling." This feature was not included in the morphological analysis by Urbatsch et al. (2003); it was noted by Urbatsch and Roberts (2004) as a feature of all of the original nine *Xylothamia* species, but it was not mentioned as a synapomorphy.

Xylothamia riskindii is disparate among the four species considered here as *Xylothamia* sensu stricto, as evidenced by the following contrast.

1. Leaves flat, obovate-spatulate; heads solitary; ray florets 7–13; involucres 7–8 mm diam.; disc florets 30–50 __________ **X. riskindii**
1. Leaves involute, appearing terete; heads in loose or compact cymes or sessile in groups of 2–3 at branch apices; ray florets 0 or 1–3 hidden within the involucre; involucres 2.5–4 mm diam.; disc florets 3–7__________ **X. diffusa, X. triantha,** and **X. truncata**

It also is distinct in comparison to taxa of *Gundlachia*.

1. Subshrubs ca 8–15 cm tall; heads solitary, sessile to subsessile; involucres broadly turbinate, 7–8 mm diam.; phyllaries without orange-resinous midveins; ray florets 7–13, corollas yellow; disc florets 30–50 __________ **X. riskindii**
1. Shrubs to 200 cm tall; heads in clusters of 1–5, the clusters in racemes or corymbs, in turn borne in panicles or flat-topped to slightly rounded corymboid clusters; involucres cylindric to narrowly obconic, 2–4 mm diam.; phyllaries with orange-resinous midveins; ray florets 3–8, corollas white; disc florets 3–10 __________**Gundlachia**

Urbatsch and Roberts (2004, p. 250) noted that certain evidence suggests that "*G. riskindii* may represent the ancestral state for *Gundlachia* or may be a link connecting the Caribbean and the Mexican species." In the evaluation here, *Xylothamia riskindii* remains unusual among the species placed in *Xylothamia*.

Chihuahuana, *Medranoa*, *Neonesomia*, and *Xylovirgata*

Urbatsch and Roberts (2004, p. 244) noted that "With regard to the other five species of *Xylothamia*, *X. johnstonii*, and *X. palmeri* constitute a robustly supported clade (Urbatsch et al. 2003) that is herein proposed as the new genus *Neonesomia*. The three remaining species of *Xylothamia* are each treated as monotypic genera [*Chihuahuana*, *Medranoa*, and *Xylovirgata*] because they are not unambiguously supported as monophyletic or placed within existing genera based on DNA sequence data (Urbatsch et al. 2003), and they are each morphologically unique."

In molecular analyses including indels (Urbatsch et al. 2003: Figs. 1A, a ratchet analysis, and 1B, a heuristic analysis), *Chihuahuana*, *Medranoa*, and *Xylovirgata* constitute a monophyletic group and *Neonesomia* is basal to the clade that includes the three other new genera above and six more (*Amphiachyris*, *Bigelowia*, *Euthamia*, *Gutierrezia*, *Gymnosperma,* and *Thurovia*). In the Bayesian analysis (Fig. 2), *Medranoa* and *Chihuahuana* have a sister relationship and *Neonesomia* is most closely related to *Thurovia*. In analyses including indel data and the morphological character matrix, the position of all four new genera is unresolved (Fig. 3, left side-bootstrap) or *Medranoa* and *Xylovirgata* show a sister relationship (Fig. 3, right side-heuristic). In a ratchet-derived consensus tree resulting from an analysis excluding indels (Fig. 4), the positions of *Neonesomia* and *Medranoa* are unresolved, while *Chihuahuana* and *Xylovirgata* are sister taxa.

While it is clear that each of the four taxa treated as a new genus by Urbatsch and Roberts is morphologically unique and that the molecular analyses do not provide unambiguous phyletic resolution for them (apart from their separation from *Xylothamia* sensu stricto), molecular data do not provide a compelling rationale to recognize four new genera among five species of the Chihuahuan Desert. Analogous to the position of *X. riskindii* among its three congeners, *X. purpusii* (below as *Medranoa purpusii*) is relatively more distinctive in morphology and on that basis might justifiably be treated as a monotypic genus apart from its four congeners. Treatment of these species within a single genus is at least as justified, based on current evidence, as is their distribution among four. Geography and morphology provide support for their recognition as a single lineage: geographic proximity commonly is an indicator of close evolutionary relationship, and the zygomorphic disc corollas (discussed above) in this group of five species provide a potential apomorphy that suggests common ancestry, as in the original delimitation of *Xylothamia*. While it cannot be definitively argued that the previous treatment is flawed, a more parsimonious and conservative taxonomy is favored here.

TAXONOMIC SUMMARY

XYLOTHAMIA Nesom, Suh, Morgan & Simpson, Sida 14:106. 1990. Type species: *Xylothamia (Aplopappus) triantha* (S.F. Blake) G.L. Nesom.

1. **Xylothamia diffusa** (Benth.) G.L. Nesom, Sida 14:109. 1990. *Ericameria diffusa* Benth.; *Gundlachia diffusa* (Benth.) Urbatsch & R.P. Roberts.
2. **Xylothamia triantha** (S.F. Blake) G.L. Nesom, Sida 14:113. 1990. *Aplopappus [Haplopappus] trianthus* S.F. Blake; *Ericameria triantha* (S.F. Blake) Shinners; *Gundlachia triantha* (S.F. Blake) Urbatsch & R.P. Roberts.
3. **Xylothamia riskindii** (B.L. Turner & G. Langford) G.L. Nesom, Sida 14:113. 1990. *Ericameria riskindii* B.L. Turner & G. Langford; *Gundlachia riskindii* (B.L. Turner & G. Langford) Urbatsch & R.P. Roberts.
4. **Xylothamia truncata** G.L. Nesom, Phytologia 73:318. 1992. *Gundlachia truncata* (G.L. Nesom) Urbatsch & R.P. Roberts.

MEDRANOA Urbatsch & R.P. Roberts, Sida 21:254. 2004. Type species: *Medranoa (Ericameria) parrasana* (S.F. Blake) Urbatsch & R.P. Roberts.

Chihuahuana Urbatsch & R.P. Roberts. Type species: *Chihuahuana* (*Ericameria*) *purpusii* (Brandeg.) Urbatsch & R.P. Roberts.
Neonesomia Urbatsch & R.P. Roberts. Type species: *Neonesomia* (Aster) *palmeri* (A. Gray) Urbatsch & R.P. Roberts.
Xylovirgata Urbatsch & R.P. Roberts. Type species: *Xylovirgata* (*Haplopapus*) *pseudobaccharis* (S.F. Blake) Urbatsch & R.P. Roberts.

Etymology.—Medranoa is chosen here, from among the four possibilities, as the name to represent this group of species because it honors a Mexican botanist, Dr. F.G. Medrano, which seems appropriate for this group of primarily Mexican species.

1. **Medranoa johnstonii** (G.L. Nesom) G.L. Nesom, comb. nov. *Neonesomia johnstonii* (G.L. Nesom) Urbatsch & R.P. Roberts; *Xylothamia johnstonii* G.L. Nesom, Sida 14:110. 1990.
2. **Medranoa parrasana** (S.F. Blake) Urbatsch & R.P. Roberts, Sida 21:255. 2004. *Ericameria parrasana* S.F. Blake; *Haplopappus parrasanus* (S.F. Blake) S.F. Blake; *Xylothamia parrasana* (S.F. Blake) G.L. Nesom.
3. **Medranoa palmeri** (A. Gray) G.L. Nesom, comb. nov. *Aster palmeri* A. Gray, Proc. Amer. Acad. Arts 17:209. 1882.; *Ericameria austrotexana* M.C. Johnston (non *Ericameria palmeri* (A. Gray) H.M. Hall); *Neonesomia palmeri* (A. Gray) Urbatsch & R.P. Roberts; *Xylothamia palmeri* (A. Gray) G.L. Nesom.
4. **Medranoa purpusii** (Brandeg.) G.L. Nesom, comb. nov. *Ericameria purpusii* Brandeg., Univ. Calif. Publ. Bot. 4:191. 1911; *Chihuahuana purpusii* (Brandeg.) Urbatsch & R.P. Roberts; *Haplopappus [Aplopappus] purpusii* (Brandeg.) S.F. Blake; *Xylothamia purpusii* (Brandeg.) G.L. Nesom.
5. **Medranoa pseudobaccharis** (S.F. Blake) G.L. Nesom, comb. nov. *Haplopappus pseudobaccharis* S.F. Blake, J. Washington Acad. Sci. 40:47. 1950; *Ericameria pseudobaccharis* (S.F. Blake) Urbatsch; *Xylothamia pseudobaccharis* (S.F. Blake) G.L. Nesom; *Xylovirgata pseudobaccharis* (S.F. Blake) Urbatsch & R.P. Roberts.

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URBATSCH, L.E. and R.P. ROBERTS. 2004. New combinations in the genus *Gundlachia* and four new genera of Astereae (Asteraceae) from northern Mexico and the southern United States. Sida 21:243–257.

TWO NEW SPECIES OF *GRATIOLA* (PLANTAGINACEAE) FROM EASTERN NORTH AMERICA AND AN UPDATED CIRCUMSCRIPTION FOR *GRATIOLA NEGLECTA*

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ABSTRACT

Gratiola section *Nibora*, a North American taxon as currently circumscribed, includes six species: *G. ebracteata*, *G. flava*, *G. floridana*, *G. heterosepala*, *G. neglecta*, and *G. virginiana*. *Gratiola ebracteata* and *G. heterosepala* are restricted to western North America and the remaining four species are mostly eastern North American. The species with the largest range and greatest degree of morphological variability is *G. neglecta*. A recent investigation of *G. neglecta* involving fieldwork, examination of herbarium specimens, morphological analysis, and phytogeographic study, has resulted in the discovery of two undescribed species, **G. graniticola** sp. nov. and **G. quartermaniae** sp. nov., both of which are endemic to rock outcrop communities of eastern North America. In this paper, both new species are described, illustrated, and compared to their widespread congener, *G. neglecta*. An updated circumscription of *G. neglecta* is provided and a key distinguishing the new species from *G. neglecta* is included.

RESUMEN

Gratiola sección *Nibora*, un taxon norteamericano como se circumscribe normalmente, incluye seis especies: *G. ebracteata*, *G. flava*, *G. floridana*, *G. heterosepala*, *G. neglecta*, y *G. virginiana*. *Gratiola ebracteata* y *G. heterosepala* están restringidas al oeste de Norte América y las restantes cuatro especies están principalmente en el este de Norte América. La especie con el rango más amplio y el mayor grado de variabilidad morfológica es *G. neglecta*. Una investigación reciente de *G. neglecta* con trabajo de campo, examen de especimenes de herbario, análisis morfológico, y estudio fitogeográfico, ha dado como resultado el descubrimiento de dos nuevas especies, **G. graniticola** sp. nov. y **G. quartermaniae** sp. nov., ambas endémicas de comunidades de afloramientos rocosos del este de Norte América. En este artículo, se describen e ilustran ambas especies, y se compraran con su congénere generalizada *G. neglecta*. Se aporta una circunscripción puesta al día de *G. neglecta* y se incluye una clave para diferenciar las nuevas especies de *G. neglecta*.

Gratiola L. section *Nibora* (Raf.) Pennell (Plantagianceae) was erected by Pennell (1935) to accommodate the annual North American species characterized by having capsules equaling or slightly exceeding the sepals, leaves sessile to scarcely clasping and obscurely glandular punctate, and seeds yellowish and faintly reticulate. Pennell (1935) recognized five species within the section: *G. ebracteata* Benth., *G. flava* Leavenw., *G. floridana* Nutt., *G. neglecta* Torr., and *G. virginiana* L. Mason and Bacigalupi (1954) added a sixth species to this section when they described *G. heterosepala* Mason & Bacig. from northern California. *Gratiola ebracteata* and *G. heterosepala* are restricted to western North America while *G. flava*, *G. floridana*, and *G. virginiana* are mostly eastern North American (*G. virginiana* is also disjunct to central Mexico). *Gratiola neglecta* is the most widespread and most variable species in the section, ranging across much of temperate North America. Throughout its broad range, *G. neglecta* inhabits a wide diversity of wetland communities and exhibits considerable variation in degree of branching, stem pubescence, leaf shape, flower morphology, and capsule size.

Recent evidence from field and herbarium studies indicates that material previously referred to *G. neglecta* includes two undescribed species. The first new species, *G. quartermaniae* D. Estes sp. nov., has a highly fragmented distribution in eastern North America and is endemic to ephemerally wet sites associated with calcareous outcrops (cedar glades) and prairies. The second new species, *G. graniticola* D. Estes sp. nov., is endemic to north-central Georgia where it is restricted to vernal pools on granitic outcrops. In this paper, both new species are described, illustrated, and compared to their widespread congener, *G. neglecta*. Because *G. quartermaniae* and *G. graniticola* have been included within the concept of *G. neglecta* by previous authors, an updated circumscription of *G. neglecta* is provided.

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MATERIALS AND METHODS

In order to clarify morphological variation within and between *G. neglecta*, *G. quartermaniae*, and *G. graniticola*, an investigation was conducted that incorporated fieldwork, examination of herbarium specimens, morphological analyses, and phytogeography. Fieldwork was conducted in portions of 26 states in the United States and the province of Ontario, Canada between 2001 and 2006. In addition, more than 4,000 herbarium specimens (including some digital images), representing all taxa from sect. *Nibora,* were examined from the following 49 herbaria: A, ALU, APSC, ASTC, AUA, BRIT, CAN, CITA, CLEMS, DAO, DUKE, EKY, FSU, GA, GH, H, ILLS, ISC, JEPS, JSU, K, KANU, LL, LSU, MIN, MISS, MO, MTSU, NCSC, NCU, NLU, NO, NY, NYS, OKL, PH, SBSC, SMU, TENN, TEX, TROY, TRT, UARK, UC, UNA, US, USCH, VDB, and VPI (herbarium acronyms follow Index Herbariorum, http://www.nybg.org/bsci/ih/search).

From the herbarium specimens examined during this project, a subset of 87 mature and complete specimens representing 55 *G. neglecta*, 15 *G. graniticola*, and 17 *G. quartermaniae*, was selected for use in a morphometric study. Specimens were chosen to represent the full geographic distribution, range of habitat, and morphological variation of each species. For each specimen, 10 quantitative vegetative and floral characters were measured (Table 1); these specimens are denoted by an asterisk in the lists of representative specimens examined. Seed measurements were taken from five of the above specimens (1 *G. graniticola*, 4 *G. neglecta*) plus an additional 14 specimens representing a total of 10 widespread populations of *G. neglecta*, four of *G. graniticola*, and five of *G. quartermaniae.* Twenty seeds from a single capsule were measured per population, and three quantitative characters were scored per seed (Table 1). Specimens used for seed measurements are indicated by a dagger (†) in the lists of specimens examined. For each scored character, summary statistics including mean, standard deviation, and range were calculated; these values are presented in Table 1. In the taxonomic key and species descriptions, measurements for characters are given as the mean ± one standard deviation with extreme values, based on additional observations, given in parentheses. In order to reveal discontinuities in the data and to determine which characters are most useful for delimiting taxa, pairwise comparisons of characters were conducted using scatter diagrams and box plots. Seeds and trichomes of all three species were also examined with the aid of scanning electron microscopy (SEM) to search for useful taxonomic characters. The geographic distribution of *G. neglecta, G. graniticola,* and *G. quartermaniae* was determined by examining the collection data included on herbarium specimens and plotting the county-level distribution of each species on outline maps. Each point on these maps is represented by at least one herbarium specimen examined.

RESULTS AND DISCUSSION

Morphology

Gratiola neglecta, G. quartermaniae, and *G. graniticola* form a morphologically cohesive group referred to here as the *Gratiola neglecta* complex. A fourth species, *G. floridana*, also belongs to this complex; however, it is quite distinct morphologically in spite of sharing a suite of features uniting it with the other three species. *Gratiola floridana* differs from the other members of the complex in its overall larger features including much larger flowers 13–25 mm long (vs. 5–14 mm), longer proximal fruiting pedicels averaging 23–43 mm long (vs. 12–25 mm), and longer seeds averaging 0.79–0.9 mm (vs. 0.4–0.6 mm). This species tends to inhabit forested sites whereas the others mostly grow in open communities. It is also the southernmost member of the complex ranging from northwestern Florida and southeastern Louisiana (historically) north into southeastern Tennessee. The distribution of *G. floridana* only slightly overlaps with the ranges of *G. neglecta* and *G. quartermaniae* in the northern portion of its range. Since *G. floridana* is one of the most distinctive species of the genus and has rarely been confused with *G. neglecta* or the two new species, it will not be discussed further.

Several characters distinguish *G. graniticola* from *G. neglecta* and *G. quartermaniae* (Table 2; Fig. 1, Fig. 2). *Gratiola graniticola* has shorter leaves (normal leaves that subtend pedicels are also referred to as bracts or bracteal leaves in this paper) that are widest at or below the middle (Fig. 2 A), shorter pedicels that

Table 1. Morphological characters measured for *Gratiola graniticola, G. neglecta,* and *G. quartermaniae* and their means ± standard deviations and ranges (parentheses). *N*=sample size.

Characters	***G. graniticola (N=15)***	***G. neglecta (N=55)***	***G. quartermaniae (N=17)***
Stem height (cm)	14.8 ± 5.9 (7.4–29.4)	19.9 ± 5.5 (10.2–33.2)	16.5 ± 5.1 (5.8–29)
Stem diameter (mm)	1.2 ± 0.2 (0.7–1.4)	1.6 ± 0.5 (0.8–2.9)	1.4 ± 0.4 (0.6–2.3)
Leaf length (mm)	10 ± 2.8 (6.3–17.7)	30.8 ± 10.3 (11–66)	25.1 ± 7.0 (16–43)
Leaf width (mm)	2.1 ± 1.0 (1.1–5.2)	7.7 ± 2.6 (2.7–18)	3.3 ± 0.8 (1.8–4.5)
Leaf length/leaf width (ratio)	4.6 ± 1.0 (2.8–7.45)	4.1 ± 0.80 (2.6–6.1)	7.7 ± 1.8 (5.5–11.2)
No. teeth per leaf margin	1.0 ± 0.7 (0–3)	3.5 ± 1.2 (1–7)	1.2 ± 1.1 (0–3)
Proximal pedicel length (mm)	12.4 ± 4.9 (5.3–22)	20.6 ± 7.7 (10.5–37)	17 ± 4.2 (8–22)
Bract length (mm)	8.7 ± 2.2 (5.3–11.2)	28.8 ± 9.5 (11.5–66)	21.8 ± 6.6 (12.5–33)
Pedicel length/bract length (ratio)	1.5 ± 0.4 (0.9–2.3)	0.8 ± 0.3 (0.3–1.3)	0.8 ± 0.3 (0.5–1.6)
Capsule length (mm)	3.2 ± 0.3 (2.9–3.6)	4.3 ± 0.6 (2.6–5.7)	4.1 ± 0.6 (3.4–5.1)
	G. graniticola *(N=80)*	***G. neglecta*** *(N=200)*	***G. quartermaniae*** *(N=100)*
Seed length (mm)	0.40 ± 0.03 (0.31–0.47)	0.54 ± 0.06 (0.42–0.7)	0.59 ± 0.04 (0.43–0.71)
Seed diameter (mm)	0.22 ± 0.02 (0.17–0.27)	0.24 ± 0.02 (0.18–0.29)	0.29 ± 0.03 (0.19–0.37)
Seed length/seed width (ratio)	1.86 ± 0.24 (1.32–2.53)	2.3 ± 0.27 (1.67–3.03)	2.05 ± 0.27 (1.47–2.6)

are longer relative to their subtending bracts (Fig. 2, D–E), smaller corollas that have a purplish or pinkish posterior lobe and beard of whitish trichomes, bracteoles that are shorter than to only slightly exceeding the calyces, smaller more subglobose purple-tinged capsules (Fig. 2 F), smaller seeds (Fig. 2 G–H; Fig. 3 A), and bulbous-based trichomes (Fig. 3). *Gratiola neglecta* and *G. quartermaniae* have longer leaves (Fig. 2 A), longer pedicels that are mostly equal to or shorter than their subtending bracts (Fig 2, D–E), larger corollas that usually lack purplish or pinkish coloration and that have a beard of yellow trichomes inside the corolla orifice, bracteoles that are mostly longer than the calyces, larger more ovoid and brownish capsules (Fig. 2 F), larger seeds (Fig. 2, G–H; Fig. 3 B–C), and slender-based trichomes (Fig. 3, E–F). A scatter diagram of leaf length vs. capsule length between *G. graniticola*, *G. neglecta*, and *G. quartermaniae* reveals two primary clusters that exhibit minimal overlap (Fig. 1 A). In this scatter plot, specimens of *G. graniticola* mostly group separately from the second unresolved cluster that consists of specimens of *G. neglecta* and *G. quartermaniae*. A scatter plot of proximal pedicel length/subtending bract length vs. leaf width also distinguishes *G. graniticola* from *G. neglecta* (Fig. 1 B).

Gratiola quartermaniae differs from *G. neglecta* in having a glabrous midstem, narrower (Fig. 2 B) and more falcate, fewer veined and fewer toothed leaves that have a larger length to width ratio (Fig. 2 C) and seeds that average longer, thicker, and darker (Fig. 2, G–H). In comparison to *G. quartermaniae*, *G. neglecta* has mostly pubescent (rarely glabrate in some New England estuarine populations) midstems, wider (Fig. 2 B), more veined and more toothed leaves that have a smaller leaf length to width ratio (Fig. 2 C). The seeds

Table 2. Qualitative morphological characters useful for distinguishing *G. graniticola, G. neglecta,* and *G. quartermaniae.*

Character	*G. graniticola*	*G. neglecta*	*G. quartermaniae*
Stems	simple–rarely branched	branched–rarely simple	simple–rarely branched
Leaf shape	lanceolate-ovate to narrowly oblong	narrowly elliptic, rhombic, or oblanceolate	linear, linear-lanceolate, or elliptic-lanceolate
Basal leaf disposition	± congested	not congested	± congested
Widest point of leaf	middle or below middle	middle or beyond middle	middle
Proximal bract to pedicel ratio	bract < pedicel	bract ≥ pedicel	bract ≥ pedicel
Mid-stem vestiture	glandular-pubescent	glandular-pubescent	glabrous
Trichome shape	bulbous-based	slender-based	slender-based
Ratio bracteole length/calyx length	bracteoles ≤ to slightly exceeding calyx	bracteoles ≥ calyx	bracteoles ≥ calyx
Posterior corolla lobe color	purplish or pinkish	white (rarely pinkish)	white (rarely pinkish)
Beard color	white	yellow	yellow
Capsule shape	subglobose	ovoid	ovoid
Capsule color	purplish	brown	brown
Seed color	grayish-brown	yellowish-brown	grayish-brown
Habitat	granite outcrops	various wetland types, rarely on outcrops	limestone/dolomite outcrops, calcareous prairies

of *G. neglecta* are lighter in color and average slightly shorter and are not as thick as those of *G. quartermaniae* (Fig. 2, G–H). In Fig. 1 C, a scatter plot of leaf length/leaf width vs. number of teeth per margin for *G. neglecta* and *G. quartermaniae* reveals two clusters of specimens.

Distribution and Ecology

Gratiola neglecta has the largest distribution of the three species, being found throughout most of temperate North America (Fig. 4). It ranges from Nova Scotia and British Columbia, Canada, south in the United States to central Georgia, coastal Texas, northern Arizona, and northern California. The species is most common in the eastern United States particularly in the lower Mississippi, Missouri, and Ohio River valleys. West of the Mississippi River, the range of *G. neglecta* mostly follows the major river systems toward the Great Plains. From the upper Missouri River watershed, *G. neglecta* ranges south into the southern Rocky, Cascade, and Sierra Nevada mountains. Several populations in the western United States are associated with reservoirs; these may represent recent introductions by migrating waterfowl. Interestingly, *G. neglecta* has also been collected in France (*Simon s.n.* FSU; *Rastetter 11653* UC) and Finland (*Lampinen 5629* H; see Suominen 1984) where probably introduced.

Gratiola neglecta grows in a broader array of wetland communities and endures a greater range of environmental conditions than *G. graniticola* or *G. quartermaniae*. It grows from sea level to an elevation of 2400 m in the mountains of the western United States. Compared to the new species, *G. neglecta* occurs more frequently in the deeper soil of agricultural fields, openings in bottomland hardwood forests, wet meadows, mudflats, and pond margins. Rarely, *G. neglecta* occurs in salt marshes or on various types of shallow-soiled rock outcrops including igneous, sandstone, limestone, and granite formations.

Gratiola quartermaniae has a fragmented range (Fig. 5) and is most common in the limestone cedar glades of the Interior Low Plateau of middle Tennessee and northern Alabama. From this core range, it is disjunct to the alvars of southeastern Ontario, Canada, a distance of ca. 1200 km. Most of the Ontario populations are associated with the Napanee limestone plain but a few are found in the Dummer Moraine and Prince Edward Peninsula physiographic regions (Chapman & Putnam 1984). Numerous other species that are more common on calcareous outcrops in the southeastern United States also occur on Canadian alvars including several of the species commonly associated with *G. quartermaniae* in Tennessee and Alabama such as *Carex granularis* Muhl. ex Willd., *C. crawei* Dewey, *C. molesta* Mack. ex Bright, *Isanthus brachiatus* (L.)

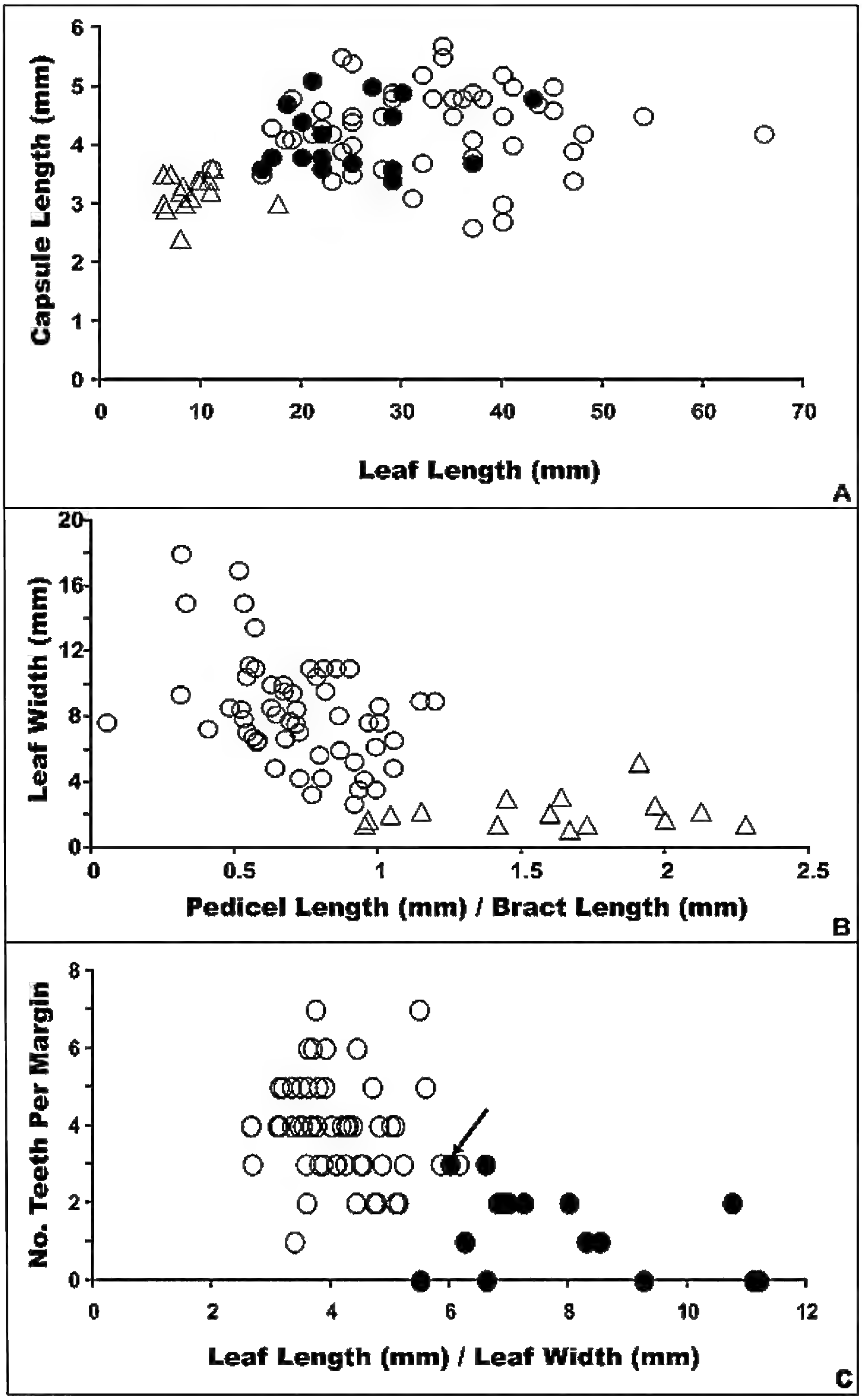

Fig. 1. Scatter plots of leaf length vs. capsule length (A), proximal pedicel length/subtending bract length vs. leaf width (B), leaf length/leaf width vs. number of teeth per margin (C) for *G. graniticola* (open triangles), *G. neglecta* (open circles), and/or *G. quartermaniae* (closed circles). Note that open circles in panel C represent specimens with pubescent mid-stems, and solid circles represent plants with glabrous mid-stems with one exception; the solid circle marked with an arrow has features typical of *G. quartermaniae* except for having a pubescent mid-stem. This specimen (*Kral 52812*, VDB, Cannon Co., TN) was collected from a seep over limestone at the edge of the range of *G. quartermaniae* and may represent a hybrid.

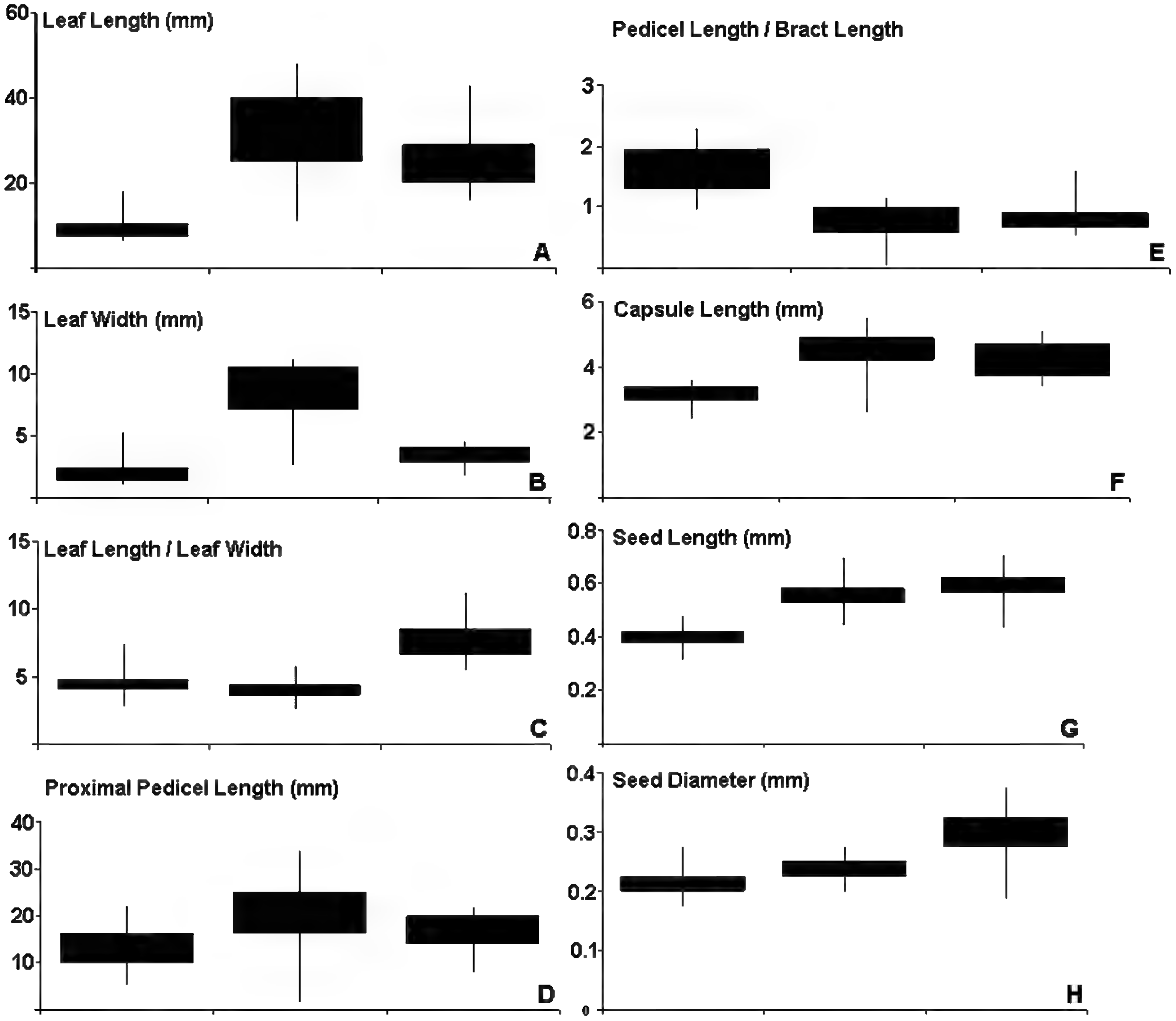

Fig. 2. Graphical comparison of eight selected characters for *Gratiola graniticola* (left), *G. neglecta* (center), and *G. quartermaniae* (right): leaf length (A), leaf width (B), ratio of leaf length to leaf width (C), proximal pedicel length (D), ratio of proximal pedicel length to subtending bract length (E), capsule length (F), seed length (G), and seed diameter (H).

B.S.P., *Scutellaria parvula* Michx., and *Sporobolus vaginiflorus* (Torr. ex Gray) Wood. *Gratiola quartermaniae* is also disjunct to Will County, Illinois from its main range in central Tennessee, a distance of approx. 600 km. Two limestone glade near-endemics, *Dalea foliosa* (Gray) Barneby and *Astragalus tennesseensis* Gray ex Chapman, share this similar distribution pattern (Baskin & Baskin 2003). *Gratiola quartermaniae* is also disjunct to the Edward's Plateau of Texas, a distance of ca. 1200 km. Interestingly, *Juncus filipendulus* Buckley, a species that *G. quartermaniae* frequently occurs with in Alabama and Tennessee, is also disjunct to the Edward's Plateau where it occurs with *G. quartermaniae*. Therefore, while the disjunction patterns exhibited by *G. quartermaniae* are unusual, further examination indicates that in each of these areas *G. quartermaniae* occurs in similar habitat and always occurs with other calciphilous species, some of which have similar patterns of disjunction. This species should be searched for in other regions where calcareous outcrops and prairies occur such as the limestone glades of the southern Ridge and Valley of southeastern Tennessee and northwestern Georgia, the Blackbelt prairies of Mississippi and Alabama, the limestone glades of central and western Kentucky, the Ozark glades of southern Missouri and northern Arkansas, and alvar habitats in New York, Michigan, and Ohio.

Gratiola quartermaniae is found on limestone or dolomite outcrops and calcareous prairies. In these

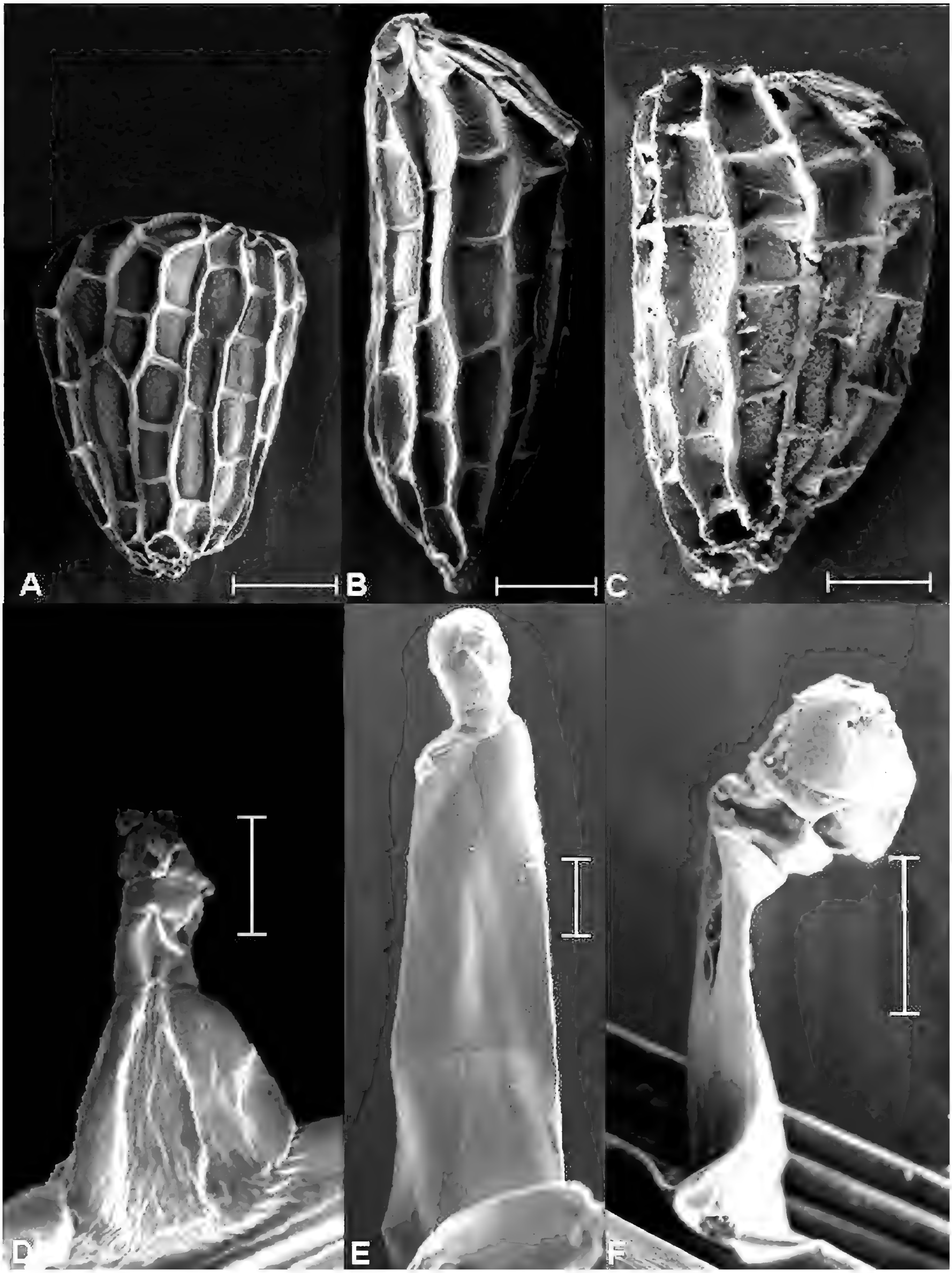

Fig. 3. Seeds of *Gratiola graniticola* (A), *G. neglecta* (B), and *G. quartermaniae* (C); scale bars = 100 µm. Trichomes of *G. graniticola* (D), *G. neglecta* (E), and *G. quartermaniae* (F); scale bars = 20 µm.

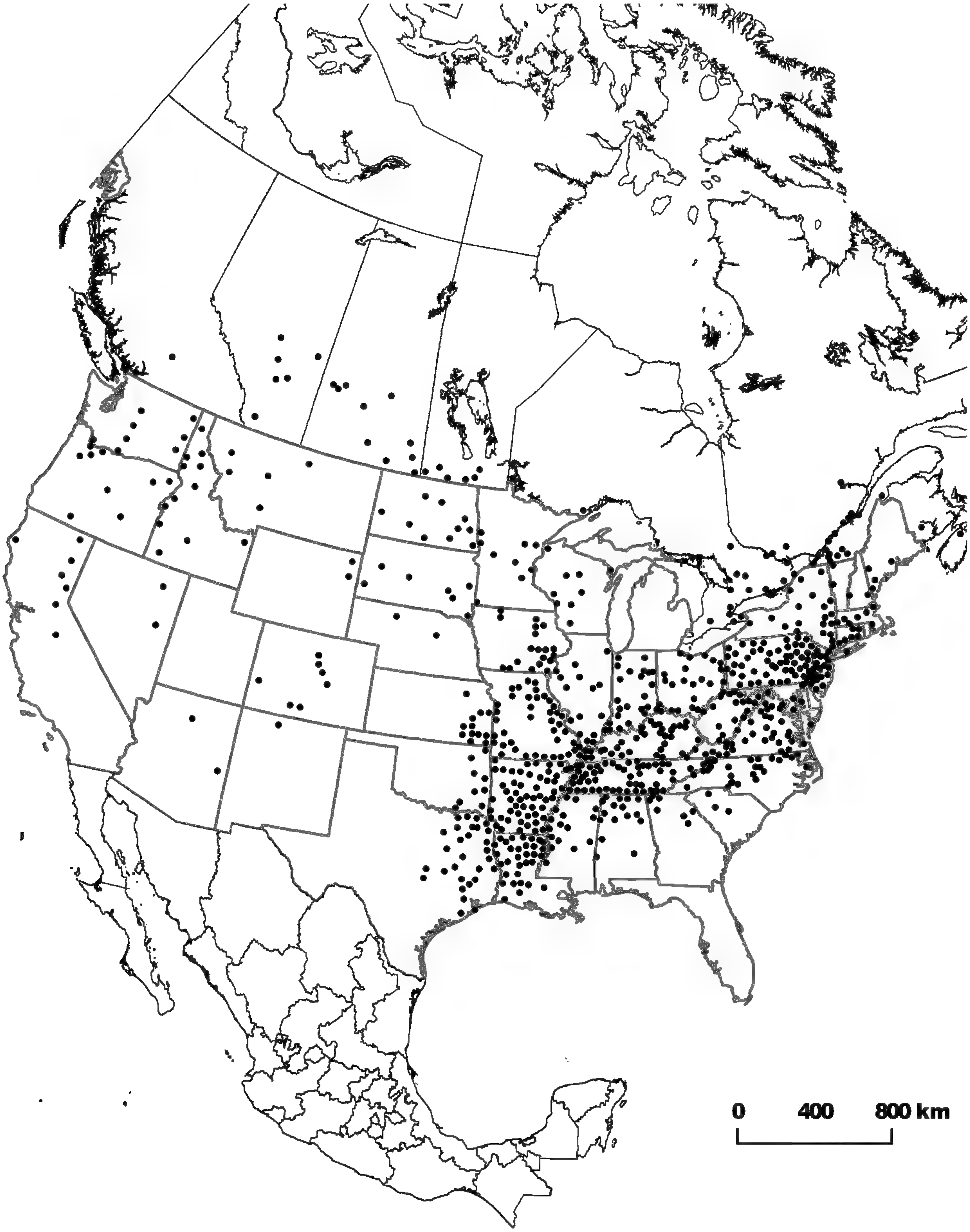

Fig. 4. Geographic distribution of *Gratiola neglecta* in North America.

habitats, the species predominantly occurs in shallow clayey soils of ephemeral pools, seasonal streambeds, and periodically wet meadows on or immediately adjacent to outcrops. These sites are usually flat to slightly sloping and are located in areas that receive high to moderate levels of sunlight. They are wet in late winter

Fig. 5. Geographic distribution of *Gratiola quartermaniae*.

and early spring but become severely desiccated by late spring and early summer. Rarely, *G. quartermaniae* occurs in situations otherwise more typical for *G. neglecta* such as low wet fields, open wet woods, and marsh edges, but these populations are always located within close proximity to glade habitat. Limestone glade endemics such as *Leavenworthia alabamica* Rollins, *L. crassa* Rollins, *L. torulosa* Gray, and *Lesquerella lyrata*

Rollins are sometimes found in disturbed non-outcrop habitats often in association with *G. quartermaniae.* In central Tennessee and northern Alabama, *G. quartermaniae* is almost always associated with limestone cedar glade endemics or calciphiles such as *Allium cernuum* Roth, *Carex crawei*, *C. granularis*, *Dalea foliosa*, *D. gattingeri* (Heller) Barneby, *Eleocharis bifida* S.G. Smith, *Hypericum sphaerocarpum* Michx., *Isoetes butleri* Engelm., *Juncus filipendulus*, *Leavenworthia* spp., *Ludwigia microcarpa* Michx., *Mecardonia acuminata* (Walt.) Small, *Sedum pulchellum* Michx., *Sporobolus vaginiflorus*, and *Talinum calcaricum* Ware. In areas where *G. quartemaniae* is disjunct as in Ontario, Illinois, and Texas, the species is associated with a number of additional calciphilous taxa, including a few of those listed above.

Gratiola graniticola is restricted to granite outcrops in 13 counties on the Piedmont Plateau of Georgia (Fig. 6). Of the approx. 17 Piedmont granite outcrop endemics (McVaugh 1943; Weakley 2007), *G. graniticola* is one of only five species, along with *Isoetes melanospora* Engelmann, *I. piedmontana* (N.E. Pfeiffer) C.F. Reed, *I. tegetiformans* Rury, and *Amphianthus pusillus* Torr., restricted to the ephemeral pools of the outcrops. Interestingly, *I. tegetiformans* and *G. graniticola* are the only Piedmont granite outcrop endemics completely restricted to Georgia.

All known populations of *G. graniticola* occur on granite outcrops in water-filled depressions lined with a thin layer of soil. These depressions are filled with water during the winter and spring months but dry out in the summer and fall. Species commonly associated with *G. graniticola* include *Croton willdenowii* G.L. Webster, *Cyperus granitophilus* McVaugh, *Diamorpha smallii* Britt. ex Small, *Eleocharis obtusa* (Willd.) Schult., *Isoetes piedmontana* (N.E. Pfeiffer) C.F. Reed, *Juncus georgianus* Coville, *Lindernia monticola* Muhl. ex Nutt., *Minuartia uniflora* (Walt.) Mattf., *Packera tomentosa* (Michx.) C. Jeffrey, *Pilularia americana* A.Braun, *Rhynchospora* sp., and *Schoenolirion croceum* (Michx.) A. Gray.

Gratiola quartermaniae is sympatric with *G. neglecta*; however, the two species generally occupy different habitat types. They occur syntopically at a few sites in middle Tennessee and northern Alabama where the typical glade habitat of *G. quartermaniae* occurs in close proximity to habitats preferred by *G. neglecta*. Each of these sites is located within ca. 500 m of a cedar glade or glade-like area. Plants at these sites appeared to belong either to *G. quartermaniae* or to *G. neglecta* with no obvious hybrids observed at most sites. One specimen (*Kral 52812* VDB, MO) collected from a seep over limestone in Cannon County, Tennessee appears to be typical *G. quartermaniae* in general morphology and habitat; however, the middle portion of the stems on this specimen are slightly pubescent and more typical of *G. neglecta* (Fig. 1 C). It is possible that this specimen represents a hybrid between *G. neglecta* and *G. quartermaniae.* Although *G. neglecta* was not found on any cedar glades in middle Tennessee or northern Alabama, the species has been collected from a variety of rock outcrop types elsewhere where it exhibits morphological features typical of non-outcrop populations. *Gratiola floridana* is sympatric with both *G. quartermaniae* and *G. neglecta* in northern Alabama's Moulton Valley (Lawrence and Morgan counties). Although these three species have been found within 1 km of each other, sites supporting all three species are unknown. *Gratiola floridana* and *G. quartermaniae* occur syntopically at one site in Lawrence County, Alabama (*Whetstone et al. 16471* JSU, mixed collection of *G. floridana* and *G. quartermaniae*). *Gratiola floridana* usually inhabits shaded muddy sites in forested bottoms or ravines but in northern Alabama it rarely occurs in habitats more typical of *G. quartermaniae.* No obvious hybrids between *G. floridana* and *G. quartermaniae* or between *G. floridana* and *G. neglecta* have been discovered.

The range of *G. graniticola* lies near the southern edge of the range of *G. neglecta* and the two species overlap only in northeastern Georgia (Elbert and Greene counties). Although the Greene County specimen of *G. neglecta* (*Allison 2630* GA) was collected from a granite outcrop, the two species have never been observed growing syntopically and no putative hybrids have been found. A disjunct population of *G. graniticola* reportedly occurs on a granite outcrop in Lancaster County, South Carolina (J. Allison, Georgia Natural Heritage Program, pers. comm.), but specimens needed to confirm this report have not been located.

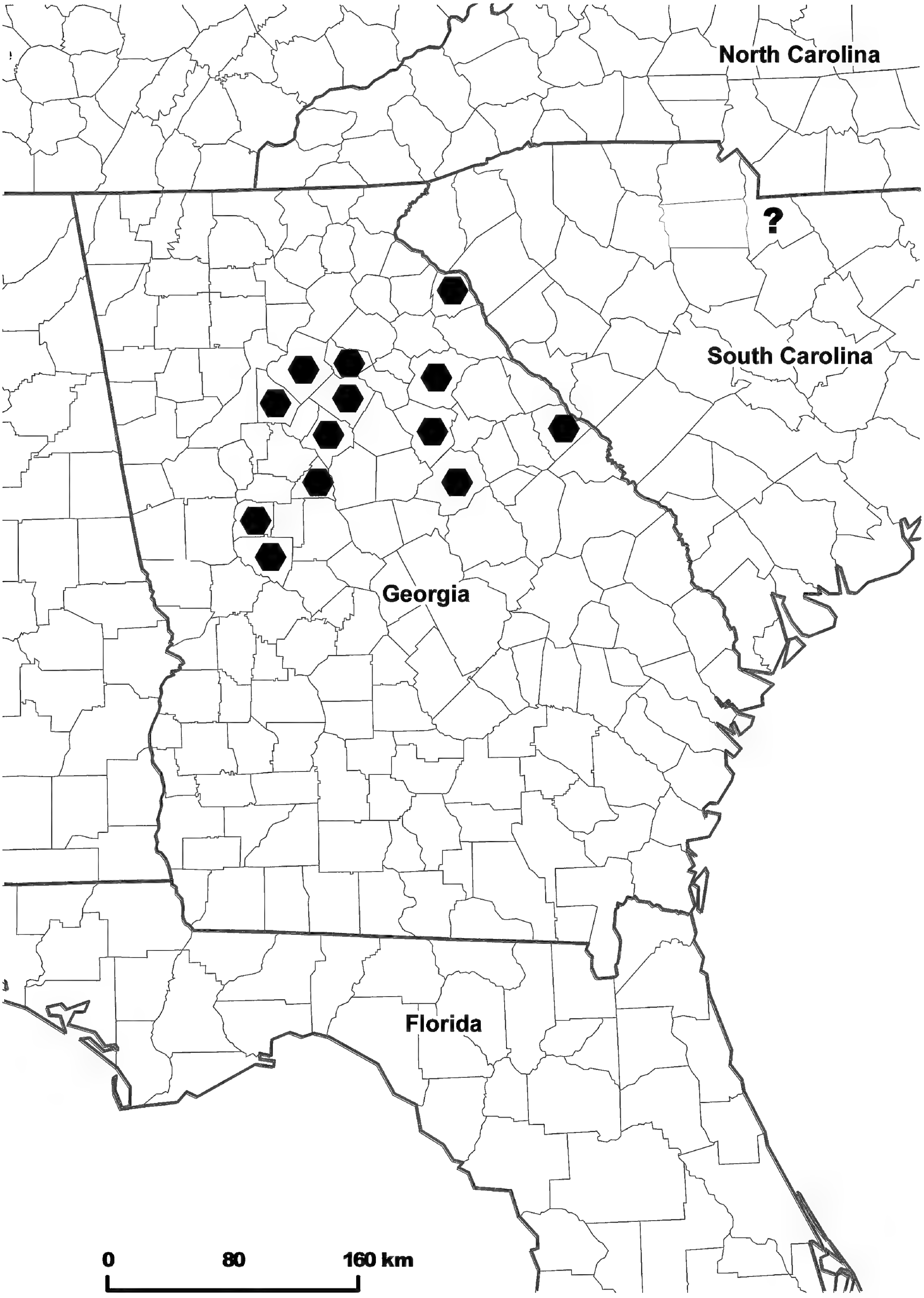

Fig. 6. Geographic distribution of *Gratiola graniticola*. The question mark represents an unconfirmed report from Lancaster Co., South Carolina.

KEY TO THE SPECIES OF THE *GRATIOLA NEGLECTA* COMPLEX

1. Flowers 13–25 mm long, adaxial surface of the corolla lobes pilose; proximal fruiting pedicels (20–)23–43(–55) mm long; seeds (0.6–)0.79–0.9 mm long, trichomes short stalked, the stalks approximately equaling or shorter than the glandular head **G. floridana**
1. Flowers 5–14 mm long, adaxial surface of the corolla lobes glabrous; proximal fruiting pedicels (5–)12–25(–37) mm long; seeds (0.3–)0.4–0.6(–0.7) mm long, trichome stalks ≥ 1.5 times as long as the glandular head.
   2. Mid-stem leaves (11–)20–41(–66) mm long; proximal fruiting pedicels (8–)13–25(–37) mm long, (0.3–)0.5–1(–1.6) times as long as the subtending bracteal leaves; bracteoles slightly longer to conspicuously longer than the sepals; posterior corolla lobe white (rarely inconspicuously tinged with pink or lavender); beard inside corolla orifice of yellow trichomes; mature capsules ovoid, brown; seeds (0.4–)0.5–0.6(–0.7) mm long and (0.18–)0.21–0.29(–0.37) mm thick, trichomes slender-based.
      3. Leaves narrowly elliptic or rhombic to oblanceolate, not conspicuously falcate, (2.7–)5–11(–18) mm wide at widest point; length to width ratio (2.5–)3.5–5(–6), each margin with (1–)3–5(–7) often conspicuous teeth, primary veins 3–5 (7); mid-stem moderately to densely glandular pubescent (rarely glabrate), seeds (0.18–)0.22–0.26(–0.29) mm thick **G. neglecta**
      3. Leaves linear, linear-lanceolate, to elliptic-lanceolate, often falcate, (1–)2.5–4(–4.5) mm wide at widest point, length to width ratio (5.5–)6–9.5(–11), entire or each margin with 1–2(–3) inconspicuous teeth, primary vein 1(–3); mid-stem glabrous, seeds (0.19–)0.26–0.32(–0.37) mm thick **G. quartermaniae**
   2. Mid-stem leaves (6–)7–13(–18) mm long; proximal fruiting pedicels (5–)7–17(–22) mm long, (0.9–)1–2(–2.3) times as long as the subtending bracteal leaves; bracteoles shorter than to barely exceeding sepals; posterior corolla lobe conspicuously tinged with pink or purple; beard inside corolla orifice of white trichomes; mature capsules subglobose, purplish; seeds (0.3–)0.36–0.42(–0.5) mm long and (0.17–)0.20–0.24(–0.27) mm thick, trichomes bulbous based **G. graniticola**

TAXONOMIC TREATMENT

Gratiola neglecta Torr,, Catal. Pl. New York. 10, 89. 1819. (**Fig. 7**). Type: [no locality data on specimen, but as noted by Stuckey (1979) this specimen was donated to the Schweinitz herbarium by John Torrey. Torrey (1819) gives the locality as "Inundated and moist places, New York."], [no collection date provided on sheet or in Torrey (1819)], [collector not specified on sheet but Pennell (1935) noted "it is almost certainly a plant of Torrey's collecting…"]. (lectotype, here designated: PH!; isolectotype, here designated: K-digital image!).

Conobea borealis Spreng., Neue Entdeck 3:26. 1822.
Gratiola missouriana Beck, Amer. Jour. Sci. 10:258. 1826.
Gratiola odorata Raf., Autik. Bot. 43. 1840.
Gratiola heterophylla Raf., Autik. Bot. 43. 1840.
Gratiola gracilis Benth., Prod. Syst. Nat. Regn. Veg. 10:402. 1846.
Gratiola officinalis Michx. *ß caroliniensis* Pers., Syn. Plant. 1:14. 1850.
Gratiola lutea Raf. var. *glaberrima* Fernald, Rhodora 34:149. 1932. *Gratiola neglecta* Torr. var. *glaberrima* (Fernald) Fernald, Rhodora 51:84. 1949.

Plants annual, solitary, erect herbs, (10–)16–27(–33) cm tall. Roots simple, fleshy, whitish with numerous rootlets. Stems erect, somewhat fleshy, simple or with few to many spreading-ascending branches, terete or slightly rounded-quadrangular in cross section, (0.8–)1.2–2.2(–2.9) mm in diameter at midstem; with (6–)7–10(–12) leafy nodes, mid-stem internodes (17–)28–45(–48) mm long, basal internodes not conspicuously shortened; stem green, usually densely short glandular-pubescent from below middle to apex, becoming glabrate near the base or rarely glabrate throughout, trichomes spreading, translucent, slender-based and gland-tipped. Leaves simple, oppositely-decussate, narrowly elliptic or rhombic to oblanceolate, or uncommonly falcate, spreading, 3–5(–7)-veined, thin, mid-cauline blades (11–)24–44(–66) mm long and (3–)5–11(–18) mm wide, (2.5–)3.5–5(–6) times longer than wide, median leaves usually largest decreasing in size toward base and apex, apex acute, widest at or just distal to the midpoint, margins with (1–)2–5(–7) remotely spaced low and inconspicuous to sharp and evident teeth per margin, base acuminate and sessile or slightly clasping; blades green, glabrate to moderately glandular pubescent. Flowers solitary in axils of upper median and distal bracteal leaves, erect to spreading, zygomorphic, perfect; pedicels slender, ascending to divergent, (10–)12–30(–37) cm long, (0.27–)0.44–0.94(–1.33) times as long as the bracteal leaves, densely to sparsely pubescent with slender-based gland-tipped trichomes. Bracteoles 2, paired, closely subtending

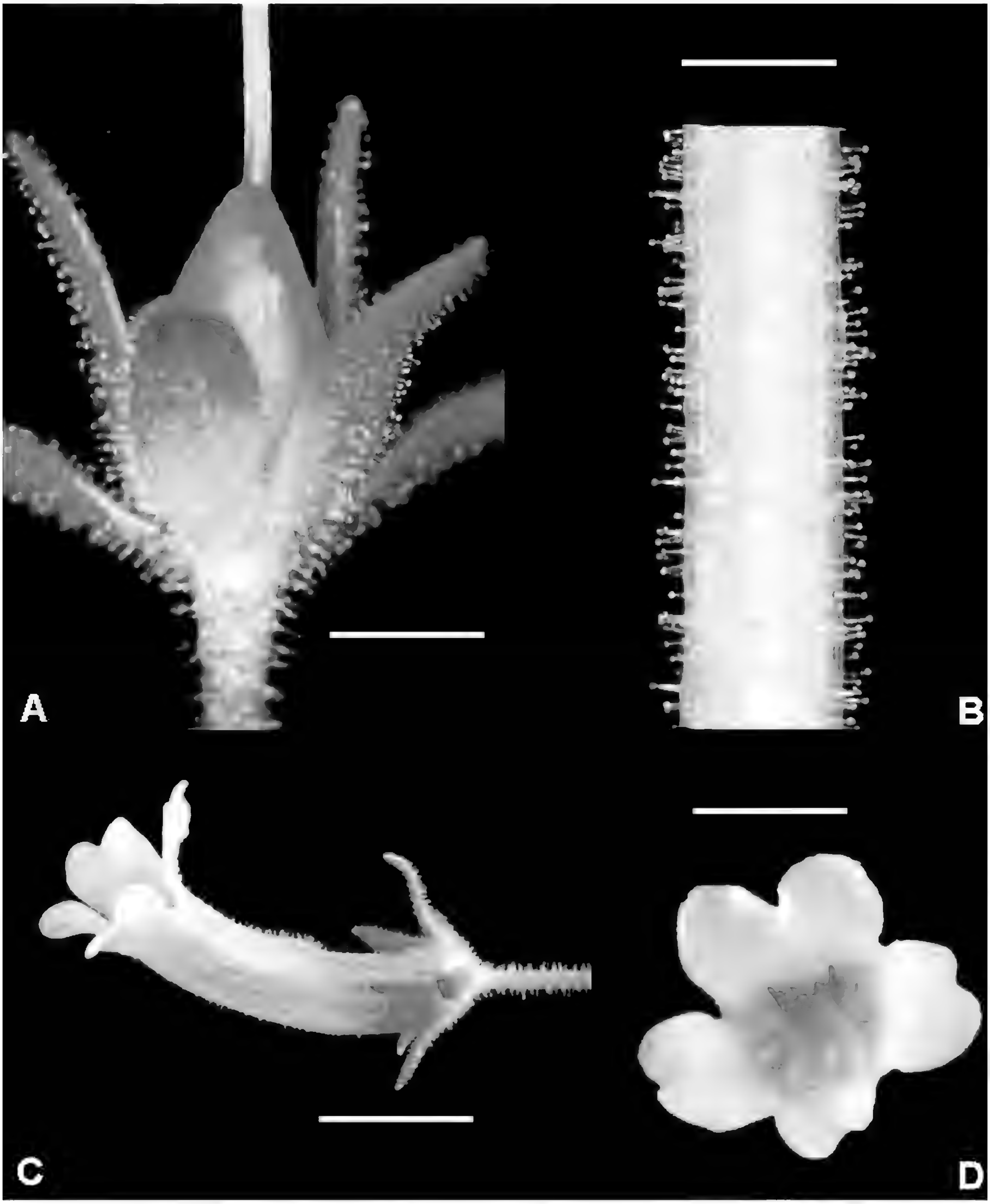

Fig. 7. ***Gratiola neglecta*. A. Flowering calyx (corolla removed) and bracteoles (scale bar = 2 mm). B. Close-up of mid-stem (scale bar = 2 mm). C. Flower, lateral view (scale bar = 4 mm). D. Flower, front view (scale bar = 2.5 mm).**

the calyx, lanceolate, narrowly elliptic, to oblanceolate, sometimes falcate, apex narrowly obtuse to acute, margins with 1–2 inconspicuous teeth, bases straight or tapering, longitudinally 3-nerved, in flower 2.5–7 mm long and 0.5–1 mm wide, enlarging as fruit matures and becoming foliose and up to 15 mm long and 2 mm wide, thin, green or minutely purple-tipped, sparsely to densely covered with slender-based gland-tipped trichomes on both surfaces. Calyx irregularly campanulate with 5 subequal sepals; these distinct, lanceolate, longitudinally 3-veined, slightly fleshy, green, (2.2–)3–4.4(–5) mm long and ca. 0.5 mm wide, apex narrowly obtuse, margins entire, sparsely to densely covered with gland-tipped trichomes. Corolla tubular, gamopetalous, zygomorphic, slightly marcescent, 6.5–12 mm long; corolla tube quadrangular, dorsal surface with a prominent hump near midpoint, the ventral surface canaliculate, to 9 mm long, to 2.1 mm in diameter proximal to dorsal hump, pale yellow, yellowish-cream, or yellowish-green, with many dichotomously forking brownish-violet lines extending from the tube base to the base of the corolla lobes, sparsely to moderately glandular pubescent pubescent externally with slender gland-tipped trichomes, inner surface near orifice at base of posterior corolla lobe with moderate to dense beard of clavately thickened yellow trichomes, proximal and median inner corolla tube pilose with eglandular trichomes; corolla lobes 5, generally slightly broader than high and obtuse to emarginated, spreading, white, 1.7–2.5 mm long and 3.2–3.8 mm wide; the posterior lobe generally largest, the two lateral lobes and lower lobe equal or slightly smaller, adaxial surfaces glabrous, abaxial surfaces glabrous or slightly glandular pubescent. Stamens 2, inserted near the middle of dorsal surface of the corolla tube, filaments to 1.2 mm long, anthers transversely oriented to the filaments, 0.6–0.8 mm long and 0.4–0.6 mm wide, connective greatly dilated around the two anther sacs, whitish; staminodes inserted ca. 1.5 mm above base of corolla or absent, when present ca. 0.3 mm long and not capitate. Gynoecium 5.3–6.8 mm long, subtended at the base by an orange nectary ring, ovary 1.4–3.3 mm long and to 2.1 mm in diameter, style 3.0–3.9 mm, stigma 2-lobed, dilated and flattened, ca. 0.7 mm long. Capsules ovoid, apex acute to obtuse, usually widest below the middle, (2.6–)3.6–5(–6) mm long, 3–5 mm in diameter, brown at maturity. Seeds several hundred per capsule, brownish-yellow, 10–13 ribbed, longitudinal ridges more conspicuous than the transverse ridges, asymmetrically ovoid to cylindric, often oblique at one end, reticulate with rectangular alveolae, alveolae covered by a thin iridescent membrane, (0.42–)0.48–0.60(–0.70) mm long and (0.18–)0.22–0.26(–0.29) mm in diameter, (1.7–)2–2.6(–3) times longer than wide. Chromosome number: 2N=18 (Gervais et al. 1999).

Phenology.—Flowering and fruiting from March to October

Common Name.—Clammy hedge-hyssop

Specimens Measured.—**CANADA. ONTARIO:** Thunder Bay District, 8 km SW of Thunder Bay City, 17 Aug 1978, *Garton 18549* (ISC*). **QUEBEC: Montmorency Co.:** Ange-Gardien, 23 Jul 1963, *Cinq-Mers et al. 69-169* (UC*). **Portneuf Co.:** Portneuf, 7 Jul 1941, *Rouleau 1045* (PH*). **SASKATCHEWAN**: 8 mi E of Saskatoon, 6 Jul 1950, *Ledginham 890* (SMU*).

U.S.A. ALABAMA: Greene Co.: Smith Lake (swamp) ca. 14 mi due WNW of Eutaw, 1 May 1980, *Haynes 7775* (UNA*). **Limestone Co.:** Beaverdam Creek 0.01 mi N of US Hwy 72 / Alt. 20 bridge, Wheeler Wildlife Refuge, 20 May 1980, *Meigs 555* (UNA*). **ARIZONA. Apache Co.:** River Reservoir, Greer Lakes, 1.4 mi E of AZ Hwy 373, 2 airmi NE of Greer, and 9 airmi W of Eagar, 30 Aug 1988, *Ricketson & Raechal 4415* (MO*). **ARKANSAS. Union Co.:** El Dorado, 3 May 1940, *Demaree 22048* (PH*†). **CONNECTICUT. Hartford Co.:** Suffield, 20 Jun 1923, *Weatherby s.n.* (NCSC*). **DELAWARE. New Castle Co.:** 0.5 mi W of Glasgow, 15 Jun 1929, *Benner 3572* (PH*). **GEORGIA. Bartow Co.:** Big Belfry Pond, 4.8 mi E of Adairsville, 5 May 1951, *Duncan 12316* (US*). **Walker Co.:** Chickamauga, 16 May 1900, *Biltmore 3913a* (US*). **ILLINOIS. Johnson Co.:** Ferne Clyffe State Park; floodplain of Buck Branch, 21 May 1992, *Mibb 692* (NLU*). **McHenry Co.:** McHenry, 15 Jun 1925, *Benke 4083* (US*). **INDIANA. Vanderburgh Co.:** 0.5 mi S of Staser, 26 May 1926, *Deam 42953* (PH*). **KANSAS. Cherokee Co.:** 0.5 mi W of Crestline, 6 Jun 1970, *Magrath 5352* (VDB*†). **Greenwood Co.:** T28S, R13E, sec 9, edge of temporary pool of valley in scrub oak woodland, 13 May 1987, *McGregor 38094* (GA*). **KENTUCKY. Warren Co.:** along Warren Co. Rt. 1288, ca. 1 mi from intersection with Warren Co. 961, 5 Jun 1968, *Nicely 1666* (NCSC*). **LOUISIANA. Richland Parish:** beside S side of I-20E ca. 1.7 mi W of the Rayville Exit (La. 137), 8 May 1990, *Thomas 115,966* (TENN†). **MASSACHUSETTS. Berkshire Co.:** Mount Washington, 25 Aug 1923, *Meredith s.n.* (PH*). **Worcester Co.:** Boylston, 24 Jun 1962, *Richardson s.n.* (MO*). **MINNESOTA. Carlton Co.:** between Holyoke and Foxboro, 4 Jul 1942, *Lakela 4986* (SMU*). **MISSISSIPPI. Carroll Co.:** field beside MS 7, at Avalon, 17 May 1973, *Thomas & Marx 34783* (SMU*†). **Washington Co.:** ca. 3.5 mi NE Leland, 12 May 1988, *Bryson 7637* (VPI*). **MISSOURI. Pulaski Co.:** Falls Hollow Sandstone Glade, Ft. Leonard Wood, 13 May 1994, *Hays 434* (MO*). **MONTANA. Lake Co.:** 4 mi S and 2 mi W of Ronan, 8 Jul 1956, *Harvey 6517* (NCU*). **NEVADA. Elko Co.:** 0.8 road mi E of Deeth on the road to O'Neil Basin, backwaters of the Marys River, 4 Jul 1986, *Tiehm 10727* (BRIT*). **NEW JERSEY. Cumberland Co.:** Maurice River W of Bricksboro, 3 Jun 1934, *Long 43311* (PH*). **NEW MEXICO. Rio Arriba Co.:** vicinity of Chama, 9 Jul 1911, *Standley 6659* (US*). **NEW YORK. Clinton Co.:** Rouses Point, 7 Aug 1910, *Williamson s.n.* (PH*). **Monroe Co.:** near Rochester, 4 Jul 1913, *Baxter s.n.* (MO*). **NORTH CAROLINA. Cabarrus Co.:** Rocky River at NC Rd. 73, 25 May 1969, *Daggy 5478* (TENN†). **Caswell Co.:** by Hyco Creek SE of Hightowers, 22 May 1958, *Bell 11947* (NCU*). **Chatham Co.:** 3 mi W of Mann's Chapel on Co. Rd. 1536, 22 May 1974, *Massey & Levesque 3988* (NCU*). **NORTH DAKOTA. Cass Co.:** Harwood, 30 Jun 1937, *Stevens 246* (GA*); 7 mi W of Enderlin, 28 Aug 1968, *Barker 5213* (MO†). **Richland Co.:**

Wyndmere, 18 Jun 1965, *Stevens 2775* (US*). **OHIO. Champaign Co.:** Thackery, 11 Jun 1914, *Leonard s.n.* (US*). **Crawford Co.:** ca. 1.5 mi NW of Lykens, 30 Sep 1979, *Stuckey 9962* (PH*). **Erie Co.:** W of Ceylon, Berlin Township, 15 Jul 1973, *Jones 73-7-15-802* (TENN†). **OKLAHOMA. Le Flore Co.:** along Poteau River, near Howe, 25 May 1931, *Palmer 39340* (MO*). **McCurtain Co.:** near Harris, ca. 2 mi N of the Red River, 20 Apr 1946, *Nelson, Nelson, & Goodman 5579* (TEX*). **OREGON. Crook Co.:** Farewell Bend, 17 Jul 1894, *Leiberg 456* (US*). **PENNSYLVANIA. Chester Co.:** French Creek near Hallman, 25 Jun 1927, *Stone s.n.* (PH*). **SOUTH DAKOTA. Brookings Co.:** T112N R52W S32 SW4 SW4, restored prairie pothole wetland, 15 Jul 1991, *Galatowitsch s.n.* (ISC*). **Custer Co.:** Custer, 25 Jul 1892, *Rydberg 924* (US*). **TENNESSEE. Gibson Co.:** floodplain of North Fork of Forked Deer River near jct. with Hwy 104, 6 Jul 1979, *Boom, Whitten, and Wofford 529* (TENN†). **Giles Co.:** NW side of Ardmore, N of Hwy 7 along N side of Austin Witt Rd. E of intersection of Austin Witt Rd. and Union Hill Church Rd., 5 May 2001, *Estes 02059* (TENN*). **Hardin Co.:** side of Pittsburgh Landing Rd., S of Walker Branch, 18 May 1989, *Guthrie & Tennesen 2235* (NCU*). **Weakley Co.:** E side of TN 89 along floodplain of Cane Creek, ca. 1.5 mi N of Palmerville, 25 May 1981, *Webb 3919a* (VDB*). **TEXAS. Franklin Co.:** 3 mi E of Mount Vernon, off US 67, 3 May 1945, *Lundell 13701* (LL*). **Jasper Co.:** 9.3 mi NE of Burkeville, 14 Apr 1960, *Shinners 27909* (SMU*). **VIRGINIA. Giles Co.:** Flat Top Mtn. near the upper end of Pearis Thompson Branch, NE of Holly Brook, 7 Aug 1990, *Wieboldt 7368* (NCU*). **Warren Co.:** Waterlick, 19 Jun 1924, *Pennell 12113* (US*). **WASHINGTON. Klickitat Co.:** Lyle, small shoal in Columbia River on the east side of the mouth of the Klickitat River, 26 Aug 1993, *Halse 4697* (K*). **Spokane Co.:** margin of Newman Lake, 2 Jul 1927, *St. John 8811* (MO*). **Whitman Co.:** wet pond beds, Pullman, 1 Aug 1896, *Elmer 163* (US†). **WEST VIRGINIA. Tucker Co.:** 0.25 mi S of Burley's Camp, Cabin Mtn. Range, 8 Jul 1941, *Allard 9055* (US*†). **Wetzel Co.:** near Littleton, 1 Jul 1961, *Haught 7127* (BRIT*). **WISCONSIN. Lincoln Co.:** Tomahawk Twp., 18 Jul 1950, *Seymour 11687* (MO*). **Taylor Co.:** near Rib River, 22 Jun 1957, *Schlising 648* (UC*).

Gratiola quartermaniae D. Estes, sp. nov. (**Fig. 8**). Type: CANADA. Ontario. Hastings Co.: Tyendinaga Township, "Toddary" alvar, Daley Road, ca. 7.5 km N of Lonsdale, 44.3404 N, 77.14539 W, moist open areas on alvar, with *Eleocharis compressa, Rumex crispus, Eleocharis obtusa,* 22 Jun 2006, *Oldham, Norris, & Van Sleeuwen 32809* (holotype: TENN; isotypes: BRIT, CAN, DAO, NHIC, NY, MO).

Gratiola quartermaniae a *G. neglecta* Torr. differt herba magis sparsim pubescente; caulibus plerumque simplicibus vel infrequenter ramosis, ad medium glabris; foliis angustioribus falcatis, lineari-lanceolatis vel elliptico-lanceolatis, marginibus integris vel inconspicue dentata, laminis plerumque uni- vel trinervis; seminis parum longioribus crassioribusque, magis fusce brunneis.

Plants annual, solitary, erect herbs, (6–)11–22(–30) cm tall. Roots simple, fleshy, whitish with numerous rootlets. Stems erect, fleshy, simple or with few ascending branches, terete or slightly rounded-quadrangular in cross section, (0.6–)1–1.9(–2.3) mm in diameter at midstem; with 7–10(–11) leafy nodes, mid-stem internodes (12–)19–35(–38) mm long, basal internodes shortened, 1–7 mm long; green or suffused with reddish or reddish-pink pigments, especially near the base or upper nodes; glabrous or nearly so from the base to above the middle, becoming sparsely glandular pubescent among the upper flower-bearing nodes with spreading, translucent, slender-based gland-tipped trichomes. Leaves simple, oppositely-decussate, similar in shape but gradually reduced in size from base to apex, lowermost often congested due to the shortened internodes and sometimes early deciduous, linear, linear-lanceolate to elliptic-lanceolate, often falcate, spreading or ascending, mostly with one evident main vein, sometimes trinerved with two short secondary veins, rarely the two secondary veins well-developed, slightly fleshy-thickened, mid-cauline blades (16–)18–32(–43) mm long and (1–)2.5–4(–4.5) mm wide, (5.5–)6–9.5(–11) times longer than wide, apex acute or narrowly obtuse, widest near the middle, base sessile or slightly clasping; margins entire or each margin with 1–2(–3) remote, low, bluntly pointed teeth beyond the middle; blades green, the basal blades sometimes suffused with red; glabrous or nearly so. Flowers solitary in the axils of middle and upper bracteal leaves, erect to spreading, zygomorphic, perfect; pedicels slender, ascending to divergent, (8–)13–22 mm long, 0.5–1.1(–1.6) times as long as the subtending bracteal leaves, sparsely pubescent with slender-based gland-tipped trichomes. Bracteoles 2, paired, closely subtending the calyx, equaling or to 2.3 times longer than the sepals, linear-oblanceolate to linear-lanceolate and often falcate, one-nerved or inconspicuously trinerved with two small lateral nerves, in fresh material bracteoles often appearing nerveless, fleshy-thickened, in flower 2.8–8.2 mm long, lengthening in fruit to 11.8 mm long, 0.7–1.0 mm wide, apex obtuse, margins entire, surface green, sparsely to moderately covered with slender-based gland-tipped trichomes. Calyx irregularly campanulate with 5 subequal, distinct, lanceolate sepals, each inconspicuously longitudinally three-nerved, in fresh material appearing single-nerved or apparently nerveless, fleshy-thickened, green, 2.7–5.1 mm long and 0.7–1.0 mm wide, apex obtuse, margins entire, sparsely covered with slender-based gland-tipped trichomes. Corolla tubular-funnelform, gamopetalous, zygomorphic, slightly marcescent,

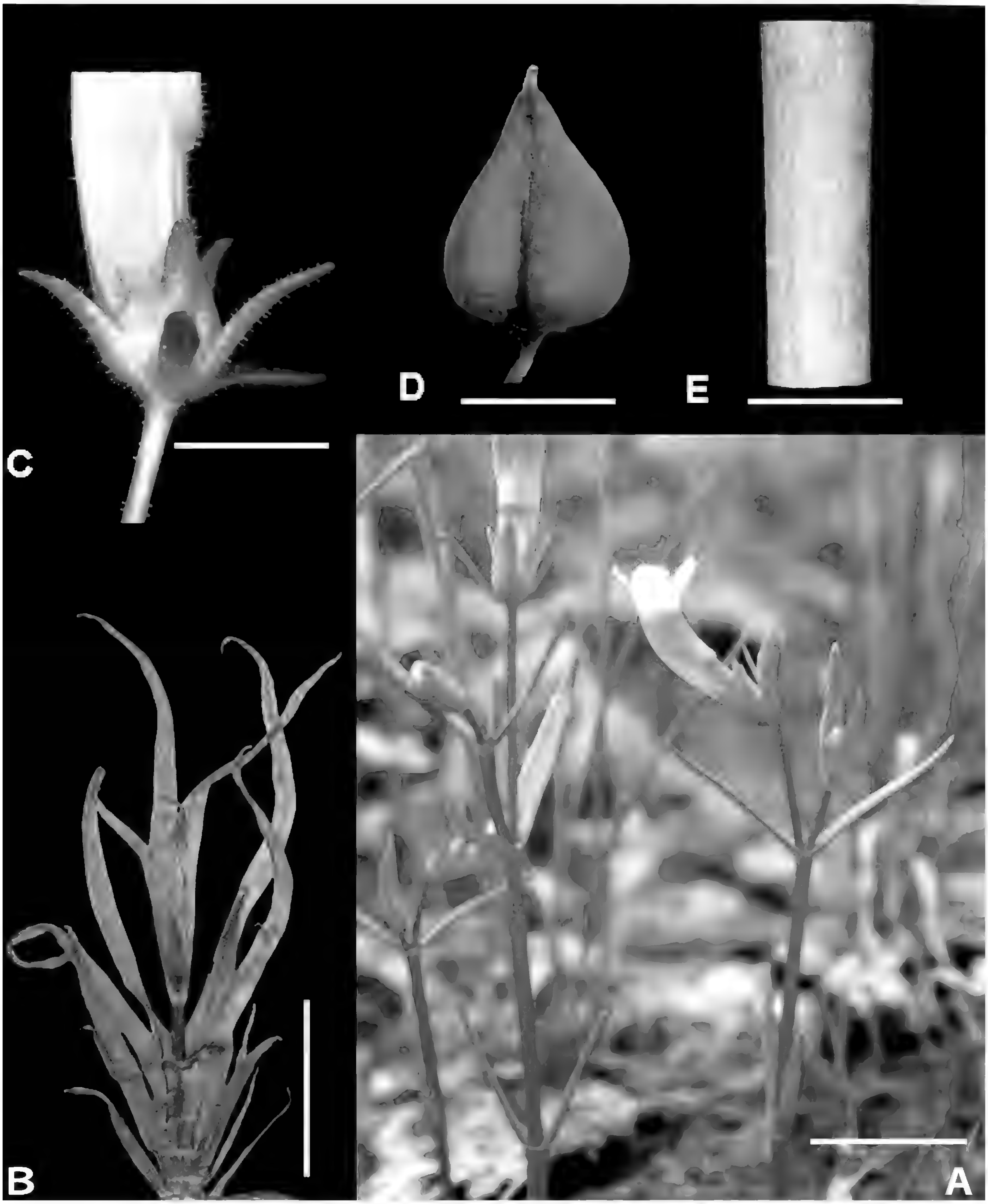

Fig. 8. *Gratiola quartermaniae*. **A.** Habit of *G. quartermaniae* at type locality (photo by M. Oldham, 2 Jun 2006). **B.** Pre-flowering specimen showing congested basal leaves (pressed specimen from *D. Estes 04359* TENN; scale bar = 2 cm). **C.** Flowering calyx and bracteoles (scale bar = 4 mm). **D.** Capsule (from *Oldham et al. 32877* TENN; scale bar = 3.5 mm). **E.** Close-up of mid-stem (scale bar = 2 mm).

6–13.7 mm long; corolla tube quadrangular, dorsal surface with a prominent hump near midpoint, the ventral surface canaliculate, to 9.3 mm long, 1.3–2.7 mm in diameter proximal to dorsal hump, greenish-yellow, creamy yellow, or bright yellow, with many brownish-purple lines extending the length of the tube, sparsely pubescent externally with slender-based gland-tipped trichomes, inner surface near orifice at base of posterior corolla lobe with moderate to dense beard of clavately thickened yellow trichomes, proximal and median inner corolla surfaces pilose with eglandular trichomes up to 0.8 mm long; corolla lobes 5, generally slightly broader than high and emarginate, white, 2.0–3.6 mm long and 2.4–5.4 mm wide; the posterior lobe generally largest, the two lateral lobes and lower lobe equal or slightly smaller, adaxial surfaces glabrous, abaxial surfaces glabrous or slightly glandular pubescent. Stamens 2, inserted near the middle of the dorsal surface of the corolla tube, filaments 0.8–1.5 mm long, anthers transversely oriented to the filaments, 0.8–1.3 mm long and 0.5–0.9 mm wide, connective whitish and greatly dilated around the two anther sacs; staminodes inserted 1.4–1.8 mm above base of corolla or absent, when present to 0.3 mm long, not capitate. Gynoecium 5.9–7.6 mm long, subtended at the base by an orange nectary disc, ovary 1.6–4.3 mm long and 1–2.8 mm in diameter, style 3.1–4.6 mm, stigma 2-lobed, dilated and flattened, 0.6–0.9 mm long. Capsules ovoid, apex acute, usually widest below the middle, (3.4–)3.6–4.7(–5.1) mm long, 2.9–4.5 mm in diameter, brown at maturity. Seeds several hundred per capsule, grayish-brown to reddish-brown, 10–13 ribbed, longitudinal ridges more conspicuous than the transverse ridges, asymmetrically ovoid to oblong-cylindric, often oblique at one end, reticulate with rectangular alveolae, alveolae covered by a thin iridescent membrane, (0.43–)0.55–0.63(–0.71) mm long and (0.19–)0.26–0.32(–0.37) mm in diameter, (1.5–)1.8–2.3(–2.6) times longer than wide. Chromosome number unknown.

Phenology.—Flowering and fruiting from April to early June in Alabama, Tennessee, Texas and from June to August in Illinois and Ontario, Canada

Etymology.—This species is named in honor of Dr. Elsie Quarterman, retired Vanderbilt University plant ecologist, who has dedicated her career to the study of the ecology of the limestone cedar glades and the species that inhabit them.

Common Name.—Quarterman's hedge-hyssop; limestone hedge-hyssop.

Conservation Status.—*Gratiola quartermaniae* is most common in the limestone cedar glades of middle Tennessee where it is known from ca. 30 populations in nine counties. Although it appears to be secure in Tennessee, the mid-state area where this species occurs is one of the most rapidly developing regions in the southeastern U.S. and the once abundant glade habitat preferred by this species is increasingly being destroyed. Consequently, while *G. quartermaniae* is not sufficiently rare in Tennessee now to warrant state or federal conservation status, its populations should be monitored in the next few decades. In Alabama, Illinois, Texas, and Ontario this species appears to be quite rare and is restricted to small geographic areas. In these regions it should be afforded protection at the state or provincial level.

Representative Specimens.—**CANADA. ONTARIO. Hastings Co.:** Belleville, May 1861, *Macoun* [number illegible] (K); vicinity of Belleville, Jun 1867, *Macoun 17454* (CAN*); flats near the Iron Bridge at Belleville, Jun 1868, *Macoun 41730* (CAN); Belleville, 10 Jun 1871, *Macoun 123* (TRT); Belleville, 24 Jun 1871, *Macoun 1261* (DAO); Pt. Anne, Belleville, Ontario, 13 Jun 1972, *Morton 5091* (CAN, QK, TRT, WAT); Hungerford Township, Larkins Alvar, ca. 9.5 km SE of Tweed, ca. 1.5 km SW of Larkins, S of Marlbank Rd., 30 Jun 2006, *Oldham, Norris, & Van Sleeuwen 32877* (DAO, MICH, MO, NHIC, TENN, US); Richmond Township, Roblin Dump alvar, ca. 1.5 km SE of Roblin, ca. 9 km SSE of Marlbank, 30 Jun 2006, *Oldham, Norris, Sutherland & Van Sleeuwen 32869* (CAN, MICH, MO, NHIC, NY, TENN, TRTE, US, UWO). **Lennox and Addington Co.:** Camden East Township, ca. 10 km NW of Newburgh, ca. 15 km N of Napanee, road to Roblin Hell Holes, off Centreville Road, 30 Jun 2006, *Oldham 32868* (BRIT, CAN, DAO, HAM, MICH, MO, MT, NHIC, TENN, US, VDB). **Peterborough Co.:** alvar ca. 2 mi N of Nogies Creek in Harvey Tp., 11 Jul 1974, *Catling & McKay s.n.* (CAN, TRT); 1.79 air mi NE of Nogies Creek, 1.1 air mi NNW of jct. of Co. Rd. 36 and Quarry Rd., 0.37 road mi NW from jct. of Quarry Rd. and Ledge Rd., 18 Jun 2005, *Estes 07955* (CAN, DAO, NY, MICH, TENN, VDB). **Prince Edward Co.:** Big Sand Bay, Long Point, 7 Jun 1963, *Brassard & Hainault 2702* (CAN*, TRT); ca. 2 mi SE of Milford, 5 Aug 1951, *Soper & Heimburger 5412* (TRT); South Marysburgh Township, Hilltop Rd., ca. 5 km SE of Milford, near South Bay, 19 Jun 2006, *Oldham 32786* (DAO, MICH, MO, NHIC, NY, TENN, TRT, US).

U.S.A. ALABAMA. Franklin Co.: ca. 5–6 mi E of Russellville along N side of New Hwy 24, just W of jct. of New Hwy 24 and County Rd. 83, 15 May 2003, *Estes 04625* (TENN). **Lawrence Co.:** by Ala. 36 ca. 2 mi. e. jct. Ala. 157, 6 May 1978, *Kral 61662* (JSU, VDB*); approx. 4 mi NW of Mt Hope, ca. 1.5–2 mi E of Franklin County line, W of Town Creek, at Prairie Grove Glades preserve, 15 May 2003, *Estes 04611* (TENN†); ca. 0.2 to 0.4 mi ESE of Landersville, south of junction of Hwy 24 and County Rd. 55, growing in wet ditch over limestone on west side of County Rd. 55, 34°28'09" N, 87°23'46"W, 29 Apr 2004, *Estes 05928* with *Webb* (CAN, MO, TENN, UNA). **Morgan Co.:** 5.6 mi. W of Falkville, 23 Apr 1968, *Kral 30494 B* (GA, VDB*); seep in sandy clay field 1 mi E jct AL 157 by AL 36, W of Danville, 14 Apr 1978, *Kral 61500* (JSU, MO, VDB); N side of Morgan Co Rd 55, 0.9 mi E of Massey (McKendree Church), 2.1 mi W of Lebanon Church and 6 mi W of int. US 31 at Falkville, 28 Apr 1989, *Orzell & Bridges 9380* (TEX*). **ILLINOIS. Will Co.:** Romeo, 18 Jun 1898, *Umbach s.n.* (US). **TENNESSEE. Bedford Co.:** N side Deason by US 231, 28 Apr 1974, *Kral 52571* (MO, VDB); 0.2 mi N of US 41A at Rover along Bunker Hill Rd, 3 Jun 1993, *Kral 82558 with Rust* (VDB); approx. 5 mi NE of Unionville, ca. 0.75 mile S of Newtown, near intersection of Longview Rd. and Putnam Well Rd., on east side of Longview Rd., 22 May 2003, *Estes 04583 with Wofford et al.* (CAN, GH, TENN†). **Cannon Co.:** by US 71S, 0.5 mi E of Readyville, 20 May 1974, *Kral 52812* (MO, VDB*). **Coffee Co.:** Manchester prairie, 4 mi E of Manchester on US 41, 7 Jun 1966, *Baskin & Caudle 258* (VDB). **Davidson Co.:** Hamilton Creek Recreation Area, SE side of Nashville, W of Percy Priest Lake, E side of Ned Shelton Rd., 15 Jun 2003, *Estes 04894* (EKY, GA, JSU, TENN*, UNA). **Giles Co.:** S of Pulaski, Cedar Grove community, growing on W side of Hwy 166, south of Everly Branch and just N of Cedar Grove Church, 18 Apr 2003, *Estes 04454* (TENN*). **Marshall Co.:** 2.1 mi ESE Pottsville on TN 99, 2 Jun 1969, *Kral 34776* (MO, VDB*); N side TN 99, just inside W county border, 14 May 1988, *Kral & Kral 74722* (VDB); approx. 4 mi NE of Chapel Hill near Beasley community, ca. 100–200 yards east of intersection of Hwy 99 and Beasley Rd., S side of Beasley Rd., 22 May 2003, *Estes 04582 with Wofford et al.* (GH, MO, NCU, NY, TENN†, TEX, UC). **Maury Co.:** ca. 2 mi NW of Pottsville, 1.5 mi NE of jct of Hwy 412 and Rally Hill Rd., E side of Rally Hill Rd., 22 May 2003, *Estes 04672 with Wofford et al.* (TENN†). **Rutherford Co.:** 10 mi. E Beech Grove along US 41, 9 Jun 1970, *Kral 26889* (FSU*, SMU, TENN, VDB); SE of Eagleville, 1 mile off S.R. 99, 28 May 1996, *Rust 66* (VDB*); WSW of Fosterville, ca. 2 mi W of US Hwy 231, 0.33 mi N of Squire Hall Rd., E side of Harrison Rd., 22 May 2003, *Estes 04586 with Wofford et al.* (NCU, TENN†, VDB); E of Murfreesboro, approx. 1 mi SE of Halls Hill Pike, S side of Factory Rd., Flat Rock Cedar Glade and Barrens State Natural Area, 22 May 2002, *Estes 03337* (TENN*); approx. 4 mi E of Murfeesboro on Hall Hill Pike, turn S onto Smith Hall Rd. (a dead-end road), E side of road, 22 May 2002, *Estes 03336* (TENN*); N Murfeesboro, ca. 1 mile W of intersection of E Northfield Blvd. and Hwy 96, 22 May 2003, *Estes 04574 with Wofford et al* (TENN*); approx. 4–5 mi E of Murfreesboro, W side of Factory Rd., Flatrock Cedar Glades/Barrens State Natural Area, 1 May 2003, *Walck s.n.* (TENN*); base of Garrett Knob, 29 May 2003, *Bailey & Lincicome s.n.* (TENN). **Wilson Co.:** Lebanon, 2 Jun 1923, *Pennell 11377* (PH); Cedars of Lebanon State Forest and Natural Area, N of Moccasin Rd. / Proctor Trail, 8 May 2003, *Bailey s.n.* (TENN). **TEXAS. Bell Co.:** 6 mi SE of Belton, *Wolff 2317* (SMU). **Llano Co.:** Llano River east of Packsaddle Mountain, 4 May 1947, *Whitehouse 18477* (SMU, UC, US). **Williamson Co.:** Round Rock, 24 March 1890, *Bodin s.n.* (PH, MIN-digital image); ca. 3.9 mi SSW of Liberty Hill, along CR 284, 1.3 mi W of jct CR 282, S side rd, 29 Apr 2005, *Turner & Turner 122* (BRIT, MO, TENN, TEX); southern part of co., just NW of Round Rock, FM 1431 at jct Sam Bass Rd., SE corner, 150 m S of FM 1431, 29 Apr 2005, *Turner & Turner 119* (BRIT, GH, MO, TENN, TEX).

Gratiola graniticola D. Estes, sp. nov. (**Fig. 9**). Type: U.S.A. Georgia. DeKalb Co.: Rock Chapel, GA hwy 124 at Rock Chapel County Park, gneiss flatrock, W side of highway, vernal pools, 2 May 1984, *Allison 2101* (holotype: GA).

Gratiola graniticola a *G. neglecta* Torr. differt herba trichomatibus brevioribus basi bulbosis vestita; caulibus gracilioribus, simplicibus vel infrequenter ramosis; foliis brevioribus angustioribusque, lanceolato-ovatis vel anguste oblongis, marginibus subintegris vel inconspicue dentatis, basibus magis valde amplectentibus; pedicellis folia bractealia subtendentia aequantibus vel eos duplo longioribus; bracteolis calycibus brevioribus vel eis vix superantibus; floribus minoribus lobis posterioribus purpurascentibus, barba in corollae orificio e trichomatibus albidis translucentibusve constante; capsulis minoribus, magis subglobosis purpura suffusis; seminibus minoribus magis obscure cinereis.

Plants annual, solitary, erect herbs, (7–)9–21(–29) cm tall. Root simple, fleshy, whitish with numerous rootlets. Stems erect, somewhat fleshy, simple or with few ascending branches, terete or slightly rounded-quadrangular in cross section, (0.7–)0.9–1.2(–1.5) mm in diameter at midstem; with (6–)7–10(–12) leafy nodes, mid-internodes (15–)17–30(–36) mm long, basal internodes shortened (1.5–8 mm); green or suffused with reddish or reddish-pink pigments, especially near the base and upper nodes; glabrous or glabrate near base becoming increasingly pubescent upward, with spreading, translucent, conical or bulbous-based, glandular trichomes. Leaves simple, oppositely decussate, similar in shape but gradually reduced in size from base to apex, lowermost often congested due to the shortened internodes and sometimes early deciduous, lanceolate-ovate to narrowly oblong usually widest at or below the middle, horizontally spreading with tips curved upward, with one evident main vein or trinerved with two short secondary veins, slightly fleshy-thickened, blades (6–)7–13(–18) mm long and 1–3(–5) mm wide, (2.8–)3.5–5.7(–7.4) times longer than wide, apex narrowly obtuse, margins entire or with 1–2(–3) pairs of remote, low, bluntly pointed teeth beyond the middle, base usually amplexicaulate; blades green or leaf tips, teeth, and basal leaves often suffused with reddish pigments; proximal leaves glabrate, median and distal leaves moderately pubescent with bulbous based trichomes. Flowers solitary in axils of upper bracteal leaves, erect to spreading, zygomorphic, perfect; pedicels slender, ascending, (5–)8–17(–22) mm long, (0.9–)1–2(–2.3) times as long as the subtending bracteal leaves, sparsely to moderately pubescent with bulbous based trichomes. Bracteoles 2, paired, closely subtending the calyx, usually shorter than or equaling the sepals, lanceolate and often falcate, longitudinally 3-nerved (sometimes single nerved) though not often evident when fresh, fleshy-thickened, 2–4.5 mm long and 0.5–1.0 mm wide,

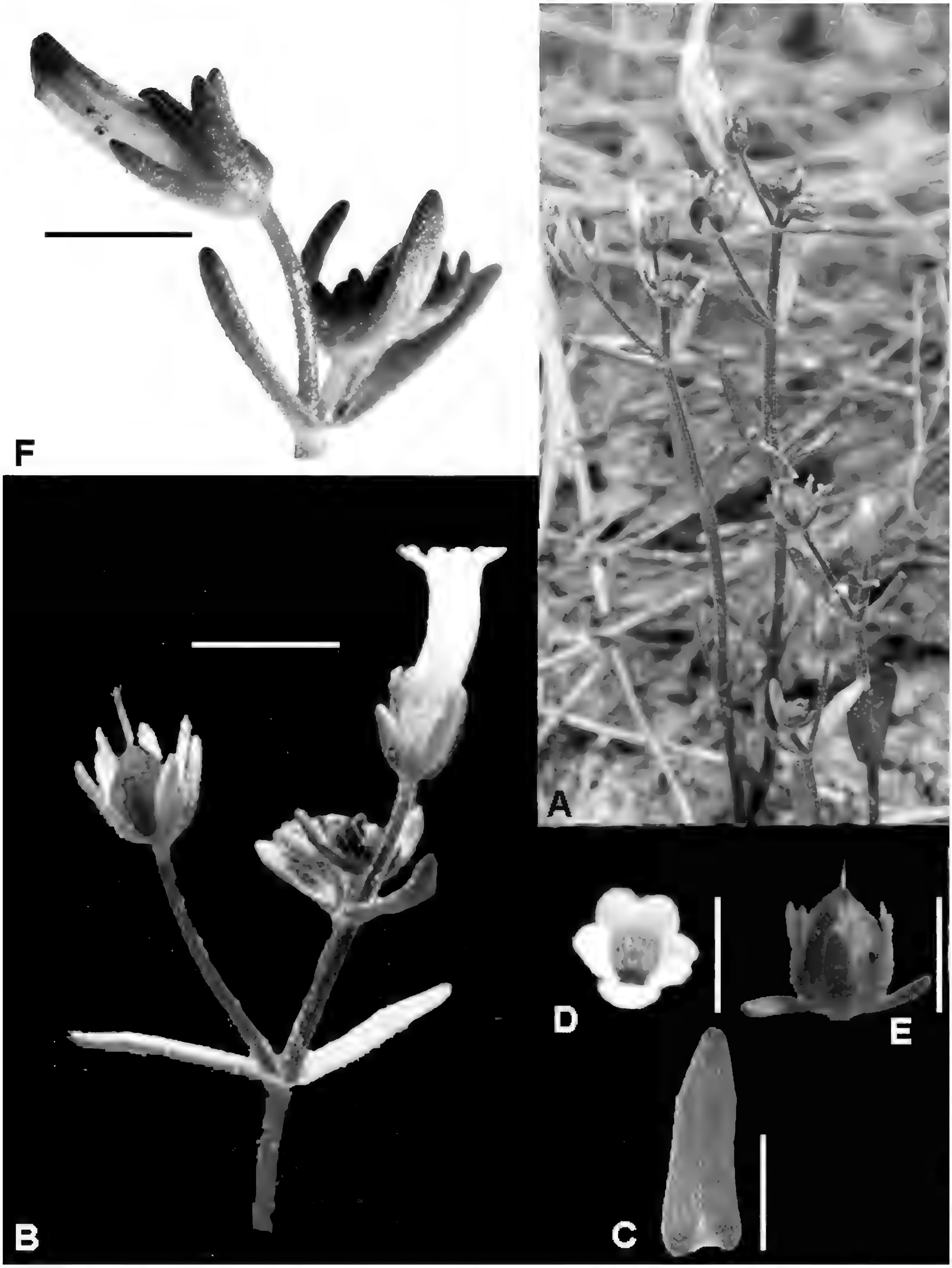

Fig. 9. *Gratiola graniticola*. **A.** Habit, in Butts Co., Georgia, 10 Apr 2004. **B.** Upper stem with flower and immature capsule (scale bar = 6 mm). **C.** Leaf (scale bar = 5 mm). **D.** Flower, front-view (scale bar = 2 mm). **E.** Immature capsule with subtending calyx and bracteoles (scale bar = 3.5 mm). **F.** Unopened flower showing purplish corolla lobes (scale bar = 4.5 mm).

apex obtuse, margins entire, surface green, apex purple-tipped, abaxial surface convex, moderately covered on both surfaces with bulbous-based trichomes. Calyx irregularly campanulate with 5 subequal, distinct, lanceolate sepals, longitudinally 3-nerved (sometimes single nerved) though not often evident when fresh, fleshy-thickened, green on the surface with a minute purple tip, 2–4.2 mm long and 0.5–1.3 mm wide, apex obtuse, margins entire, moderately covered, especially abaxially, with conical or bulbous-based trichomes. Corolla tubular-funnelform, gamopetalous, slightly marcescent, and zygomorphic, 6.8–9.0 mm long; corolla tube quadrangular, dorsal surface with a hump near midpoint, 5.5–6.8 mm long and 1.3–1.9 mm in diameter, outer surface pale yellowish-green or cream-colored, often purplish or pinkish dorsally, faintly to conspicuously purple-lined exteriorly, scarcely pubescent with conical or bulbous-based trichomes, inner surface near orifice at base of posterior corolla lobe with sparse beard of clavately thickened whitish to translucent trichomes, proximal and middle inner corolla surfaces pilose with eglandular trichomes; corolla lobes 5, each usually broader than high and often emarginated at apex, spreading, the lower three white or cream-colored, the upper two strongly suffused with purple or pink, the lobes 1.0–1.7 mm high and 1.5–2.3 mm wide, adaxial surfaces glabrous, abaxial surfaces glabrous. Stamens 2, inserted near the middle of the dorsal surface of the corolla tube, filaments to 1.2 mm long, anthers transversely oriented to the filament, 0.5–0.7 mm long and 0.5–0.6 mm wide, connective greatly dilated around the two anther sacs, whitish; staminodes inserted ca. 1–1.3 mm from base of corolla tube or absent, when present minute and ca. 0.2 mm long, not capitate. Gynoecium 4.4–4.8 mm long, subtended at the base by an orange nectary ring, ovary 1.6–2.0 mm long and 1.2–1.7 mm in diameter, style 1.9–2.2 mm long, stigma 2-lobed, dilated and flattened, 0.5–0.6 mm long. Capsules subglobose to slightly ovoid, (2.4–)2.8–3.6 mm long, 2.1–3.7 mm in diameter, purple tinged when mature. Seeds several hundred per capsule, brown to grayish-brown, 10–13 ribbed, longitudinal ridges more conspicuous than the transverse ridges, asymmetrically ovoid to short cylindric, often oblique at one end, surface reticulate with rectangular alveolae, alveolae covered by a thin iridescent membrane, (0.3–)0.36–0.42(–0.47) mm long and (0.17–)0.2–0.24(–0.27) mm wide, (1.3–)1.6–2.1(–2.5) times longer than wide. Chromosome number unknown.

Phenology.—Flowering and fruiting from April to May.

Etymology.—The ephithet *graniticola* was chosen to reflect the granite flatrocks that this species inhabits.

Common Name.—Granite hedge-hyssop.

History of Taxon.—*Gratiola graniticola* was apparently first collected in 1928 (*Wherry & Benedict s.n.* PH) from “pools on granite ledges” in Gwinnett County, Georgia. A decade later, Pyron and McVaugh (*2866* GA, PH), collected a specimen of *G. graniticola* from granitic areas in Oglethorpe County, Georgia. McVaugh sent a specimen of this Oglethorpe County collection to F.W. Pennell who wrote “your collection, with that of Wherry and Benedict…differ from *G. neglecta* Torr. by bracts shorter relative to pedicels, capsules smaller (3 mm long), upper corolla-lobes purple or purplish, and seeds smaller and grayer” (McVaugh 1943). He added that these specimens seemed to match his description and photograph of *G. gracilis* Benth., a species described by Bentham (1846) from Texas.

Bentham (1846) described *G. gracilis* Benth. from material collected by Drummond near Harrisburgh, Texas (near present-day Houston) in ca. 1834. Unfortunately, Drummond failed to note the habitat from which he collected the plants. A second specimen annotated by Pennell as *G. gracilis* was collected by Lindheimer (*43* MO) from nearby Galveston in ca. March (May?, illegible) 1842. Like Drummond, Lindheimer did not provide specific locality or habitat information. Despite being known only from herbarium specimens, *G. gracilis* was maintained as a species by Small (1903) and Pennell (1921). Later, Pennell (1935) reduced *G. gracilis* to synonymy with *G. neglecta* noting the characters Bentham used to distinguish *G. gracilis* from *G. neglecta* “are all variable features that occur without geographic correlation.”

During this study, a photograph of the holotype of *G. gracilis* (*Drummond coll. 3, n. 284*, K) and an isotype (GH) were examined. As Pennell noted, these specimens do share some features with those plants from the Georgia granite outcrops, most notably in the length of the leaves and the ratio of the length of the pedicel and subtending bract. While of rare occurrence, *G. neglecta* can have relatively short leaves and bracteal leaves shorter than the pedicels (e.g., *Guthrie 1002* VDB, Lake Co., TN). The three *G. gracilis* specimens also differ from *G. graniticola* in that they lack purple coloration on the corollas and capsules, features diagnostic for *G. graniticola*. In terms of habit, the stems of the *G. gracilis* specimens are more branched like those of *G. neglecta* compared to those of *G. graniticola*, which are mostly simple. Lastly, *G. graniticola* is endemic to granite outcrops and has not been found in non-granitic areas. Since there are no granite outcrops in southeastern Texas, it is reasonable to assume that the plants collected by Drummond and Lindheimer likely came from a different habitat type. Based on the evidence presented above, we follow Pennell and recognize *G. gracilis* as a synonym of *G. neglecta*.

Conservation Status.—*Gratiola graniticola* should be considered a rare species in Georgia due to the small number of populations and limited distribution.

Representative Specimens Examined.—**U.S.A. GEORGIA. Barrow Co.:** Winder, GA Hwy 81, roughly 0.25 mi S of junction with US Hwy 29, E side of highway, 30 Apr 1984, *Allison 2095* (GA*); same site, 19 May 2003, *Estes 04590 with Allison* (TENN*†). **Butts Co.:** ca. 2.7 mi NNE of Jackson, GA Hwy 36, ca. 0.5 mi S of Cedar Rock Church, E side of highway, 13 May 1984, *Allison 2175* (GA*); same site, 10 Apr 2004, *Estes 05742* (TENN). **Columbia Co.:** ca. 4.25 mi ESE of Appling, ca. 0.45 mi NNW of confluence of Little Kiokee Creek and Benton Branch, adjacent to Heggies Rock Preserve, 10 May 1987, *Allison 2842* (GA*). **DeKalb Co.:** across from Rock Chapel Park, 4 mi N of railroad track in Lithonia, along State Hwy 124, 16 Apr 1978, *Patrick 592 with Wofford et al.* (TENN*); Lithonia, ca. 0.3 mi N of intersection of Interstate 20 and Hwy 124, NW side of the intersection of Hwy 124 and Conyers Street on small concealed granite outcrop, 10 Apr 2004, *Estes 05733* (TENN); same site as previous, 01 May 2004, *Estes 05954* (TENN*, MO, NY). **Greene Co.:** 8.2 mi SSE of Greensboro, 5.8 mi W of White Plains, 2 May 1987, *Allison 2834* (GA*); ca. 9 mi SSE of Greensboro, ca. 1.5 mi SW of Mosquito Crossing, S side of Leach Flatrock Rd., 33.46738 N, 83.13214 W, 19 May 2003, *Estes 04585 with Allison* (NCU, TENN†). **Gwinnett Co.:** 6 mi SW of Grayson, 3 May 1928, *Wherry & Benedict s.n.* (PH); 4.25 mi E of Snellville, 2.25 mi SSE of Grayson, Langley Rd., 0.34 mi by air NW of junction with US Hwy 78, E side of road, 13 Jun 1984, *Allison 2306* (GA). **Hancock Co.:** 3.5 mi SE of Sparta, 11 May 1952, *Duncan 13533* (GA, digital image); ca. 1 mi or less NE of Sparta, 0.3 mi N of Hwy 16, 0.3 mi W of Twomile Creek, 33.29098 N, 82.95428 W, *Estes 04659 with Allison* (TENN*). **Hart Co.:** 5.3 mi NNE of Vanna, 1.5 mi NNE of Goldmine, ca. 0.2 mi E of county road 141 at a point ca. 0.45 mi NW of junction with county road 140, 15 Apr 1986, *Allison 2625* (GA*); same site, 19 May 2003, *Estes 04588 with Allison* (NCU, TENN†). **Newton Co.:** ca. 3 mi NE of Covington, ca. 1.25 mi NE of the intersection of Hwy 142 and Alcovy Rd., S side of Alcovy Rd., 19 May 2003, *Estes 04584 and Allison* (TENN†); same site, 10 Apr 2004; *Estes 05738* (TENN). **Oglethorpe Co.:** Echols' Mill, May 1938, *Pyron & McVaugh 2866* (GA, PH); ca. 0.5 mi E of Echols' Mill, ca. 9.3 mi N 45 deg. of Lexington, 7 May 1978, *Treiber & Nesom 1518* (NCU*). **Pike Co.:** 1.6 mi S of Hollonville on Concord Road, E side of road, 19 May 1984, *Allison 2254* (GA*); same site, 01 May 2004, *Estes 05953* (MO, NY, TENN). **Upson Co.:** NE corner of county, ca. 0.4 mi S of Lamar County line and just E of Barnesville-Yatesville Rd., 18 May 1984, *Allison 2235* (GA*). **Walton Co.:** 4.9 mi WNW of Walnut Grove, Ace Moon Road (county road 197), just S of junction with Sharon Church Road (county road 106), E side of road, 11 May 1984, *Allison 2141* (GA*); by GA 138, 1 mi. NE of Walnut Grove, 17 May 1989, *Kral 72517* (FSU, GH, VDB*).

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REVIEW OF *CRATAEGUS* SERIES *APRICAE*, SER. NOV., AND *C. FLAVA* (ROSACEAE)

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ABSTRACT

This paper revises **Crataegus** ser. **Apricae**, ser. nov., remodeled from old ser. *Flavae* after the removal of *C. flava*. Twelve species are recognized in the series, plus a number of other forms which represent possibly undescribed taxa, taxa only known from type gatherings and one more of doubtful serial assignation. Full descriptions and synonymy as well as complete typification are provided for all taxa fully treated. The principal species all have line illustrations and county level distribution maps. Keys distinguish all taxa and unnamed forms recognized. *Crataegus flava*, although transferred to ser. *Intricatae*, is treated here for convenience.

Key Words: *Crataegus* series *Apricae*, ser. nov., taxonomic revision, *C. flava*, ser. *Intricatae*

RESUMEN

En este artículo se revisa **Crataegus** ser. **Apricae**, ser. nov., remodelado de la antigua ser. *Flavae* después de eliminar *C. flava*. Se reconocen doce especies en la serie, además de cierto número de formas que probablemente representan taxa no descritos, taxa sólo conocidos de colección del tipo y uno más de asignación dudosa a la serie. Se aportan descripciones completas y sinonimia así como tipificación de todos los taxa tratados. Las principales especies están ilustradas y tienen mapas de distribución a nivel de condado. En las claves se distinguen todos los taxa y las formas no nombradas que se reconocen. *Crataegus flava*, aumque se haya transferido a la ser. *Intricatae*, se trata aquí por conveniencia.

INTRODUCTION

This paper is the sixth in a series reviewing hawthorns of the southeastern United States, a region for a long time lacking proper revisions after the huge burst of activity at the turn of the last century which culminated in Beadle's (1903) seminal contribution to Small's regional flora. Beadle's treatment of 185 *Crataegus* species for the region, many described by Beadle himself, was based on the collection of hundreds of specimens for the Biltmore Herbarium in which endeavor Beadle was ably assisted by T.G. Harbison. Beadle thus developed unparalleled personal experience although his species concepts have been considered overly narrow. Only one later treatment covered *Crataegus* for the entire region, this being by Tidestrom (1933) in which he recognized 33 species in J.K Small's new flora of the area. As is pointed out in earlier works, e.g., Phipps and Dvorsky (2006), Tidestrom omitted entire series and even the unique species *C. triflora* although it can be found, grossly incorrectly synonymized, under *C. intricata.* The almost complete lack of synonymy further reduces the value of Tidestrom's taxonomy. The *Crataegus* expert Palmer in Vines (1960), a work which covers the 'southwest', an area deemed to reach east to the Mississippi, produced a treatment with 71 species, only 30 of which are in the southeast as routinely interpreted in my papers and which reaches west to Louisiana and Arkansas following Cronquist (1980). Vines' work is illustrated with woodcuts that singularly fail to distinguish any but the most dissimilar species of hawthorn and, largely lacking series *Flavae* in the old sense, therefore does not significantly contribute Palmer's usually valuable insights to the matters addressed in this paper. Later floristic workers produced treatments more in the vein of Tidestrom, as is evidenced, for instance, by their taxon selection and routine omission of *C. triflora*, when it occurred in their areas. The result has been that the southeastern United States, an area very rich in *Crataegus*, has become floristically the worst-served part of the flora of North America area for this genus. Only a few floristic writers bucked this trend, Kurz and Godfrey's (1982) *Crataegus* treatment in their "Trees of Northern Florida" being a good example of this, although, even here, it appears that the authors did not consult types. Murrill's closely observed descriptions of northern Florida hawthorns in the early 1940s, e.g., Murrill (1942), are difficult to match with known species and may represent extremes of variation of them and are here mainly ignored.

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It is with this background that examination of over 10,000 specimens for the first author's studies in the southeastern United States *Crataegus* flora, together with numerous field trips to the region which yielded many personal (JBP) collections, as well as the receipt of over 500 duplicate specimens from R. Lance, in addition to experience derived from earlier papers in this series fully confirms Beadle's position that the southeastern United States is a region of great species richness for *Crataegus*. Consequently, treatments like that of Tidestrom can at best be only accepted in part. Nevertheless, a parallel realization is that the *Crataegus* taxonomy of the region is not particularly straightforward even though basic attention to type material permits attaching an appropriate name to nearly all morphotypes encountered. This is so because nearly all Beadle's names can readily be lectotypified if necessary even if those of Ashe cannot (and neotypification of the latter's names is usually fraught with difficulty) and Beadle's names appear sufficient to account almost completely for observed variation. This may all be observed in miniature in the current revision of ser. *Apricae*.

Crataegus series *Apricae* represents a remodeling of series *Flavae* (Loud.) Rehder in the sense used in Palmer (1925), Phipps et al. (2003) and Phipps et al. (1990). In the last two publications mentioned the species lists for ser. *Flavae* were understood to be incomplete, the studies presented here being then worked up. There proved to be more difficult taxonomic problems associated with series *Apricae* than for any other series dealt with so far by the first author for the southeastern United States *Crataegus* flora. These may be listed as follows.

1. For many years floristic authors treated ser. *Flavae* as a very inclusive concept, this generally speaking, being collapsed from the 81 species of Beadle (1903) which that author had organized into 13 groups. Recently, however, the first author (Phipps 1988a), removed most of these groups to ser. *Lacrimatae* and it therefore became necessary to ask whether this action left the residual ser. *Flavae* homogeneous.

2. *Crataegus flava*, type species of ser. *Flavae*, appears to be easily the most distinct species of the series whether or not ser. *Lacrimatae* is included in ser. *Flavae*. This paper formalizes the position, previously suggested in Phipps (1988a), that *C. flava*, the type species, should be removed from the remainder of old ser. *Flavae*.

3. Subsequently, therefore, is the new residuum, after both ser. *Lacrimatae* and *C. flava* are removed, sufficiently homogeneous to exist as a single series?

4. If yes, the question then arises as to an appropriate name for the residual series.

5. None of the species of the series as finally demarcated below appears to be really common and several are very rare or local, limiting the effect of insights from modern fieldwork.

6. Species limits in the new series were sometimes found to be not particularly clear cut, in part because of a relative paucity of material which always makes taxonomic decisions more difficult. This problem is heightened with several species in the series being generally less well-marked than is often the case, particularly in the *visenda* group. Nevertheless, uniting such species carries its own difficulties, especially with the phenetic breadth of the amalgamated species and the fact that variation does not necessarily flow smoothly throughout. On the other hand, species such as *C. frugiferens* would be difficult to unite with anything.

Nevertheless, the study of 274 specimens, including 20 types, from 26 herbaria plus the additional understanding gained from modern fieldwork has created the opportunity to offer the following elaboration of the first author's treatment that will appear in Flora of North America, vol. 9. It is rooted in the work of C.D. Beadle (in Small 1903), who knew the group better than anyone else, and who remains the only guide among the earlier generations of botanists. Also note that the first full and accurate description of *Crataegus flava* is provided here for comparative purposes.

TAXONOMIC TREATMENT

The treatment presented here follows the form established for other series of the southeastern United States hawthorns (Phipps 1988a, 1988b; Phipps & Dvorsky 2006a, etc.). This entails detailed series and species descriptions, key to species, full typification, line illustrations of the taxa and county level distribution maps prepared by K. Dvorsky. There is also an appendix of cited specimens. The treatment will commence by elaborating the separation of the new series. A few extra recent collections were added to the list of cited specimens in proof and do not appear in the maps.

The reasons for the exclusion of *Crataegus flava* and the separation of new ser. *Apricae* from ser. *Lacrimatae* are most conveniently summarized as a detailed key, given below. *Crataegus flava* will be placed in ser. *Intricatae* in the FNA treatment. A combination of plant habit, indumentum, leaf shape, and anther color characters are emphasized.

KEY SEPARATING SER. *APRICAE* FROM SER. *LACRIMATAE* AND *C. FLAVA*

1. Leaves relatively large, 5-8 cm long, thin, mesomorphic; petioles highly glandular with sessile to very short stipitate glands; twigs not flexuous at nodes; stamens 10, anthers purple; fruit narrow-pyriform (unripe) to pyriform (ripe), yellowish to yellow-orange, with somewhat elevated calyx __________ **C. flava**
1. Leaves smaller, 1-5 cm long, slightly to much more xeromorphic; petioles variably glandular but quite without stipitate glands (except in ***C. frugiferens***); stamens usually 20, anthers white (cream) or pink to purple; twigs slightly to very zigzag at nodes (except in ***C. frugiferens***); fruit subspherical to slightly tapered at base, yellow to red in color, lacking elevated calyx.
    2. Leaves ± cuneate to ± parallel-sided; veins exiting near the end of the leaf, often only 1-3 per side; sides lacking lobes for most of their length __________ **ser. Lacrimatae, p.p.**
    2. Leaves ± rhombic, ovate or elliptic; veins exiting between the half-way point and the end of the leaf, frequently 4-6 per side; sides clearly lobed except in a few species with very short leaves (<1cm long).
        3. Ultimate branches conspicuously lacrimate (except in two dwarf species <1.5 m tall); leaves and inflorescence branches ± tomentose young; anthers ivory to cream; leaves lobeless or with 1-2 blunt lobes per side (except ***C. dispar***, with sharp lobes) __________ **ser. Lacrimatae, p.p.**
        3. Ultimate branches not conspicuously lacrimate; leaves variably hairy to glabrous, never tomentose; inflorescence branches glabrous to densely pubescent, never tomentose ; anthers usually pink to purple; leaves with 3-4 distinct and usually sharp lobes per side __________ **ser. Apricae**

Series **Apricae** J.B. Phipps, ser. nov. Type Species: *Crataegus aprica* Beadle.

Frutices vel arbores parvae; cortex truncorum interdum ater aut atrocinereus, ± rimosus, sed raro commemoratus; ramuli vulgo tortuosi sed recti in *C. frugiferenti*, saepe subrufo-brunnei post unum annum; spinae vulgo 1.5–4.5 cm longae, ± rectae vel leviter recurvatae. Folia decidua, marginibus et petiolis glandulosis; laminae 1.5–5 cm longae, late-ovatae vel rhombo-ellipticae in forma generali; lobi nulli vel 1–3 per latus, vadosi vel (interdum tantum apiculi) obscure vel raro moderate profundi (et acuti in *C. ignava*); venatio craspedodroma, venis 3–5(6–7 in *C. frugiferenti*) per latus; tenues vel ± chartaceae. Inflorescentiae (1–)2–6(–7) floratae; rami glabri vel pubescens (interdum dense), ferentes parvas, caducas, lineares, membranaceas, glandulo-marginatas bracteolas. Flores 13–25 mm diam.; hypanthium glabrum vel pubescente (interdum dense); lobi calycis angusto-triangulares, marginibus glandulo-serratis; petala ± circularia, alba; stamina ca. 20(10), antheris roseis vel purpureis, interdum albis; styli 3–5. Fructus 8–15 mm diam., subglobosi vel globosi, aurantiaco-rubri vel rubri, glabri vel cum pilis raris; lobi calycis reflexi; pyrenae 3–5, dorsaliter sulcatae, lateribus planis.

Shrubs or small trees; bark on trunks seldom recorded, when so, black or dark gray, ± rimose; most twigs slightly zigzag, except straight in *C. frugiferens*, often reddish brown after 1 yr.; thorns mainly 1.5–4.5 cm long, ± straight to slightly recurved. Leaves deciduous, margins and petioles glandular; blades 1.5–5 cm long, broad-ovate to rhomb-elliptic in general shape; lobes none or 1–3 per side, if so, shallow (sometimes mere apiculi) or obscurely to more rarely moderately deep (and quite sharply acute in *C. ignava*); venation craspedodromous, 3–5(–6–7 in *C. frugiferens*) lateral veins per side; thin to somewhat coriaceous. Inflorescences (1–)2–6(–7) flowered; branches glabrous or pubescent, sometimes densely, bearing small, caducous, linear, membranous, gland-margined bracteoles. Flowers 13–25 mm diam.; hypanthium glabrous or pubescent, sometimes densely so; calyx lobes narrow-triangular, margins glandular-serrate; petals ± circular, white; stamens usually 20(–10), anthers usually pink to purple, occasionally white; styles 3–5. Fruit 8–15 mm diam., subglobose to spherical, orange-red to red, smooth or with scattered hairs; calyx lobes usually reflexed; nutlets 3–5, dorsally grooved, sides plane.

Series *Apricae* is essentially southern Appalachian/adjacent Piedmont in distribution with some extension into the coastal plain in northern Florida and South Carolina where its species constitute a characteristic element of the *Crataegus* flora in sunny places. Here, 12 species are named with certainty, only a few of which are reasonably common, for instance, *C. mira*. Several more are known only from their types and receive full descriptions. An interesting *Crataegus* flora from the Augusta sandhills of a hundred years ago and now unknown is treated as fully as material permits and special attention is drawn to it. Perhaps it is in the *C. flava* alliance. A full and updated treatment of *C. flava*, except for illustrations, for which the reader is referred to Phipps (1988a), is also provided in this paper because that is where it would customarily be sought and a parallel treatment of ser. *Intricatae* is not anticipated.

Crataegus series *Apricae* represents a remodeling of series *Flavae* (Loud.) Rehder in the sense that was used in Phipps et al. (2003) and Phipps et al. (1990). This is due to the transfer of its type species to ser. *Intricatae*. The species included here belong to Beadle's groups *Euflavae* (minus *C. flava*), *Ignavae*, *Sororiae*, *Segnes* and *Visendae*.

Species limits in the new series were found to be not always very clear cut, in part because of a relative paucity of material, and the present treatment takes a narrow view of specific limits generally following Beadle (1902) and Beadle (1903) because of the potential arbitrariness of lumping in such cases. Beadle knew the group better than anyone else, having described most of the taxa, and remains the only guide among the earlier generations of botanists. None of the species of the series as finally demarcated here appears to be really common and several are very rare or local, limiting insights from modern fieldwork. Some of the taxa recognized could well be local hybrids or apomictic races and the only ploidy level recorded is 3× for a cultivated specimen that might be *C. aprica* (Talent & Dickinson 2005).

KEY TO SERIES APRICAE AND *CRATAEGUS FLAVA*

1. Twigs ± zigzag, except in ***C. frugiferens***; leaves 2–5 cm long; anthers usually pink to purple; fruit orange-red to red, subglobose.
  2. Stamens 20.
    3. Inflorescence branches tomentose-canescent or scabrous-pubescent.
      4. Inflorescence branches tomentose-canescent; leaf-blades ± isodiametric; petioles with sessile glands __________ **6. C. sororia**
      4. Inflorescence branches scabrous-pubescent; leaf-blades ovate to rhombovate or obovate; petioles usually with at least some glands stipitate __________ **11. C. frugiferens**
    3. Inflorescence branches at most thin-pilose or pubescent.
      5. Leaf-blades suborbiculate to ellipt-rhombic or obovate, lobes of leaf-blades small, mere apiculi, or obscure or lacking.
        6. Blades broad-elliptic-rhombic to suborbicular; lobes clearly present, though small.
          7. At least some leaves usually tending to suborbiculate in shape; lobing small, neat and regular, ± acute at anthesis, becoming more obscure later in the season; flowers 20–25 mm diam. __________ **7. C. mira**
          7. No leaves tending to suborbiculate in shape, larger ovate, smaller elliptic to rhombelliptic; lobing somewhat irregular; flowers 15–20 mm diam.
            8. Anthers purple __________ **8. C. leonensis**
            8. Anthers ivory __________ **13. C.** sp. cf. **C. annosa**
        6. Blades usually widest distally, if widest in the centre then not even approximately rhombic, with 1-several small and irregular lobes per side, or cuspidate and at the most terminally denticulate; flowers 14–25 mm diam. ('***visenda*** group').
          9. Blades smaller, 1.5–3 cm long, broadly or narrowly obovate to rhombovate in general shape, seldom less than 1.5 × as long as broad; flowers 14–20 mm diam.
            10. Leaves rhombic-elliptic to rhomb-obovate in general shape, the tip cuspidate; many irregularly short-lobed __________ **2. C. visenda**
            10. Leaves narrow-obovate to narrow-elliptic in general shape, nearly without discernible lobes __________ **3. C. galbana**
          9. Blades larger, 2–3.5 cm long, broadly elliptic or rhombelliptic to obovate in general shape; flowers 15–18 mm diam. __________ **4. C. segnis**
      5. Leaf-blades ± rhombic; lobes well-defined, sharp to somewhat blunt.
        11. Blades 1.5–2.5 cm long; inflorescence branches pubescent __________ **1. C. egregia**
        11. Blades 2.5–4.0 cm long; inflorescence branches glabrous __________ **9. C. ignava**
  2. Stamens 10 (occasionally12–15).
    12. Leaf-blades 3–5 cm long, lobes and teeth sharp; flowers 16–20 mm diam., anthers pink or purple.
      13. Inflorescence branches glabrous; stamens 10 __________ **10. C. allegheniensis**
      13. Inflorescence branches pilose-pubescent; stamens 12–15 __________ **12. C. extraria** and **C.** sp. cf. **extraria**
    12. Leaf-blades 2.5–5 cm long, lobes, if any, apiculi; teeth blunt or sharp; flowers 13–16 mm diam.; anthers pink or cream.
      14. Leaves widest near the mid-point, teeth not sharp, ± coriaceous at maturity; petiolar glands all sessile; anthers cream; inflorescence branches quite densely pilose __________ **5. C. aprica**

14. Leaves ovate in general shape, sharply toothed, relatively thin at maturity, 2.5–5 cm long; petioles usually with some glands stipitate; anthers pink or cream; inflorescence branches apressed scabrous-pubescent ____ **11. C. frugiferens**

1. Twigs not zigzag; leaves 5–8 cm long; anthers pink to purple; fruit yellowish, narrow ____ **[C. flava (ser. Intricatae), see end of treatment]**

1. Crataegus egregia Beadle, Biltmore Bot. Stud. 1:82. 1902. (**Fig. 1**). TYPE: U.S.A. FLORIDA. Liberty Co.: Bristol, 24 Aug 1901, *T.G. Harbison 4942* (LECTOTYPE SELECTED HERE: A).

Small tree 4–6 m tall; thorns none or several, 3–4 cm long, dark, slender, straight; twigs ± slender, barely flexuous, bark brown at 1 yr., older grayish; trunk bark dark, very rough. Leaves deciduous; petioles ca. 1 cm long, 30–50% length of blade, slender, pubescent, very glandular; blades 1.5–2.5 cm long at anthesis, 2–3 cm long at maturity; rhombic in general shape, generally with 1 main lobe per side; margins shallowly crenate, teeth gland-tipped; apex acute to subacute, base cuneate; venation craspedodromous, lateral veins ca. 3/side; nearly glabrous on both sides with scattered hairs adaxially young; thin. Inflorescences ca. 3-flowered; branches pubescent, bearing caducous, narrow-oblong, membranous, greenish, gland-bordered bracteoles. Flowers ca.15 mm diam.; hypanthium thin–pilose; calyx lobes narrow-triangular from a wide base, abaxially glabrous, gland-margined on barely discernible teeth; stamens 20, anthers bright purple, styles 3–4. Fruit 9–12 mm diam., slightly pyriform, red at maturity, glabrous; sepals reflexed; nutlets 3–4, dorsally grooved, sides plane.

Habitat and Distribution.—Most specimens come from Bristol, Florida. It is also recorded from two other locations in Florida as well as several from South Carolina and one each from Alabama and Georgia (Fig. 2). It is a rare species that I (JBP) have not encountered in the field.

Comment.—*Crataegus egregia* is a distinct looking plant with a unique leaf shape which is understood primarily from its type. Herbarium material is in some ways like a large *C. egens* (ser. *Lacrimatae*) but with larger, more rhombic leaf-blades and, where present, longer thorns. South Carolina specimens are thorny, typical material is thornless. Unmapped material represented by about six specimens with similar leaves but more or less tomentose pedicels and much smaller fruit may be the same.

2. Crataegus visenda Beadle, Biltmore Bot. Stud. 1:79. 1902. (**Fig. 3**). TYPE: U.S.A. FLORIDA. Liberty Co.: Bristol, 29 Mar 1901, *T.G. Harbison 4031* (LECTOTYPE selected here: A).

Crataegus arrogans Beadle, Biltmore Bot. Stud. 1:81. 1902. TYPE: U.S.A. ALABAMA. Russell Co.: Phenix City, 26 Aug 1901, *C.D. Beadle 4869* (LECTOTYPE selected here: US).

Crataegus sodalis Beadle, Biltmore Bot. Stud. 1:80. 1902. TYPE: U.S.A. GEORGIA. Burke Co.: Girard, 26 Aug 1901, *C.D. Beadle* 4868 (LECTOTYPE selected here: NY).

Crataegus tristis Beadle, Biltmore Bot. Stud. 1:84. 1902. TYPE: U.S.A. GEORGIA. Floyd Co.: Rome, 25 Apr 1901, *C.D. Beadle 4194* (LECTOTYPE selected here: A).

Large shrub or small tree to 10 m tall; bark on trunk rough, dark gray or brownish; 1 year old twigs dark brown; thorns few to numerous, 1.5–3 cm long, ± straight, very dark at 1 year. Leaves deciduous; petioles slender, 25–40% length of blade, gland-margined, pilose, winged above; blades 1.5–3.0 cm long, rhomb-elliptic to rhomb-obovate in general shape, not or shallowly 1–2-lobed per side, tip ± cuspidate; margins obscurely crenate at maturity (sharper younger); venation craspedodromous with 3–4(–5) pairs of lateral veins; when young conspicuously pilose on the veins adaxially, thinly so abaxially, otherwise nearly glabrous. Inflorescences 2–4-flowered; branches nearly glabrous to pilose, bearing caducous, linear, membranous, gland-margined bracteoles. Flowers 14–18 mm diam.; hypanthium externally glabrous to pilose; calyx lobes triangular, margins irregularly serrate and very glandular; petals ± circular, white; stamens 20, anthers pale to bright purple; styles (2–)3–5. Fruit 10–12 mm diam., subglobose to pyriform, glabrous, orange or orange flushed red to red, calyx lobes recurved; nutlets grooved dorsally, laterally smooth.

Habitat and Distribution.—Nearly all material seen is form northern Florida but there are a few records from southeastern Alabama and southwestern Georgia. *Crataegus visenda* is found in dry woods, on gravelly

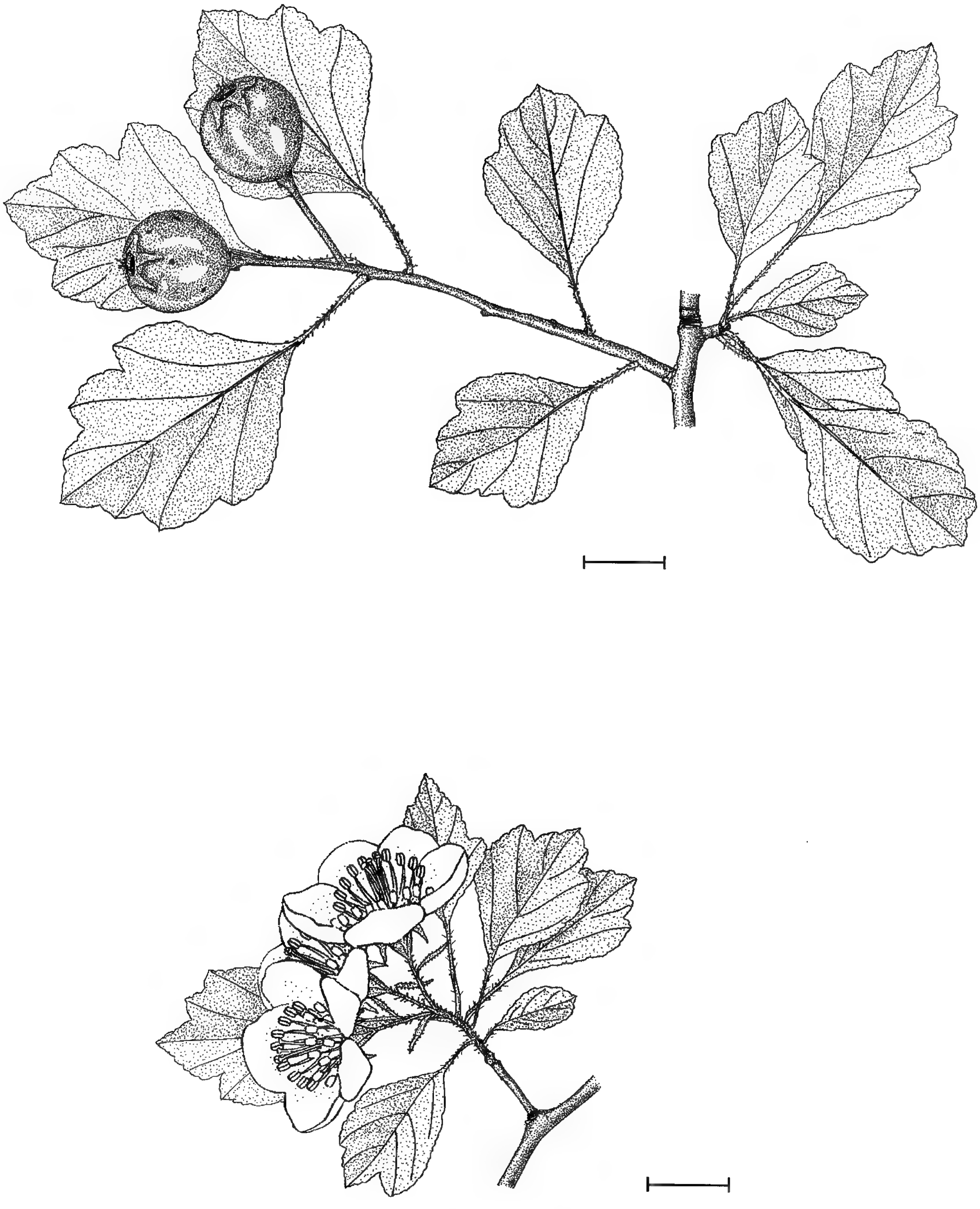

Fig. 1. Line drawing of *Crataegus egregia* from two sheets of *Harbison 4924* (A), flowering and fruiting. Scale bars =1 cm. S. Laurie-Bourque del.

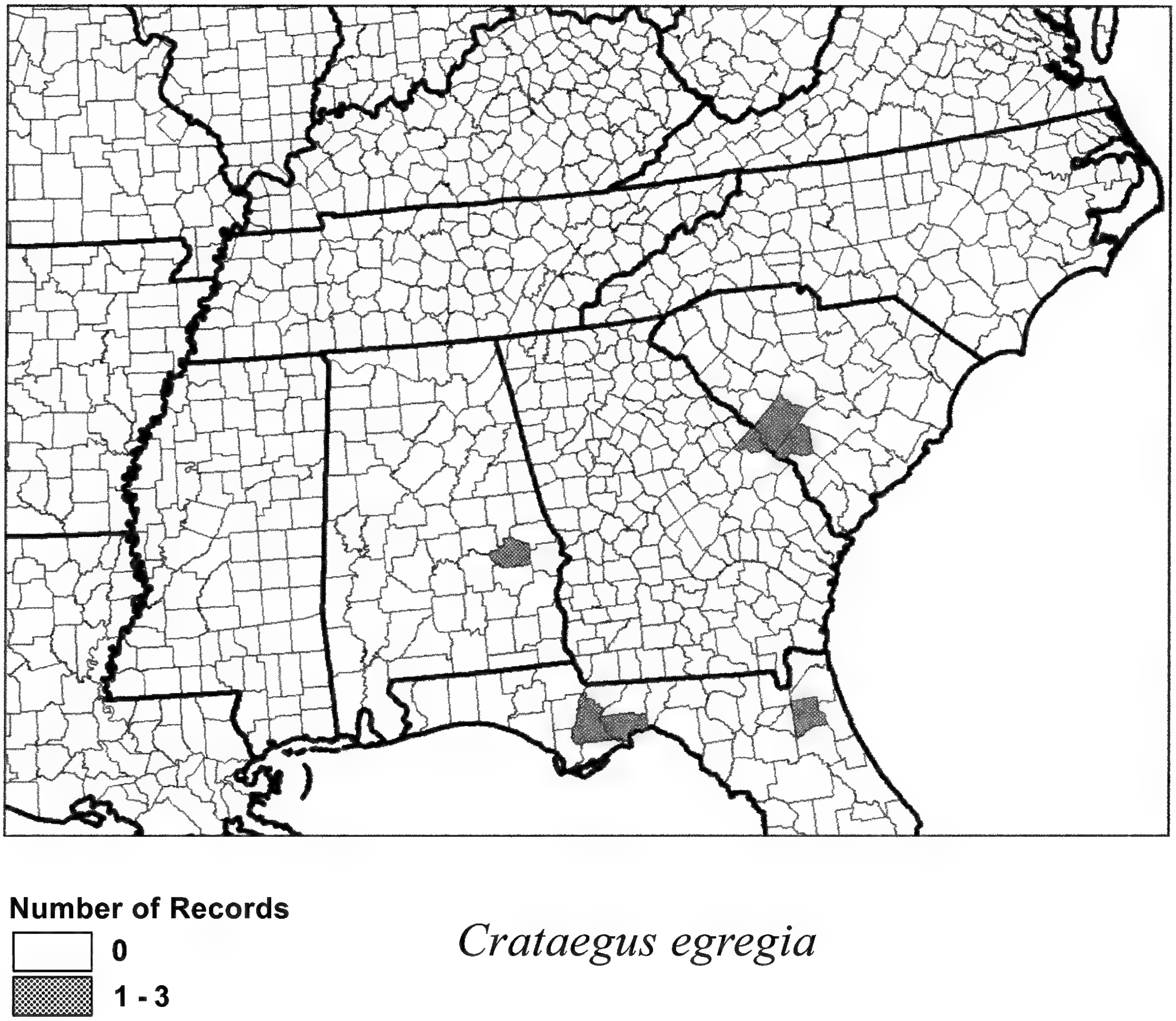

Fig. 2. County level distribution map of *Crataegus egregia.*

ridges and in sandy soil. This species is mapped collectively with *Cc. galbana* and *segnis* as the informal '*visenda* group' (Fig. 6).

Comment.—Beadle recognized 10 species in his *Visendae* from which I have removed *C. annosa* and *C. egens. Crataegus furtiva*, rather similar to C. *visenda* but with tomentose pedicels and hypanthia, is in ser. *Lacrimatae.*

3. Crataegus galbana Beadle, Biltmore Bot. Stud. 1:74. 1902. (**Fig. 4**). Type: U.S.A. Florida. Gadsden Co.: southwest of River Junction, 3 Apr 1900, *C.D. Beadle 2083* (lectotype selected here: NY).

Large shrubs or small trees; twigs somewhat zigzag, at 1 year old dark brown, but partly covered with abraded cutin, later pale to mid gray; thorns none to numerous, 1.5–2.5 cm long, straight, purple-brown at 1 year, gray later. Leaves deciduous; petioles 30–45% length of blade, slender, gland-margined, pubescent; blades 1.5–3 cm long, narrow-obovate to narrow-elliptic in general shape, apex acute to sometimes slightly cuspidate, base ± rapidly narrowed; margins ± devoid of lobes except sometime a few distal half; margins crenate-serrate, the teeth gland-tipped; venation craspedodromous with 3–4 pairs of lateral veins; when young thin hairy adaxially especially on the mid-vein, nearly glabrous abaxially young, except along the mid-vein and in the main axils, ± glabrescent. Inflorescences 1–5-flowered; branches finely pubescent, bearing several caducous, narrow-oblong, membranous, gland-margined bracteoles. Flowers 14–20 mm

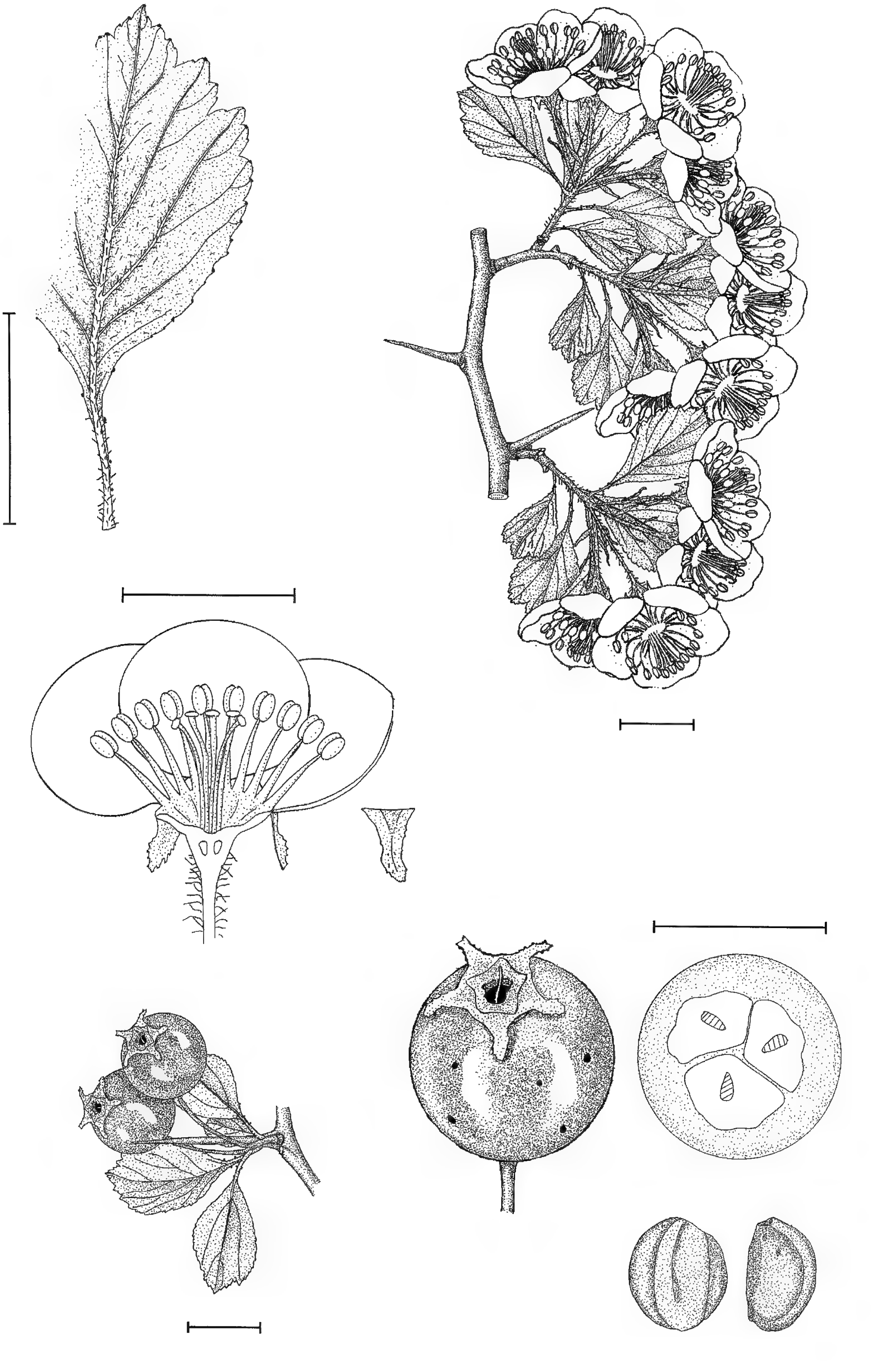

FIG. 3. Line drawing of *Crataegus visenda* from *Lance 2114* (UWO), flowering and *Godfrey 79895* (UWO), fruiting. Scale bars =1 cm. S. Laurie-Bourque del.

Fig. 4. Line drawing of *Crataegus galbana* from *Cuthbert 1* (FLAS) and *Duncan 2832* (GA), fruiting and *Duncan 4116* (GA) and *Porter 343* (USCH), flowering. Scale bars =1 cm. S. Laurie-Bourque del.

diam.; hypanthium externally thinly pilose; calyx lobes triangular, margins glandular and strongly serrate, abaxially glabrous; petals ± circular, white; stamens 20, anthers pale purple; styles 3–5. Fruit 10–15 mm diam., subglobose, glabrous, orange flushed red to red; calyx lobes recurved; nutlets ca. 3–5, grooved dorsally, laterally smooth.

Habitat and Distribution.—Locally common in the Florida Panhandle, *Crataegus galbana* ranges to south-central Alabama throughout Georgia to South Carolina with two records from North Carolina. It occurs in open woodland and scrubby places. This species is mapped collectively with *Cc. visenda* and *segnis* as the informal '*visenda* group' (Fig. 6).

Comment.—*Crataegus galbana* is the least similar to *C. visenda* of this group of species and might perhaps be confused with *C. aprica*. Nevertheless, the smaller, differently shaped leaves and 20 pale purple anthers will readily distinguish it from *C. aprica*. A good many specimens of this species were annotated '*C. consanguinea*'.

4. Crataegus segnis Beadle, Biltmore Bot. Stud. 1:32. 1901. (**Fig. 5**). Type: U.S.A. Alabama. Butler Co.: Greenville, 24 Aug 1901, *C.D. Beadle 2155²* (lectotype selected here: A).

Crataegus consanguinea Beadle, Biltmore Bot. Stud. 1:34. 1901. Type: U.S.A. Florida. Leon Co.: W of Tallahassee, 28 Mar 1900, *C.D. Beadle 2044* (lectotype selected here: US).

Large shrubs or small trees; twigs somewhat zigzag, at 1 year old dark brown, but partly covered with abraded cutin, later pale to mid gray; thorns none to numerous, 1.5–2.5 cm long, straight, purple-brown at 1 year, gray later. Leaves deciduous; petioles slender, 30–45% length of blade, slender, gland-margined, pubescent; blades 1.5–2.5 cm long, broadly elliptic or rhombelliptic to obovate in general shape, apex acute and often somewhat cuspidate, base ± rapidly narrowed; usually not but sometimes very obscurely lobed, margins crenate-serrate, the teeth gland-tipped; venation craspedodromous with 3–5 pairs of lateral veins except in the smaller leaves; when young thin hairy adaxially especially on the mid-vein, nearly glabrous abaxially young, except along the mid-vein and in the main axils, ± glabrescent. Inflorescences 1–5-flowered; branches quite long pilose, bearing several caducous, narrow-oblong, membranous, gland-margined bracteoles. Flowers ca.15–18 mm diam.; hypanthium externally thinly pilose; calyx lobes triangular, margins irregularly strongly glandular and serrate, abaxially glabrous; petals ± circular, white; stamens 20, anthers pale purple; styles 3–5; Fruit 10–15 mm diam., subglobose, glabrous, orange flushed red to red; calyx lobes recurved; nutlets ca. 3–5, grooved dorsally, laterally smooth.

Habitat and Distribution.—*Crataegus segnis* occurs around Greenville, Alabama and in northern Florida. This species is mapped collectively with *Cc. visenda* and *galbana* as the informal '*visenda* group' (Fig. 6).

Comment.—This species has generally the largest and broadest leaves in the *visenda* group. The fruit is subglobose and red.

5. Crataegus aprica Beadle, Bot. Gaz. 30:335. 1900. (**Fig. 7**). Type: U.S.A. North Carolina. Buncombe Co.: Biltmore, 11 May 1899, *Biltmore Herb. C14* (lectotype selected here: NY).

Shrubs, generally 2–3 m tall; branchlets somewhat flexuous; extending twigs olive-green with somewhat sparse pubescence; 1-year old twigs reddish-brown, pubescent, older dark gray-brown glabrous; 2-year old thorns 3–4 cm long, slender, straight or recurved; dark gray-brown. Leaves deciduous; petioles 3–8 mm long, 30–50% length of blade, pubescent, glandular; leaf blades 1.5–4 cm long, the blades rhomb-elliptic or broad-elliptic in general outline, widest in the middle, apically blunt, sharply constricted at the base and tapered into the winged upper petiole; extremely shallowly lobed to unlobed, lobes more prominent (mere apiculi) young; margins crenate or obtusely serrate, the teeth gland-tipped; venation craspedodromous, with 3–4 lateral veins per side; surfaces pilose above when young but glabrescent later, glabrous below except on the midvein; ± coriaceous at maturity. Inflorescences 3–6 flowered; branches ± densely pilose, bearing caducous, linear, membranous, gland-margined bracteoles; anthesis April. Flowers 13–15 mm diam.; hypanthium pilose, at least near the base; calyx lobes ca. 4 mm long, narrow triangular, gland-toothed, sparsely pubescent abaxially, with a prominent mid-vein in some; petals ± circular, white; stamens 10, anthers ivory

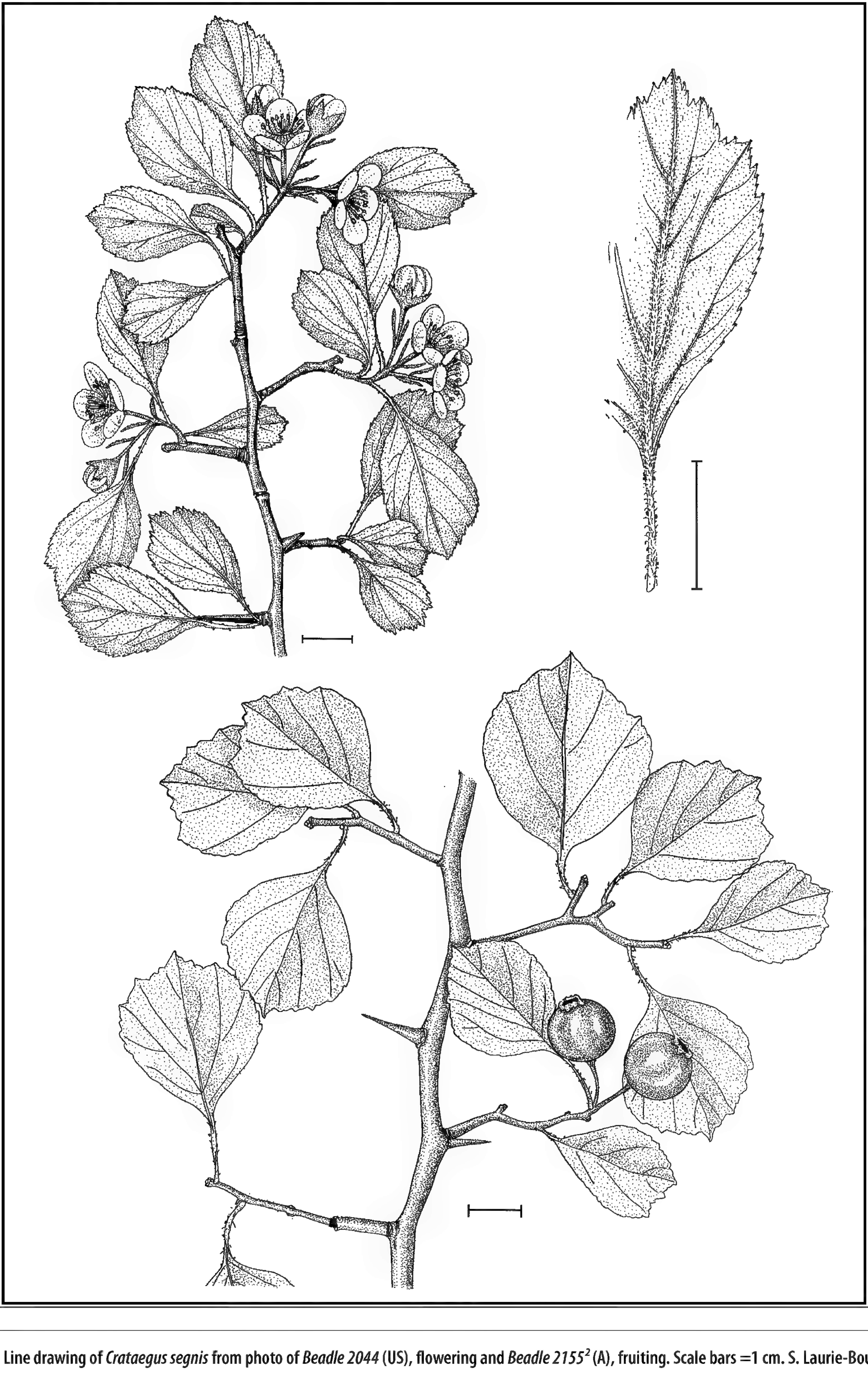

Fig. 5. Line drawing of *Crataegus segnis* from photo of *Beadle 2044* (US), flowering and *Beadle 2155²* (A), fruiting. Scale bars =1 cm. S. Laurie-Bourque del.

or cream; styles 3–5. Fruit 9–15 mm diam., ± orbicular, with a few hairs, red or reddish-orange; calyx lobes patento-reflexed; nutlets 3–5, dorsally sulcate, laterally smooth.

Common Name.—Sunny Hawthorn.

Habitat and Distribution.—*Crataegus aprica* is found mainly around the southern end of the Appalachians from northern Florida to Virginia with a single record each for Alabama and Tennessee (Fig. 8). It occurs at 50–3000 ft in open brushy areas where it may be quite common.

Comment.—Vegetatively, *C. aprica* is not unlike members of the *visenda* group but it has 10 stamens and ivory anthers. The record from Barbour Co., Alabama has a thinner inflorescence tomentum and generally larger (3.0–4.5 cm long), longer petiolate (1.5–2.0 cm long), thinner leaves.

6. Crataegus sororia Beadle, Bot. Gaz. 30:336. 1900. (**Fig. 9**). Type: U.S.A. Georgia. Floyd Co.: hills above Silver Creek, Rome, 18 Sep 1897, *C.D. Beadle 1257* (lectotype selected here: A).

Shrubs, generally 2–3 m tall; trunk bark rimose; branchlets somewhat flexuous; extending twigs olive-green with somewhat sparse pubescence; 1-year old twigs reddish-brown, pubescent, older dark gray-brown glabrous; 2-year old thorns 3–4 cm long, slender, straight or recurved; dark gray-brown. Leaves deciduous; petioles 3–8 mm long, 30–50% length of blade, pubescent, glandular; leaf blades 1.5–4 cm long, the blades broad-elliptic to circular in general outline, widest in the middle, apically blunt, sharply constricted at the base and tapered into the winged upper petiole; rather sharply lobed, lobes more prominent young; margins finely serrate, the teeth gland-tipped; venation craspedodromous, with 3–4 lateral veins per side; surfaces pilose above when young but glabrescent later, glabrous below except on the midvein; ± coriaceous at maturity. Inflorescences 3–6 flowered; branches tomentose, bearing caducous, linear, membranous, gland-margined bracteoles; anthesis April. Flowers ca. 15 mm diam.; hypanthium densely pilose; calyx lobes ca. 4 mm long, narrow triangular, gland-toothed, sparsely pubescent abaxially, with a prominent mid-vein in some; petals ± circular, white; stamens 20, anthers ivory, pink-purple or red; styles 4–5. Fruit 12–18 mm diam., ± orbicular, with a few hairs, reddish-orange; calyx lobes patento-reflexed; nutlets 4–5, dorsally sulcate, laterally smooth.

Habitat and Distribution.—*Crategus sororia* occurs around Rome, Georgia where it is still common, in adjacent areas of Alabama and in Aiken Co., South Carolina (Fig. 10). It is found in open scrubby areas.

Comment.—This species, most similar to *C. aprica*, differs in leaf shape (proportionately broader), stamen number and anther color. Beadle (1900) says that *C. sororia* is found south to Florida but I have not seen specimens of it from that state.

7. Crataegus mira Beadle, Biltmore Bot. Stud. 1:78. 1902. (**Fig. 11**). Type: U.S.A. Georgia. Cobb Co.: 9 May 1901, *C.D. Beadle* 4287 (holotype selected here: US).

Shrubs, generally 2–3 m tall; branchlets somewhat flexuous; extending twigs olive-green with somewhat sparse pubescence; 1-year old twigs reddish-brown, pubescent, older dark gray-brown glabrous; 2-year old thorns 3–4 cm long, slender, straight or recurved; dark gray-brown. Leaves deciduous; petioles 3–8 mm long, 30–50% length of blade, pubescent, glandular; leaf blades 2–3.5 cm long, the blades broad rhomb-elliptic to ± circular in general outline, widest in the middle, apically acute, sharply constricted at the base and tapered into the winged upper petiole; shallowly but sharply lobed, lobes more prominent young; margins crenatoserrate to serrate, the teeth particularly prominent around anthesis, gland-tipped; venation craspedodromous, with 3–4 lateral veins per side; surfaces pilose above when young but glabrescent later, glabrous below except on the midvein; ± coriaceous at maturity. Inflorescences 3–6 flowered; branches glabrous to pilose, bearing caducous, linear, membranous, gland-margined bracteoles; anthesis April. Flowers 20–25 mm diam.; hypanthium thin-pilose to more or less glabrous; calyx lobes ca. 5 mm long, narrow triangular, gland-toothed, sparsely pubescent abaxially, with a prominent midvein in some; petals ± circular, white; stamens 10–20, anthers cream or purple; styles 4–5. Fruit 9–15 mm diam., ± orbicular, with a few hairs, red or reddish-orange; calyx lobes patento- reflexed; nutlets 4–5, dorsally sulcate, laterally smooth.

Habitat and Distribution.—The main range of *C. mira* is the Florida panhandle to central Georgia but

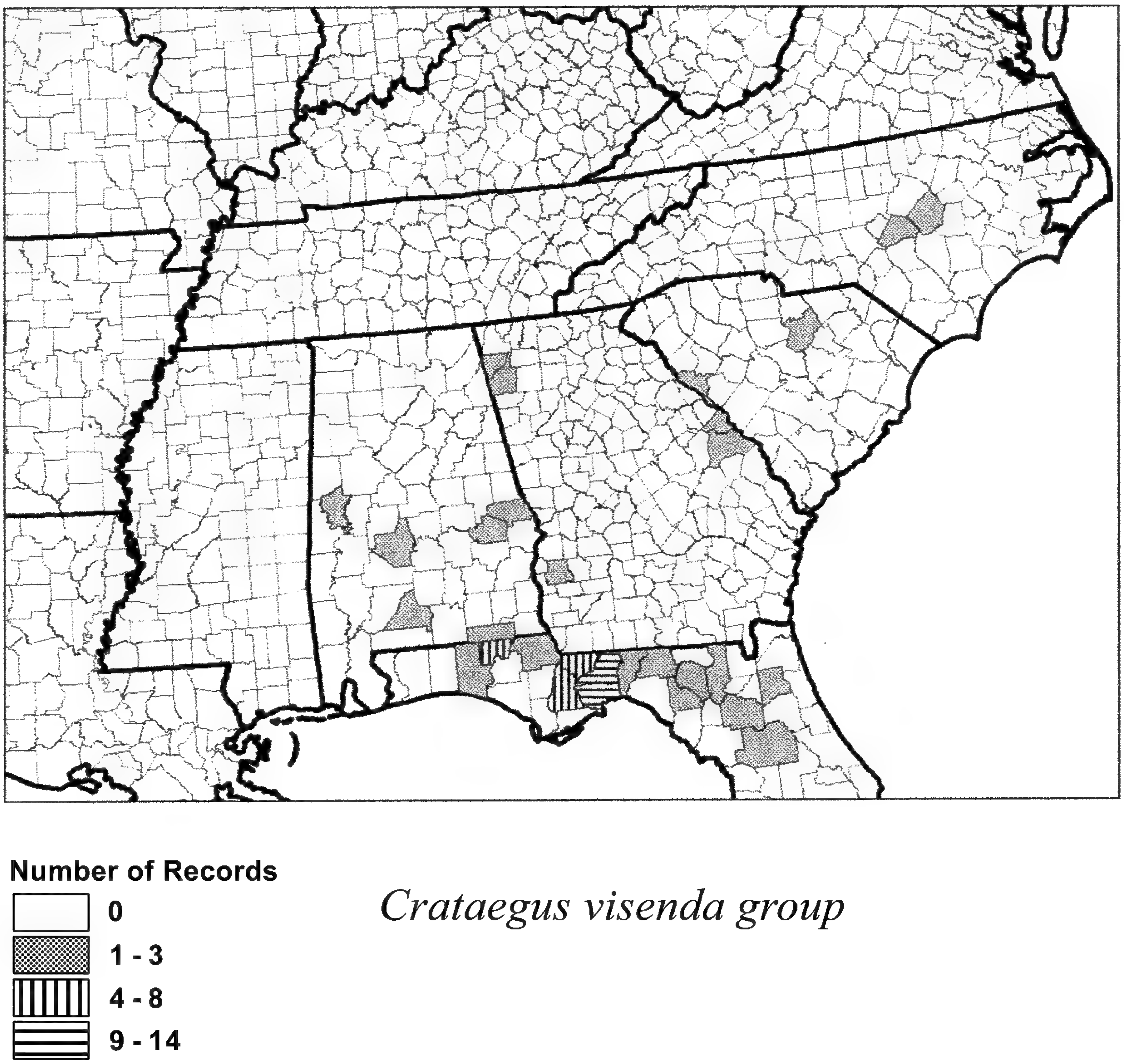

Fig. 6. County level distribution map of *visenda* group.

it extends to the Carolinas and Alabama (Fig. 12). It is found in open brushy areas where it may be quite common.

Comment.—This striking species is most similar to *Crataegus sororia* and *C. aprica* but differs in its broader and often larger leaves, thinner inflorescence indumentum and larger flower size.

8. Crataegus leonensis E.J. Palmer, J. Arnold Arbor. 13:422. 1932. Type: U.S.A. Florida. Leon Co.: near Tallahassee, 3 Apr 1923, *T.G. Harbison 6072* (holotype, A).

Tree 10–12 m tall, with wide-spreading intricate branches; trunk bark thick, ridged, dark gray to nearly black: twigs somewhat zigzag, very dark at 1 yr.; thorns sparse, to 3.5 cm long, straight, very dark at 1 yr. Leaves deciduous; petioles slender, 25–30% length of blade, extremely glandular, pubescent in the sulcus; blade 2.5–3.5 cm long, oblong to rhombovate or narrowly obovate in general shape, tip acute; base cuneate; sides obscurely or very shortly 1–2 lobed; margins finely to obscurely crenate-serrate, the teeth gland-tipped; venation craspedodromous, 3–4 veins per side; nearly glabrous but with some pilosity along the main veins adaxially and abaxially (Palmer implies glabrous abaxially); rather thin. Inflorescences 3–7 flowered;

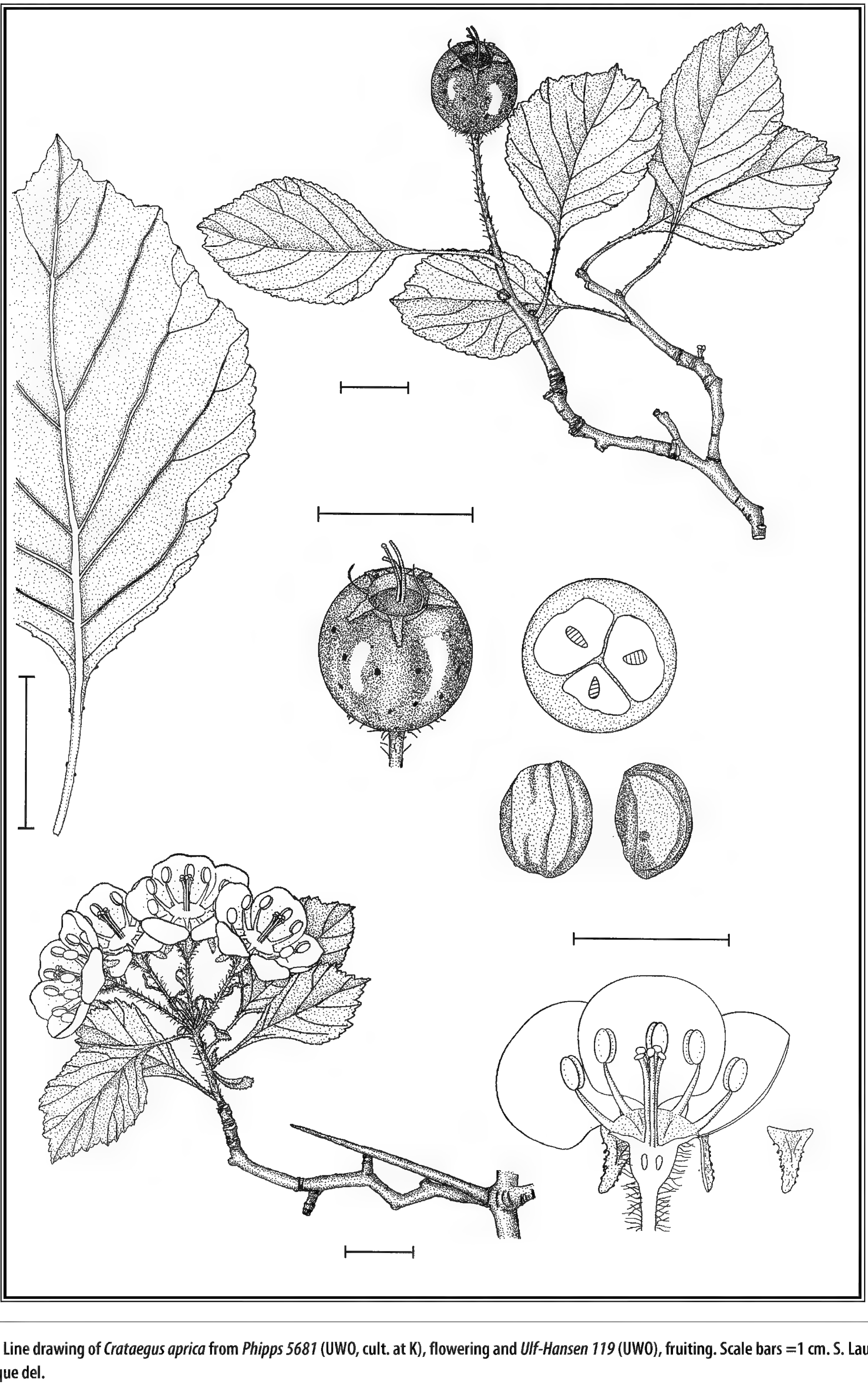

Fig. 7. Line drawing of *Crataegus aprica* from *Phipps 5681* (UWO, cult. at K), flowering and *Ulf-Hansen 119* (UWO), fruiting. Scale bars =1 cm. S. Laurie-Bourque del.

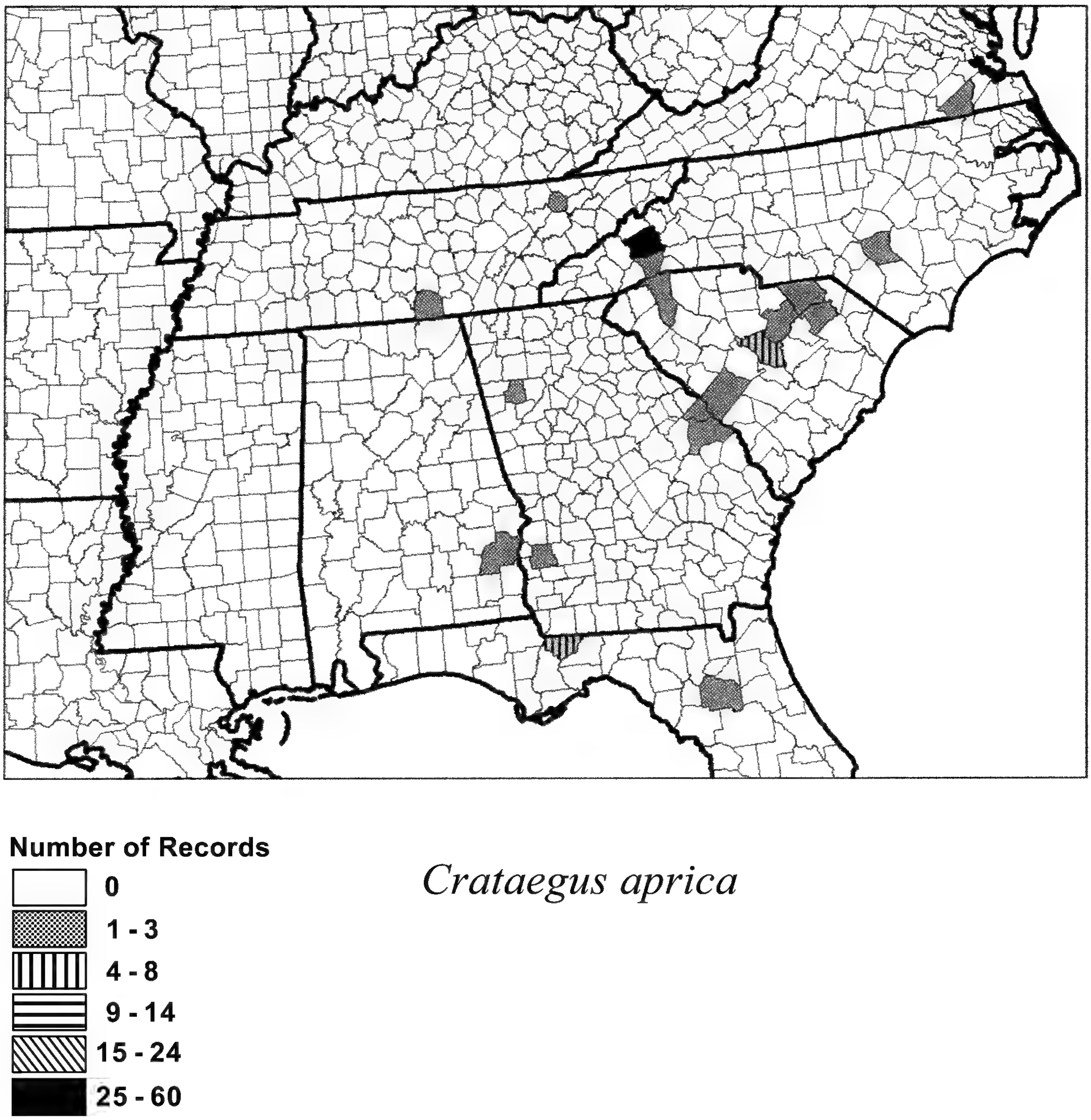

Fig. 8. County level distribution map of *Crataegus aprica*.

branches subglabrous to moderately pilose, bearing narrow-oblong, caducous, membranous, gland-bordered bracteoles. Flowers 16–20 mm diam., hypanthium glabrous externally; calyx lobes triangular, glandular-serrate, abaxially glabrous; stamens 20, anthers pink; styles 2–5. Fruit 9–12 mm diam., subglobose, glabrous, orange-red to russet, or often green-mottled; calyx lobes somewhat elevated, spreading, prominent; nutlets (2–)3–4(–5), dorsally grooved, laterally plane.

Habitat and Distribution.—This is a local species mainly known from Leon Co., Florida. A few specimens are also known from southern Georgia (Fig. 10). It is recorded from sandy upland woods.

Comment.—*Crataegus leonensis* is similar to *C. mira*, but it has smaller flowers than that species and differently shaped leaves (see key). It is possibly just an extreme from of *C. mira* but more field study of these two entities is needed to determine this. One of the flowering specimens on *Canby & Sargent 27* (DOV) from Chattahoochee, Georgia has a much more pubescent inflorescence but is otherwise indistinguishable. Murrill's *C. subflavida* is perhaps the same but has larger yellow fruit.

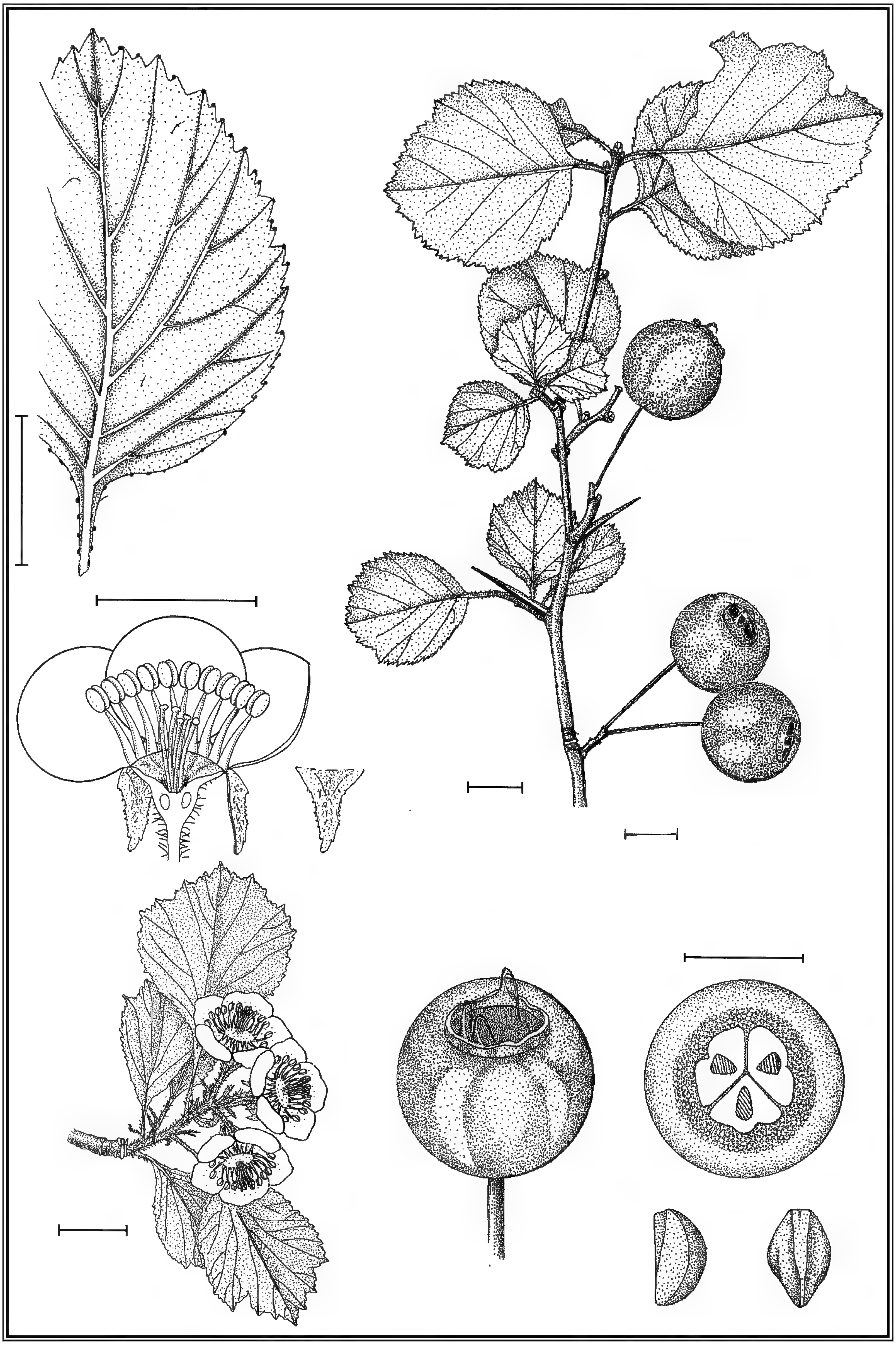

Fig. 9. Line drawing of *Crataegus sororia* from *Ulf- Hansen 020* (UWO), flowering and *Phipps 5176* (UWO), fruiting. Scale bars =1 cm. S. Laurie-Bourque del.

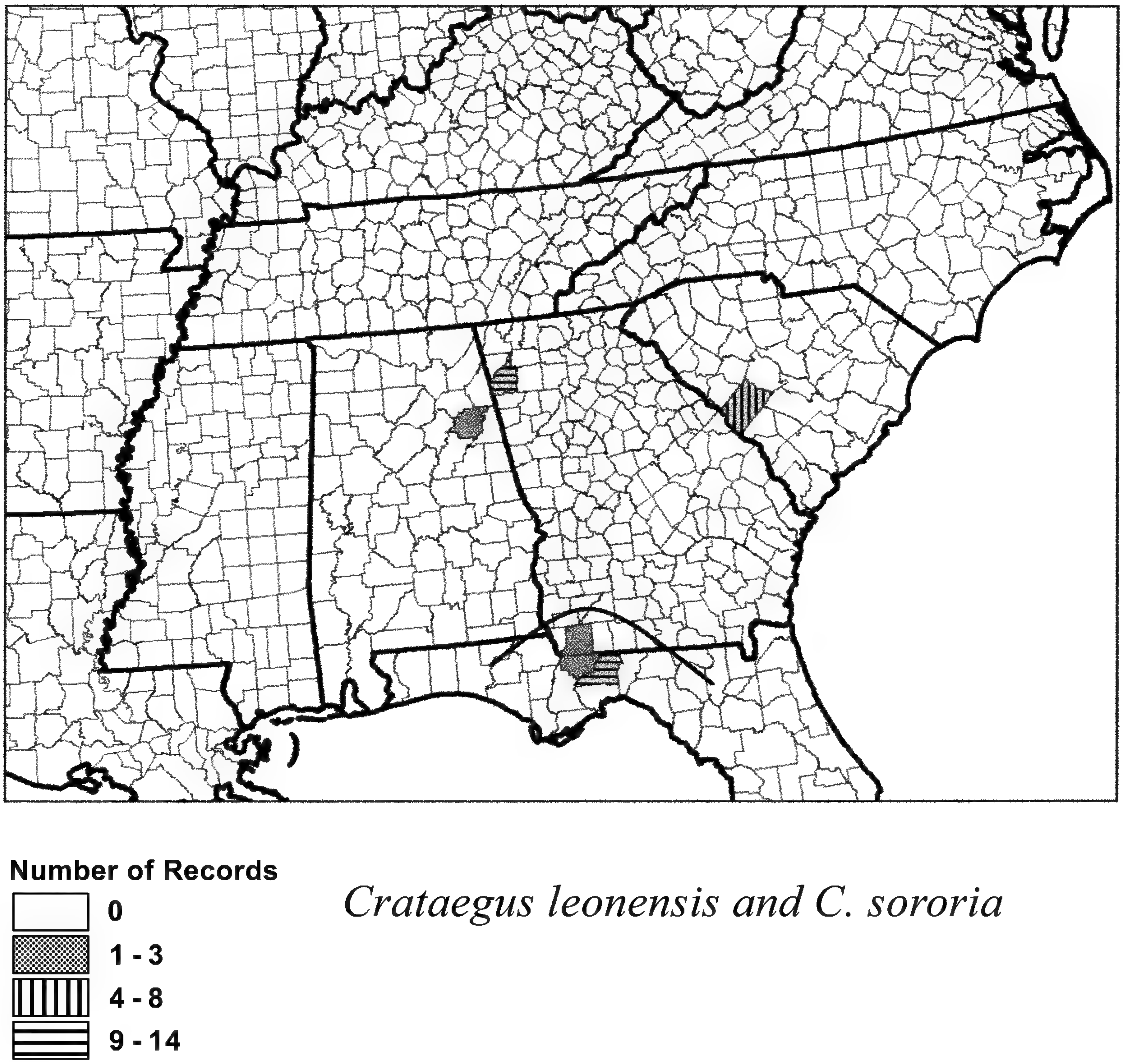

Fig. 10. County level distribution map of *Crataegus sororia* (northern) and *C. leonensis* (southern). The two species are separated by the curved line.

9. Crataegus ignava Beadle, Biltmore Bot. Stud. 1:31. 1901. (**Fig. 13**). Type: U.S.A. Alabama. De Kalb Co.: Lookout Mountain, Valley Head, Oct 1900, *C.D. Beadle 2289*^{2} (lectotype selected here: US).

Shrubs, 2–4(–5) m tall; ± thorny, thorns 2–3 cm (3–5) long at 2-yr. old, straight, ± fine, black; extending shoots glabrous; 1-yr old tan to chestnut, shiny; older ± dark gray, often reddish tinged. Leaves deciduous; petioles ca. 1 cm long, glabrous, black-glandular; blades ca. 2.5–3.5 cm long in our material, narrow-ovate to ovate-rhombic or broad-ovate in general shape; acute at the tip and wide-cuneate or somewhat rounded at the base; with 2–3 sharp lobes on either side; margins obscurely crenate-serrate, the teeth gland-dotted; venation craspedodromous, lateral veins 4–5 per side; thinly pilose above when young, but soon glabrescent, ± coriaceous at maturity. Inflorescences 2–5 flowered; branches glabrous, bearing numerous caducous, linear, herbaceous to membranous, gland-margined bracteoles. Flowers ca. 15 mm wide; hypanthium externally glabrous; calyx lobes 6 mm long, narrow-triangular, abaxially glabrous, the margins glandular-serrate; petals ± circular, white; stamens 20, anthers pale pink (pale purple); styles (3–5). Fruit 10–17 mm diam., subglobose, orange-red; calyx lobes spreading-recurved; nutlets 3–5, dorsally furrowed, laterally plane.

Fig. 11. Line drawing of *Crataegus mira* from *Lance 2121* (UWO), flowering and *Phipps 6684* (UWO), fruiting. Scale bars =1 cm. S. Laurie-Bourque del.

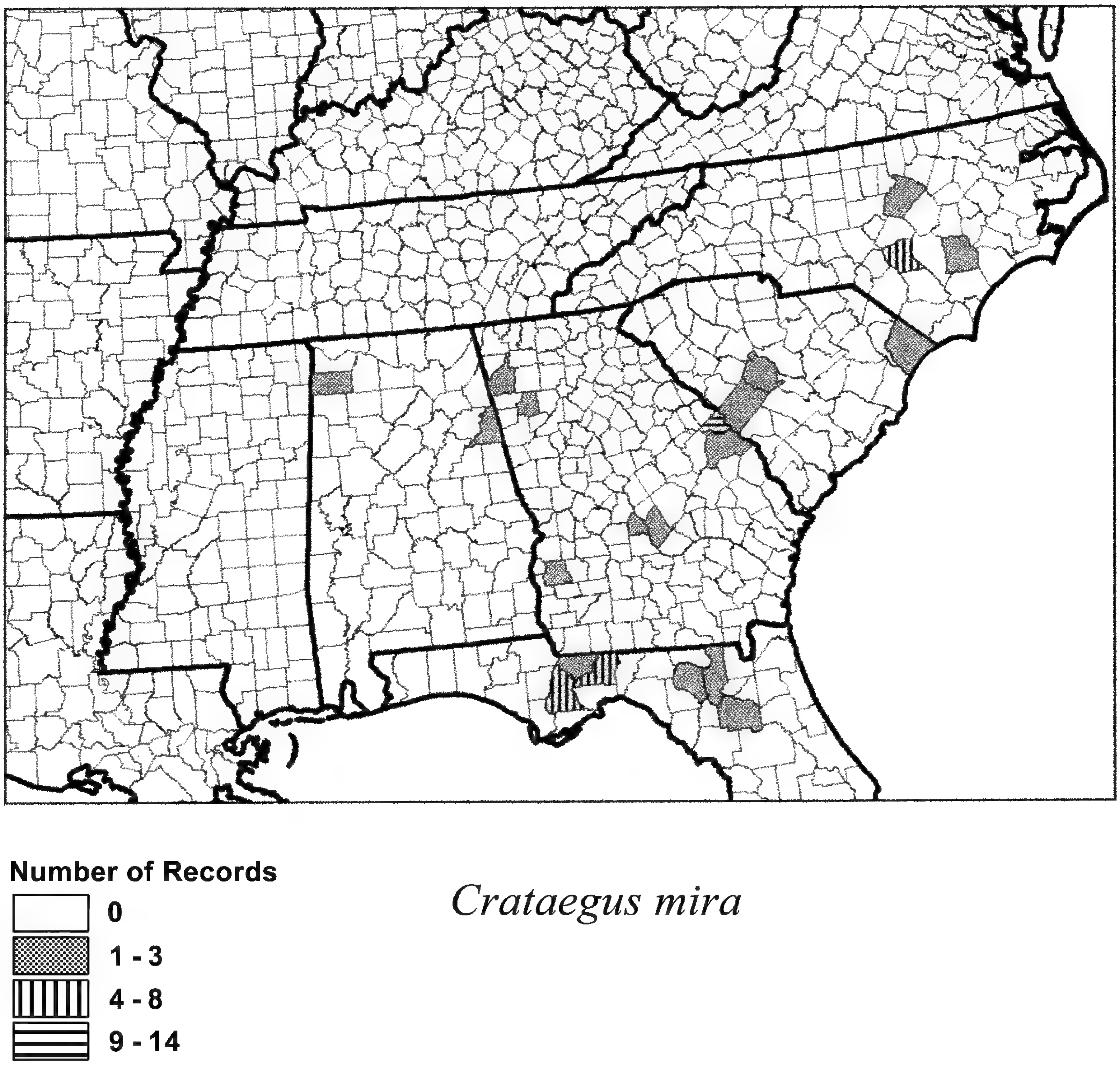

Fig. 12. County level distribution map of *Crataegus mira.*

Habitat and Distribution.—*Crataegus ignava* is a locally common plant of east-central Alabama and north-central and central Georgia (Fig. 14). The senior author has collected it from rocky hills bearing stunted trees of this species near Anniston, Alabama and red soils in central Georgia.

Comment.—If Murrill's *C. subflavida* is the same, this species also occurs near Gainesville, Florida. *Crataegus ignava* can be a very handsome plant with its bright orange-red fruit, which is sometimes very large, and striking foliage.

10. Crataegus allegheniensis Beadle, Bot. Gaz. 30:337. 1900. (**Fig. 15**). Type: U.S.A. Alabama. De Kalb Co.: Lookout Mountain, Valley Head, 7 May 1900, *C.D. Beadle 2290* (lectotype selected here: US).

Shrubs, 2–4(–5) m tall; thorns at 2 yrs 1.5–4 cm long, straight or slightly recurved, deep chestnut brown to blackish; extending twigs reddish, glabrous, at 1 yr old reddish-gray, older gray. Leaves deciduous; petioles 0.75–1.5 cm long, very glandular, glabrous; blades (2–)3–5 cm long elliptic-ovate in general shape, acute above, broadly cuneate below with about 3 sharp lobes per side, LII ca. 15%; margins finely toothed, the teeth with small glands; venation craspedodromous, with ca. 5 pairs of veins; upper surface pilose when

Fig. 13. Line drawing of *Crataegus ignava* from *Smith & Spaulding 4* (UWO), flowering and *Phipps 7783* (UWO), fruiting. Scale bars =1 cm. S. Laurie-Bourque del.

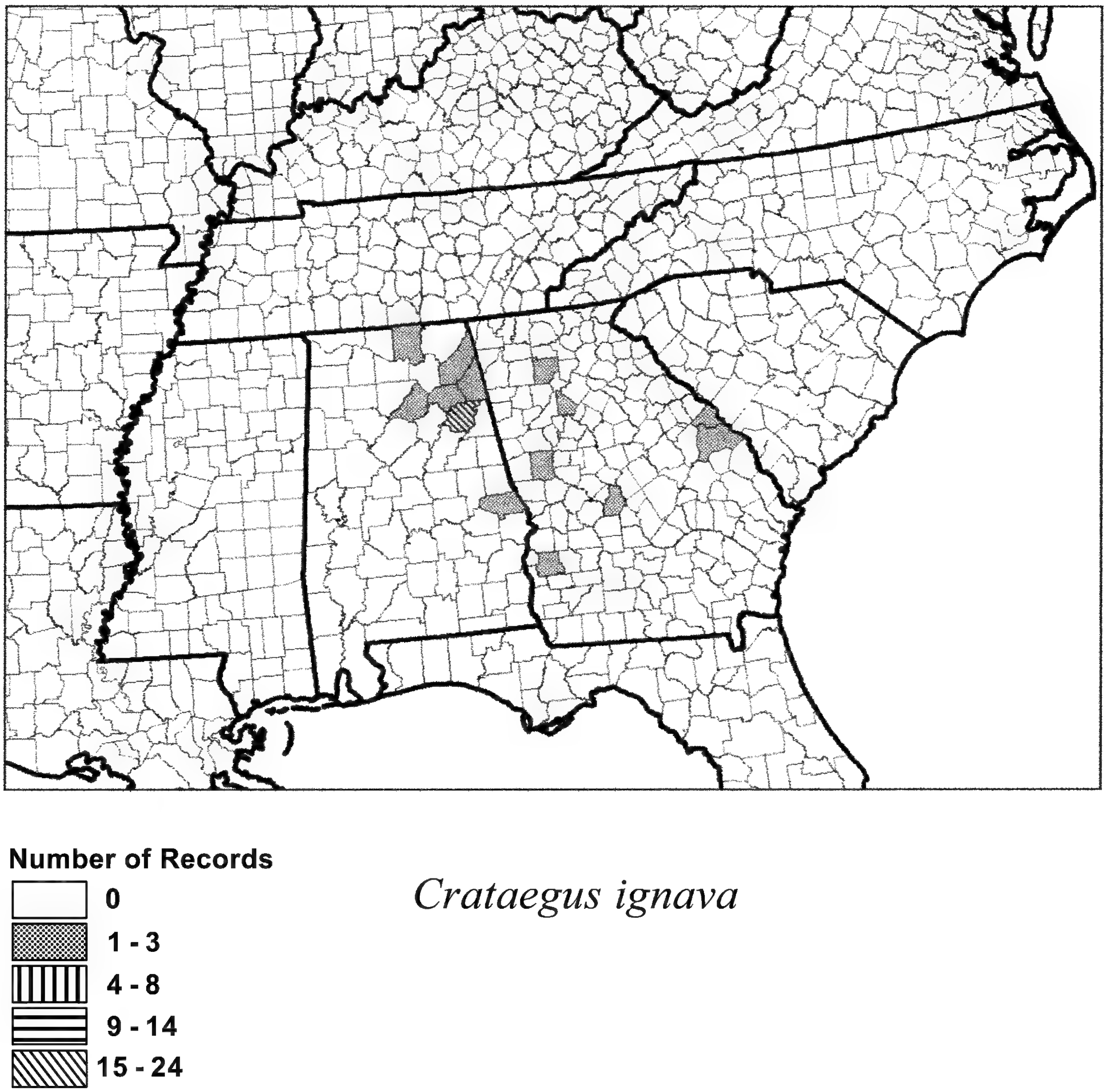

Fig. 14. County level distribution map of *Crataegus ignava*.

very young, soon glabrescent, below glabrous. Inflorescences 2–4 flowered; branches glabrous, bearing early caducous, linear, membranous, gland-margined bracteoles. Flowers 20 mm diam.; hypanthium externally glabrous; calyx lobes 5 mm long, narrowly triangular, abaxially glabrous, margins glandular-serrate; petals ± circular, white; stamens 10, anthers pink; styles ca. 4. Fruit 8–12 mm thick, globose-pyriform, glabrous, red; nutlets 2–5 (Beadle).

Habitat and Distribution.—*Crataegus allegheniensis* is known from a few locations in northeastern Alabama, Tennessee and Georgia and is apparently scarce (Fig. 16). It occurs in various brushy places and in Alabama on rocky hills.

Comment.—This species is superficially similar to *C. frugiferens* and may perhaps turn out to be only a glabrous form of that species.

11. Crataegus frugiferens Beadle, Biltmore Bot. Stud. 1:30. 1901. (**Fig. 17**). Type: U.S.A. Alabama. Cullman Co.: Cullman, 24 Aug 1901, *T.G. Harbison 2116* (lectotype selected here: US).

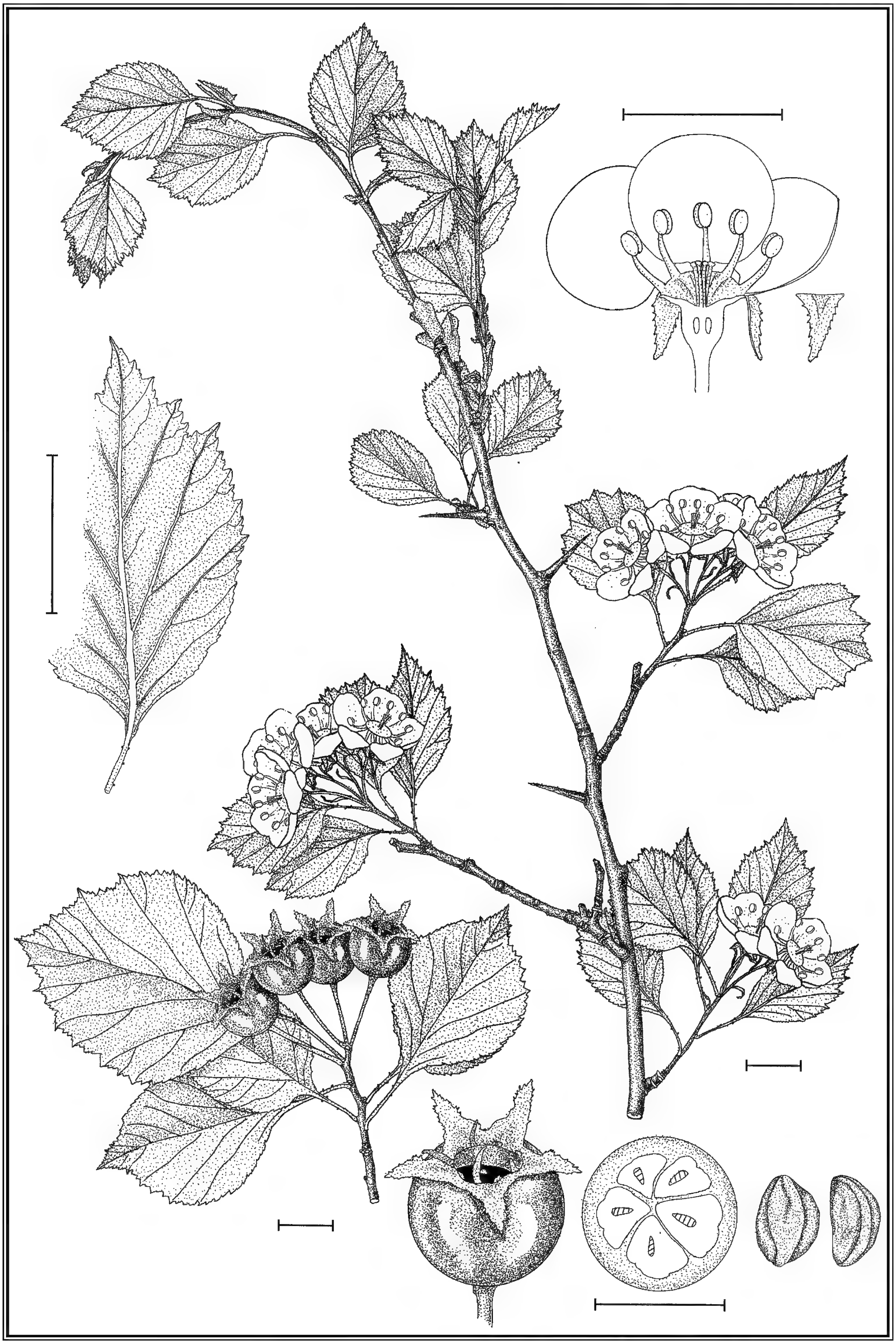

Fig. 15. Line drawing of *Crataegus allegheniensis* from *Barber et al. 1546* (UWO), fruiting and *Phipps 7655* (UWO) flowering. Scale bars =1 cm. S. Laurie-Bourque del.

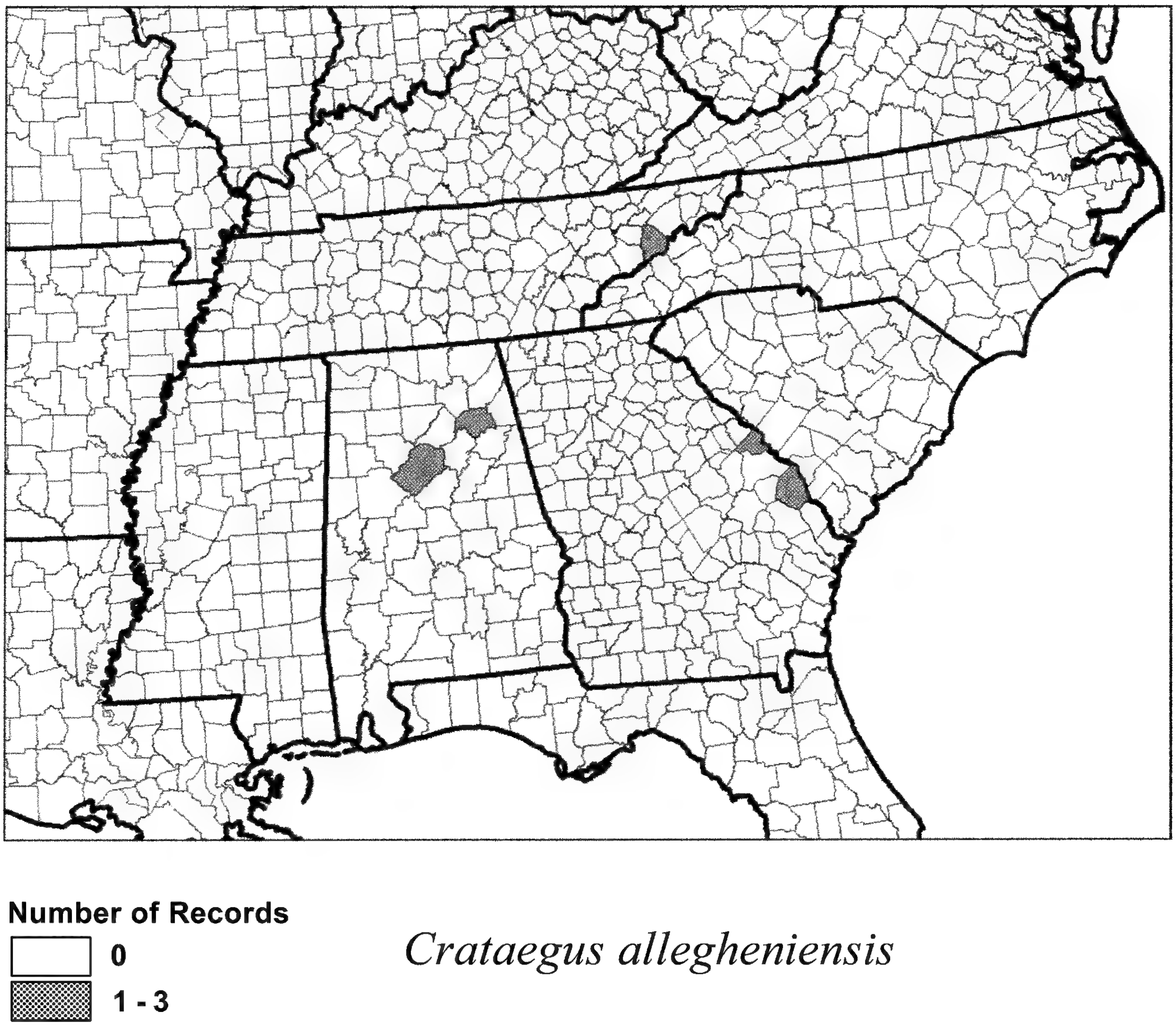

Fig. 16. County level distribution map of *Crataegus allegheniensis*.

Shrubs 3–6 m tall; thorns at 2 yr. 2–5 cm long, ± fine, straight to slightly recurved shiny dark brown or blackish, older gray; extending shoots ± appressed pubescent, reddish when young; at 1 yr. ± shiny tan, older gray. Leaves deciduous; petioles 25–40% length of blades, slender, thinly pubescent, more so in adaxial groove, bearing a few, often stipitate, glands; blades 2.5–5 cm long, ovate to rhombovate, tip acute, base cuneate to broadly cuneate, 0–3 lobed per side; lobes very shallow, sometimes little more than apiculi, max LII 0–5%; margins serrate with gland-tipped teeth basally, these glands sometimes stipitate; venation craspedodromous, 5–6(–7) veins per side; appressed scabrous-pubescent above young, later ± glabrescent, below glabrous on the surface, thinly scabrous on the veins; thin. Inflorescences 3–7 flowered; branches appressed scabrous-pubescent; bracteoles very few, apparently early caducous, linear, membranous, gland-margined. Flowers 15–16 mm diam.; hypanthium externally appressed scabrous-pubescent at least below; calyx lobes 4–5 mm long, narrow triangular, margins glandular-serrate; petals ± circular, white; stamens 10 or 20, anthers cream or pink; styles 3–4. Fruit not known to me but according to Beadle 9–12 mm thick, subglobose or slightly pyriform, red at maturity; calyx lobes reflexed, margins glandular-serrate; pyrenes 3–5.

Habitat and Distribution.—The main range of *Crataegus frugiferens* is in north central Alabama and adjacent Georgia. A single record is also known from Mississippi (Fig. 18). It is a somewhat scarce species found both in thick woodland and rocky outcrops.

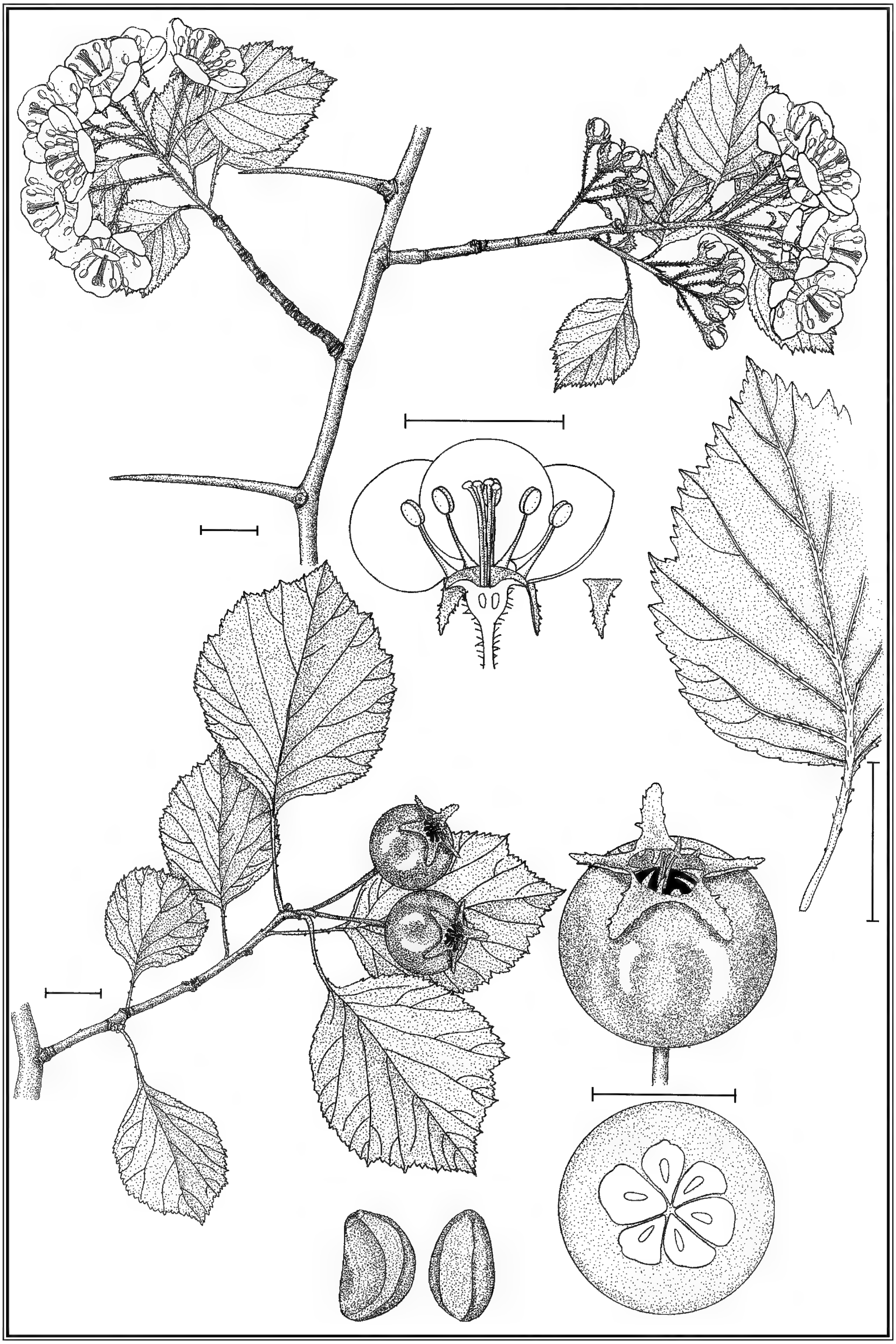

Fig. 17. Line drawing of *Crataegus frugiferens* from *Phipps & Wells 5309* (UWO), flowering and *Phipps & Spaulding 7771* (UWO), fruiting. Scale bars =1 cm. S. Laurie-Bourque del.

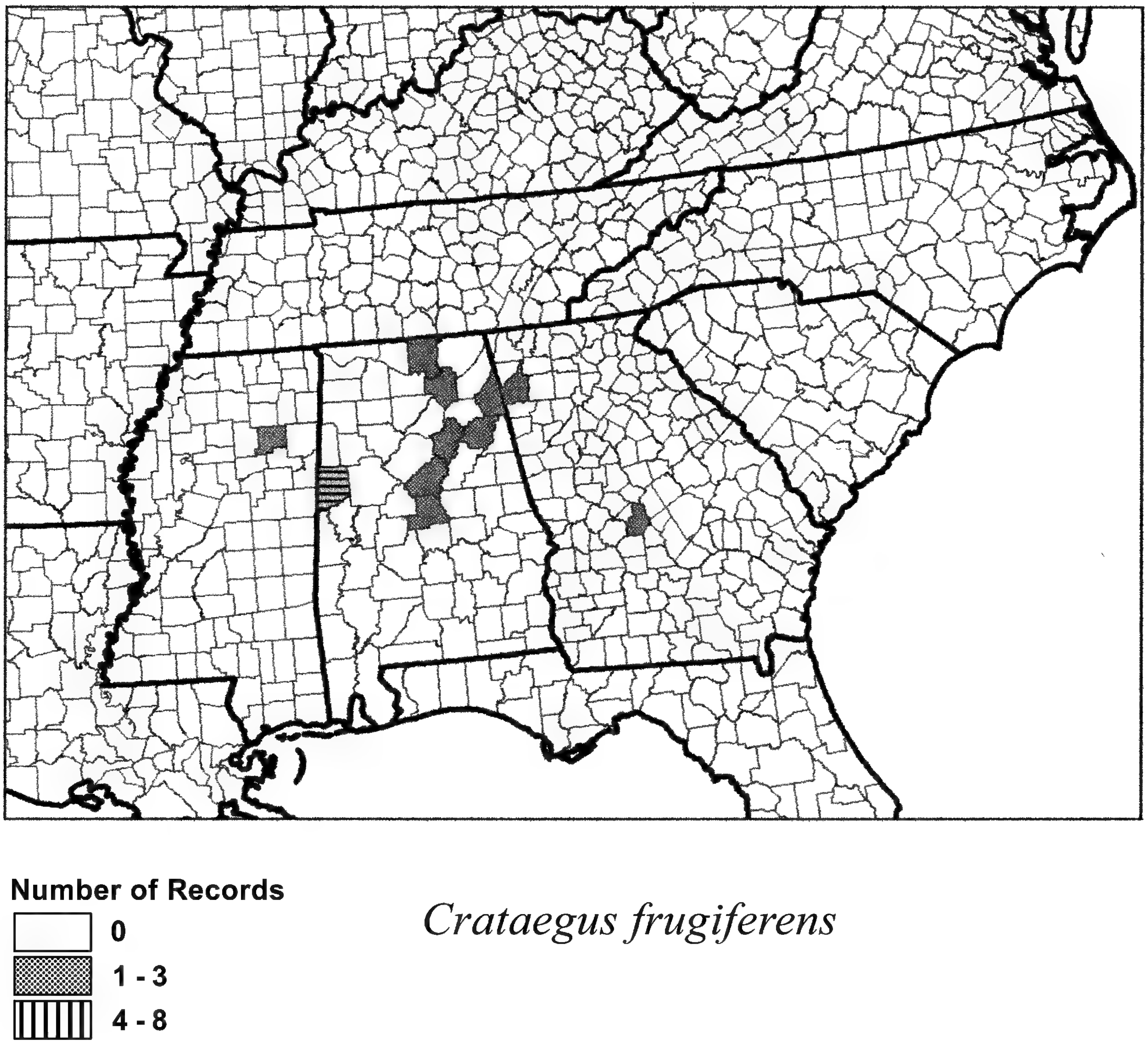

Fig. 18. County level distribution map of *Crataegus frugiferens*.

Comment.—*Crataegus frugiferens* is one of the more distinct species of ser. *Apricae*, even to being superficially similar to *C. collina* from which it differs in its glandular, often stipitately so, petioles and leaf bases as well as leaf shape which is relatively broader with much more wide-cuneate base. It also has more strongly glandular-serrate calyx lobes and usually, deeper red, softer fruit. The leaves at anthesis are no larger than the flowers, as is common in *C. collina*. Its thin leaves make it less xeromorphic than other members of the series. Specimens of this species have been annotated '*C. rigens*'.

12. Crataegus cf. **extraria** Beadle, Biltmore Bot. Stud. 1:73. 1902. Type: U.S.A. Georgia. Cobb Co.: Marietta, 11 Sep 1901, *C.D. Beadle 2485*^{2} (lectotype selected here: US).

Shrub, 2.5 m tall; 1 yr. old twigs reddish-brown; older dark purple-brown. Leaves deciduous; petioles 1–1.5 cm long, glandular, thinly hairy; blades 3–4 cm long, rhomb-ovate in general shape; tip acuminate, base cuneate; sides with 2–3 sharp to obscure lobes per side, max. LII 10–15%; margins fine-serrate, teeth gland-tipped; venation craspedodromous with 4–5 main veins per side; at maturity leaves glabrous above, green below, somewhat pubescent on the veins and thinly so on the surface. Inflorescences 3–5 flowered; branches pilose-pubescent, bracteoles not recorded. Flowers 16–20 mm diam.; hypanthium externally pilose-pubescent; calyx lobes narrow-triangular, margins glandular-serrate; stamens12–15(–20), anthers dark purple, styles 2–3(–4). Fruit 9–12 mm diam., ± spherical, glabrous, red but yellow-orange when not fully ripe on pilose pedicels; calyx lobes spreading, elevated on a distinct collar; stamen remnants ca. 20 in specimen studied; nutlets ca. 4.

Habitat and Distribution.—*Crataegus extraria* has always been very rare and occurred in scattered localities in North Carolina and Virginia. Somewhat similar forms (*C.* cf. *extraria*) were known from Alabama and one such has been found recently, collected in Georgia on 5 Sep 1999 by R. Lance on the Tallulah R. Gorge, Rabun Co. The Alabama specimen reported differs from the type description in possessing 20 stamens.

Comment.—Due to the rarity of *C. extraria* itself, and the very scattered distribution *C.* cf. *extraria*, plus their collective variability, this entity, which may represent more than one taxon, is neither mapped nor illustrated and perhaps in part constitutes sporadic hybrids between other species.

13. **Crataegus** cf. **annosa** Beadle

The following entity is known from a number of specimens. It was thought to be *C. annosa* during annotations but it has only apricoid foliage.

Tree, 5–8 m tall; bark of trunk rough and dark; twigs somewhat flexuous at the nodes, at 1 year old dark reddish-brown, older gray; thorns at 1 year 2–3.5 cm long, ± straight, shiny dark reddish-brown, very slightly recurved. Leaves deciduous; petioles1.5–2 cm long, slender, pubescent young, thinning older, glandular; blades 3–5 cm long, broadly elliptic to rhombic in general shape; tip subacute to obtuse, base cuneate; sides ± shallowly but ± sharply1–3-lobed, margins shallowly crenate; venation craspedodromous, 4–5 lateral veins per side; thinly hairy above at first, especially along the midvein, becoming glabrous, thinly hairy on the abaxial surface, more densely so on the midvein and main lateral veins, glabrescent. Inflorescences 3–5-flowered; branches pubescent, bearing caducous, linear, membranous, gland-margined bracteoles. Flowers 15–20 mm wide; hypanthium externally thinly pubescent; calyx lobes narrow triangular, margins deeply incised with glandular teeth; petals ± circular, white; stamens 20, anthers ivory; styles 3–5. Fruit 12–15 mm diam., subglobose, orange-red or red and orange when ripe, glabrous; calyx lobes erose or spreading; nutlets 3–5, dorsally grooved, sides plane.

Habitat and Distribution.—Occurs in Alabama, northern Florida, Georgia and North and South Carolina. This is a rare plant of well-drained soils in woodland.

Comment.—This entity can be somewhat intermediate between *C. ignava* and *C. flava* in leaf shape though in size rather smaller than *C. ignava* but it is a much more hairy plant, has 20 stamens, reddish subglobose fruit and much of the material has quite distinctly rhombic leaves. For similar reasons to *C. extraria*, this taxon is neither mapped nor illustrated.

IMPERFECTLY KNOWN SPECIES

Here follows a number of forms, superficially quite distinctive but only known from a limited amount of material. It seems important to draw attention to these forms but we consider it inappropriate to apply definite names based on the limited knowledge. None of these entities is known today.

1. **Crataegus** cf. **C. flava** Aiton

“Small tree” in only known indication of habit (on the Harbison specimen); twigs ± flexuous at the nodes, very dark at two years; thorns 1.5–2.5 cm long, blackish, straight. Leaves deciduous; petioles 25–30% length of blade, glandular; blades 2–4 cm long at full expansion, 1.75–3 cm at anthesis, predominantly obovate to rhombobovate to rhombelliptic; lobes lacking on mature short-shoot leaves, mere notches or with LII to 15%, if latter, obtuse to subacute at maturity but at anthesis lobes may be more prominent and even acute; venation craspedodromous, 2–4 lateral veins per side; margins finely crenate-serrate almost to base; glabrous except for hairs along veins adaxially young. Inflorescences 1–5-flowered; branches thin-pilose, bearing plentiful, narrow, membranous, short-stipitately glandular bracteoles. Flowers 15–18 mm diam.; hypanthium sparsely hairy; calyx lobes somewhat foliaceous, strongly glandular-serrate, nearly glabrous (few short hairs near tip) adaxially; stamens 20, anthers “white”; styles 3–4. Fruit not known.

Habitat and Distribution.—This entity is known only from six flowering specimens from Augusta, Georgia collected at different times from 1900–1919. The Augusta sand hills yielded many interesting hawthorns at the beginning of the last century and similar areas in and around Augusta should be searched assiduously for these and others by those in a position to do so.

Comment.—The leaves are extremely similar in form to those of true *C. flava* but the above plants cannot automatically be placed there on account of a complete absence of fruiting material and the fact that they have 20 stamens and white anthers. Also the twigs are generally more flexuous than in *C. flava*. Similar to the above description but with more ovate leaves and purple anthers are *Harbison 32* and *Sargent s.n.* (24 Apr 1900)—see cited specimens.

2. Crataegus calva Beadle, Biltmore Bot. Stud. 1:83. 1902. TYPE: U.S.A. ALABAMA. Dale Co.: Ozark, 4 Sep 1901, *T.G. Harbison 5004* (LECTOTYPE selected here: US).

Shrubs 3–6 m tall; bark of trunk rough; crown irregular-spreading; twigs at 1 yr old slightly flexuous, color not recorded; extending twigs not recorded; thorns 1.5–2 cm long, ± straight, chestnut-brown in second year. Leaves deciduous; petioles slender below, winged above, unwinged portion ca. 30% length of blade, minutely glandular; blades 1.5–2.5 cm long, (those of extension shoots to 4 cm) broad elliptic to obovate or rhombobovate in general shape, sides tapered into the winged upper part of the petiole; tip ± subacute (more rarely obtuse or acute); often with 1 subacute lobe per side distally, LII 0–15%; margins crenate except near base; venation craspedodromous, 2–3 lateral veins per side; when young with a few weak hairs on midrib and principal veins below; somewhat coriaceous at maturity. Inflorescences 3–5 flowered; branches glabrous, bearing deciduous, oblong-linear, membranous, gland-bordered bracteoles; flowering early to mid-April. Flowers 16–18 mm wide; hypanthium externally glabrous; calyx lobes 3–4 mm long, narrow-triangular, margins subentire to finely toothed, teeth glandular; petals ± circular, white; stamens 20, anthers cream or ivory; styles 3–5. Fruit typically 7–10 mm diam., globose, yellow or orange-red; calyx lobes erose or reflexed; nutlets 3–5, dorsally grooved, sides plane.

Habitat and Distribution.—In woods and on ridges, Ozark, Alabama, not certainly known from elsewhere.

3. Crataegus arrogans Beadle, Biltmore Bot. Stud. 1:81. 1902. TYPE: U.S.A. ALABAMA. Russell Co.: Phenix City, 26 Aug 1901, *C.D. Beadle 4869* (LECTOTYPE selected here: US).

Tree, 4–5 m tall; bark 'rough', dark; thorns 1.5–2 cm long, straight to slightly recurved, ± stout; twigs flexuous. Leaves deciduous; petioles 25% length of blade, glandular leaf blades 1.5–2 cm long, elliptic, pointed at both ends; suggestions of pointed apiculi on some; veins 3–4/side; margins weakly and finely crenate distally, teeth sometimes glandular; glabrous at maturity. Inflorescences few flowered; branches pubescent. Flowers, diam. not recorded; hypanthium pubescent; sepals short, triangular, margins glandular-serrate; stamens 20, anthers bright purple; styles 3–4. Fruit 9–12 mm diam., pyriform, red at maturity.

Habitat and Distribution.—Only known with certainty from the type locality.

Comment.—This is undoubtedly ser. *Apricae*, probably the *visenda* group.

4. Crataegus extraria Beadle Biltmore Bot. Stud. 1:73. 1902. TYPE: U.S.A. GEORGIA. Cobb Co.: Marietta, 11 Sep 1901, *C.D. Beadle 4285*^{2} (LECTOTYPE selected here: US). Regrettably the lectotype is a very poor specimen, having lost most of its foliage.

Large shrub, 2–4 m tall; trunk bark rough or scaly, dark gray or brownish; twigs somewhat flexuous; thorns 2.5–4 cm long, slender, slightly recurved. Leaves deciduous; petioles 25–40% length of blade, winged above; blades 2–3.5 cm long (few seen) broad rhombic to broad rhombovate in general shape; conspicuously though shallowly acute lobed across distal end; margins with conspicuous sharp teeth; venation craspedodromous, 3–4?-veined per side; glabrous; leaves on extension shoots much larger, often ovate, sharply 3–4-lobed per side. Inflorescences 3–5-flowered; branches pilose-pubescent; bracteoles not recorded. Flower diam. not recorded; hypanthium pilose-pubescent; sepals 4–5 mm long, margins glandular-serrate; stamens 12–15, anthers pale purple; styles 2–3. Fruit 9–12 mm diam., subglobose to ellipsoid, red at maturity, nutlets 2–3.

Habitat and Distribution.—Only known with certainty from the type locality.

Comment.—Provisionally this should be assigned to ser. *Apricae* though not enough is known about its glandularity.

DOUBTFUL SPECIES

SERIES *APRICAE* OR *LACRIMATAE*

Crataegus annosa Beadle, Biltmore Bot. Stud. 1:83. 1902. Type: U.S.A. Alabama. Russell Co.: Phenix City, without date, *C.D. Beadle 4103* (lectotype selected here: US; isolectotype: A). The lectotype is a fruiting specimen and isolectotype, *C.D. Beadle 4103*[2], with the same label data, is a flowering specimen.

Tree sometimes 8 m tall; bark of trunk rimose, dark; thorns on twigs 2–3 cm long, chestnut-brown or gray. Leaves deciduous; petioles 5–20 mm long, slender, glandular, pubescent at least young; blades 2–4 cm long, (rhomb-elliptic to obovate or obtrullate with small lobes across the apical part); venation craspedodromous, 2–3 lateral veins per side (on extension shoots 3–4 pairs); thinly hairy. Inflorescences 3–5 flowered; branches densely pubescent. Flowers 15–20 mm diam.; hypanthium pubescent; sepals 3–4.5 mm long, margins glandular-serrate; stamens 20, ivory anthers; styles 3–5. Fruit 10–12 mm diam., reddish-orange to yellow, washed red; sepals reflexed; nutlets 3–5, plane-sided, grooved dorsally.

Habitat and Distribution.—Known with certainty only from the type, more material is needed to come to any definite conclusions.

Comment.—In foliage and fruit, except for the narrower leaves, *C. annosa* is of typical form for ser. *Apricae*, but in anther number and color and the form of the narrower leaf set among the short-shoot leaves it is a typical member of ser. *Lacrimatae*.

EXCLUDED SPECIES

SERIES *INTRICATAE*

Crataegus flava Aiton, Hortus Kewensis 1:169. 1789. Type: U.K: Kew, cultivated, 1781, *Herb. Bishop Goodenough* (holotype: K). See Phipps 1988a for a line drawing, photograph of type, and distribution map.

Shrubs or small trees, 5–6 m. tall; branchlets ± straight; extending twigs glabrous; 1-year old twigs glabrous (? always), purple-brown; older dark gray; 2-year old thorns 2–3 cm long, slender, purple-brown, straight to slightly recurved. Leaves deciduous; petioles 0.75–1.5 cm long, slightly pubescent, winged above, conspicuously black-glandular, the glands usually sessile, sometimes short-stipitate; blades 5–8 cm long in UK-cultivated material, rhomb-obovate in general outline, shallowly 1–3 lobed per side, lobes obtuse to acute, at the apex subacute to obtuse, at the base cuneate, and tapered into the winged upper part of the petiole; margins crenate to crenate-dentate, the teeth gland-tipped; venation craspedodromous, 3–4 pairs of lateral veins; pubescent above when young, glabrescent. Inflorescences 4–6 flowered; branches slightly villous or glabrous, bearing caducous, linear, membranous, gland-margined bracteoles; anthesis early April. Flowers 16–18 mm diam.; hypanthium externally glabrous; calyx lobes 4–5 mm long, narrow triangular, gland-margined; petals ± circular, white; stamens 10, anthers purple; styles 3–5. Fruit 8–12 mm diam., ± pyriform-oblong, dull orange; calyx lobes ± reflexed, slightly elevated on a collar; nutlets 3–5, dorsally sulcate, laterally smooth.

Common Name.—Yellow hawthorn.

Habitat and Distribution.—This is a rare species of the southeast United States from southeastern Georgia to South Carolina and northern Florida with one record from Alabama and another from North Carolina. There are also possible records for Virginia. It is usually found in deep sandy soils.

Comment.—Long known in cultivation in England where it was described by William Aiton at Kew. Unfortunately the name *C. flava* got transferred to *C. lacrimata* Small or a similar species due to an error by Sargent (1902) that has been perpetuated by many workers on the flora of the southeastern United States. Sargent's (1890) treatment of this species is, however, nearer the mark in leaf shape although typical material is glabrous to nearly so in the inflorescence. Aiton's original interpretation was eventually resuscitated by the first author (Phipps 1988a). The true *C. flava* differs in significant ways from other species of series *Flavae*, sens. auctt. Amerr. (= ser. *Lacrimatae* + ser. *Apricae*) as is discussed in the treatment for ser. *Apricae*. In its new series (ser. *Intricatae*) *C. flava* shows most similarity to *C. rubella* in fruit shape and color as well as general glandularity. It is no longer recorded in cultivation.

No recent collections match typical *C. flava* though several from central and southern Georgia have the foliage characters of *C. flava* but possess a more globose fruit and ca. 20 stamens on which basis they would key to an unknown form of ser. *Pulcherrimae* not referred to in Phipps and Dvorsky (2006). The unique leaf shape is substantially the same as in *C.* sp. cf. *C. flava* from the Augusta sand hills, discussed above, but the forms currently alluded to have straight twigs. Much more material is needed to sort out this assemblage of forms.

APPENDIX

Further cited specimens (species, states, and counties arranged alphabetically).

Crataegus alleghaniensis Beadle
ALABAMA. Etowah Co.: Hind's Rock, near Noccalua Falls, 8 Apr 1998, *J.B. Phipps 7655* (UWO). **Jefferson Co.:** along AL 150 ca. 0.5 mi S of junction with Co. Rd. 972, *J.P. Barber, M.G. Bussey, R.D. Whetstone & K.E. Landers 1546* (JSU, UWO). **GEORGIA. Richmond Co.:** Augusta, 15 Apr 1902, *A. Cuthbert s.n.* (FLAS); Augusta, 27 Apr 1903, *A. Cuthbert s.n.* (FLAS). **Screven Co.:** Blue Springs, 25 Apr 1966, *R.L. Park s.n.* (NCU). **TENNESSEE: Cocke Co.:** within 3 mi of Wolf Creek Station, along the French Road, 24 Aug 1897, *Thos. H. Kearney, Jr. 697* (UWO photo of US 313179).

Crataegus annosa Beadle
ALABAMA. Russell Co.: Phenix City, 1901, *Biltmore Herb. 4103*^{2} (A); Phenix City, 26 Aug 1901, *C.D. Beadle 4108*^{2} (A).

Crataegus sp. cf. **C. annosa** Beadle
FLORIDA. Liberty Co.: Torreya State Park, 21 Oct 1950, *H. Kurz s.n.* (FSU); Torreya State Park, 24 Mar 1951, *H. Kurz s.n.* (FSU). **Wakulla Co.:** on US 98, jct. FLA 365, 11 Apr 1966, *Beckner and D'Arcy 932* (LAF, FLAS). **NORTH CAROLINA. Durham Co.:** 9 May 1901, *W.W. Ashe 1949* (CM). **SOUTH CAROLINA. Aiken Co.:** SC 4, 7 km E of 394, 11Aug 1993, *J.B. Phipps 6676* (UWO). **Camden Co.:** 27 Mar 1923, *T.G. Harbison 6052* (A). **Chesterfield Co.:** 6 Jun 1976, *J. Castrale 184* (USCH); Haw Ridge, 3 Apr 1935, *V. Matthews* and *B.E. Smith 218* (USCH).

Crataegus aprica Beadle
ALABAMA. Barbour Co.: Hwy. 55 300 m E of Mt. Olive, 8 Jun 1992, *D.J. Drennen and J. Daniel 00039* (UWO). **FLORIDA. Alachua Co.:** 15 Jun 1940, *W.A. Murrill s.n.* (GA). **Gadsden Co.:** Aspalaga, May, *J.K. Small 297c* (NY); Aspalaga, 1898, *no collector s.n.* (MO); Quincy (14 mi W of), 6 Sep 1940, *W.B. Tisdale and W. A. Murrill s.n.* (FLAS); Chattahoochee, 15 Apr 2006, *J.B. Phipps & R. Lance* 9079 (UWO). **GEORGIA. Burke Co.:** Rte 56, N of intersection with 80, N of Lake Crystal Rd. to E, 9 Apr 1991, *J.B. Phipps 6497* (UWO). **Houghton Co.:** Oaky Woods WMA, 14 Apr 2006, *J.B. Phipps & R. Lance 9061* (UWO). **Paulding Co.:** 3/4 mi W of Dallas, 1 Aug 1948, *W.H. Duncan 8643* (MO). **Randolph Co.:** SE of Coleman, 9 Apr 2001, *R. Lance, 2107* (UWO). **Richmond Co.:** Augusta, no date, *S.F. Olney and J. Metcalf s.n.* (NY); Columbia, 19 May 1934, *E.J. Palmer 42408* (NY); Augusta, 11 Apr 1916, *W.W. Ashe 26* (NCU). **NORTH CAROLINA. Buncombe Co.:** (60) E of Asheville, Swannanoa River, 28 Sep 1888, *W.M Canby s.n.* (NY); Biltmore, 20 Sep 1902, *Biltmore Herb. C.* (NY); near Asheville, 18 Apr 1929, *E.J. Palmer 35436* (NY, A); Biltmore, alt. 2000-2500 ft, 15-19 Sep 1908, *W.W. Eggleston 4125* (NY); Biltmore, 12-15 May 1897, *Biltmore Herb. 297b* (NY); Biltmore, 7 May 1899, *W.M. Canby 34* (DOV); Biltmore, 11 May 1899, *Biltmore Herb. s.n.* (NY); Biltmore, 7 Sep 1899, *Biltmore Herb. s.n.* (NY); Biltmore, 17 Sep 1897, *Biltmore Herb. 297b* (NY); Biltmore, 8 May 1896, *W.W. Eggleston 297* (NY); Biltmore, 12 Aug 1896, *W.W. Eggleston 297* (NY); Biltmore, 20 Sep 1902, *C.D. Beadle C* (NY); Hwy. 191 0.6 mi S of junction with Blue Ridge Pwy., Oct 1993, *R. Lance 93.17* (UWO); Biltmore, 15 Sep 1908, *W.W. Eggleston 4125* (NY); Biltmore, 12 May 1897, *C.D. Beadle 297b* (NY); Biltmore Estate, by riverside on steep cliff, 7 Sep 1984, *P.F.Ulf-Hansen PF119* (UWO); Asheville, 15 Sep 1908, *W.W. Eggleston 4125* (NY); E of Asheville, 28 Sep 1888, *Wm. Canby s.n.* (NY); Biltmore, 8 May 1896, *C.D. Beadle 297* (NY, NCC); Biltmore, 15 May 1902, *C.D. Beadle C* (NY); near Asheville, 18 Apr 1929, *E.J. Palmer 35436* (A, MO); Biltmore Estate, 15 May 1902, *C.D. Beadle 2335* (CM); Biltmore, 7 May 1899, *C.S. Sargent s.n.* (A); Biltmore, 23 Apr 1933, *T.G. Harbison &Totten s.n.* (NCU); Asheville, 15 Aug 1909, *W.W. Eggleston 4425* (MO); Biltmore, 11 May 1899, *C.D. Beadle C14* (GH, NY); near Biltmore, 11 May 1899, *C.D. Beadle C13* (A); Asheville, 26 Oct 1898, *C.S. Sargent s.n.* (A); Biltmore, 28 Sep 1917, *C.D. Beadle s.n.* (A); Biltmore, 7 Sep 1899, *C.D. Beadle C500* (A, NY); Biltmore, 15 Sep 1908, *W.W. Eggleston 4125* (UWO); Biltmore, 11 Sep 1899, *C.D. Beadle C500=C14* (GH); Biltmore, 15 May 1897, *Biltmore Herb. 297b* (GH, MO); Biltmore, 24 Jul 1891, *Biltmore Herb. C42* (A); along Hwy 191, 0.6 mi S of junction with Blue Ridge Parkway, S end of "Sandy Bottoms" picnic area, Oct 1993, *R. Lance RO-93.17* (UWO); 19 Sep 1908, *W.W. Eggleston 4125* (BH, CM, GH); Sep 1926, *W.W. Ashe s.n.* (NCU); 10 Oct 1905, *T.G. Harbison 12* (A); no date, *Biltmore Herb. 318* (A); 8 May 1896, *Biltmore Herb. 297* (DOV, NCC); 15 May 1902, *Biltmore Herb. 2027* (DOV). **Cumberland Co.:** Fayetteville, 12 Oct 1908, *W.W. Eggleston 4017a* (NY); Fayetteville, 31 Oct 1908, *W.W. Eggleston 4016* (NY). **Henderson Co.:** 3.5 mi SE of Hendersonville, 17 May 1942, *F.R. Fosberg 18791* (NUC); *Hendersonville, no date, H.L.B. 8819* (DUKE); Flat Rock, 9 Sep 1899, *no collector, s.n.* (NCU). **Wake Co.:** William B Umstead State Park, 22 Aug 1964, *G. Sawyer & W. Ahles 1539* (USCH). **Unknown Co.:** 31 May 1907, *W.W. Ashe 1949* (CM); Western North Carolina, 20 Aug 1901, *W.W. Ashe 1949* (CM); Western North Carolina, 31 May 1907, *W.W. Ashe 1949* (CM); 7 Jun 1900, *A.R. s.n.* (MO). **SOUTH CAROLINA. Aiken Co.:** 12-15 Sep 1909, *W.W. Eggleston 5031* (MO). **Chesterfield Co.:** On Haw Ridge, 23 Apr 1933, *T.G. Harbison s.n.* (NCU). **Darlington Co.:** Hartsville, Swift Creek, 5 May 1941, *E.B. Smith 949* (USCH); 6.5 mi S of Patrick on SC 102, 18 Jul 1958, *J.A. Duke 1556* (NUC).

Greenville Co.: lower slopes of Caesar's Head Mt., 20 Sep 1934, *E.T. Wherry s.n.* (A); Caesar's Head Mt., 20 Sep 1934, *E.T. Wherry s.n.* (A). Kershaw Co.: Middleton, 2 mi S of Camden Junction, 20 Apr 1897, *L.F. Ward s.n.* (NY). **Richland Co.:** near Columbia; woods, 19 May 1934, *E.J. Palmer 42408* (A, NY, SC). **TENNESSEE: Union Co.:** Area 24 Pill, Walkers Pond Refuge, 17 Jul 1936, **L.B. Kalter 361** (TENN). **VIRGINIA: Franklin Co.:** Franklin, 27 Aug 1909, *W.W. Eggleston 4925* (NY). **Southampton Co.:** 29 Jun 1893, *A. Heller s.n.* (GH, MO); 29 Jun 1893, *A. Heller 20a* (A).

Crataegus egregia Beadle
ALABAMA. Macon Co.: Tuskegee National Forest, 2 Apr 1967, *T. Rankin 21* (NCU). **FLORIDA. Clay Co.:** Magnolia Springs, 23 Sep 1923, *T.G. Harbison 5664* (A). **Liberty Co.:** Bristol, 24 Aug 1908, *Biltmore Herb. No. 4924* (A); Bristol, 31 Mar 1907, *Biltmore Herb. No. 4924* (A). **Wakulla Co.:** S of Wakulla Springs, 21 Aug 1951, *H. Kurz s.n.* (FSU). **GEORGIA. Richmond Co.:** Augusta, sandhills, 9 Sep 1902, *A. Cuthbert s.n.* (FLAS). **SOUTH CAROLINA. Aiken Co.:** no location, 20 Jun 1952, *W.R. Kelley & W.T. Batson s.n.* (USCH); no location, 14 Jul 1952, *W.R. Kelley & W.T. Batson s.n.* (USCH). **Barnwell Co.:** Barnwell State Park, 27 Aug 1956, *C.L. Porter 342* (USCH); no location, no date, *W.R. Kelley & W.T. Batson s.n.* (USCH).

Crataegus extraria Beadle and **C.** cf. **extraria** Beadle
ALABAMA. Lee Co.: Auburn, 18 Apr 1896, *Earle and Underwood* (NY); Auburn, 18 Apr 1894, *C. Mohr* (CM). **GEORGIA. Lumpkin Co.:** Porter Springs, *W.W. Ashe* (NCU). **NORTH CAROLINA. Cumberland Co.:** Fayetteville, 26-31 Aug 1908, *W.W. Eggleston 4019* (NY); Fayetteville, 16 Apr 1903, *Biltmore Herb. B8066=B7272* (NY); Fayetteville, 17 Oct 1902, *Biltmore Herb. B7272* (NY); Fayetteville, 17 Oct 1902, *Biltmore Herb. 7272* (NY); Fayetteville, 16 Apr 1903, *Biltmore Herb. 8006* (NY). **Richmond Co.:** Washington Rd., N of Augusta, GA, 14 Oct 1916, *W.W. Ashe* (NCU). **VIRGINIA: Wight Co.:** S of Zuni, 17 Oct 1936, *M.L. Fernald & B.Long 6818* (NY).

Crataegus frugiferens Beadle
ALABAMA. Calhoun Co.: Fort McClellan Military Reservation, 8 Apr 1998, *J.B. Phipps 7645* (UWO); Anniston, Natural History Museum grounds, 30 Sep 1998, *J.B. Phipps & D. Spaulding 7771* (UWO); Coldwater Mountain, woodland border next logging road, 20 Apr 1999, *D. Spaulding 10606* (UWO). **Cherokee Co.:** Cherokee 19, 1 mi N of 278, 8 Oct 1998, *J.B. Phipps 7834* (UWO). **Chilton Co.:** Bluffs above quarry at Coosa River, 4 Oct 2000, *J.B. Phipps 7669* (UWO); Bluffs above quarry at Coosa River, 4 Oct 2000, J.*B. Phipps 7670* (UWO). **Madison Co.:** Deer Haven Rd., NE of Huntsville, 25 Apr 1983, *P.F. Ulf-Hansen 034* (UWO). **Marshall Co.:** Lake Guntersville State Park, Cutchenmire Trail near Berry Point, 21 Apr 1999, *J.B. Phipps, R.J. O'Kennon & D. Spaulding 7968* (UWO). **Pickens Co.:** 8.3 mi E of Ethelsville, 5 Apr 1968, *S. McDaniel 10447* (ALU, FSU, IBE, LAF, NO). **Shelby Co.:** near Pelham, AL 33, approx 0.75 km N of Co. Rd. 52, 5 Apr 1984, *J.B. Phipps & T.C. Wells 5309* (UWO); near Pelham, E side of AL 33, approx 0.75 km N of Co. Rd. 52, 5 Apr 1984, *J.B. Phipps & T.C. Wells 5310* (UWO). **St. Clair Co.:** Pottsville, 4 Jun 1963, *P.E. Bostick s.n.* (NCU). **GEORGIA. Floyd Co.:** McGee Bend Rd., off GA 100 (WSW of Rome), 4 Apr 2000, *J.B. Phipps 8207* (UWO). Houston Co.: Oaky Woods WMA, Green Violet Prairie, 14 Apr 2006, *J.B. Phipps & R. Lance 9067* (UWO). **MISSISSIPPI: Chickasaw Co.:** MS 41 to SE of Natchez Trace Parkway, 13 Apr 1998, *J.B. Phipps 7714* (UWO).

Crataegus galbana Beadle
ALABAMA. Conecuh Co.: Hwy. 29 at Sepulga River, 17 Aug 1985, *A.R. Diamond 1529* (AUA). **Geneva Co.:** 7.5 mi S of Samson, 7 Jun 1969, *R. Kral 35109* (AUB); near Smith Lake, 12 Sep 1967, *J.Thomas 1218* (ALU). Greene Co.: near Smith Lake, 12 Sep 1967, *J.L. Thomas 1218* (ALU). **Lee Co.:** Auburn, 10 Oct 1900, *F.S. & E. Earle 23* (GH). **FLORIDA. Alachua Co.:** 30 Jun 1927, *Manning and Wiegand 1386* (GH); Nr. Gainesville, 14 Apr 1941, *W.A. Murrill s.n.* (GA); NW of Gainesville, 10 Sep 1940, *W.A. Murrill s.n.* (A). **Columbia Co.:** Camp Oleno, 8 Sep 1940, *W.A. Murrill s.n.* (GA). **Gadsen Co.:** 8 mi SW of Chattahoochee, 20 Aug 1966, *D.B. Ward 5918* (FLAS); 1 mi S of River Junction, 6 Sep 1940, *W.B. Tisdale & W.A. Murrill s.n.* (FLAS). **Holmes Co.:** 1 mi N of Westville, 17 Mar 1982, *R.K. Godfrey 79427* (FSU, IBE); Nr. Westville, 31 Mar 1940, *M.G. Henry 1993* (GA). **Jackson Co.:** 2 mi E of Grand Ridge, 27 Mar 1964, *S. McDaniel 4011* (IBE, FSU); 2 mi E of Grand Ridge, 27 Mar 1964, *S. McDaniel 4011* (IBE). **Jefferson Co.:** No locality, 10 Jul 1940, *W.A. Murrill s.n.* (FLAS). **Lafayette Co.:** 4 mi W of Mayo, 21 Aug 1939, *W.A. Murrill and W.B.Tisdale s.n.* (A). **Leon Co.:** Tallahassee, 3 Apr 1901, *Biltmore Herb. 4052* (GH); Tallahassee, 29 Aug 1901, *Biltmore Herb. 4948* (GH); Tallahassee Junior Museum, SW of Tallahassee, 17 Aug 1982, *R.K. Godfrey79926* (FSU, UWO); Tallahassee, Apr 1893, *C.S. Sargent s.n.* (MO). **Madison Co.:** 3 mi NNE Pinetta, 2 Sep 1968, *R.A. Norris 1086* (IBE); Lee (2.5 mi E of), 22 Aug 1940, *W.A. Murrill s.n.* (FLAS). Suwanee Co.: O'Brien (5 mi W of), 9 Aug 1946, West and Arnold s.n. (FLAS). Wakulla Co.: US 98, W of jct. FL 365, 11Apr 1966, J. Beckner s.n. (LAF). GEORGIA. Burke Co.: On Savannah River, 20 Jun 1941, *W.M. Duncan 3385* (GA). **Chattooga Co.:** Summerville, no date, *Biltmore Herb. 6113* (NY). Floyd Co.: no location, no date, *A.W. Chapman s.n.* (AUB); Rome, 22 Apr 1900, *C.S. Sargent s.n.* (GH). **Richmond Co.:** Augusta, Sand Bar Ferry, 14 Aug 1902, *A. Cuthbert s.n.* (FLAS). **NORTH CAROLINA. Harnett Co.:** 2 mi W of Spout Springs, 29 Sep 1970, *R.M. Downs 11614* (NCSC). **Johnston Co.:** Selma, 9 Apr 1912, *T.G. Harbison 10834* (NCU). **SOUTH CAROLINA. Kershaw Co.:** 6 mi E of Camden, 17 Jun 1933, *T.G. Harbison & H.R. Totten 4052* (NCU). **McCormick Co.:** Clark Hill Dam, 5 Nov 1900, *C. McComb 97* (GA).

Crataegus ignava Beadle
ALABAMA. Blount Co.: Ridge of Blount Mtn., 25 Apr 1983, **P.F. Ulf-Hansen 31** (UWO). E of Highland Lake on ridge of Blount Mtn., 25 Apr 1983, *P.F. Ulf-Hansen 33* (UWO). **Calhoun Co.:** Fort McClellan Military Reservation, near Anniston, 30 Sep 1998, *J.B. Phipps & R. Smith 7773* (UWO); Fort McClellan Military Reservation, near Anniston, 8 Apr 1998, *J.B. Phipps 7642* (UWO); Fort McClellan Military Reservation, near Anniston, 2 Jul 1998, *R. Smith & D. Spaulding A, B, C* (UWO, 3); Fort McClellan Military Res-

ervation, near Anniston, 22 Apr 1998, *R. Smith & D. Spaulding 4* (UWO); Logging Road on Coldwater Mountain, 20 Apr 1999, *D. Spaulding 10605* (UWO). **Cherokee Co.:** AL 9, N of Piedmont, 19 Apr 1999, *J.B. Phipps & R. J. O'Kennon 7947* (UWO). **Etowah Co.:** Hind's Rock, near Noccalua Falls, 8 Apr 1998, *J.B. Phipps 7655* (UWO). **Jefferson Co.:** along AL 150 ca. ½ mi S of jct. with Co. Rd. 97 and 2, 23 May 1985, *J.P. Barber, M.G. Bussey, R.D. Whetstone and K.E. Landers 1546* (JSU, UWO). **FLORIDA. Gadsden Co.:** S of Chattahoochee, 15 Apr 2006, *J.B. Phipps, R. Lance & A.. Gholson 9090* (UWO). **GEORGIA. Burke Co.:** NE of Waynesboro, s of McBean 11 Apr 2006, *J.B. Phipps 9040* (UWO). **Screven Co.:** Blue Springs, 25 Apr 1966, *R.L. Park s.n.* (NCU). Randolph Co.: Few mi W of Cuthbert, 29 Mar 1948, *R.F. Thorne & W.C. Muenscher 7748* (UWO, photo). **Richmond Co.:** Augusta, 15 Apr 1902; *A. Cuthbert s.n.* (FLAS); Augusta, 23 Apr 1903; *A. Cuthbert s.n.* (FLAS). **TENNESSEE: Cocke Co.:** within 3 mi of Wolf Creek Station, along the French Road, 24 Aug 1897, *Thos. H. Kearney Jr. 697* (UWO).

Crataegus leonensis E.J. Palmer
FLORIDA. Gadsden Co.: Chattahoochee, May 1899, *Wm Canby & C.S. Sargent 27* (DOV). **Leon Co.:** Tallahassee, Horseshoe Plantation, 28 Mar 1914, *C.S. Sargent s.n.* (A); Tallahassee, Horseshoe Plantation, 16 Sep 1919, *T.G. Harbison 2* (A); Tallahassee, Horseshoe Plantation, 6 Apr 1920, *T.G. Harbison 5645, 5646* (A,2); Tallahassee, Horseshoe Plantation, Oct 6 1920, *T.G. Harbison 5648* (A); Tallahassee, Horseshoe Plantation, 3 Apr 1923, *T.G. Harbison 6071* (A); Tallahassee, Horseshoe Plantation, 27 Sep 1923, *T.G. Harbison 6182, 6183* (A, 2); Tallahassee, Horseshoe Plantation, 12 Apr 1931 *E.J. Palmer 38557* (A); Lake Lamonia, 15 Mar 1951, *E.J. Palmer s.n.* (FSU). **GEORGIA. Decatur Co.:** 7 mi S of Bainbridge, 1 Apr 1970, *R.K. Godfrey 69336* (FSU).

Crataegus mira Beadle
ALABAMA. Cleburne Co.: Talladega Nat. Forest, 5 mi S of Fruithurst, F.S. Road 2700, 18 Jun 1966, *T.A. Heard & R.C. Clarke 2767* (NCU). **Franklin Co.:** no locality, 21 Apr 1968, *J.G. South s.n.* (JSU). **FLORIDA. Alachua Co.:** W of Gainesville, 1 Aug 1940, *W.A. Murrill s.n.* (GA). **Columbia Co.:** 2 mi from main road towards Camp Oleno, 30 Jun 1940, *W.A. Murrill s.n.* (FLAS); By rock at Camp Oleno, 13 Apr 1941, *W.A. Murrill s.n.* (FLAS). **Gadsden Co.:** Aspalaga, May, no day, no year, *A.W. Chapman 297c* (NY); Aspalaga, 1898, *A.W. Chapman 2799* (MO); 6 mi S of Quincy on the Blountstown Rd., 12 Sep 1928, *W.W. Ashe s.n.* (NCU). **Leon Co.:** Tallahassee, by US 319 near Neesmith's Nursery, 11 Apr 1983, *R.K. Godfrey 80460* (FSU, UWO - 5); W of Tallahassee, 1 mi E of Ochlockonee R., 17 Mar 1982, *R.K. Godfrey 78429* (FSU); Tallahassee, by US 319, near Neesmith's Nursery, 20 Jun 1983, *R.K. Godfrey 80732* (UWO). **Liberty Co.:** Torreya State Park, 30 Mar. 1975, *R..K. Godfrey 74198* (FSU, FLAS). **Suwannee Co.:** 1mi S of O'Brien, 22 Aug 1940, *W.A. Murrill s.n.* (FLAS). **GEORGIA. Burke Co.:** Rte. 56, 13 Apr 1993, *J.B. Phipps 6709* (UWO). **Floyd Co.:** Radio Springs Road, near metal shack, 24 Apr 1983, *P.F. Ulf-Hansen s.n.* (UWO). **Dodge Co.:** E side of Ocmulgee River, 6 Jul 1966, *J.R. Bozeman 5508* (NCC). **Pulaski Co.:** Jct. Wimberly Rd. and US 341, 10 Apr 2001, *R. Lance 2123* (UWO). **Paulding Co.:** 10 mi SW of Dallas, 1 Aug 1948, *W.H. Duncan 8643* (GA). **Randolph Co.:** SE of Coleman by hwy. 160, 10 Apr 2001, *R. Lance 2117* (UWO); S of Cuthbert by US 27, 10 Apr 2001, *R. Lance 2121* (UWO). **Richmond Co.:** Augusta, 21 Apr 1903, *A. Cuthbert 935* (FLAS); Augusta, 24 Apr 1901, *A. Cuthbert s.n.* (FLAS); Augusta, 6 Jul 1882, *M.W. Ravenel s.n.* (MO); Augusta, 24 Apr 1902 *C.S. Sargent 67* (UWO, photo); Augusta, 21 Apr 1902, *A. Cuthbert 628* (FLAS). **NORTH CAROLINA. Cumberland Co.:** Fayetteville, 12 Oct 1908, *W.W. Eggleston 4016a,* (GH, NY); Fayetteville, Haymount, 12 Oct 1908, *W.W. Eggleston 4017a* (NY); Fayetteville, Haymount, 12 Oct 1908, *W.W. Eggleston 4016* (NY). **Dublin Co.:** 2.6 mi N of Magnolia, 27 Apr 1957, *H.E. Ahles 24051* (NCC). **Wake Co.:** Camp Crabtree waterfront, Wm. B. Umstead State Park, 22 Aug 1964, *G.P. Sawyer, Jr., H.E. Ahles & J.B. Whitney 1539* (USCH). **SOUTH CAROLINA. Aiken Co.:** by US 302, W side, 12 Aug 1993, *J.B. Phipps 6684* (UWO); Aiken, 12–15 Sep 1909, *W.W. Eggleston 5031* (MO). **Horry Co.:** Little River, Neck Road, 1 May 1966, *J.F. Matthews, W.C. Williams & J.L. Kellerman s.n.* (UCC). **Lexington Co.:** Rte. 303, W side of road, 10 Apr 1991, *J.B. Phipps 6504* (UWO).

Crataegus segnis Beadle
FLORIDA. Leon Co.: 3 mi N of Chaires, 29 Mar 1956, *R. Kral 2160* (FSU). **Liberty Co.:** Torreya State Park, 22 Mar 1982, *R.K. Godfrey 79451* (FSU). **Wakulla Co.:** Vicinity of Crawfordville, 29 Mar 1975, *R.K. Godfrey 74196* (FSU). **Walton Co.:** Black Creek Rd. off US 331, 30 Mar 1975, *Mr. & Mrs. H.A. Davis 16321* (FSU).

Crataegus sororia Beadle
ALABAMA. Calhoun Co.: No location, 7 Apr 1988, *R. Lance s.n.* (UWO). **GEORGIA. De Kalb Co.:** Yellow River, near Stone Mtn., 15 Jul 1899, *A.H. Curtiss 6920* (DOV). **Floyd Co.:** Rome, hills above Silver Creek, Sep 1899, *C.D. Beadle s.n. but from 'type tree'* (A); Rome, Apr 1902, *C.S. Sargent s.n.* (A); Rome, hills above Silver Creek, cotype, 18 Apr 1899, *C.D. Beadle 1257* (A); Rome, 22 Sep 1902, *C.D. Beadle 7142* (A, 3); Rome, 26 Oct 1905, *T.G. Harbison 2138 = tree 35* (A); Horseleg Mtn., Rome, 7 Oct 1982, *J.B. Phipps 5176* (UWO); Horseleg Mtn., Rome, 4 Apr 1984, *J.B. Phipps 5302* (UWO); Horseleg Mtn., Rome, 23 Apr 1983, *P.F. Ulf-Hansen 020, 021* (UWO). **SOUTH CAROLINA. Aiken Co.:** Nr. Aiken, 4 Jun 1880, *G. Engelmann 14* (MO); Hwy. 47 km E of jct. 394, 16 Apr 1999, *J.B. Phipps 6512* (UWO).

Crataegus visenda Beadle
ALABAMA. Dallas Co.: Selma, 11 Apr 1912, *T.G. Harbison 10827* (NCU); Rte. 140, ca. 9 mi E of Selma, 10 Apr 1998, *J.B. Phipps 7689* (UWO). **Macon Co.:** 2.3 mi E of Tuskegee, 2 Apr 1973, (ALU). **FLORIDA. Clay Co.:** Magnolia Springs, 7 Apr 1920, *T.G. Harbison 15678* (UWO, photo). Gadsden Co.: Chattahoochee, 5 Apr 1900, *C.S. Sargent s.n.* (DOV); River Junction at Dolan Road, 23 Jun 1983, *R.K. Godfrey 79895* (UWO). **Jackson Co.:** Three Rivers State Park, N of Sneads, 10 Jun 1982, *R.K. Godfrey 79854* (UWO). **Leon Co.:** no date, *T.G. Harbison 5453* (NCU); 1.3 mi E of Micosukee, 7 Aug 1951, *H. Kurz s.n.* (FSU, 2); Tallahassee, 15 Apr 1920, *T.G.*

Harbison 15718 (NCU); Tallahassee, 24 Mar 1951, *H.A. Kurz s.n.* (FSU). **Liberty Co.:** Bristol, 2 Apr 1902, *T.G. Harbison 6022* (NCU); Bristol, 29 Mar 1902, *T.G. Harbison 6012* (TENN); Bristol, 30 Aug 1901, *T.G. Harbison 4031* (A); **Marion Co.:** Rainbow Springs, 11 Nov 1945, *H.R. Totten s.n.* (NCU). **Wakulla Co.:** E of Wakulla River, 13 Aug 1951, *H. Kurz s.n.* (FSU); no locality, 11 Apr 1966, *J. Beckner & W. D'Arcy s.n* (FLAS); near Crawfordville, 2 Apr 1955, *R.K. Godfrey 53118* (ALU, FLAS, FSU, GA, NCSC, TENN, USF); 1.5 mi S of Crawfordville, 25 Mar 1982, *R.K. Godfrey 79461* (IBE). **GEORGIA. Randolph Co.:** SE of Coleman, W of Co. Rd., 4.2 mi N of jct. with unknown Hwy., 9 Apr 2001, *R. Lance 2114* (UWO).

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TAXONOMY AND NOMENCLATURE OF *TAXUS* (TAXACEAE)

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ABSTRACT

A taxonomic treatment of *Taxus* (Taxaceae) is presented, based on morphological characters. The genus is proposed to have 24 species and 55 varieties; 24 species and 26 varieties are presented in a key and classified into three main groups, two subgroups, and two alliances. Previously existing names were applied to 15 species and six varieties—*T. baccata* L. and its varieties—var. *dovastoniana* Leighton, var. *elegantissima* Hort. ex C. Lawson, var. *glauca* Jacques ex Carrière, var. *pyramidalis* Hort. ex C. Lawson, and var. *variegata* Watson; *T. brevifolia* Nutt., *T. caespitosa* Nakai, *T. canadensis* Marshall, *T. celebica* (Warb.) H.L. Li, *T. chinensis* (Pilg.) Rehder, *T. contorta* Griff., *T. cuspidata* Siebold & Zucc., *T. fastigiata* Lindl., *T. globosa* Schltdl., *T. mairei* (Lemée & H. Lév.) S.Y. Hu ex T.S. Liu, *T. recurvata* Hort. ex C. Lawson, *T. sumatrana* (Miq.) de Laub., *T. umbraculifera* (Siebold ex Endl.) C. Lawson, *T. wallichiana* Zucc. and var. *yunnanensis* (W.C. Cheng & L.K. Fu) C. T. Kuan. Six new species—**T. biternata** Spjut, **T. florinii** Spjut, **T. kingstonii** Spjut, **T. obscura** Spjut, **T. phytonii** Spjut, and **T. suffnessii** Spjut, and four new varieties—**T. brevifolia** Nutt. var. **polychaeta** Spjut, **T. brevifolia** Nutt. var. **reptaneta** Spjut, **T. caespitosa** Nakai var. **angustifolia** Spjut and **T. contorta** Griff. var. **mucronata** Spjut are described. Eight new combinations are made: **T. caespitosa** var. **latifolia** (Pilg.) Spjut**, T. canadensis** var. **adpressa** (Carrière) Spjut, **T. canadensis** var. **minor** (Michx.) Spjut, **T. globosa** var. **floridana** (Nutt. ex Chapm.) Spjut, **T. mairei** (Lemée & H. Lév.) S.Y. Hu ex T.S. Liu var. **speciosa** (Florin) Spjut, **T. umbraculifera** var. **hicksii** (Hort. ex Rehder) Spjut, **T. umbraculifera** var. **microcarpa** (Trautv.) Spjut, and **T. umbraculifera** (Siebold ex Endl.) C. Lawson var. **nana** (Rehder) Spjut. Taxonomy and nomenclature are discussed for each species and variety.

RESUMEN

Se presenta un tratamiento taxonómico de *Taxus* (Taxaceae) basado en caracteres morfológicos. Se propone que el género tenga 24 especies y 55 variedades; 24 especies y 26 variedades se presentan en una clave y se clasifican en tres grupos principales, dos subgrupos, y dos alianzas. Los nombres existentes previamente se aplicaron a 15 especies y seis variedades—*T. baccata* L. y sus variedades—var. *dovastoniana* Leighton, var. *elegantissima* Hort. ex C. Lawson, var. *glauca* Jacques ex Carrière, var. *pyramidalis* Hort. ex C. Lawson, y var. *variegata* Watson; *T. brevifolia* Nutt., *T. caespitosa* Nakai, *T. canadensis* Marshall, *T. celebica* (Warb.) H.L. Li, *T. chinensis* (Pilg.) Rehder, *T. contorta* Griff., *T. cuspidata* Siebold & Zucc., *T. fastigiata* Lindl., *T. globosa* Schltdl., *T. mairei* (Lemée & H. Lév.) S.Y. Hu ex T.S. Liu, *T. recurvata* Hort. ex C. Lawson, *T. sumatrana* (Miq.) de Laub., *T. umbraculifera* (Siebold ex Endl.) C. Lawson, *T. wallichiana* Zucc. y var. *yunnanensis* (W.C. Cheng & L.K. Fu) C. T. Kuan. Se describen seis especies nuevas—**T. biternata** Spjut, **T. florinii** Spjut, **T. kingstonii** Spjut, **T. obscura** Spjut, **T. phytonii** Spjut, and **T. suffnessii** Spjut, and four new varieties—**T. brevifolia** Nutt. var. **polychaeta** Spjut, **T. brevifolia** Nutt. var. **reptaneta** Spjut, **T. caespitosa** Nakai var. **angustifolia** Spjut y **T. contorta** Griff. var. **mucronata** Spjut. Se hacen ocho nuevas combinaciones: **T. caespitosa** var. **latifolia** (Pilg.) Spjut**, T. canadensis** var. **adpressa** (Carrière) Spjut, **T. canadensis** var. **minor** (Michx.) Spjut, **T. globosa** var. **floridana** (Nutt. ex Chapm.) Spjut, **T. mairei** (Lemée & H. Lév.) S.Y. Hu ex T.S. Liu var. **speciosa** (Florin) Spjut, **T. umbraculifera** var. **hicksii** (Hort. ex Rehder) Spjut, **T. umbraculifera** var. **microcarpa** (Trautv.) Spjut, y **T. umbraculifera** (Siebold ex Endl.) C. Lawson var. **nana** (Rehder) Spjut. Se discute la taxonomía y la nomenclatura de todas las especies y variedades.

INTRODUCTION

The genus *Taxus* (Taxaceae) has long been indicated to have 7–12 species or subspecies (Cope 1998; Farjon 1998, 2001; Pilger 1903, 1916; Silba 1984, 1986; Spjut 1992); however, Spjut (2000c; www.worldbotanical.com) has proposed recognition of 24 species and 55 varieties. The taxonomy of *Taxus* has been controversial because the species do not appear reproductively isolated except by geography (Farjon 1998; Pilger 1903; Silba 1984), although Collins et al. (2003) reported that *Taxus* hybrids may have impaired meiosis or less functional pollen. The genus ranges from temperate North America into subtropical Central America, and from temperate Eurasia to subtropical Southeast Asia (Cope 1998).

Molecular and morphological studies of *Taxus* have distinguished genotypes that differentiate (1) individuals within populations (Collins et al. 2003; El-Kassaby & Yanchuk 1995; Saikia et al. 2000; Spjut 2007), (2) distinct populations within geographic regions (Doede et al. 1993; El-Kassaby & Yanchuk 1994; von Hertel and Kohlstock 1996; Hilfiker et al. 2004; Spjut 2007), and (3) alleged geographically distinct species

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(Collins et al. 2003; Doede et al. 1993; Florin 1948a, 1948b, 1948c; Hils 1993; J. Li et al. 2001; N. Li & Fu 1997; Krupkin unpublished, 1994; Orr 1937; Spjut 2007; Vance & Krupkin 1993). Molecular studies for the most part have been geographically based, in which plants have been randomly selected; little attempt has been made to correlate genetic differences or haplotypes with morphological characters (Corradini et al. 2002), while new species have been recently described based on morphology and geographical data (N. Li & Fu 1997).

The geographic species of *Taxus* that have received support from molecular and/or morphological studies include those in North America (*T. brevifolia* Nutt., *T. canadensis* Marshall, *T. globosa* Schltdl. var. *globosa*, and var. *floridana* [Nutt. ex Chapm.] Spjut; Hils 1993; J. Li et al. 2001; Spjut 1992, 1993, 2007; Vance & Krupkin 1993), the Euro-Mediterranean *T. baccata* L., the Sino-Japanese *T. cuspidata* Siebold & Zucc. (Collins et al. 2003; J Li et al. 2001), and the tropical Southeast Asian *T. sumatrana* (Miq.) de Laubenfels (received as *T. chinensis* (Pilg.) Rehder (Phyton Inc., Krupkin pers. comm. 1994). Jianhua Li et al. (2001) have further shown that the North American species, *T. brevifolia* and *T. globosa* (from both Mexico and Florida), which belong to Spjut's (1998b, 2000b) *Wallichiana* Subgroup, form a well-supported clade separated from a large weakly supported clade represented by *T. baccata, T. canadensis, T. chinensis, T. cuspidata* and cultivars, and that "low sequence divergence between *T. floridana* from Florida, and *T. globosa* from Mexico suggest very recent separation between the lineages in these regions and is consistent with treating these populations as belonging to the same species."

There is also molecular data to support distinction of less geographically separated species. Wang et al. (2000) showed a sharp contrast between RAPD bands of *T. chinensis* and *T. mairei* (Lemée & H. Lév.) S.Y. Hu ex T.S. Liu among other species of taxads included in their study. An unpublished report on Himalayan yews found the northwestern Himalayan yew (*T. contorta* Griff.) distinct from the East Himalayan *T. wallichiana* Zucc. and the Euro-Mediterranean *Baccata* Alliance (Amin pers. comm.). A specimen received from Phyton Inc., reportedly from southwestern China, was thought to be distinct from *T. chinensis* (Kadkade pers. comm. 1997); indeed, it had been proposed as a new species from morphological study of herbarium specimens (*T. florinii* Spjut in adnot., June 1996, A).

Despite the wealth of papers on the chemistry of *Taxus* in regard to developing anticancer diterpenoid compounds (taxoids) for use in cancer chemotherapy (Appendino 1995; Kingston et al. 1990; Kingston 2005), not a single comprehensive study has emerged on the phylogeny of the genus. One might expect that a genus with supposedly only eight species (Silba 1986) would be relatively simple to resolve taxonomically by molecular data. Undoubtedly the traditional geographic species of *Taxus* have been investigated by molecular data, but lack of a definitive phylogenetic treatment would seem to reflect the need for morphological studies to define the species as a guide for the molecular investigations.

Spjut (1998a, 2006, 2007) suggested that much of the variation in leaf anatomical features of *Taxus*—in the eastern Himalayas to southwestern China—could be explained by post-Pliocene hybridization between formerly distinct Tertiary species. *Taxus engelhardtii* Kvaček, for example, a Tertiary species discovered from leaves in Oligocene deposits in Europe, is much like the extant *T. mairei* (Lemée & H. Lév.) S.Y. Hu ex T.S. Liu in subtropical laurophyll forests of southern China; the fossil species differs in having papillae on the abaxial leaf midrib (Spjut 2007). Similarly, a *Taxus* sp. from a Middle Miocene deposit in western North American (Kvaček & Rember 2000) has the leaf anatomical features of *T. brevifolia* (papillose abaxial margins and midrib, large marginal cells, stomata in 4–7 rows), but differs slightly in the the leaves appearing flattened and less mucronate; recently, it has been described as a new species (Kvaček & Rember submitted). Two other Tertiary leaf fossils of *Taxus* from European deposits of late Miocene to Pliocene age are closely similar to *T. canadensis* (Kvaček 1984, Spjut 2007), a species native to east-central North America but also recognized to occur in the Euro-Mediterranean region (Spjut 2000b, 2007). Intermediates between extant *T. baccata* and *T. canadensis* in the Euro-Mediterranean region, which have a partially papillose marginal zone, seem best explained by hybridization (Spjut 2006).

Collins et al. (2003), in a molecular study of *Taxus canadensis*, *T. cuspidata*, and *T. baccata*, identified three different DNA chloroplast types, which support three stomata band types described by Spjut (2003, www.worldbotanical.com) for the *Baccata* Group, and suggested that these differences indicate "a long period of isolation." Their study also included numerous cultivars or "hybrids" ("*T.* × *media*") between *T. cuspidata* and *T. baccata* and between *T. canadensis* and *T. cuspidata*, none of which were found to have identical genotypes. To explain the higher level of diversity in cultivars, they suggested that multiple hybrid events have occurred over time, but it is also likely that other genotypes, which may belong to other species, have contributed to the hybrid complex not present in their putatively wild samples. This reflects a conservative view that only one species of *Taxus* exists within a geographic region; further, in the view here, distinct morphological ecotypes of *Taxus* with parapatric distributions are considered worthy of taxonomic rank as species or varieties.

The IUCN (2004, 2006), in reference to a Conifer Specialist Group 1998 (Farjon & Page 1999), which adopted the nomenclature in Farjon (1998), recently listed *Taxus brevifolia* as a threatened species, one that is not rare but reportedly threatened due to the need for taxol derivatives from plant sources for the commercial production of anticancer drugs. Other species of *Taxus* listed by the IUCN are *T. globosa* (including var. *floridana*) and *T. wallichiana*. The latter name is meant to also include *T. contorta*, but Farjon's (2001) treatment of *T. contorta* as a synonym of *T. wallichiana* is without taxonomic support (no types or specimens were cited, no keys are provided, nor are there any references to such data; see also CITES (2001, 2004). Awaiting a standard taxonomic foundation upon which species and varieties can be identified according to the International Code of Botanical Nomenclature (ICBN, Greuter et al. 2000), all species and varieties in the genus *Taxus*, whether described or undescribed, perhaps should be considered rare, threatened, or endangered.

This paper presents a key to 24 species and 26 varieties of *Taxus* based on chemical (byproducts) and morphological differences. Six new species and four new varieties are described, and eight new combinations are made. Lectotypes or neotypes are designated or proposed for 23 of the species and the additional varieties mentioned. Descriptions and specimen citations are provided primarily for new taxa in connection with a paper on biogeographical data of *Taxus* (Spjut 2007). Also included in the present study are varieties of *T. brevifolia*, *T. caespitosa* Nakai, *T. canadensis,* and *T. umbraculifera* (Siebold ex Endl.) C. Lawson, which are not mentioned in Spjut (2007); therefore, specimen citations are also provided for these. The taxonomy and nomenclature of each taxon are discussed.

MATERIALS AND METHODS

More than 1,000 specimens of *Taxus* have been studied, 845 of which are documented with details on leaf anatomical data (Spjut 2007).

Early in the study, ca.100 representative specimens of *Taxus* throughout its range identified 11 species and one variety by morphological features that best fit the traditional geographical concept (Spjut 1992, 1993; Spjut in Hils 1993). The characters were based on leaf anatomical features that included the number of stomata rows, distribution of papillae on abaxial midrib, shape of epidermal cells, curvature of the abaxial midrib, and the color of the stomata bands as compared to the non-stomata regions (Spjut 1992).

As the study progressed, many specimens from Eurasia could not be accommodated in the morphological key according to the traditional geographic species concept; consequently, this concept was abandoned. Herbarium specimens were then strictly classified according to pattern recognition as evident from characters of branching, bud-scale texture and size, change in color of branchlets from 1st to 2nd year, leaf arrangement, leaf shape, leaf thickness, leaf color, leaf curvature lengthwise and across both surfaces, changes in leaf curvature near margins and along midrib, shape of cones in bud and at maturity, distribution of papillae along the abaxial leaf margin, and other characters of lesser importance (described in DELTA format, Spjut USDA Memorandum 1995). Data on numbers of stomata rows and number of marginal cells are presented elsewhere (Spjut 2007). Only color and phyllotaxy are further discussed (below). References for eco-geographical data on species are cited when relevant to data on herbarium specimens.

Results of the author's revised taxonomic concepts were presented at annual scientific meetings in Baltimore (Spjut (1998a,b) and Portland (Spjut 2000a,b,c), which included papers on the evolution in the *Taxus* leaf, phytogeography of the genus *Taxus*, a key to all species and varieties of *Taxus* (Spjut 2000a), and the occurrence of *Taxus canadensis* in both North America and the Euro-Mediterranean region (Spjut 2000b). Manuscripts were also submitted for peer review in 1999 and 2000; one of these was later placed on the internet (Spjut 2003) from which data were extracted and incorporated into the present paper.

Taxonomic species concept

The species concept in *Taxus* in the sections that follow is based on pattern recognition employing the traditional method of defining species in keys; a taxonomic method in which my primary objective has been to classify specimens in the fewest number of species and varieties that can be reasonably distinguished from one another. Their character features, as presented in the following keys, can be seen in specimen photos with data from labels at www.worldbotanical.com. My view of *Taxus* species is that they were most distinct by the end of the Tertiary as a result of former geographical and ecological isolation, and that hybridization and introgression since the Pliocene has blurred their distinction (Spjut 2007). Examples of species and varieties that were allegedly more widespread and appear to be losing their identity through introgression are *Taxus* OCR (*T. ocreata* Spjut ined.) (China), *Taxus* SCU (*T. scutata* Spjut ined.) (China), *T. suffnessii* Spjut (Myanmar), *T. wallichiana* var. *yunnanensis* (W.C. Cheng & L.K. Fu) C. T. Kuan (NE India to SW China), and *T. contorta* Griff. var. *mucronata* Spjut (Bhutan, Nepal).

The taxonomic value of characters was evaluated subjectively by their apparent correlation with other characters. Species identification usually depended upon specimens having a combination of two or more character attributes. As experience was acquired in identifying *Taxus*, many species could be recognized by gross morphological features of branching, phyllotaxy, and color; however, detailed examination of a leaf under a microscope for other character features was also necessary to confirm identification (e.g., see discussion under *T. kingstonii* Spjut). Ideally, one might further employ chromatographic or molecular characters, but it remains to be demonstrated whether such information can be efficiently extracted from herbarium specimens. Needles from a number of herbarium specimens were subjected to DNA extraction, but there was little extractable DNA (Da Cheng, pers. comm. 2007; Krupkin, pers. comm. 1994).

Variation in color as it may relate to chemotaxonomic characters

A key character for recognizing differences between species groups is the occurrence and distribution of reddish colored cells in leaf tissues as seen in dried herbarium specimens. Differences in color are also employed as taxonomic characters at the species level; for example, *T. baccata* has nearly concolorous leaf surfaces in contrast to strongly discolorous leaf surfaces in *T. recurvata* Hort. ex C. Lawson, and *T. kingstonii* is identified by its rusty orange color compared to a blood red color in *T. mairei*.

The reddish to orange cells are obviously the result of chemical byproducts. These have yet to be identified, but they apparently are phenolics that oxidize slowly in collected and dried specimens to form the reddish resinous substances observed in cell walls of leaf epidermal and mesophyll layers. The color changes may occur over a period of many months or years except for species in the *Sumatrana* Group in which the color change occurs usually within a week after a specimen is collected and dried. *Taxus* contains cyanogenic glucosides (Khan & Parveen 1987) that break down and release benzaldehyde related componds when plants are damaged (Seigler 1991; van Genderen et al. 1996). These include taxiphyllin, dhurrine, triglochinine, and isotriglochinine (Khan & Parveen 1987).

Other potentially useful compounds in *Taxus* are biflavones, which are known to have chemotaxonomic value in gymnosperms in addition to biological value as antifungal, anti-bacterial, and antiviral agents (Krauze-Baranowska & Wiwart 2003). For example, in the Podocarpaceae, the presence or absence of various flavonoid glycosides (Markham et al. 1985) has been found to correlate with recent morphological taxonomic concepts of its genera and species (de Laubenfels 1969), and biflavones have been shown to be localized in leaf epidermal cells of conifers with the aid of aluminum chloride-induced fluorescence (Gadek et al.1984). *Taxus* biflavones include sciadopitysin, ginkgetin, kayaflavone, amentoflavone 7-O-methylamentoflavone in European and Himalayan species, and bilobetin and 4-O-methylamentoflavone in samples from Poland (Krauze-Baranowska & Wiwart 2003). Appendino (1995) has noted uncharacterized pro-anthocyanidins, "based on 3-flavanols of the *cis* and *trans* type," are "probably responsible for the red color of a paste made from bark of a Himalayan species." Also, apocarotenoids have been found in a Himalayan yew but not in European yew (Appendino 1995).

Leaf parenchyma of *Taxus* also contains essential oils, but *Taxus* is deficient in monoterpenes that are usually present in conifers (Appendino 1995; Jean et al. 1993). *Taxus* is best known for anticancer diterpenoid compounds (taxoids), particularly taxol (Wani et al. 1971), from which semi-synthetic derivates are used for treating cancer (Kingston et al. 1990; Kingston 1996, 2005). Numerous novel taxoids have been discovered in the genus (Appendino 1995); however, most reports are of little taxonomic value because studies have focused on novel discoveries (Appendino 1995) and because the genus has been in critical need of taxonomic study. Most taxoids of pharmacological interest are widely distributed and vary in yield according to plant parts, location, season, drying conditions, and species (Croom 1995; Dempsey & Hook 2000; Griffith & Hook 1996; Hook et al. 1999; van Rozendaal et al. 2000). Nevertheless, Spjut et al. (1993) reported chemotaxonomic relationships based on taxoid content between similar morphs of *T. brevifolia* var. *reptaneta* when compared to var. *brevifolia*, and Chang (unpublished, pers. comm.) found chemotaxonomic differences for taxoid hplc profiles between cultivars and between *Taxus kingstonii* and other *Taxus* species in Taiwan. Although chemotaxonomic studies are lacking, Appendino (1995) has suggested that yews in Europe are characterized by the presence of taxine B, those in the Pacific Northwest by the presence of abeotaxane type alkaloids, and the Himalayan yews have 13,14-dihroxylated taxoids not found in other regions.

Leaf phyllotaxy (frequency), arrangement (distribution), and orientation

These terms have similar but slightly different meanings in this paper.

Phyllotaxy.—refers to the frequency at which leaves develop along a twig as determined between two leaves that occur in direct alignment. The frequency is generally expressed as a ratio of the number of leaf cycles over the number of leaves in a cycle over the total number of leaves, the latter being a sum of the preceding two numbers and representing what are known as Fibonacci numbers. Camefort (1956) recognized four different patterns in *Taxus baccata*, a 2-3-5 that may spiral to the left or to the right, a 3-5-8, and a 5-8-13. Because differences in phyllotaxy can relate to branch thickness (Camefort 1956), phyllotaxy is generally described as dense, lax, or remote and by whether adjacent leaves along one side of the branch overlap along their margins.

Leaf arrangement.—The phyllotaxy in *Taxus* may also be described as spiral, as opposed to opposite, whorled, or alternate in other plant genera; however, a distinction is also made in regard to the directional and distribution pattern in which leaves spread from branchlets. In the Dovaston yew (*T. baccata* var. *dovastoniana* Leighton), for example, leaves on the uppermost side of the branchlet point upwards and towards the branch apex, while those along the sides and underneath spread outwards (horizontally). In the Maire's yew (*T. mairei*), leaves spread horizontally along two sides of branchlet nearly in one plane and thus appear distichous or "two-ranked" (but not truly two-ranked), in contrast to a radial arrangement of the Irish yew (*T. fastigiata* Lindley, not a true whorl), in which the leaves are mostly erect except for curving downwards along the blade. A further distinction is whether leaves along one side of a branchlet are mostly parallel to one another (e.g., *T. baccata*) or crisscross (e.g., *T. recurvata*) as seen in pressed specimens, and whether they appear more imbricate (e.g., *T. caespitosa*) or decussate (e.g., *T. umbraculifera*).

Leaf orientation.—This is in regard to the direction that leaves spread as a result of phototropic response. Leaves generally twist and/or bend towards light so that the adaxial surface faces upward (Hill & Scriven 1998). Leaves in most species of *Taxus* tend to spread horizontally in shade and upwards in sunlight. Habit and branching may also be correlated with leaf orientation. For example, the columnar growth form of the Irish yew (*T. fastigiata*) with ascending to erect branches appears to be an adaptation to growth in open habitats. Because the branchlets ascend upwards, the leaves would not be expected to spread much outwards; thus, their erect radial orientation is seen as a correlated feature. *Taxus caespitosa*, sometimes found with prostrate branches in open habitats, exhibits a phyllotaxy that may be described as dense with a leaf arrangement referred to as radial-imbricate, and because all the leaves on horizontal (caespitose) branchlets point upwards in the same direction, the orientation is also referred to as erect-secund.

Species Groups, Subgroups, Alliances, and Complexes

No formal classification of sections or subsections within the genus is proposed at this time, but species of *Taxus* are classified into three groups. Within the groups, two subgroups and two alliances are recognized, based on leaf epidermal cell shape, development of epidermal papillae, and on color of stomata bands in contrast to adjacent epidermal regions (Spjut 1998b). The ***Wallichiana*** **Group** includes the *Wallichiana* and *Chinensis* Subgroups; the ***Baccata*** **Group** includes the *Baccata* and *Cuspidata* Alliances; the ***Sumatrana*** **Group** is not subdivided. Alliances refer to taxa that share morphological features within geographical regions, whereas taxonomic groups and subgroups are not geographically isolated. Within species alliances or groups, species complexes are recognized to distinguish, for example, plants with radial distribution of leaves (*T. umbraculifera* complex) vs. leaves appearing in a two-ranked arrangement (*T. cuspidata* complex).

Nomenclature, references, authorities

Species and varietal names are typified to validate the data in this study and in Spjut (2007). Descriptions of species and full details on specimens cited are omitted for species already established; detailed descriptions and specimen citations for all taxa can be found online at www.worldbotanical.com. Six new species are described, *Taxus biternata*, *T. florinii*, *T. kingstonii*, *T. obscura*, *T. phytonii*, and *T. suffnessii*, because their leaf anatomical data are relevant to taxonomic data in another study (Spjut 2007) that supports the taxonomy in this paper. Authors for scientific names are indicated in full when the taxon name is first mentioned and are subsequently abbreviated (fide Brummitt & Powell 1992) when there is no reference to a publication.

KEYS TO GROUPS, SUBGROUPS AND ALLIANCES OF *TAXUS*

1. Leaf epidermal cells tall rectangular or ±angular-isodiametric in T-sect. and usually reddish in herbarium specimens, papillose on the abaxial midrib; North America (SE Alaska and W Florida) to Central America (Honduras, El Salvador), Himalayas, SW China **I. Wallichiana Group (IA Wallichiana Subgroup)**

1. Leaf epidermal cells ±elliptical or wide rectangular in T-sect., 1.5–3.5 times as wide as tall, or if isodiametric not reddish in dried herbarium specimens, variable in development of midrib papillae.

    2. Stomata bands in dried leaves not sharply differentiated from adjacent marginal and midrib regions, the abaxial surface green to yellowish green, slightly darker green on midrib and along margins, or uniformly reddish green.

        3. Leaves with reddish cells primarily epidermal; papillae ± equally developed across stomata bands and midrib, often more prominent along cell walls; stomata sometimes on midrib, (11–)13–19(–21) rows per band; E Himalayas to China **IB. Wallichiana Group (Chinensis Subgroup)**

        3. Leaves with reddish cells primarily in mesophyll; papillae often less developed on midrib than on stomata bands, or more medial than marginal (*T. baccata* Alliance, Euro-Mediterranean, W Himalayas), or papillae reduced along cell walls—appearing concrescent (*T. cuspidata* Alliance, NE temp. Asia); stomata less than 13 rows per band in NE temp. Amer.; Euro-Mediterranean, up to17 rows per band in temp. E Asia **III. Baccata Group**

    2. Stomata bands in dried leaves distinct from glossy marginal and midrib epidermal cells, the midrib entirely smooth to papillose on outer half, or smooth from mid region to base, often discolored—blood red—in contrast to the yellowish green to yellowish orange stomata bands.

        4. Leaf epidermis with cell walls meeting at sharp angles, mostly smooth on midrib and marginal region (8–36 cells wide); stomata rarely in transverse rows; leaf papillae more medial than marginal; E Himalayas to Indonesia **II. Sumatrana Group**

        4. Leaf epidermis with cells meeting at rounded angles, mostly papillose to 2–6(–12) cells from margin, sometimes less on midrib; stomata often in transverse rows; leaf papillae marginal; E Himalayas to Indonesia **IB. Chinensis Subgroup**

KEYS TO THE SPECIES AND VARIETIES OF *TAXUS*

I. *WALLICHIANA* GROUP: SUBGROUP IA *WALLICHIANA*

1. Stomata 12 or more rows per band; E Himalayas, SW China.
    2. Persistent bud-scales relatively large, 2–3 mm long, nearly plane with distinct midnerve (Fig. 1); Myanmar **4. T. suffnessii**
    2. Persistent bud-scales nerveless, or nearly so, concave, less than 2 mm long and 1 mm wide (Fig. 2), if scales not evident or leaves obtuse see *Chinensis* Subgroup; E Himalayas, Nepal to SW China (var. *yunnanensis* distinguished by abaxial leaf marginal zone having long narrow cells bordered by shorter and much wider papillose cells with medial papillae, or by a lanceolate leaf shape in SW China) **5. T. wallichiana**
1. Stomata less than 12 rows per band.
    3. Abaxial leaf epidermal cells gradually narrower and shorter from stomata band to margin, mostly isodiametric in T-sect., generally 3–10× l/w, fusiform and sinuous (wavy along cell walls) on abaxial surface, or rarely rectangular; *Taxus globosa*.
        4. Papillae prominent on most of the abaxial leaf surface, the marginal cells mostly sinuous (Fig. 3, type); El Salvador to NE Mexico **3a. T. globosa** var. **globosa**
        4. Papillae less prominent on midrib and marginal zone than on stomata band, the marginal cells ± rectangular (Fig. 4, type); Mexico (Nuevo Leon/Tamaulipas, Veracruz), U.S. (Florida) **3b. T. globosa** var. **floridana**
    3. Abaxial leaf epidermal cells abruptly shorter and wider in marginal region, often taller than wide in T-sect.
        5. Stomata 7–10(–12 rows); China (Yunnan, Sichuan) **2. T. florinii**
        5. Stomata 4–7(–9) rows; NW North America **1. T. brevifolia**
            6. Cones elongate, often with a narrow stipelike base **1b. T. brevifolia** var. **polychaeta**
            6. Cones appearing sessile.
                7. Trees, reproducing by adventitious shoots **1a. T. brevifolia** var. **brevifolia**
                7. Layering shrubs, often forming thickets **1c. T. brevifolia** var. **reptaneta**

I. SUBGROUP IB *CHINENSIS*

1. Dried leaf surfaces ±concolorous, or yellowish green on abaxial surface.
    2. Bud-scales conspicuous at base of branchlets; Yunnan, Sichuan **11. Taxus** sp. SCU
    2. Bud-scales minute, vestigial or absent at base of 1st yr branchlets.
        3. Leaves obtuse, usually oblong (less than 10× l/w); Vietnam, China **6. T. chinensis**
        3. Leaves acuminate (10–15× l/w); Vietnam, Philippines, China (Taiwan), Indonesia. **9. Taxus** sp. REH
1. Dried leaf surfaces discolorous, or yellowish orange on abaxial surface.
    4. Leaves obtuse, dull rugose on adaxial surface; Yunnan, Sichuan **10. Taxus** sp. OCR
    4. Leaves acute to acuminate, smooth or glossy on adaxial surface when dried.
        5. Leaves spreading parallel at nearly right angles; Nepal, NE India, Malaya, China (Taiwan, Yunnan), Philippines **8. T. phytonii**
        5. Leaves spreading at oblique angles, crisscrossing in pressed specimens; Myanmar, China (Fujian, Taiwan), Philippines, Indonesia (Sulawesi, Sumatera) **7. T. obscura**

II. *SUMATRANA* GROUP

1. Dried leaves rusty orange, at least near apex, often rust colored on abaxial surface in contrast to a darker green or bronze green colored adaxial surface, generally twisted obliquely to the stem axis, often recurved along blade to sharply pointed apex, with midrib rounded on both surfaces; generally thick and rigid; mostly 1700–3000 m, NE India to China (including Taiwan) **13. T. kingstonii**
1. Dried leaves green to reddish, or with a blood reddish discoloration along abaxial margins and on midrib, generally twisted nearly perpendicular to stem axis, the adjacent leaf edges often closely parallel, obtuse to acuminate, the abaxial midrib usually elevated and truncate, or flush, usually with a channel; generally thin and flaccid; mostly below 1200 m in China.
    2. Leaves oblong to linear, obtuse to acute, or elliptical and acuminate; leaf epidermal cells larger (mammillose) on abaxial than adaxial midrib in T-sect., appearing short trapezoidal from surface view; S China **14. T. mairei**
        3. Branchlets limp, often much isodichotomous; leaves closely parallel along one side of branchlet; seed purplish **14a. T. mairei** var. **mairei**
        3. Branchlets rigid, occasionally isodichotomous; leaves unevenly spaced along branchlets; seed tan **14b. T. mairei** var. **speciosa**
    2. Leaves long linear to lanceolate, acuminate; leaf epidermal cells in T-sect. not larger on abaxial than adaxial midrib, nearly rectangular in surface view; E Himalayas to Indonesia, Philippines.

FIG. 1. *Taxus suffnessii.* Close-up of persistent scales showing prominent midnerve; *Kingdon Ward 20902,* Myanmar (isotype, BM).

4. Dried leaves plane to convex on adaxial surface __________ **12. T. celebica**
4. Dried leaves puckered, especially upper third of leaf __________ **15. T. sumatrana**

III. *BACCATA* GROUP

1. Abaxial surface of leaves mostly papillose between margin and stomata band—to within 8 rows of cells from margin (e.g., Fig. 5), papillae nearly medial, the cell walls thin or smooth; leaves often curved downwards along the blade (except *T. contorta* var. *mucronata*); Euro- Mediterranean, W & C Himalayas __________ **16. T. baccata Alliance**
   2. Leaf mesophyll with idioblasts (parenchyma cells with reddish walls), loosely connected; NW to central Himalayas (var. *mucronata* distinguished by shorter more reflexed leaves with a wider bare marginal zone of cells) __________ **17. T. contorta**
   2. Leaf parenchyma cells often dark in color, not reddish, adhesive.
      2a. Plants columnar; leaves radial, recurved __________ **18. T. fastigiata**
      2a. Plants variable in habit; leaves overlapping, not distinctly radial.
         2b. Leaf surfaces discolorous, blades recurved, convex, revolute __________ **19. T. recurvata**
         2b. Leaves ±concolorous, straight or falcate, plane or revolute __________ **16. T. baccata**
            2c. Leaves spreading outwards along two sides of branchlets in one plane, appearing distichous.
               2d. Leaves not overlapping, branching isodichotomous __________ **16a. T. baccata** var. **baccata**
               2d. Leaves overlapping, branching irregular __________ **16c. T. baccata** var. **elegantissima**
            2c. Leaves spreading outwards along two sides of branchlets in one plane, appearing distichous.
            2c. Leaves erect or radial on lower parts of branchlets.
               2e. Branchlets and leaves yellowish orange in part; branchlets often recurved; leaves erect near ends of branchlets __________ **16d. T. baccata** var. **glauca**
               2e Branchlets uniformly green, yellowish green to dark green; branchlets not recurved, spreading or drooping; leaves variable.
                  2f Branching mostly pinnate __________ **16f. T. baccata** var. **variegata**
                  2f. Branchlets crowded terminally, appearing to arise digitately or isodichotomously.
                     2g. Leaves yellowish green, falling off by the third year; branching isodichotomous __________ **16e. T. baccata** var. **pyramidalis**

Fig. 2. Taxus *wallichiana* var. *wallichiana*. Close-up of persistent scales lacking distinct midnerve; Khasia, India, *Hooker & Thomson 77 ex Herb. Bunge* (P).

2g. Leaves dark green, persistent; branching subdigitate, pinnate, or subfastigiate ______ **16b. T. baccata** var. **dovastoniana**

1. Leaves mostly smooth between stomata band and margin, usually lacking papillae across 8–24 rows of cells, the papillae often concrescent on upper surface of cells near cell walls; leaf blades often curved upwards, or sharply bent or curved downwards along petiole; temperate E Asia and NE North America, Euro-Mediterranean ______ **23. T. cuspidata Alliance**
   3. Leaves spreading more by narrow petioles, the petioles more curved than sharply bent, or petiole curving nearer junction with branchlet than with blade; stomata (4–)5–9(–11) rows per band; leaf papillae often obscure; plants usually low, creeping shrubs ______ **22. T. canadensis complex**
      4. Leaves acute to acuminate, gradually tapering to an acute margin as seen in T-sect., usually revolute along margins, the abaxial surface with keeled midrib and mostly rectangular epidermal cells; common in NE N America, occasional in Euro-Mediterranean: Morocco, Portugal (Madeira), Spain, Sweden, Estonia ______ **22a. T. canadensis** var. **canadensis**
      4. Leaves obtuse to acute, rounded along margins in T-sect., not revolute, with flush midrib and with trapezoidal or rectangular epidermal cells.
         5. Leaves crowded, erect, recurved; NE Amer., Madeira______ **22c. T. canadensis** var. **minor**
         5. Leaves lax, mostly straight, spreading nearly at right angles); occasional, England, Madeira, France, Sweden, Norway, Estonia, Slovenia, U.S. (Iowa).______ **22b. T. canadensis** var. **adpressa**
   3. Petioles more bent than curved, bending nearer junction with blade and also clasping the branchlet, the blades often (ad)pressed to branchlet; stomata (7–)9–14(–17) rows per band; papillae always prominent in stomata bands; plants variable in habit.
      6. Leaves mostly two ranked to apex of branchlets; seed angled ______ **T. cuspidata complex**
         7. Branchlets short and much divided; leaves in a flat (horizontal) spray (Fig. 6), more strongly revolute in upper third when dried; common understory tree, NE temp. Asia ______ **20. T. biternata**
         7. Branchlets mostly long pinnate; leaves erect (Fig. 7), uniformly revolute along margins when dried; shrub or tree—appearing adapted to exposed habitats, Japan, Korea ______ **23. T. cuspidata**
      6. Leaves in ±two or more decussate ranks or radial; seed rounded ______ **24. T. umbraculifera complex**
         8. Leaves ± erect and imbricate______ **21. T. caespitosa**

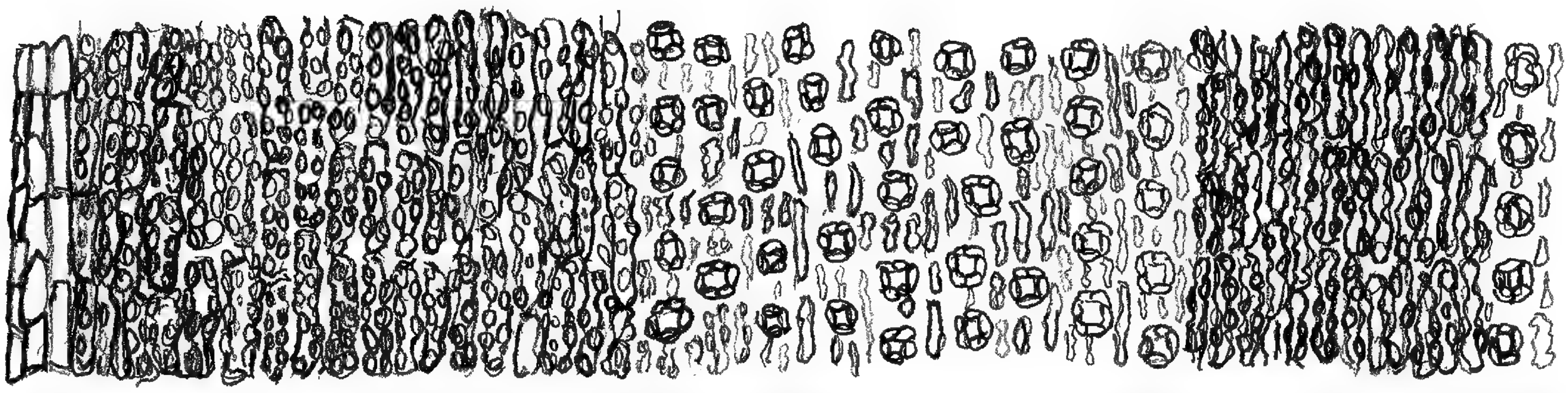


Fig. 3. *Taxus globosa* var. *globsoa*. Illustration of abaxial surface of leaf as seen in the medial region from margin to midrib; showing stomata band with 9 rows of stomata and sinuous epidermal cells, a character feature related to the marginal position of papillae on epidermal cells, drawn from lectotype (K).

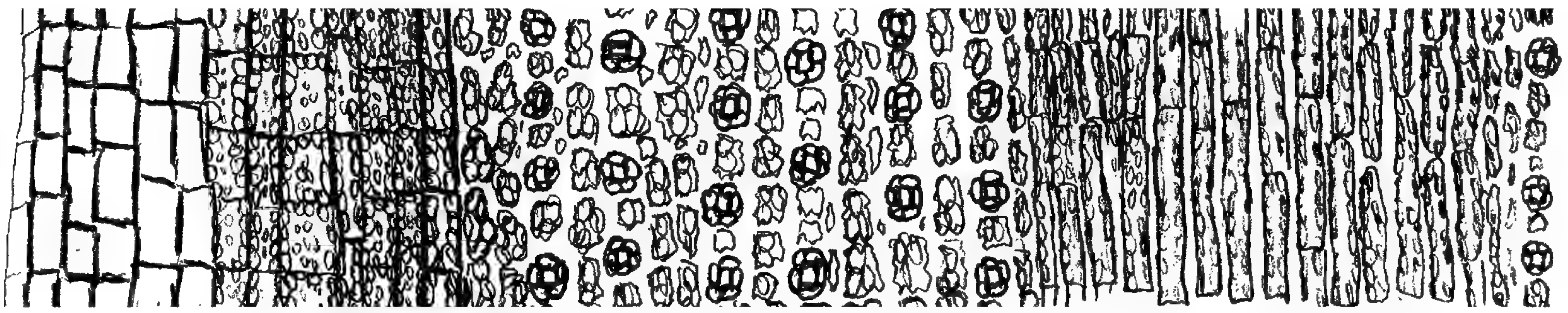
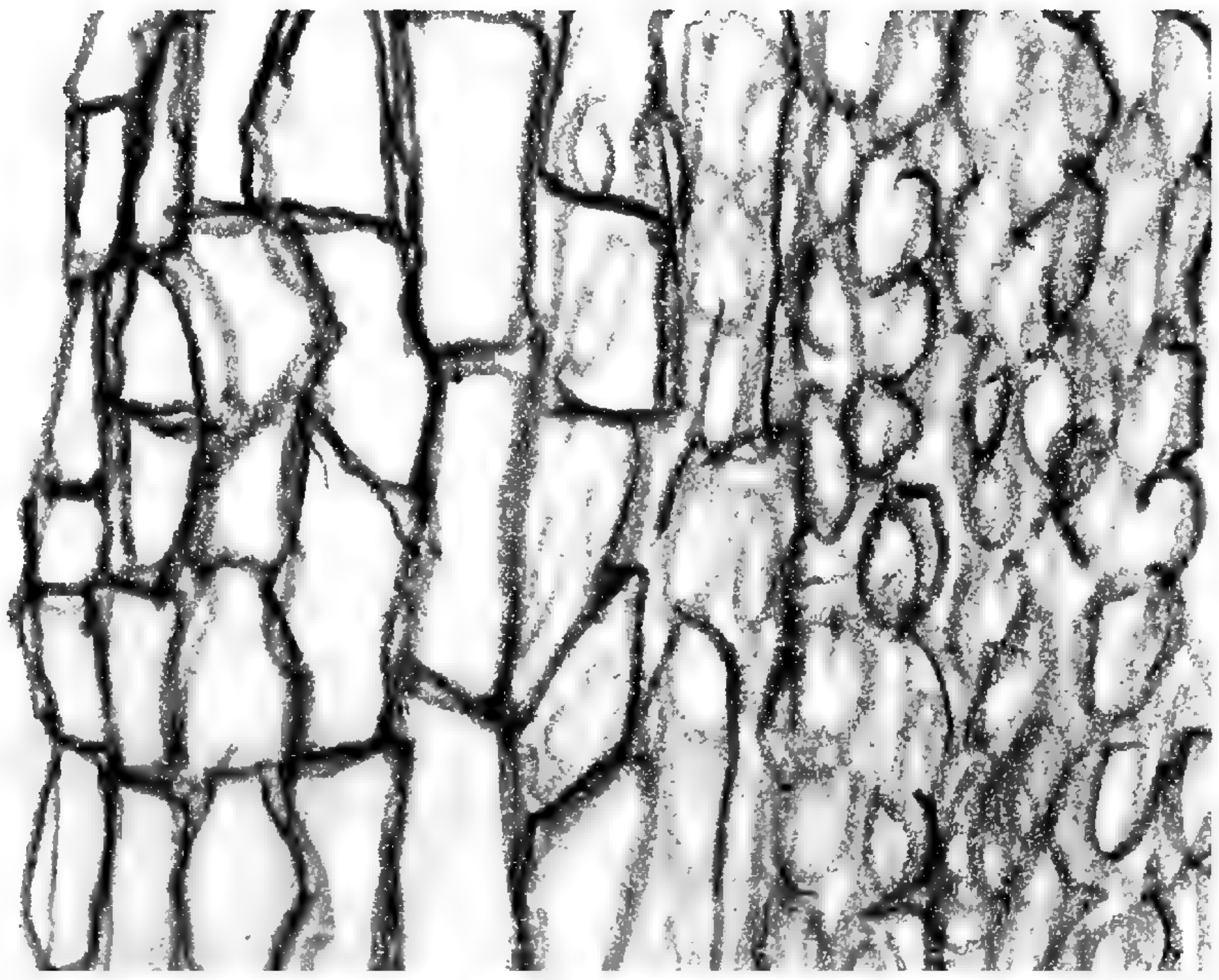


Fig. 4. *Taxus globosa* var. *floridana*. Illustration of abaxial surface of leaf as seen in the medial region from margin to midrib; showing stomata band with 7 rows of stomata and rectangular epidermal cells with less prominent papillae in comparison to var. globosa, drawn from original material (K).

Fig. 5. Abaxial lef margin with 5 rows of smooth cells, followed by 2 rows of obscurely papillose cells and 3 rows of prominently papillose cells. Image scanned from author's sketch of leaf fragment on specimen packet of *Taxus recurvata*, *Lewis 721* (BM).



9a. Branches ascending to erect with many short, crowded branchlets; leaves mostly radial (Fig. 8); Japan **21a. T. caespitosa** var. **caespitosa**

9a. Plants with distinct trailing or wide spreading branches; branchlets with mixed two-ranked and erect secund leaves.

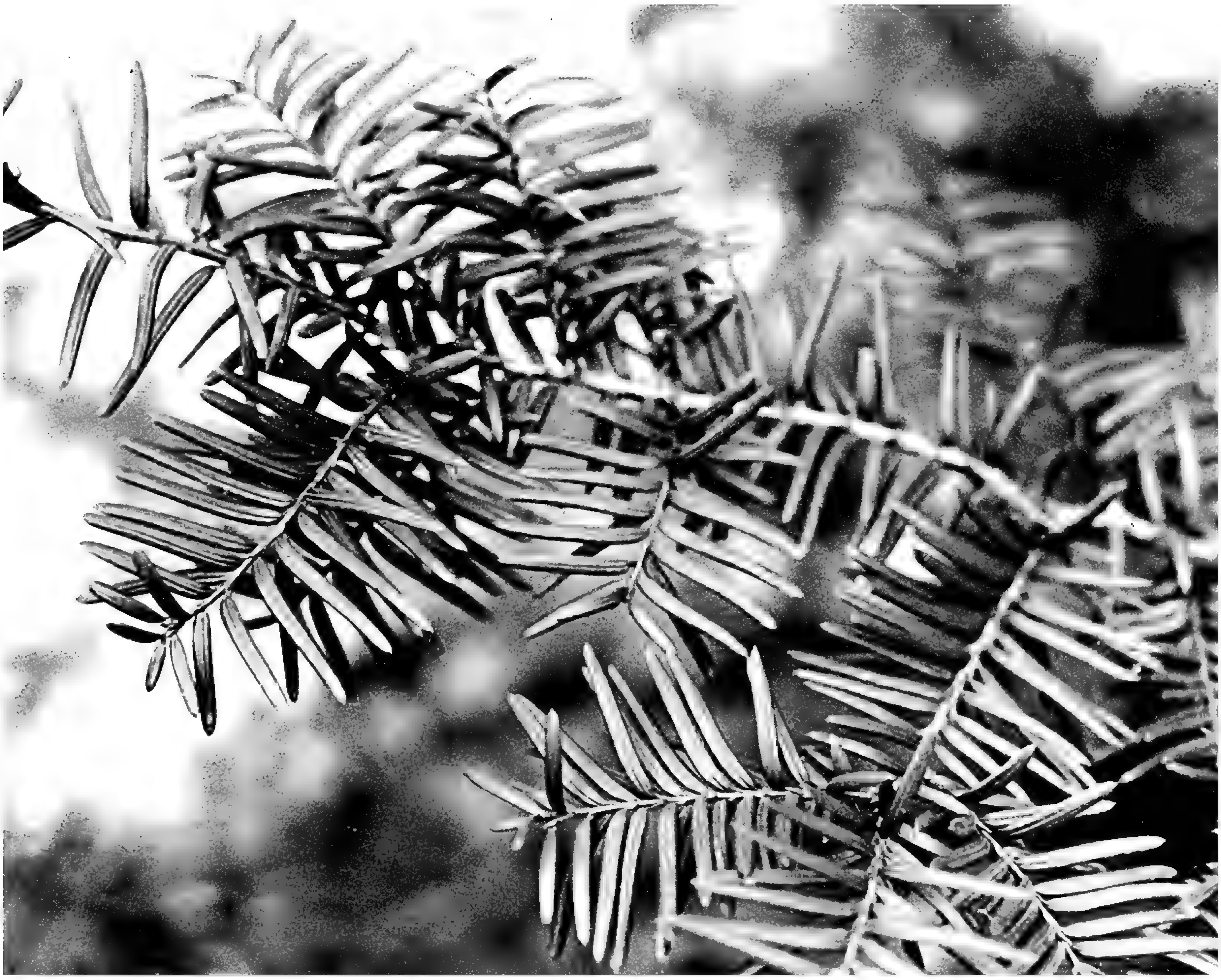
  9b. Branches ascending to wide spreading; leaves oblong or linear, 2-4 mm wide; Korea, Japan, SE Russia, NE China **21c. T. caespitosa** var. **latifolia**

  9b. Branches prostrate with erect branchlets; leaves linear, relatively narrow, ca. 2 mm wide; Korea, Japan **21b. T. caespitosa** var. **angustifolia**

8. Leaves ± reflexed and decussate (Fig. 9) **24. T. umbraculifera**

10a. Flat-topped shrub, layering **24c. T. umbraculifera** var. **microcarpa**

10a. Hemispherical to columnar shrub or tree.



Figs. 6–7. Comparison of branching in *Taxus* species of the Cuspidata Alliance. **6** (top). *Taxus biternata*, cultivated, Forestry Research Institute, South Korea, photo and specimen by *Kang Hyeon Ka s.n.* 7 (bottom). *Taxus cuspidata*, cultivated, Secrest Arboretum, Wooster, Ohio, photo by Richard Spjut.

10b. Low rounded shrub ____ **24d. T. umbraculifera** var. **nana**
10b. Tall shrubs or trees.
    10c. Columnar with ascending to erect branchlets ____ **24b. T. umbraculifera** var. **hicksii**
    10c. Pyramidal, diffusely branched ____ **24a. T. umbraculifera** var. **umbraculifera**

TAXONOMY AND NOMENCLATURE

I. *WALLICHIANA* GROUP

The *Wallichiana* (Species) Group is recognized by the leaves having reddish epidermal cells and scarcely differentiated stomata bands as seen in herbarium specimens, in contrast to idioblasts in the spongy mesophyll in the *Baccata* Alliance, which includes the northwestern Himalayan *T. contorta*.

IA. *Wallichiana* Subgroup.—This subgroup is differentiated from the *Chinensis* Subgroup by leaves having taller than wide or isodiametric angular epidermal cells in transverse section, and by the obscurely differentiated stomata bands; the papillose epidermal cells often extend to four cells or less from the margin. Included are three species distributed from the eastern Himalayas to Yunnan, Sichuan, and western Hubei (2000–3700 m elevation) and two species in North America (from near sea level to 2670 m).

1. Taxus brevifolia Nutt., N. Amer. Sylva 3:86. 1849, t. 108 captioned "*Taxus occidentalis,*" without reference to specimens. (**Fig. 10**). *Taxus baccata* L. var. *brevifolia* (Nutt.) Koehne, Deutsche Dendrol. 6. 1893. *Taxus baccata* L. subsp. *brevifolia* (Nutt.) Pilger in Engler, Planzenreich 4(5):113. 1903. Type: U.S.A. [Oregon]: "Columbia woods," "Nuttall Herb." without collector, date of collection and collector's number (lectotype designated here: from uncited specimens—original material: Nuttall Herbarium—BM! # 38752, annotated "*T. occidentalis,*"—top left specimen of three on one sheet, with mature male cones; ISOLECTOTYPES: K!, PH!).

Taxus boursieri Carrière, Rev. Hort. sér 4, 3:228. 1854. Type: U.S.A. CALIFORNIA: Siskiyou Co.: Shasta Springs, Aug. 1894, *Jepson s.n.* (NEOTYPE designated here: US!). Carrière cited no specimens and original material is unknown, but he noted that the species was from California: "Forests near stream with *Pseudotsuga, Abies grandis, Pinus lambertiana*; arborescent shrub with slender branches, leaves 1.5–1.8 cm long, glaucous below."

Taxus lindleyana M.A. Murray, Edinburgh New Philos. J. 1:294. 1855. Also, Rev. Hort. sér 4, 4:379. 1855 (by J. Decainse). Type: U.S.A. California: N and E of San Francisco between 40° and 41° latitude [Klamath Region], "along sides of a glen.under the shade of larger trees" (LECTOTYPE designated here: selected from original material of two uncited specimens at E, the one with the following handwritten notations (1) "*Taxus lindleyana*" (in bold black ink, handwriting probably Murray) (2) "Murray," "Ed. N. Philos. Journ.1854," "Legn. California" (in red faded ink, handwriting undetermined, perhaps R. Jameson) and (3) "probably only a form of *T. baccata*, perhaps the *T. cuspidatus* [spelling?] of Sieb. & Zucc." (in thin black ink, handwriting unknown—appearing different from the other two), and with the accession number E 00030316!). Described by Murray in his publications as a large tree, 30–40 ft high, with a circumference 50–70 inches in diam, and with very long pendant branches. The other specimen is indicated to have come from Vancouver, possibly collected by Murray before 1855. Judging from other plants described by Murray from his California trip in 1854, the lectotype may have been collected near Dunsmuir in Oct. 1854.

Common name.—Pacific yew.

Distribution and ecology.—SE coastal Alaska to central California—the Klamath Mts., Coast Ranges and W Sierra Nevada to Sequoia Natl. Park—and from the S Canadian Rockies in British Columbia and W Alberta south to W Montana. Often in shade of old-growth forests on N slopes, but also valley forests and seral communities along streams and forest margins; from sea level to 2650 m, in mixed evergreen and montane coniferous forests, generally Douglas fir (Eliot 1938) and lowland fir (Bolsinger & Jaramillo 1990), western hemlock along W Cascades (Franklin & Dyrness 1969), or sitka spruce and western red cedar in the northern range (Taylor 1932; Taylor & Taylor 1980).

This species was first discovered by David Douglas in 1825 (Sargent 1896), who after arriving in Astoria OR that year on April 11 (Oldham 2005) had spent much of that year collecting in the Pacific Northwest. His base of operations was the Hudson Bay Company located at Fort Vancouver just north of Portland on the Washington state side of the Columbia River, arriving there on April 20 (Oldham 2005). However, there apparently are no specimens of *T. brevifolia* by Douglas. Nuttall had also collected along the Columbia River during 1834–1835 (Graustein 1950/51); one of the labels on the type sheet refers to *T. floridana*, a species that was not discovered until 1833, a name that Nuttall had proposed sometime before 1860, the year it was legitimately described. Hitchcock et al. (1969) indicated reference to a type "*Nuttall*, 'In the dense maritime

Figs. 8–9. Comparison of leaf arrangements in *Taxus* species of the Cuspidata Alliance. 8 (top). *Taxus caespitosa* with imbricate ascending leaves, cultivated, Secrest Arboretum, Wooster, Ohio. 9 (bottom) *Taxus umbraculifera*, with spreading to reflexed somewhat decussate leaves, cultivated, Secrest Arboretum.

Figs. 10A–C. Type specimens of *Taxus brevifolia*. A (left). Herbarium sheet at BM, Nuttall Herbarium. B (top right), close-up of lectotype (BM), upper left specimen, showing adaxial surface of leaves and mature male cones on 1st yr branchlets. C (lower right). Close-up of the abaxial surface of leaves and persistent bud-scales at the base of branchlets in the lower specimen on the herbarium sheet in Fig. 10A.

forest of the Oregon'" while Pilger (1903) noted that yew had been observed by Douglas in the Oregon forests along the Columbia River. A review of the geographical distribution of *T. brevifolia* by Spjut (1977) reported the occurrence of Pacific yew near Portland and other areas in the nearby Mt. Hood National Forest where trees were known to reach a height of 20–25 m. The presence of mature male cones on the type indicates it would likely have been collected during the spring. Thus, Oregon is likely the state locality for the type where possibly collected by Nuttall himself during the spring of 1835; the handwriting on the type label compares favorably with that on other Nuttall types (NY, virtual herbarium of types, particulary for specimens from the "Columbia woods").

Taxus brevifolia is distinguished from the closely related *T. globosa* by the leaves having enlarged epidermal cells along the abaxial surface between the stomata bands and margins, narrower stomata bands with fewer stomata rows, and leaf blades tapering to an obtuse but mucronate apex. Leaf stomata range from 4–7(–9) rows per band with the higher counts (7–9 rows) more frequent in specimens from the Sierra Nevada and lower counts (4–6 rows) more often found in the Klamath Region, Coast Ranges, Cascades, and Rocky Mountains (Spjut 2007). The relatively wide abaxial leaf margins lack papillae on 2–11 cells across.

The leaf epidermal cells in transverse leaf sections often appear tall rectangular as in the East Himalayan *T. wallichiana*, *T. suffnessii*, and the Southwest China *T. florinii*. The similar number of stomata rows per band between *T. florinii* and *T. brevifolia* may be the result of convergent evolution (homoplasy) within the *Wallichiana* Subgroup.

The type has leaves spreading nearly at right angles and appearing dark metallic green on the adaxial surface. Other specimens differ by a reddish orange color (e.g., lectotype for *T. lindleyana*), or by a glaucous abaxial surface (e.g., neotype for *T. boursieri*). These differences may justify reevaluations of taxonomic status in further studies.

Taxus brevifolia has been a major source of taxol (paclitaxel) employed in cancer chemotherapy, first isolated from stem-bark (Wani et al. 1971). Historical accounts on the procurement of *Taxus* species for the NCI antitumor screening are given by Croom (1995) and by Goodman and Walsh (2001); the latter draws extensively on information from memoranda, letters, and interviews concerning availability of *T. brevifolia* for supply of taxol in the short and long term.

Currently, three varieties are recognized by differences in cones, habit, and vegetative reproduction. The typical variety, a tree usually scattered in the understory of old growth forests, produces cones similar to most other yew species. Variety *polychaeta* is distinguished by longer cones with persistent scales, whereas var. *reptaneta* differs by the layering habit in which the plants often form thickets, in contrast to the typical variety reproducing vegetatively by adventitious shoots from trunks or roots.

1a. Taxus brevifolia var. brevifolia

Common name.—Pacific yew.

Tree, *reproducing by adventitious shoots* from trunks or roots, 6–13(–25) m tall, bole to 60(–130) cm diam.; branches horizontal to upwardly ascending, sometimes drooping near ends, dividing more unequally than equally, yellowish orange to reddish orange, or maroon; bud scales persistent on 2nd–3rd yr branchlets, conspicuous, 2–3 seriate, paleaceous, chartaceous, closely to loosely adnate, plane to slightly concave, indurate, brownish, 1–1.5(–2) mm long. *Cone scales forming a basal hemispherical cup*; male cones ellipsoidal in bud, 4 mm long, 2 mm wide; *sporangia exserted*. Seed on 1st or 2nd yr or older branchlets, *longer than the pedunculate axis*, rounded, slightly 2–4 angular, ellipsoid to ovoid, tapering to apex from mid region, or rather abruptly near apex, 5–8 mm long, to 4 mm diam.; aril red, reddish orange, yellowish orange, or rarely yellow, Aug–Sep.

1b. Taxus brevifolia Nutt. var. **polychaeta** Spjut, var. nov. (**Fig. 11**). TYPE: U.S.A. WASHINGTON. Thurston Co.: Mud Bay, near Tacoma, 3 Sep 1938, *F.G. Meyer 1589* (HOLOTYPE: K!).

Ab var. *brevifolia*, strobili elongati, lumbriciformis, squamae persistentibus.

Similar to *T. brevifolia* var. *brevifolia* in habit, differing by the longer seed cones; the seed appearing stipitate, seed shorter than the long crooked cone axis (stalk) in the type, cone scales persistent; male cones elongate with scales persistent to near apex.

Common name.—Worm-cone yew.

Distribution and ecology.—California (Mendocino Co., Sonoma Co.), Washington (Thurston Co. near Mud Bay and Tacoma), Idaho (near Coeur d'Alene); observed to be rare in a redwood-grand fir-nutmeg forest in Sonoma Co., California.

Additional specimens. **CALIFORNIA. (Marin, Sonoma, or Mendocino Co.):** 1854, *Bigelow s.n.* (US); Salmon Creek (Sonoma or Mendocino Co.?), *McMurphy 315* (US). **Sonoma Co.:** near Mendocino Co. line, 7 km E of Stewarts Point, *Rich Spjut & Rick Spjut 16021* (BM, BRIT, E. GH, K, US, wba). **IDAHO.** Without collection data, US Forest Service, received from Marion Blatch, Coeur d'Alene Nursery, 26 June 1992 (wba).

Variety *polychaeta* is distinct for its elongate, worm-like cones. The California specimens have shorter cones than those specimens from further north—coastal Washington (type) and from near the Idaho/Washington state line. In var. *reptaneta*, female cones may appear similarly elongate on older branchlets, while both male and female cones on younger branchlets appear typical of the species. This is in further contrast to the male specimen of var. *polychaeta* collected by John Milton Bigelow from California.

A specimen of var. *polychaeta* that was collected by James Ira McMurphy (1871–1943), who had lived in Mendocino County, mentions only Salmon Creek; it may have been from the town of Salmon Creek just

Fig. 11. Close-up of branchlet of *Taxus brevifolia* var. *polychaeta* showing three wormlike cones, one with seed; near Tacoma WA, *Fred.Meyer 1589* (holotype, K).

north of Bodega Bay in Sonoma Co., or from west of the town along Salmon Creek itself, or possibly from Big Salmon Creek just south of Albion along the Mendocino coast, or another more inland site in Mendocino County where there is a Salmon Creek ca. 12 km E of Willits in the Mendocino National Forest. A recent plant inventory of Big Salmon Creek does not include yew (Chanslor Wetlands Wildlife Project, website accessed 2006), although this area had been logged.

In any case, the coastal occurrence of yew in California is rare. One record for Sonoma County was by Milo Baker from near Annapolis where populations have since been reported from nearby Fuller Creek and its north-facing drainages; however, in a brief survey of this area we were able to find only the one tree; which belonged to var. *polychaeta*; it was growing next to *Torreya californica* Torr. in a redwood forest (*Rich Spjut & Rick Spjut 16021*). John Bigelow was also known to have collected in Marin, Sonoma, and Mendocino counties (CNPS, Marin Chapter, website); thus, the McMurphy specimen of var. *polychaeta* was probably collected just north of Bodega Bay in view of our find (*Spjut & Spjut 16021*), which also seems significant in regard to18 endemic taxa that are recognized for Sonoma County (Best et al. 1996). Another report for southern Mendocino County indicated that yew is rare in a ravine on Sea Ranch; however, this area was reportedly logged in early 1900s and early 1990s; thus, yew may once have been more common there. It is of interest to note the plant associations of two rare disjunct taxa of closely related yew in the United States that include both US species of *Torreya*, one in California (*Torreya californica*) that is first reported here with *Taxus* in a redwood forest region, and the other in Florida (*Torreya taxifolia*) in a white cedar forest as described in more detail under *T. globosa* var. *floridana*.

A duplicate specimen of *F.G. Meyer 1589* at the Smithsonian Institution (US) is not considered an isotype because the seed cone in this specimen is typical for *T. brevifolia*. This may lead one to question whether cone development in var. *polychaeta* is some sort of aberration within the 'normal' population; however, both male and female cones of *T. brevifolia* var. *polychaeta* show the morphological feature of elongated cones.

Also, most collections of var. *polychaeta* appear coastal. Molecular differences have been reported between coastal and inland plants of *T. brevifolia* (El-Kassaby et al. 1994, 1995), which included a distinct genotype on Vancouver Island in contrast to other yew populations studied in British Columbia.

1c. Taxus brevifolia Nutt. var. **reptaneta** Spjut, var. nov. (**Figs. 12–13**). Type: U.S.A. California. Siskiyou Co.: near corner of Humboldt and Trinity Cos., Salmon Mts., 1 mi E to SE of Salmon Mt., near the NW corner of the Trinity Alps Wilderness boundary, Klamath Natl. For., 19 mi S of the town of the Forks of the Salmon on McNeal Creek Rd, West Fork of Knownothing Creek, ca. 1250 m, along N-facing slopes of ravine in mixed evergreen forest of Douglas fir, white fir, ponderosa pine, tan oak, snowbush, dogwood, hazelnut and big-leaf maple, shrub with long scandent stems ascending to 5 m or more, stems layering, forming thickets, both male and female plants present, occasional male cones with pollen, female cones with seed but mostly without fleshy aril, one with pale yellowish aril, 11 Sep 1990, *R. Spjut & T. Spjut 11835*, with seed (holotype: US!; isotypes: BM!, BRIT!, E!, GH!, K!, wba!).

Differt a var. *brevifolia* frutex caulibus ascendentibus, ramis reptanibus, 0.3–5 m altis, propaginis, faciens dumetia.

Rhizomatous (layering) shrub with decumbent to ascending or contorted trunks, to 5 m high, typically forming dense impenetrable thickets on open steep, narrow ravines, or more distantly spaced, either as low creeping shrubs or arborescent in understory on slopes or in valleys with coniferous forests. Leaves similar to var. *brevifolia*, often darker and duller on upper surface, slightly revolute along margins, more densely papillose on abaxial midrib with papillae in 3–4 rows on each cell; midrib appearing more elevated, often ca. 18 cells wide; stomata often in 4–6 regular rows per band. Male cones abundantly produced, ovoid in bud, 3 mm long and 2 mm wide, scales ca. 5 in series; sporophylls ca. 8, united into a column ca. 2 mm long, umbrelliform above, each with 5 microsporangia (0.9 mm diam.). Female bud cones ca. 1 mm long, scales overlapping, ca. 5 seriate; seed maturing on 1st or 2-yr growth; rounded, ellipsoid to ovoid, 6–8 mm long, 4 mm diam., often without fully developed aril. Aril red, reddish orange, yellowish orange, or rarely yellow, maturing Aug–Sep.

Common name.—Thicket yew.

Distribution and ecology.—Rocky Mountains in British Columbia, Idaho and Montana; E Cascades in Oregon and Washington; Klamath Mountains in Oregon and California; scattered or forming dense thickets on steep sunny slopes of avalanche shoots, along streams, or in dense shade of valley forests, 1000–2000 m; in the Siskiyou Mountains occurring regularly between 3500 and 4000 ft on N to E slopes; probably in the Coast Ranges, Oregon to British Columbia (Arno & Hammerly 1977), reported also from the Cascade Ranges in California, near Mt. Shasta (Bolsinger, pers. comm. 2007).

Additional Specimens: **CALIFORNIA**. **Siskiyou Co.:** Klamath Natl. For., Marble Mountain Wilderness, Lake-of-the-Island, 1722–1820 m, forming thickets, mostly male plants on open talus and steep rocky slopes, or one female thicket observed on level soil in forest understory along lake shore, in association with red fir, mountain hemlock, western white pine, incense cedar and other conifers, *Spjut 16013–16015* (BRIT, GH, US, wba). **MONTANA. Lincoln Co.:** near northern panhandle of Idaho, Kootenai National Forest, Libby Mt., Snowshoe Mine Rd, T28N R31W Sec. 5, 48 °12' N, 115°38.34'W, 3287 ft, *Spjut & Deevy 12303* (wba); **Flathead Co.:** Flathead Natl. For., 4 mi N of Columbia Falls, Spur For. Rd 316G (Canyon Creek Rd), ½ mi W of jct. 316 and 316 G, T31N R20W Sec. 9, 3800 ft, 48°28' N, 114° 10' W, 3491 ft, with subalpine fir, grand fir, white pine, red cedar, hemlock, aspen, larch, plants predominantly male, *Spjut & Donner 12306* (US, wba). **OREGON. Clackamas Co.:** Mt. Hood Natl. For., ca.4 mi. N of Timothy Lake, FS Road 58 to Little Crater Lake, ca. 0.5 mi from jct. with RS Road 42 (Skyline Drive), ravine or basin forest, 121°43'W, 54°08.59'N, 3400 ft, *Spjut 12301* (US, wba). **WASHINGTON. Chelan Co.:** N Cascades: Wenatchee Natl. For., Icicle Creek drainage, 18 mi W of Leavenworth, Black Pine Horse Camp, scattered, somewhat scandent, at base of conifer trees in old growth forest of Douglas fir, grand fir, western white pine, and Englemann spruce, and also forming thickets locally on flats or gentle slopes, 47°36' N, 120°56'W, 3050 ft, *Spjut 12302, 12101* (US, wba).

Taxus brevifolia var. *reptaneta* is recognized by its layering habit; however, as with *T. canadensis*, the layering branch may die and rot away, leaving the individuals solitary (Bannan 1942). Plants vary in size, density and branching, but trunks are similar in their ascending form (Fig. 13). In the typical habitat—along steep open ravines—distinct trunks develop to 50 cm or more in diameter and grow within 1 m of each other, each bearing many divaricate branches that are often longer than the main trunk. The collective growth forms impenetrable thickets, hence the epithet *reptaneta*. In more shaded environments—as in the eastern Cascades of Washington—plants are less crowded and sometimes exhibit a peculiar growth in that individuals sprawl around the base of trees such as Douglas fir, occasionally twisting and wrapping around its trunk. In the Rocky Mountains other shrub forms grow less than 50 cm high, creeping along the ground

Fig. 12A–B. *Taxus brevifolia* var. *reptaneta*, seed and mature male cones, Klamath Mts., CA. **A** (top). Herbarium specimen in part, showing persistent scales at base of branchlets, abaxial surface of leaves with recurved margins, and seed without fleshy aril; near Salmon Mt., *R. Spjut & T. Spjut 11835* (isotype, wba). **B** (bottom). Close-up of branchlet with mature male cones; N-facing slope above Lake-of-the-Island, Marble Mt. Wilderness, *Spjut 16013* (wba).

Fig. 13A–C. Habit of *Taxus brevifolia* var. *reptaneta*. A (top). Eastern slopes of the Cascades, E of Portland, OR, growing on fairly level ground in forested valley, trunks sharply ascending near base. B–C (bottom). Rocky Mts., NW Montana, Libby Mt. B (bottom left). Massive prostrate trunk pointed to by the USDA Forester David Deevy. C (bottom right). Shows the numerous old trunks of yew as they grew, defoliated and debarked for extraction of the anticancer chemical taxol (paclitaxel).

much like some *T. canadensis* of northeastern North America. Yew thickets may be male or female, but male thickets were observed to be more common.

In the Klamath Mountains of California, I have observed thicket yew to occur predictably in steep ravines and on steep banks with a north to northeast exposure at elevations from 1000–1200 m; however, I have also found it at higher elevations in the Marble Mountain Wilderness such as near English Peak (1720–1820 m, Lake-of-the-Island, *Spjut 16013*). It is interesting that the typical variety generally occurs at higher and lower elevations in the California Klamath Region (e.g., 450 m, E fork of Willow Creek, *Terrell et al. 4170*; 700 m, Tannery Gulch, Trinity Lake, *Spjut 10179*; 1500–2000 m, Marble Mt. Wilderness near Lovers Camp, *Spjut 10721*). Many of the more northern locations of var. *reptaneta*—in Oregon and Washington—are at slightly lower elevations, corresponding to the more northern latitude occurrences. These observations suggest that var. *reptaneta* is a distinct ecotype within the range of var. *brevifolia*.

Other shrub forms in the Rocky Mountains of Canada are also evident. A specimen from the Selkirk Range (British Columbia) differs by broader (oblong) clasping leaves with a pale glaucous green color on the adaxial surface, while other leaves on the same plant are narrower and linear on what appears to be a layering branch. Another growing on steep exposed rocky cliffs near Golden (British Columbia) has ascending stems from a burl-like base. In further study these plants, which are considered here as belonging to var. *reptaneta*, may prove to be new varieties.

Eight samples of var. *reptaneta* were collected from Califonia, eastern Cascades in Oregon and Washington and from the Rocky Mountains in northwestern Montana to determine whether differences in taxoid content were correlated with tree and shrub varieties of *T. brevifolia* (Spjut et al. 1993). The taxoid content was most similar in samples that were also most similar morphologically, which were from northwestern Montana and northern California (type locality for var. *reptaneta*), in comparison to samples of var. *brevifolia*. These plants differed from those at other locations by the darker green thick leaves and by an abundance of male cones on branchlets of the current season.

2. Taxus florinii Spjut, sp. nov. (**Fig. 14**). Type: CHINA. Yunnan: Litiping between Likiang and Weihai, tree 17 ft, in mixed forests by stream,11 Oct 1939, *R.C. Ching 21980* (holotype: A!, stomata 10 rows per band, abaxial marginal zone 5–6 cells across, the cells thick-walled).

Similis a *T. wallichiana*, praecipue differt foliis decrescentes stomata et latis marginali, 7–12 seriata/zona.

Shrub or tree to 13 m high; young branchlets yellowish green, abruptly changing to reddish purple in 2nd yr; bud-scales persistent on 1–2 yr branchlets in most specimens, 2–3 seriate, deltoid, concave, ca. 0.3–0.5 mm long, obscurely to prominently carinate, closely attached. Leaves arranged ±distichous, homomallous, linear-lanceolate, acuminate, straight to falcate, 1.5–3.5(–4.7) cm long, 2.0–4.0 mm wide, 200–350 µm in thick, dark glossy green above (dried leaves, similarly noted by collectors on fresh specimens), glaucous to yellowish green below (in dried specimens, also noted as yellow green in field), slightly convex above (adaxial) to a rounded midrib, channeled along each side below mid region to base, less concave below (abaxial) to a flush to slightly rounded midrib, margins plane to slightly revolute; adaxial epidermal cells nearly quadrate in transverse section, occasionally taller than wide, 20–50 µm tall, 20–40 µm wide; abaxial epidermal cells narrower and not as tall as upper along midrib and marginal regions, rounded to partly angular in transverse section, 5–12 µm tall, 15–25 µm wide, numbering 16–20 across marginal region, trapezoidal to short rectangular, 1–3× l/w near margins, longer nearer stomata bands, 3–5× l/w, and on midrib, 5–10×+ l/w; papillae lacking near margins on 2–10 cells across, positioned more marginally than medially on midrib in 1–2 alternating rows, medially to marginally on accessory cells, and along cell walls in marginal zone; stomata bands narrower than marginal zones; stomata in 7–12 rows per band. Male cones maturing on 1st and 2nd yr twigs, subcylindrical in bud, 3 mm wide, 4 mm long, yellowish green, the scales 4–5 seriate; microsporangia 5–6 on each sporophyll, pinkish, spongy. Female cones initiating on current season growth, subcylindric in bud, 2–4 mm long, maturing 1st and 2nd yr, or on much older branchlets in one specimen, the scales 5–6 seriate; seed ovoid to globose, to 5 mm long, 5 mm diam., pale (yellowish) in color, sharply pointed at apex, covered in part by red aril, Aug.

Common name.—Florin yew.

Distribution and ecology.—Endemic to China (Xinjiang Uygur, Sichuan, Yunnan); forest or pasture or along streams, 2500–3700 m.

Additional specimens. **CHINA. Sichuan.** Handwriting illegible, 3500 m, *Schneider 1429* (K); Ngaitaschekou trans flumen Yalung ad septentr oppodi. Yenyüen, 28°15'N, 2800–3500 m, *Handel-Mazzetti 2602* (K); Shalie Valley on Muzhiyan Shan above Old Muli, Muli country, ca. 2980 m, frequent in narrow, steep SW facing gulley, tree to 5 m, leaves dark green above, yellowish green below, *Fliegner et al. 1129* (K). **Xinjiang Uygur ("SoC.W. Sikiang"):** "NW Yunnan," Tamichung, tree 20–30 ft, in fr., open pasture, *R.C. Ching 21505* (A). **Yunnan.** NW, Mt. Fo Ludu, NW of Li-Kiang, W of the Yangtze, *J.F. Rock 18502* (A, US); mostly illegible, 3000–3200 m, *C. Schneider 2918* (A, K); no locality data, *T.T. Yu 11076* (A); Dokerla, 3100 m, *Yu 7848* (BM); Litiping Range, Mekong-Yangtze divide, E of Weihsi, *J.F. Rock 11573* (A, US); Sikang, Me-kong, Tsa-wa-rung, 2500 m, *C.W. Wang 65475* (A); Mekong-Salween Divide, *Forrest 19967* (S: C-2084); S Chungtien, Kung-shiang-shu, Snow Mt on the way to Kai- Lou-wei, on Yangtze bank, 2700 m, by stream in wooded side of valley, tree 20 ft, *K.M. Feng 3235* (A); same locality, 3200 m, in mixed forest, shrub 15 ft, in fruit, *K.M. Feng 1809* (A); Wei-si Hsien, 2500 m, forest, *C.W. Wang 67735* (A); Zhongdian, Haba Shan, 27°22'28 N, 100°05'50 E., 3347 m, *Alpine Garden Soc. Exped. 309* (K).

Fig. 14. *Taxus florinii*, Herbarium specimen in part, showing seed on 1st yr branchlet; Yunnan, China, *Rock 18502* (US).

Taxus florinii is recognized by the leaves having tall angular epidermal cells and narrow stomata bands relative to a broad region of marginal cells, the stomata usually in 7–12 rows per band. As in *T. brevifolia*, the Florin yew is variable in the number of leaf marginal cells that lack papillae on the abaxial surface, ranging from 2–16 cells across.

Specimens of Florin yew with fewer than 10 stomata rows per band are easily distinguished from related species in Asia, but not necessarily from those in North America; *Schneider 2918* from Sichuan, for example, is similar to *T. brevifolia* in the leaves having 7(–9) stomata rows per band bordered by short broad irregularly shaped epidermal cells in the marginal zone, whereas *Handel Manzzetti 2602*—that is also from Sichuan—has 11 stomata rows per band—and is not easily distinguished from *T. globosa*. Thus, *T. florinii* and *T. brevifolia* could be included under *T. globosa*. However, the American species generally differ by their pale yellowish green branchlets and by the more strongly convex adaxial leaf surface—especially towards leaf apex, in contrast to the dark purplish (rarely orange) branchlets in the 2nd yr and more plane leaves of *T. florinii*. Other apparent differences are the midrib epidermal cells in T-section that in *T. florinii* appear smaller, thicker-walled and less angular on the abaxial surface than the adaxial surface, whereas in the American species there seems to be less difference in the size of the epidermal cells between the two leaf surfaces as seen in the midrib region.

Etymology.—The epithet is in honor of Rudolf Florin who published extensively on taxads based on leaf anatomical characteristics. Despite his controversial ideas on taxad evolution—such as proposing that they be treated in a new class—I have found his reviews and data to be of great value.

3. Taxus globosa Schltdl., Linnaea 12:496. 1838. (**Figs. 3, 15**). *Taxus baccata* L. subsp. *globosa* (Schltdt.) Pilger, Planzenreich 18 (iv, 5):114. 1903. Type: MEXICO. Hildago: Real del Monte, Cerro de las Nabajas, [Sep] 1837, *Ehrenberg s.n.* (lectotype designated here: ex Museum botanica Berlolinense (K!); isolectotypes: L, S, US!). No specimens cited, original material at B destroyed. Parlotore (1868) cited an Ehrenberg collection with number from the type locality, *Ehrenberg 817*, which may be at FI.

Taxus globosa is characterized by leaves having quadrangular epidermal cells as seen in transverse section, stomata in (5–)7–11 rows per band, and alternately arranged papillae along cell walls. Higher counts of stomata, 9–11 rows per band, were found in specimens from Central America and southern Mexico, compared to lower counts, 5–7 rows per band seen more in specimens from the northern range in Mexico and in the Florida panhandle (Spjut 2007). The abaxial leaf margins vary from 2–5 cells across (without papillae) except for one specimen from Veracruz, while all five specimens from Florida have a slightly broader marginal (epapillose) region, 5–9 cells across.

The species is traditionally known to occur from Mexico to Honduras; however, at the northern-most range in Mexico, specimens are difficult to distinguish from those in Florida; therefore, the Florida yew is

Fig. 15. Herbarium specimen in part, *Taxus globosa, Ehrenberg s.n.* (lectotype, K).

reduced to variety of *T. globosa*.

3a. Taxus globosa var. **globosa**
Common name.—Mesoamerican yew.

Distribution and ecology.—S Mexico (Veracruz, Hidalgo, Mexico, Oaxaca), Guatemala (Baja Verapaz, El Progreso [Sierra de las Minas, Volcán de Santa Luisa], Zacapa [Volcán Gemelos, Monte Virgen] Huehuetenango [Sierra de los Cuchumatanes, Cerro Cananá]) to British Honduras (Merrendón, San Idalfonso, Omoa, Montecillos, Opalaca, Congolón) and El Salvador; montane cloud forests above 2,000 m.

3b. Taxus globosa Schltdl. var. **floridana** (Nutt. ex Chapm.) Spjut, comb. nov. (**Figs. 4, 16**). Basionym: *Taxus floridana* Nutt. ex Chapman, Fl. South. U.S. 436. 1860. *Taxus baccata* L. subsp. *floridana* (Nutt. ex Chapm.) Pilger, Planzenreich 4(5):113. 1903. *Taxus canadensis* Marshall var. *floridana* (Nutt. ex Chapm.) Silba, Phytologia Mem. 7:72. 1984. Type: U.S.A. Florida: near Aspalaga, 1833, *Croom s.n.* (lectotype designated here: PH!). No specimens cited in original description. According to Sargent (1896), the Florida yew was first discovered by Hardy Croom in 1833 near Aspalaga. He further stated that "[t]he first notice of this, without description or specific name, was published in 1834 in the American Journal of Science (xxvi. 314)…It was next mentioned by Nuttall in 1849 (Sylva iii: 92) who doubtfully attached to it the name of *Taxus montana* [synonym for *Torreya taxifolia*], although Croom's specimen in the herbarium of the Philadelphia Academy was, he says, marked *Taxus Floridana,* the name adopted by Chapman when the species was finally described in 1860." A specimen at PH was found with label in what appears to be Nuttall's handwriting bearing the name *Taxus floridana,* indicating it was collected by Croom. However, another name, *T. croomii,* had been proposed, evidently by Chapman with reference to a Chapman list (1845 fide annotation by K. Wurdach, 1987, specimen at PH) as seen on other specimens from C.W. Short (PH), Bentham Herbarium (K), Herbarium Careyanum (K), all of which may represent original material. Chapman indicated that Nuttall was the source for the epithet; the specimen at PH bearing the name *T. floridana,* therefore, was selected as lectotype. The type material for the 1860 edition of the flora by Chapman reportedly went to Columbia University, which is now at NY (Stafleu & Cowan 1976), but no possible type specimens for *Taxus* from Chapman are currently listed among the types at NY (virtual herbarium).

Fig. 16. *Taxus globosa* var. *floridana*, close-up of branchlets and leaves of a herbarium specimen; handwritten notations on a label *"Taxus croomii"* Chapman List, Florida (original material, K).

Common name.—Florida yew.

Distribution and ecology.—N Mexico (Nuevo Leon, Tamaulipas, Veracruz), W Florida (rare, Apalachicola River; *Chamaecyparis* swamp ca. 8 mi SE of Bristol).

The Florida yew, which differs by the abaxial leaf surface having a broader marginal area of nearly rectangular epidermal cells with less prominent papillae, occurs in northern Mexico and in the panhandle of Florida. In Florida it is found not much above sea level on bluffs and in ravines along 15 miles of the Apalachicola River in a mixed evergreen forest of *Fagus grandiflora* Ehrh. and *Magnolia grandiflora* L. with *Torreya taxifolia* Arn., *Kalmia latifolia* L., *Quercus laurifolia* Michx., *Pinus glabra* Walter, *Ilex opaca* Aiton, *Symplocos tinctoria* (L.) L'Hér., and *Vaccinium elliotii* Chapm., and locally in a white-cedar (*Chamaecyparis thyoides* [L.] Britton, Sterns & Poggenb.) swamp eight miles southeast of Bristol (Kurz 1937). In northern Mexico, it occurs between 2000 and 2500 m, which is at lower elevations than generally reported for the typical variety.

The Florida yew has allegedly retained the ancestral features of leaf epidermal papillae on the midrib, and the angular isodiametric epidermal cells (as seen in T-section), contrary to what might be expected for yew growing in a seasonally hot and humid climate at relatively low elevations. An example is *Taxus mairei* in mixed mesophytic forests of southern China; it lacks papillae on the abaxial midrib and has elliptical epidermal cells (T-section). Variety *globosa*, occurring in a subtropical montane forest with less seasonal variation in temperature and precipitation, shows only minor differences in numbers of leaf stomata rows and marginal cells compared to var. *floridana*. Perhaps there was not enough time for the Florida yew to have evolved significant morphological differences between the oscillating periods of climate change during the Pleistocene, or perhaps introgression has occurred between formerly distinct ecospecies, one found along the Gulf coastal plain and another in the upland areas. The overlap of key morphological features at the northernmost range of the species in Mexico would seem to indicate former contact in that region between two ecotypes, whereas the plants of limited occurrence in Florida are viewed here as relicts barely surviving instead of adapting to the present climate.

4. **Taxus suffnessii** Spjut, sp. nov. (**Figs. 1, 17**). TYPE: MYANMAR. North Triangle (Wring Burma above Ahkail), 9000–10,000 ft, in forest and thickets, young leaves bronze, shrub or small tree, 24 May 1953, *Kingdon Ward 20902* (HOLOTYPE: A!, with seed; leaf with 12–13 stomata rows/band; ISOTYPE: BM!, leaf with 16 stomata rows/band, lacking papillae across 2 marginal cells).

Arbor vel frutex similis a *T. wallichiana*, praecipue differt perulae persistens ampliatibus, ovatis, 2–3 mm longis, folia oblongas ad leviter ellpiticas, 1.5 cm longis, 3.0 mm latis, supra cellula epidermibus ca. 50–60 µm altis, ca. 50 µm latis.

Tree or shrub; branchlets unequally divided, gray to purplish on older growth; *bud scales* 3–4 seriate, persistent to the 3rd yr or longer, paleaceous, indurate, grayish, deltoid, closely to loosely adnate, lower scales concave *with a distinct midnerve*, uppermost scales slightly cuspidate and aristate, ca. 3 mm long and 2 mm wide. *Leaves* lacking on older twigs, nearly two-ranked, overlapping slightly, *oblong to slightly elliptical or widest above the mid region*, straight, mostly ca. 1.5 cm long, 3.0 mm wide, 250–350 µm thick, bronze to blackish green and concave above to a rounded or acutely keeled midrib, yellowish green and convex below to a rounded keeled midrib, abruptly revolute near margins. Adaxial epidermal cells quadrangular in T-sect., or taller than wide, to 60 µm tall and 50 µm wide; abaxial non-stomata epidermal cells not as large, 12–25 µm high and wide, quadrangular, papillose to near leaf margins; papillae prominent, globose, in 3–4 rows, notably medial on marginal cells and marginal on midrib cells or equally developed on accessory cells in a stellar arrangement; stomata 12–20 rows per band. Male cones not seen. Female cones maturing on current season growth, scales overlapping in 5–6 ranks; seed appearing succulent or deformed, conical, dark colored with notable yellowish neck, ca. 3 mm long, 1.5 mm wide.

Common name.—Suffness yew.

Distribution and ecology.—E Himalayas: Endemic to Myanmar; 1950–3048 m.

Additional specimens. **MYANMAR. Upper Burma:** Hkyet, 27°45' N, 97°50' E, 9000–10,000 ft, *Kingdon Ward 13003* (BM); Myintkyina, Sumprabum, 8600 ft, *Hla & Koko 4028* (K); W Central Esakan, 6400 ft, in thick forest, *Kingdon Ward 21901* (A).

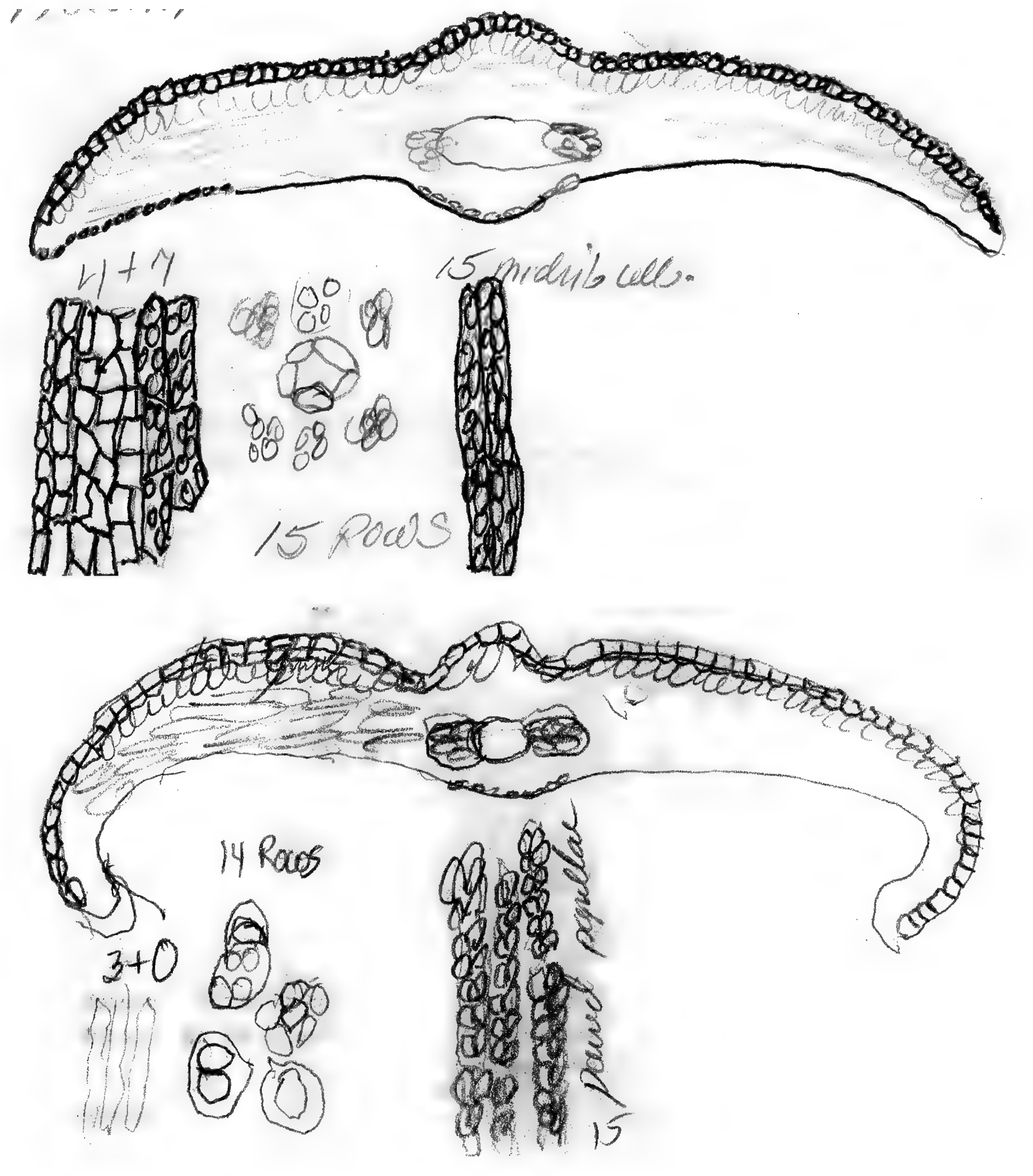
Taxus suffnessii stands apart from other species of *Taxus* in many features. These include the relatively large tall-rectangular epidermal cells, the large persistent bud-scales with a distinct mid nerve, prominent papillae on the abaxial surface of leaves extending nearly to the margin, a relatively broad leaf shape—appearing widest above the mid region, and leaves not spreading in one plane along two sides of a branchlet. Although the number of stomata rows varies from 12–20, the highest number of stomata rows seems related to the papillose cells extending to the leaf margin, or within 2 cells from the margin; essentially, the stomata band covers the entire abaxial leaf surface. The poorly differentiated stomatal bands would, therefore, seem to be an ancestral trait.

Fig. 17. ***Taxus suffnessii*, branchlets showing slightly elliptical leaves and characteristic persistent scales at base; Myanmar, *Kingdon Ward 20902* (holotype, A).**

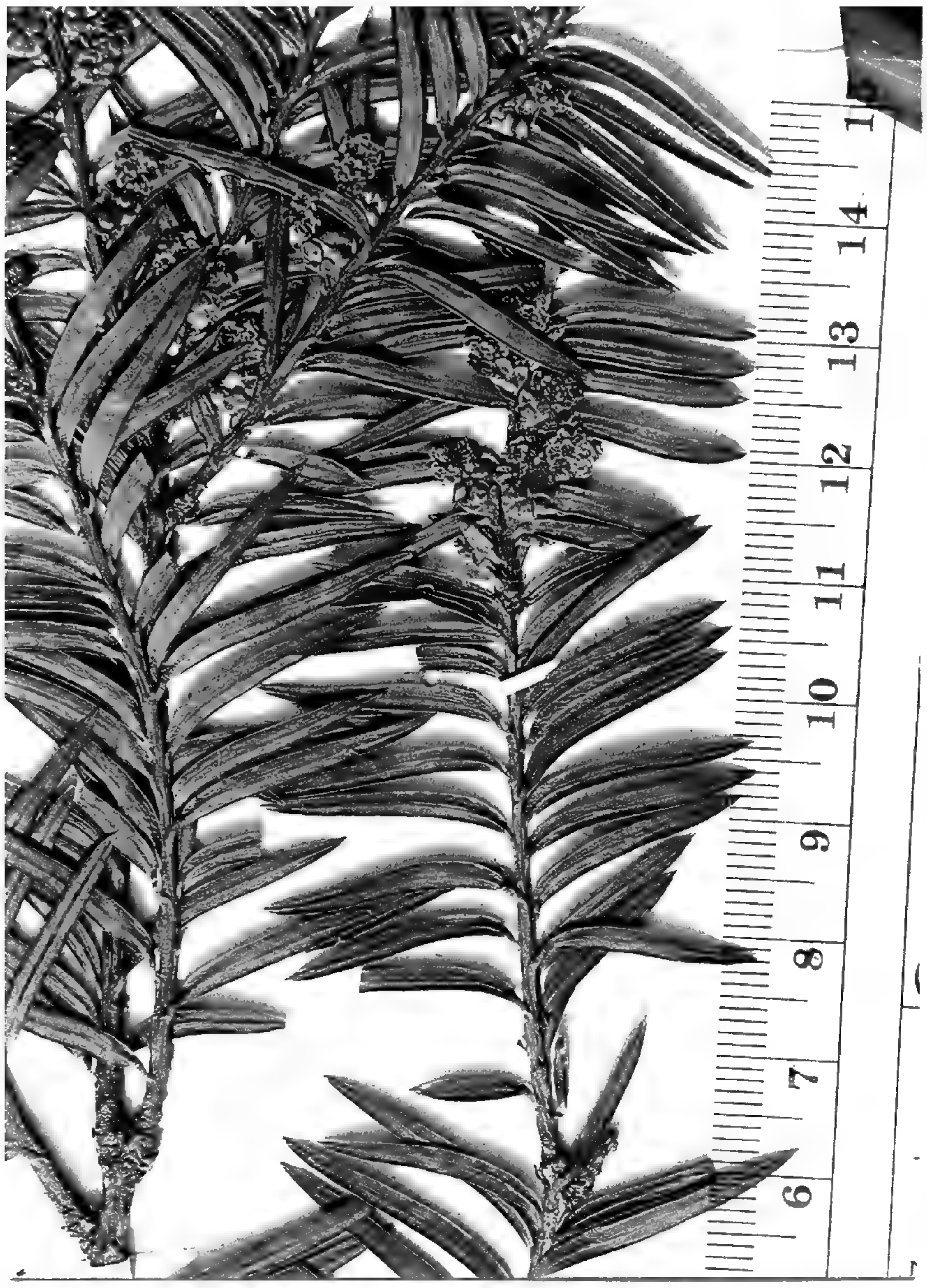
The Suffness yew is similar to *T. wallichiana* that differs by the smaller, more polished, nearly nerveless bud-scales and sometimes by the older reddish orange branchlets as seen in the typical variety from northeastern India, in contrast to a purplish color in the Suffness yew; however, intermediates are apparent. Examples are *Kingdon Ward 21901* from West Central Myanmar (at "6400 ft") and *Beer 25316* from Nepal (above Sedua, 9400 ft). They have fewer and slightly smaller bud-scales at base of branchlets but still show the characterstic midnerve, while they also differ by having longer (linear) leaves. *Kingdon Ward 21901* (BM) is referred to *T. suffnessii* by the entirely papillose abaxial leaf surface (Spjut 2007). The specimen from Nepal, however, is identified *T.* aff. *wallichiana* (Spjut 2007), while similarity to *T. suffnessii* is further evident by the tall-rectangular epidermal cells in leaf transervse sections in contrast to what is generally seen in *T. wallichiana*. The relatively large epidermal cells are a striking character feature of *T. suffnessii* and also other species such as *T. florinii* and *T. brevifolia*. The extent to which this character can be further employed to differentiate species of *Taxus* needs further study.

Taxus suffnessii is named in honor of the late Matthew Suffness in recognition of his dedication to screening natural products in the search of new drugs to treat cancer and of the strong encouragement I received from him in this endeavor. He became Chief of the Natural Products Branch in the National Cancer Institute after Jonathan Hartwell retired in 1976, following a brief leadership by John Douros. In 1986, Dr. Suffness became more involved in extramural contracts, often serving as consultant to various drug discovery groups. He focused on identifying novel leads that showed promise for development as new anticancer drugs, one of which was taxol. It is ironic that a major compilation on taxol research to which he served as sole editor (Suffness 1995) would not appear until just after his death from cancer in the spring of 1995.

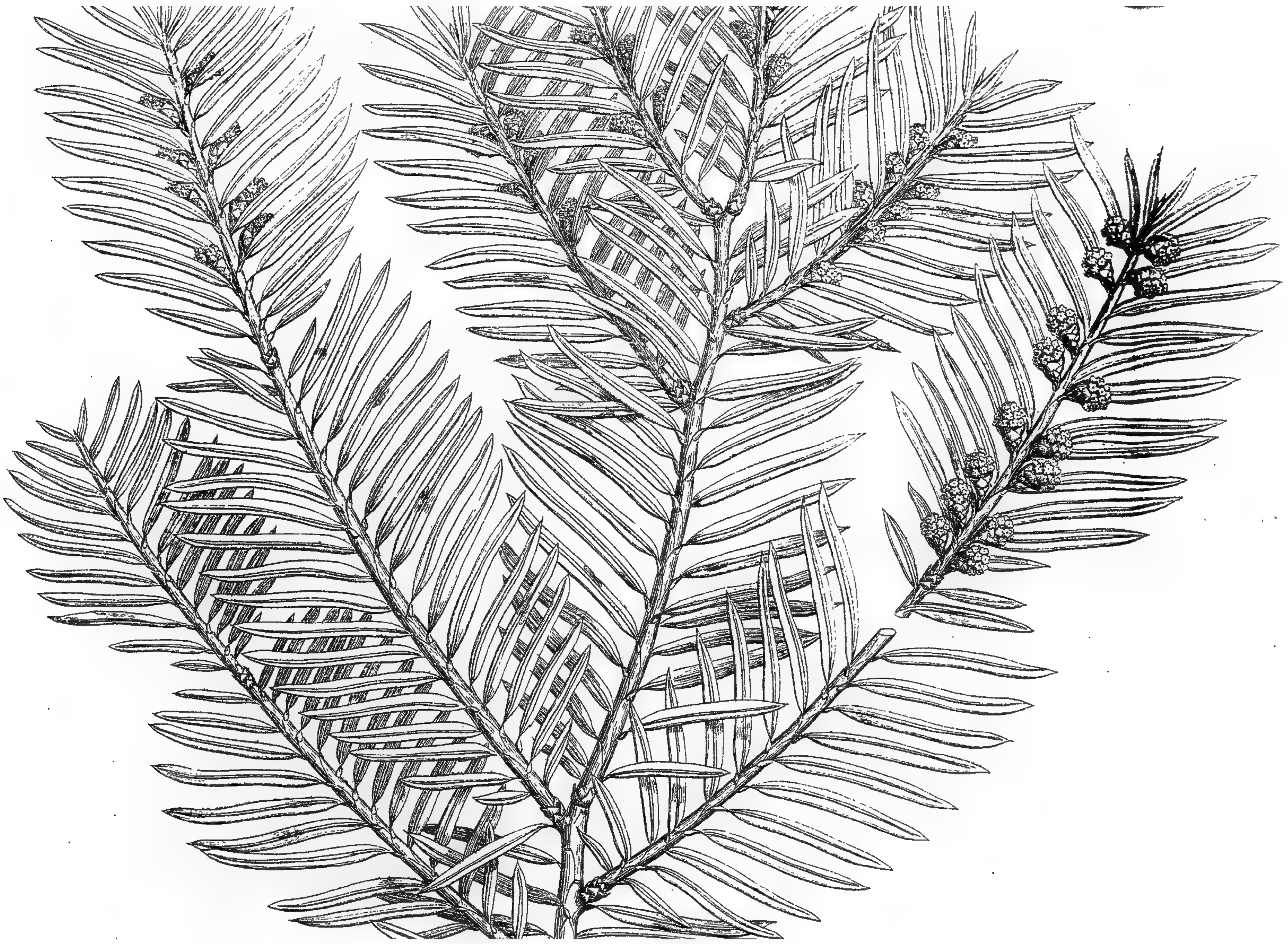
5. Taxus wallichiana Zucc. in Siebold & Zucc., Abh. math.-phys. CL.K. Bayer. Akad. Wiss. (München) 1 (3):803, Tab. 5. 1843. (**Figs. 18–21**). *Taxus baccata* L. subsp. *wallichiana* (Zucc.) Pilger in Engler, Pflanzenreich IV (5):112. 1903. *Taxus baccata* var. *wallichiana* (Zucc.) C.K. Schneider ex Silva Tarouca, Freiland-Nadelgehölz. 276. 1913. No specimens cited by Zuccarini, but he provided an illustration with reference to another earlier illustration in Wallich (1826, *Tentamen florae Nepalensis* 57, Tab. 44), Wallich's name "*Taxus nucifera*?" (excluding synonyms) and Wallich's observations that the species occurred in mountains around Sheopore [Shivapuri], Kathamadu, Nepal). Original material at M includes four specimens from Wallich and/or his collectors:



Figs. 18–19. Scanned images from sketches on 9 × 12 cm specimen packets showing leaf cross sections and abaxial epidermal sections in the mid region of a leaf for two varieties of *Taxus wallichiana*. **18** (top). Var. *wallichiana*, Bhutan, *Ludlow & Sherriff 1234* (BM), shows abaxial leaf surface to have 4 rows of irregularly quadrate to rectangular cells without papillae followed by 7 rows of epidermal cells that are slightly larger, somewhat rectangular with alternate papillae, and indicated to have 15 rows of stomata and a midrib of 15 cells across with alternate papillae. **19** (bottom). Variety *yunnanensis*, Sikkim, *J. D. Hooker* (K), indicating abaxial marginal zone has three rows of long cells without papillae, followed by 14 rows of stomata, without a region of papillose cells. Midrib cells shown to have erect opposite papillae. The revolute leaf margin as seen from the leaf cross section shown for var. *yunnanensis* is also a feature that is more common to that variety.



Figs. 20–21. Original material of *Taxus wallichiana*. **20** (left). Lectotype, *Wallich s.n.*, E India (M) showing branchlets, abaxial surface of leaves and mature male cones. **21** (below). Illustration in Siebold & Zuccarini (1843, Tab. 5).



(1) *Wallich s.n.*, year 1835, eastern India; with Herb. Zuccarini label, **(2)** [Wallich] *6054A* on label from Schultes, indicated to be from Kumaon but most likely from Nepal (see East India Co., *Numerical list of dried specimens collected under the superintendence of Dr. Wallich* [1828–1849]; determined by Spjut as *T. wallichiana*), **(3)** [Wallich] *6054/a* from Nepal, ex Herb. Hort. Bot. Calcuttensis (determined by Spjut as *T. contorta*) and **(4)** [Blinkworth] *6054B* from Kumaon (determined by Spjut as *T. contorta*). LECTOTYPE designated by Spjut inadnot, 23 March 1995 and here: INDIA: eastern, *communicavit Wallich, year 1835—Wallich s.n.* (M!) with mature male cones, and label "Herb. Zuccarini" Among the specimens at M, the lectotype is also the best match for the illustration in Siebold & Zuccarini (1843)—a photocopy reproduced here (Fig. 21). Additionally, two of the four specimens at M that bear Wallich numbers 6054/a and 6054b appear to have the wrong labels attached (or reversed) based on study of Wallich duplicates at other herbaria (GH, K, NY, P, PH, S); however, only one specimen is clearly associated with Zuccarini's study of *T. wallichiana* (Siebold & Zuccarini 1843), the lectotype. Duplicates of *Wallich 6054A*, which might be equivalent to isosyntypes (indicated as type below), are detailed as follows **by institution**: **GH**: label with handwriting similar to Wallich, "*Taxus nucifera* Wall." "Napalia." s.n. **K**: Four sheets. (1) with two specimens, the larger specimen has a pasted label below it with handwriting "*6054a*" and no indication of locality data, the smaller one is a single branch with mature seed, correctly annotated *T. wallichiana* by S. G. Harrison, but it is not *6054A*, or not a type since it is not from a male plant; (2) two specimens, one large specimen with an imprinted stamp nearby—Herb. Hookerianum, with handwriting similar to Wallich, *6054/A*, Nepal, accompanied by a smaller specimen in left corner, with a large label below, *Watt 6493* from Manipur, det. *T. wallichiana* by Spjut; (3) has four specimens, but only the lower left specimen is a type (*T. wallichiana*), below it are several labels, one printed—*ex Herb. George Gordon*, presented by J. D. Hooker, 1878, the other bears handwritten annotation—"*Taxus wallichiana*," two largest specimens with letters *a* and *b* written nearby on left and right, respectively, and with Herb. Benthamum imprinted in center, belong to *T. contorta*; uppermost annotated *T. virgata*, det. by Spjut to be a young shoot of *T. baccata*. **NY**: 2 sheets, *6054A*, NY accession numbers 30328 and 30329 (det. via photocopy). **P**: "Napalia," *6054* with "A" inserted, annotated *Taxus nucifera* Kaempf.? on label ex. Herb. Richard, and additional label ex. Herb. E. Drake. **PH**: "6054A Wallich."

Zuccarini was one of many recipients of specimens distributed by Wallich who generally assigned collection numbers to species rather than to specimens in which a particular specimen number may come from different localities and from different collectors. For example, *Wallich 6054A* has been reported from Central Midlands near Kathmandu Valley in Nepal (Anonymous 1913; Hara et al. 1978), and also from "Cachemiro" (Parlatore 1868), but most likely 6054A was collected from around Kathmandu (Dan Nicolson, pers. comm.1995) during 1822 ("Wallich's Catalogue" 1831–1832, Stafleu & Cowan 1988; Wallich 1826). Wallich was not allowed to leave the Valley of Kathmandu, while his collectors were able to collect, for example, northwest of Kathmandu Valley on the Holy mountain of Gossain (Nicolson, pers. comm., 1995). Wallich specimens of *T. wallichiana* with notations of "Kumaon" appear to be an error in numbering or labeling since collections from "Kumaon," which generally belong to *T. contorta*, were collected by Robert Blinkworth as indicated in Walllich's numerical list ("Wallich's Catalogue" 1831–1832, Stafleu & Cowan 1988). Wallich's collections for numbers 6054a, 6054b, which were collected prior to 1826, were distributed sometime between 1831 and 1832 (Anonymous 1913).

However, the lectotype, a specimen collected by Wallich from eastern India—received by Zuccarini in 1835 without number—would appear to be a later collection unrelated to the distribution of Wallich's Cataogue and herbarium. Indeed, Wallich was in Assam in 1835 (Burkhill 1965). It should be further noted that an illustration in Siebold and Zuccarini (1843, Tab. 5, reproduced here as Fig. 21) most closely resembles the lectotype among the specimens at M as seen by the branching and distribution of male cones. The lectotype is also characterized by reddish orange branchlets, non-inflated epidermal cells on abaxial surface of leaves, 12–15 stomata rows per band, and marginally positioned papillae on epidermal cells.

Two varieties are recognized by differences along the abaxial leaf margin as seen by the size and shape of epidermal cells and by the position of papillae.

5a. Taxus wallichiana var. wallichiana

Common name.—Wallich yew.

Distribution and ecology.—C Himalayas to SW China; Nepal, Bhutan, NE India (Assam, Manipur, Khasia Hills, West Bengal), Myanmar, China (SE Tibet, Sichuan, Yunnan); montane coniferous forests with *Picea, Abies, Tsuga*, or broadleaved evergreen forests of *Lithocarpus*, or *Quercus*, (1500-) 2300–3200 m. In Nepal evidently occurring abundantly with *Abies spectabilis* (D. Don) Spach on limestone (Stainton 1972), and in Bhutan apparently scattered from Ha to Mongar districts (Grierson & Long 1983).

Typical *T. wallichiana* is identified by the pale reddish orange branchlets, persistent cuspidate bud-scales (Pilger 1916), linear leaves arcuate near base (Orr 1937; Pilger 1903), conically shaped seeds (Orr 1937) that often mature on 2nd year or older branches (in the Himalayas), and angularly shaped epidermal leaf cells in T-section. Its leaves are further distinguished from those of *T. contorta* by the adhesive, bone-like parenchyma cells, and by (11–)13–18(–21) rows of stomata per band. Plants from Nepal, West Bengal, Khasia, and Bhutan are similar to the type.

Taxus wallichiana has been the name applied to all yews in southeastern Asia (Hu 1964; Pilger 1903 as subsp. *wallichiana*); however, de Laubenfels (1988) adopted *T. sumatrana* for his treatment of gymnosperm taxa in Flora Malesiana. He indicated that several species may overlap in the eastern Himalayas, suggesting that *T. wallichiana* was outside the Flora Malesiana region. *Taxus wallichiana* has largely been ignored by Rehder (e.g., Rehder 1940, 1949) and Hortus Third (Liberty Hyde Bailey Hortorium Staff 1976), while others have mentioned it as a species confined to the Himalayas (Krüssmann 1985), or more limited to the northwestern Himalayas (Wilson 1926), or as one of two partially sympatric species predominantly Himalayan in distribution (Silba 1984). Since Pilger (1903, 1916) did not cite any specimens for *Taxus* in the western Himalayas but indicated *T. wallichiana* to occur in eastern Himalayas, this omission may reflect uncertainty on his part, as he noted there were intermediates to *T. baccata*.

While I do not accept all morphological variants of *Taxus* in southeastern Asia to belong to a single species, Handel-Manzzetti (1929), Florin (1948a), and Hu (1964) also recognized more than one sympatric species in Asia by the lack of papillae on the abaxial leaf midrib, which I consider applicable to the *Sumatrana* Group as a whole.

The taxonomic and ecological significance of midrib papillae on the abaxial epidermal surface of leaves in *Taxus* has been noted by Bertrand (1874), Deryugina & Nesterovich (1981), Florin (1931, 1948b), von Frimmel (1911), Orr (1937), and Spjut (1992, 1993, 1998a, 2000a; Spjut in Hils 1993); however, Kwei & Hu (1974) and Cheng & Fu (1978) recognized intermediates with partially papillose midribs between *T. wallichiana* (papillose midrib) and *T. sumatrana* (smooth midrib). The latter was treated as a variety under two illegitimate combinations (*T. chinensis* var. *mairei*, *T. wallichiana* var. *mairei*). Spjut (1992, 1993, 1998b, 2000a), however, found other features that support their distinction not only as species but as species groups, such as epidermal cells in transverse sections appearing angular in the *Wallichiana* Subgroup of species (C & E Himalayas to SW China; North America) and elliptical in the *Sumatrana* Group of species (E Himalayas to Indonesia, Philippines).

Taxus wallichiana is interpreted to occur on Mt. Emei in Sichuan (China), where it intergrades with *T. chinensis*. Subtle differences in size of bud-scales and color of branchlets make it difficult to consistently separate the two species. Problematical plants may be hybrids between *T. wallichiana* var. *yunnanensis* and *T. chinensis* and/or possibly another species distinguishable by slightly larger and more persistent scales at the base of branchlets.

5b. Taxus wallichiana Zucc. var. **yunnanensis** (W.C. Cheng & L.K. Fu) C.T. Kuan, Fl. Sichuan. 2:215. 1983. (**Fig. 19**). *Taxus yunnanensis* W.C. Cheng & L.K. Fu, Acta Phytotax. Sin. 13(4):86, fig. 52, 4–7. 1975. *Taxus chinensis* (Pilg.) Rehder var. *yunnanensis* (W.C. Cheng & L.K. Fu) L.K. Fu, Vasc. Pl. Hengduan Mount. 1:214. 1993. Type: CHINA. Tibet: Zayul, 2100 m, 2 Aug 1973, *Zhang 916* (holotype: CAF; isotype: PE!, leaf fragment! photocopy!). Topotypes: detached leaves, without collector or date, "type locality" (PE!); *Kingdon Ward 10398* (Zayul, Rong Tö Valley, 8000 ft, spreading tree with brilliant green foliage, amongst deciduous trees on slopes and in gullies, BM!).

Common name.—Yunnan yew.

Distribution and ecology.—India (Sikkim, Nagaland), Myanmar, China (Tibet, Yunnan, Sichuan); mixed forests types, generally higher in elevation than var. *wallichiana*, 2100–3500 m, occurring with *Larix griffithiana* Carrière and *Picea spinulosa* (Griff.) A. Henry in the Sikkim region (Rau 1974).

Taxus yunnanensis has been confused with *T. wallichiana* in the *Flora of China* (Cheng & Fu 1978). The authors had evidently considered the type for *T. wallichiana* to represent the species mainly in northwestern Himalayas; consequently, they described *T. yunnanensis*—indicating it was found in the eastern Himalayas (Bhutan, Tibet, Myanmar) to Yunnan and Sichuan (Cheng et al. 1975; Cheng & Fu 1978). Later, it was reduced to a variety of *T. wallichiana*, as cited above, and more recently placed in synonymy (Li & Fu 1997), although it had been included in synonymy by de Laubenfels (1988) under his broadly circumscribed *T. sumatrana*. Li and Fu (1997), in placing *T. yunnanensis* in synonymy with *T. wallichiana*, created a new name for the yew distributed in the northwest Himalayas, *T. fuana*, but this is antedated by *T. contorta*. The English edition of the *Flora of China* (Fu et al. 1999) follows Li and Fu (1997), while Farjon (1998, 2001) maintained the illegitimate name with a narrower geographic distribution that seemed to reflect only the type locality.

Most specimens I annotated *T. yunnanensis* (A, GH, July 1996; BM, Oct. 1997; Spjut 1998b) are from Yunnan and Sichuan. They are distinguished from typical *T. wallichiana* by the leaves appearing slightly wider (nearly lanceolate), more evenly distributed, less markedly curved across the adaxial surface and paler green below than above, and having medial papillae on the abaxial epidermal cells. At the time I had seen only leaf fragments of a type—from Tibet near the border with Myanmar and India; it differed from the type of *T. wallichiana* by the abaxial surface having a broad region of large epidermal cells with medial papillae between the margin and stomata band. These features were seen more often in yew specimens from Yunnan and Sichuan than from northeastern India. Later, I received a B&W photocopy of a PE isotype from Dr. Z-y. Cao, who had earlier sent me leaf fragments of topotypes, and I found that the leaf arrangement and shape compare more closely to the type of *T. wallichiana* than to specimens from Yunnan and Sichuan. Thus, plants most typical of this variety, as seen in northeastern India and nearby Tibet, are intermediate forms distinguishable only by leaf anatomical characters. For this reason, *T. yunnanensis* is reduced to a variety. Nevertheless, it is important to differentiate these and one other related species (*T. florinii*), in order to distinguish the North American species (*T. brevifolia, T. globosa*) from their Asian relatives; otherwise, they may have to be included under *T. wallichiana*.

Variety *yunnanensis* is distinguished by the abaxial leaf marginal zone having relatively long narrow epapillose cells (2–4 cells wide) in contrast to the irregularly quadrate shape in var. *wallichiana*. This region of narrow elongate cells, 2–4 cells wide, is usually followed by much wider zone of papillose cells (5–15 cells across), but a transitional zone of papillose cells may be absent (Fig. 19B). In transverse sections the leaves also appear thinner and more revolute along margins, and specimens from Tibet (type locality), Myanmar and Naja Hill in northeastern India have taller epidermal cells along the abaxial leaf marginal zone. Another characteristic feature of var. *yunnanensis* is that papillae are mostly opposite and erect, best observed on the abaxial midrib (and also marginal cells). Photomicrographs of leaf stomata bands for species of *Taxus* in Jinxing and Yuxi (2000) show excellent resolution at 1000× for the medial (opposite) papillae that characterizes *T. wallichiana* var. *yunnanensis* (referred to as *T. yunnanensis*), in contrast to the marginal (alternate) arrangement seen in their *T. chinensis*, a species in which the papillae arrangement is similar to that of *T. wallichiana* var. *wallichiana*. Their photos presented for *T. wallichiana*, however, are of *T. contorta* as seen by the narrow linear cells with only a single row of papillae.

IB. Wallichiana Group, Subgroup *Chinensis*.—The *Chinensis* Subgroup is characterized by leaves having elliptical to rarely wide rectangular epidermal cells in transverse sections, notably larger on the adaxial surface than abaxial surface, and stomata that align both anticlinally and periclinally. Plants with angular epidermal leaf cells, as viewed in T-section, are included if they have yellowish (ochre) tinted branches, vestigial bud-scales at base of branchlets, and oblong leaves. The *Chinensis* Subgroup comprises *T. chinensis* and two proposed (undescribed) species in central China, occurring between 150 m and 2500 m in elevation, and three other species that extend into the Himalayas to Nepal and from the Pacific to the Philippines and to Indonesia, where mostly found above 2000 m (*T. obscura*, *T. phytonii*, *Taxus* sp. undescribed—*Taxus* REH).

Introgression with species of the *Sumatrana* Group, *Wallichiana* Subgroup and *Cuspidata* Alliance is evident in the northern-most and southern-most ranges of the *Chinensis* Subgroup. The northern range of the *Chinensis* Subgroup is in central China, represented by *T. chinensis*. In this region, *T. chinensis* has sharply divergent leaves devoid of papillae across 8–12 abaxial marginal cells (e.g., *Henry 7097* from western Sichuan). This is also seen in *T. umbraculifera* (*Cuspidata* Alliance) of northeastern China, Korea and Japan. At the southernmost range—in Indonesia and the Philippines—are two other species of the *Chinensis* Subgroup;

one *Taxus obscura* is similar to *T. chinensis* in the leaf shape, texture and lack of epidermal papillae across 8–9 marginal cells, and another, *Taxus phytonii*, that resembles *T. sumatrana* in the leaves having a reddish color along marginal and midrib epidermal cells. The latter is also similar to *T. wallichiana* in the linear leaf shape, two-ranked leaf arrangement, and in the persistence of bud-scales at base of branchlets.

Although leaf stomata in *Taxus* develop in periclinal rows, stomata in the *Chinensis* Subgroup often align transversely with the stoma anticlinally oriented. The *Sumatrana* Group, in contrast, has stomata arranged ±alternately to each other along adjacent rows. The anticlinal stomata in the *Chinensis* Subgroup, in which the stomata bands are further differentiated from adjacent epidermal cells by color, have been observed mostly in Taiwan and Luzon specimens. Other specimens from mainland China have less distinct stomata bands as evident by a more uniformly yellowish orange to reddish color on the abaxial leaf surface.

6. Taxus chinensis (Pilg.) Rehder, J. Arnold Arbor. 1:51. 1919. (**Fig. 22**). *Taxus baccata* L. [subsp. *cuspidata* (Siebold & Zucc.) Pilg.] var. *chinensis* Pilger, Pflanzenreich IV, 5:112. 1903. *Taxus cuspidata* Siebold & Zucc. var. *chinensis* (Pilg.) C.K. Schneider ex Silva Tarouca, Freiland-Nadelgehölz. 276. 1913. *Taxus wallichiana* Zucc. var. *chinensis* (Pilg.) Florin, Acta Hort. Berg. 14, 8:378. 1948. TYPE: CHINA. E SICHUAN: Wushanhsien, 2000–3000 m, year 1885–1888, Henry 7155, with seed (LECTOTYPE by Rehder & Wilson in Sargent, Pl. Wilson. 2:8. 1914: A-18682; ISOLECTOTYPES: BM!, E, GH!, K!, S fragment, US!). The A and GH sheets were annotated by Hu as "type" and "isotype," respectively. SYNTYPES: *Henry 6913, Farges 128.* Pilger cited several collections but did not designate a type.

Taxus baccata L. var. *sinensis* A. Henry, Elwes & Henry, Trees Gr. Brit. and Irel. 1:100. 1906. Nomen illegit. (ICBN Art. 53.3, Ex. 9). TYPE: CHINA. E SICHUAN: Wushanhsien, 2000–3000 m, 1885–1888, *Henry 7097* (LECTOTYPE designated here: E; ISOLECTOTYPES: A!, BM!, P!, US!). No specimens cited; original material at E, *Henry nos. 6913* from Hubei, *7097* and *7155* from Sichuan.

Common name.—China yew.

Distribution and ecology.—Mostly China (Guangxi, Gansu, Yunnan, Sichuan, Guizhou, Hubei, Anhui, Zhejiang), one collection from Vietnam (*Hiep & Chan 405*, P); forest, or forest margins, or open scrub, "under rocky cliffs," "often among bamboos," generally 1000–2800 m. Reported also at elevations as low as 150 m (Hu 1964). In Sichuan found more in the drier "mixed mesophytic forest" or "transitional zone" to an evergreen oak forest, in contrast with *T. wallichiana* occurring more in hemlock-spruce-fir forests (Wang 1961). In Vietnam "a shade tolerant" species of limestone in understory of evergreen forest of *Pinus kwangtungensis* Chun & Tsiang, *Podocarpus neriifolius* D. Don, *P. nilgeri* Foxw. and other broad-leaved trees, 1000–1600 m (Hiep 1998).

Taxus chinensis is distinguished by the pale yellowish green or "yellowish ochre" to "bronze" ("Prismacolor" chart) color on older branchlets ("dun colored"; Orr 1937) and by the relatively short (oblong), thick leaves, usually with conspicuous midrib papillae along epidermal cell walls. In making this distinction, I have independently reached the same conclusion as that by Pilger (1903, 1916), Orr (1937), Florin (1948a), and Hu (1964) for recognizing this taxon by its leaf and bud-scale characteristics, and also that by Orr (1937) for its branch color. Although branchlets of *T. wallichiana* vary in color from reddish orange to purplish, they lack this yellowish pigmentation, or are not yellowish green.

The leaf stomata bands are bordered by 4–12 marginal cells. The stomata develop in 11–19 (-21) rows per band and are sometimes evident on the midrib.

The name *T. chinensis* was once used for any yew occurring naturally in China (Rehder 1940), and also Taiwan, the Philippines, and Indonesia (Wilson 1926)—until the earlier legitimate names, which had been classified in *Cephalotaxus* and *Tsuga*, were applied; the ICBN (Art. 11.4, 11.5) requires that the earliest epithet be adopted regardless of the genus it was erroneously assigned to—unless conserved. Rehder (1936), for example, discovered one—*Tsuga mairei* Lemée & Lév., but continued to use his name, *T. chinensis*, whereas Parlatore (1868) and Pilger (1903, 1916) had reported several earlier names (*Cephalotaxus sumatrana, Cephalotaxus celebica*), whose epithets were eventually adopted, *T. celebica* (H.L. Li 1963), *T. sumatrana* (de Laubenfels 1978); however, the correct name for a single subtropical species as applied by these authors would have to be *T. wallichiana*.

Not all taxonomists accept just one species of *Taxus* in southern China; Florin (1948a), for example, felt there were at least two: *T. chinensis*, which he treated as a variety of *T. wallichiana* with distribution primarily

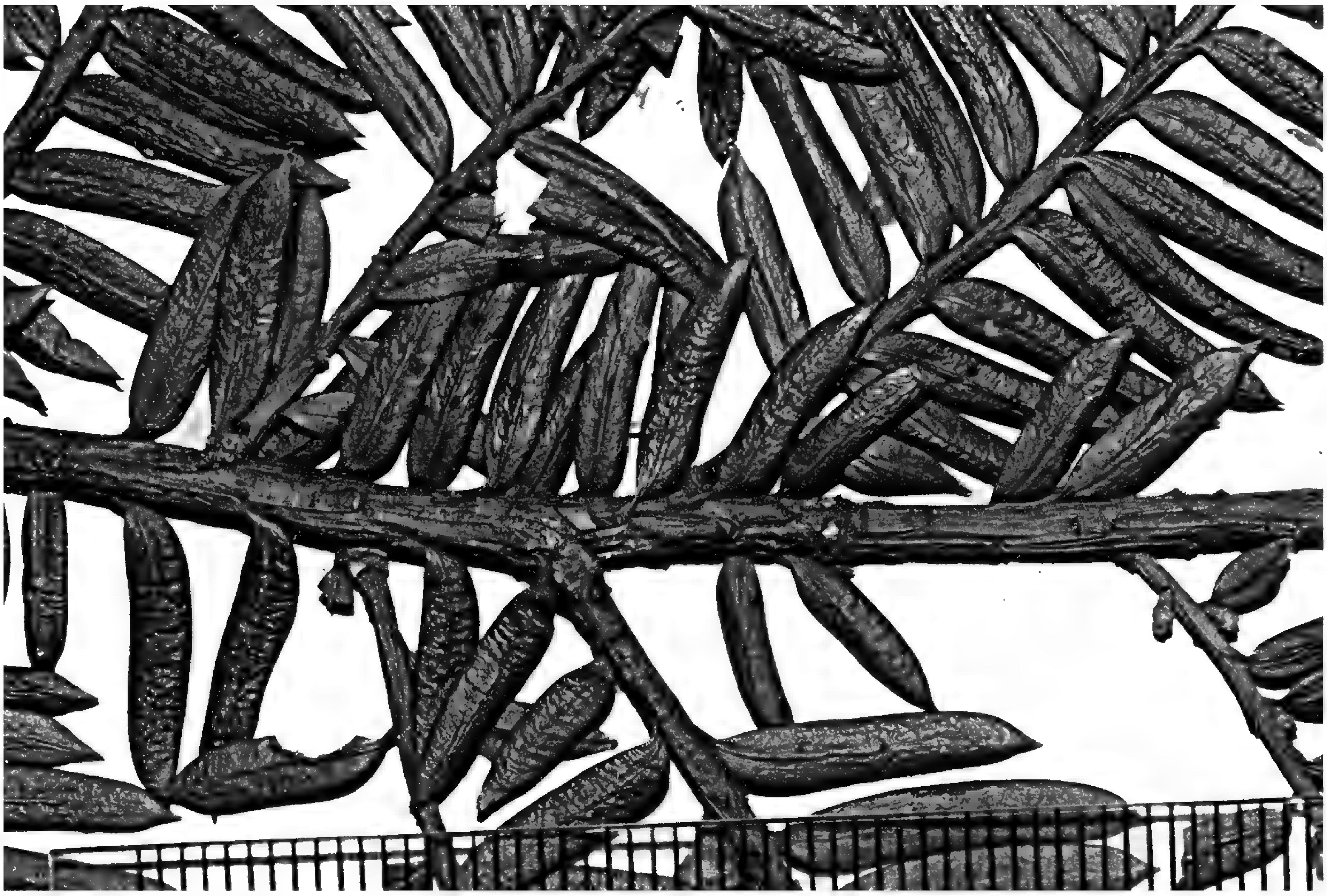


Fig. 22. *Taxus chinensis*, distinguished by absence of scales at base of branchlets and by the oblong leaves strongly convex across the adaxial surface, E Sichuan, China (isolectotype, K).

in Sichuan, and another that he considered a new species, *T. speciosa* Florin, which was not entirely new since it had been earlier described, as already indicated, and Florin himself mentioned the names in synonymy (Cheng & Fu 1978). Florin's two species were distinguished by the presence or absence of papillae on the abaxial leaf midrib, and var. *chinensis* was further distinguished from var. *wallichiana* (in the Himalayas) by the relatively shorter (oblong v. linear) leaves. He also indicated that *T. baccata* var. *sinensis* was synonymous with var. *chinensis* according to communications he had with Orr at Edinburgh, who had sent him leaves of Henry's collections (*Henry 7155*), which Henry himself had named var. *sinensis*. Although I have not studied the Edinburgh specimens of Henry's collections, the type for var.*sinensis* (*Henry 7097*) was selected based on material at E sent to Florin, who cited *Henry 7097, 7155*; the latter (7155) is the type for *T. chinensis*.

Botanists in China have since recognized up to four species and one variety of *Taxus* in China (Cheng & Fu 1978); however, they have misapplied and illegitimately combined previously known names. These included *T. chinensis* var. *mairei* (Lemée & Lév.) W.C. Cheng & L.K. Fu (illegit.), *T. wallichiana* (misapplied to *T. contorta*), and *T. yunnanensis* (superfluous for *T. wallichiana*). Hu (1964) followed Florin's treatment (1948a) except that she maintained *T. chinensis* as a species. Cheng & Fu (1978), however, reduced it again to a variety, but not according to ICBN, as just indicated. *Taxus chinensis* and *T. mairei* were considered to differ only as varieties because the distinguishing feature—presence or absence of papillae on the leaf midrib (undersurface)—could not always be clearly decided due to the occurrence of intermediates (Kwei & Hu 1974; Cheng & Fu 1978), and also because the type for *Cephalotaxus celebica* Warb. had not been studied (Hu 1964; Cheng & Fu 1978). Hu (1964) concluded that the type for *T. speciosa* did not significantly differ from that of *Taxus* (*Tsuga*) *mairei* (Lemée & H. Lév.) S.Y. Hu ex T.S. Liu, whereas the type for *Cephalotaxus celebica* might differ because the only specimen she saw from the Celebes Islands (*Neth. Ind. For. Serv. bb:19577*, A)

Fig. 23. ***Taxus obscura*****, distinguished in part by the branchlets and leaves overlapping in pressed specimens, the leaves often crisscrossing, in contrast to less crowded branchlets and a more parallel leaf arrangement in *T. phytonii*; Philippines, *de Laubenfels P668* (holotype, A).**

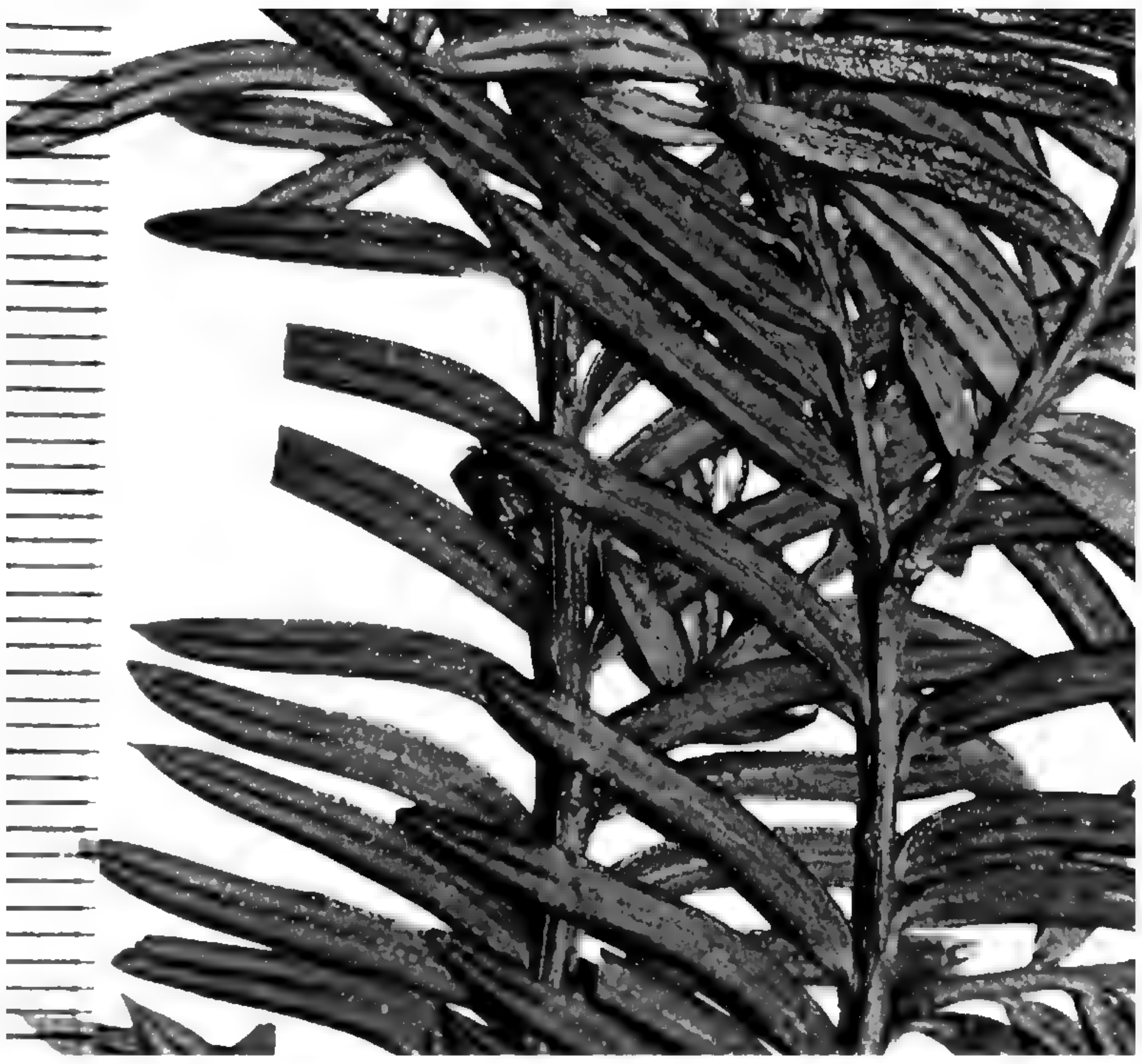


Fig. 24. ***Taxus phytonii*****, showing parallel leaf arrangement and persistent bud-scales at base of branchlets; Taiwan, *Wilson 11154* (holotype, A).**

had leaves with a papillose abaxial midrib, and in her opinion this was distinct from the types of *T. mairei* and *T. speciosa*.

I have studied the same specimens that Hu studied at the Harvard University herbaria (A GH, annotated by Hu, July 1955) and largely concur with her identifications of *T. chinensis* (Hu 1964). Additionally, I have studied other specimens from Sulawesi, namely the type for *Podocarpus* (*Taxus*) *celebicus* Hemsl. (K), *Teysmann 14190* (U), and a photocopy of a holotype fragment for *Cephalotaxus celebica* Warb. (S); these have similarly shaped leaves with a smooth midrib and broad marginal area of partially papillose cells on the abaxial surface; the "Neth. Ind For." specimen (A), in contrast, differs in having a papillose midrib as noted by Hu (1964). Based on Florin's (1948a) account and the similarity in leaf shape of the two type specimens, in which I have recognized *T. celebica* by its long acuminate leaves (tapering from mid region; e.g., *H. Smith 10401* [BM], Plate 6 in Florin 1948a), I see no reason to disagree with Florin—that the Warburg type for *Cephalotaxus celebica* lacks papillae along the abaxial midrib; thus, while Cheng and Fu (1978) could have adopted this name in their revised treatment of Taxaceae in the *Flora of China*, the correct name under their species concept is *T. sumatrana*; the basionym (*Cephalotaxus sumatrana*) was mentioned by Parlotore (1868) and Pilger (1903,), the latter of which was cited by Cheng and Fu (1978).

7. Taxus obscura Spjut, sp. nov. (**Fig. 23**). Type: THE PHILIPPINES. Luzon: Mt. Banahao, 2100 m, tree 8 m, common on ridge in mossy forest, aril bright red, 26 Aug 1978, *de Laubenfels P668* (holotype, A! [Spjut in adnot., *T. phytonii* var. *obscura* in ed.]; with seed; leaf with 11 stomata rows/band, abaxial marginal border of 4 smooth cells across in 2 quadrate rows and 2 inflated rows, trapezoidal in shape, followed by 5–6 rows of papillose cells; abaxil leaf midrib 15 cells wide, papillose on most cells, papillae covering the entire cell surface). De Laubenfels prepared a separate specimen from a male plant from the same gathering, P-669. Type also illustrated in de Laubenfels (1988).

Species haec ab *Taxus chinensis*, differt foliis linearibus, valdes discoloribus, 1–2 (-3) cm longis, 1.5–2.5 mm latis, acutibus, 0.200-0.300 mm crassis, supra convexa, subtus concava ad plana, stomata vitta ferriginea, (10–)11–13(–15) seriata/zonas.

Tree 5–15 m high; ultimate branchlets crowded, long, weeping or flexuous, yellowish green, dull rusty brown to orange with age; bud-scales scarcely persistent at base of branchlets, the scale scars similar to those of *T. chinensis*, longest persistent scales ca. 1 mm long (to 2 mm long in *Loher 7129*). Leaves often lost by the 3rd yr, spreading obliquely and closely overlapping in ± two ranks, frequently crisscrossing in herbarium specimens, especially near ends of branchlets, oblong, or slightly elliptical, recurved, evenly tapered to an acuminate sharply pointed apex, abruptly bent downwards to apex, 1–2(–3) cm long, 1.5–2.5 mm wide, 200–300 µm thick, dark olive green, resinous glossy and convex across adaxial surface to a recessed acute darker midrib with channels along each basal side, rugose in dried specimens; abaxial surface slightly concave across to a slightly elevated midrib, the midrib rounded to truncate, flush or slightly elevated, plane to abruptly revolute near margins; upper adaxial epidermal cells in transverse section broad elliptical to nearly short rectangular, thin-walled, (12–)20–25(–30) µm tall, 25–30 (–40) µm wide, abaxial margin 2–4(–11) cells across without papillae, papillose across 1–7 cells; marginal and midrib cells not as tall as those on adaxial surface, 12–15 µm tall, 15 µm wide, the epapillose marginal cells short trapezoidal to nearly quadrate, usually inflated in 2–4 rows, ± rectangular nearer stomata band, narrower and longer on midrib (3–7 l/w), usually entirely papillose across the midrib, rarely only partly papillose on midrib, or rarely lacking midrib papillae in lower half of leaf, papillae opposite or more often alternate in 1–3 irregular rows across each cell, covering most of the cell; stomata bands abruptly differentiated by color from surrounding epidermal cells, yellowish orange or yellowish green, broader than the maginal region; stomata diamphicyclic, anticlinal in orientation, in (10–)11–13(–15) continuous rows per band. Male cones subglobose in bud, 4 mm long, scales imbricate, overlapping in 4 ranks, microsporophylls lobulate; microsporangia ±8, pale pink with a broad dark reddish center. Female cones subcylindric, 2 mm long in bud; scales overlapping in 5 ranks, greenish, longest scale at base conduplicate; seed rounded, conical, 5–6 mm long, 4–5 mm diam., tapering to apex from the middle.

Common name.—Obscure yew.

Distribution.—Forest margins, 2000–2450 m. Myanmar, China (Fujian, Taiwan), The Philippines (Luzon), Indonesia (Sumatera, Sulawesi).

Additional specimens: **MYANMAR (BURMA).** Ruby Mines, 6500 ft, *Oliver* (K); Ruby Mines, no elevation data, 14 Sep 1894, *Oliver* (K). **CHINA. Fujian:** Puchen, *Chung 3866* (A). **THE PHILIPPINES. Luzon:** Mt. Pulog, 18°26' N, 120°54' E, tree 12 m, leaves dark glossy green above, dull green beneath, *Jacobs 7171* (K); Benquet Prov., Laguna, Mt. Santo Tomas, *Leaño 25128* (A, US); Mt. Tonglon, Aug 1906, *Curran s.n.* (US), *Curran 5015* (P, PH); Benquet Prov., *Merrill 839* (U, US); Mt. Pauai, 2450 m; *Sulit 7582* (A); Central Luzon, *Loher s.n.* (US); Mangitquiran, *Loher 4850* (K, US); Laguna Prov., Mt. Banahao, 2100 m, *Loher 7129* (US), *7139* (US); Luconia, summit of Mt Majayjay, 7500 ft, *ex Hook. Herb.* (K); Mt. Majayjay, *Wilkes Exped. 1838–1842* (GH); Lepanto Dist., Mt. Data, *Ramos & Edaño 40234* (K, P). Locality data uncertain: *Y. Sugilara, Ex TUS* (GH). **INDONESIA. Sulawesi:** Celebes an Ond., Gowa Lambaja, 2000 m, *Neth. Ind. For. Serv. bb:20887* (K). **Sumatera:** Tharolanden, 1400 ft, *Boschproephakion 7709* (U).

Taxus obscura is recognized by the pendulous branchlets and by the oblong leaves that in herbarium specimens show a sharp contrast in color between the adaxial and abaxial surfaces—dark glossy green above and yellowish orange (rusty) below (dried specimens). The weeping aspect of the branchlets is evident in herbarium specimens by their flexuous appearance.

Occasional specimens, e.g., *Loher 7129* (US) from the Philippines and *Lobb 461* (BM) from Malaya, have rigid branchlets. They resemble *T. kingstonii* but are referred to the *Chinensis* Subgroup by the narrow leaves with fusiform shaped epidermal cells on the abaxial midrib and irregularly shaped quadrate and inflated epidermal cells along the abaxial marginal zone. *Loher 7129* is assigned to *T. obscura* by the overlapping leaf arrangment with leaves frequently crisscrossing, but still differs from the majority of specimens assigned to this species by its rather long linear leaves, whereas *Lobb 461* with its more parallel two-ranked leaf arrangement is placed under *T. phytonii*, a determination that is further supported by the reddish colored epidermal cells on the abaxial midrib. Both specimens may be hybrids between *T. sumatrana* and *T. phytonii,* or may prove to be distinct varieties in further study.

In my 1996 annotations, a number of other specimens from Fujian, the Philippines and Indonesia were identified *T. kingstonii* by the rusty orange colored leaves with relatively thick lip-like margins (e.g., *Sulit 7582* [A], *Curran 7911* [US] and *Loher 4850* [US]). *Taxus obscura* was then distinguished as a variety of *T. phytonii* by the lack of marginal papillae on the abaxial midrib. In further study, more taxonomic emphasis was placed on branching and phyllotaxy, less on position of epidermal papillae, in distinguishing *T. obscura* from *T. phytonii*; consequently, other differences became apparent between these species. As a result the taxonomy of *T. obscura* broadened to include more specimens from the Philippines and Indonesia, while that of *T. kingstonii* was narrowed to exclude all specimens from these areas. The specimen from Fujian also differs by the leaves having a wider marginal zone of epiderma cells, 11 cells across, accompanied by lack of papillae on outer midrib cells; otherwise, it agrees with *T. obscura*.

Taxus obscura differs from *T. phytonii* not only in branching and phyllotaxy but also by leaf length and color and by the scales. The branchlets in *Taxus phytonii* spread more widely and scarcely overlap in pressed specimens, and the leaves are more distinctly linear and lie closely parallel along one side of a branchlet in pressed specimens, in contrast to a more crisscrossed crowded arrangement in *T. obscura*. The stomata bands of *T. phytonii* show a sharper contrast in color from the marginal cells, appearing yellowish green compared to the reddish margins and midrib, whereas stomata bands of *Taxus obscura* show less of a contrast in color from the adjacent midrib and marginal zones, usually the stomata bands appear yellowish orange, occasionally entirely green. The bud-scales of *T. obscura* are smaller and less persistent at base of branchlets, and cone scales are mostly imbricate, in contrast to scales of *T. phytonii* appearing more conspicuous at base of branchlets and decussate on cones.

8. Taxus phytonii Spjut, sp. nov. (**Fig. 24**). TYPE: CHINA. TAIWAN: mts. W of Karenko, 23 Nov 1918, *Wilson 11154* (HOLOTYPE: A!; ISOTYPE: US! Leaves with 12–13 stomata rows/band, abaxial marginal border of 6 smooth cells across with ± 2 rows of quadrate cells across and 4 rows of inflated trapezoidal cells, followed by a region of 10 papillose cells wide, the papillae mostly along cell walls).

Similis a *T. obscura*, praecipue differt folia longiora, linearis, 2–3 cm longis, complanatus, stomata zonatas flavovirescens, margines et costa rufus, perulae persistens.

Similar to *T. obscura*, tree 5–20 m; ultimate branchlets crowded, weeping or horizontal, yellowish green, dull rusty brown with age; bud-scales mostly persistent in 3–4 ranks, spreading, thick, ovate to lanceolate or cuspidate, concave, some smooth, others carinate, often pale yellowish or brownish, longest scales ca. 1 mm long. Leaves flaccid, two-ranked, not overlapping to slightly overlapping, linear falcate, slightly recurved, evenly tapered to an acuminate sharply pointed apex, 2–3 cm long, 1.5–2.5 mm wide, 200–300 µm thick; dark olive green and strongly convex across the adaxial surface to a depressed acute midrib that is channeled along base, mostly yellowish green to yellowish orange and slightly concave across the abaxial surface with a slightly elevated and rounded midrib, curved more near margins, or margins plane; adaxial epidermal cells in transverse section elliptical to nearly wide rectangular, thin-walled, 12–20 µm tall, 25–30 (–40) µm wide; abaxial marginal and midrib cells similar, or smaller, 12–15 µm tall, 15 µm wide, the marginal zone usually 9–13 cells across, usually papillose to about 4 cells from margins, papillose entirely in one specimen from India, or lacking in papillae across 8 cells in *Alvarey 18369* from Luzon, the epapillose cells short trapezoidal to nearly quadrate, usually inflated in 2–4 rows, rectangular nearer stomata band, narrower and longer on midrib, 3–7 times longer than wide on midrib, midrib papillose entirely or lacking in papillae from near the mid region to base of leaf, papillae strongly marginal in 1–3 irregular rows across each cell, often not covering the entire cell; stomata bands abruptly differentiated from surrounding epidermal cells by color, yellowish orange or yellowish green, broader than the marginal region; stomata diamphicyclic, anticlinal in orientation, 10–12(–14) rows/band, the abaxial margins and midrib usually reddish in herbarium specimens. Male cones subglobose in bud, 4 mm long, scales overlapping in 4 ranks, sporophylls lobulate, microsporangia ±8, pale pink with a broad dark reddish resinous center. Female cones subcylindric, and 2 mm long in bud; scales overlapping in 5 ranks, ±decussate, greenish, longest scale at base conduplicate; seed rounded, conical, 5–6 mm long, 4–5 mm diam., tapering to apex from the middle.

Common name.—Phyton yew.

Distribution.—2000–2800 m, Nepal, NE India, Thailand, China (Yunnan, Taiwan), Philippines (Luzon).

Additional specimens: **NEPAL.** *Williams 1014* (BM). **INDIA. Assam**: Pachaksihri, Laluma, 94°15'E, 27°45'N, 7000 ft, *Ludlow & Sherriff 3719* (BM). **THAILAND. Malaya:** *Lobb 461* (BM). **CHINA. Yunnan:** Wei-se Hsien 2800 m, tree 30 ft in forest *Tsai 59874* (A). **Taiwan.** Tongshi, *C-j. Chang: Tongshi 1, 5* (p.p., Rt. 210/6k), 7 (p.p., Rt. 210/16k), *TD-1* (wba). **THE PHILIPPINES. Luzon:** Mt. Banahao, *Ocampo 27920* (A, P); *Curran 7911* (US); Mt. Santo Tomas, *Elmer 6244* (P, US); Benguet Prov., *Alvarey 18369* (BM). Locality not clear—handwriting not legible, possibly Mt. Harui, *Harain Letty*, 17 Oct 1802, in adnot. *Taxus tosua topue, p.p.* (BM, GH).

Taxus phytonii differs from *T. obscura* by the relatively longer leaves, 2–3 cm long, that spread mostly parallel as seen along one side of a branchlet, and by other features as discussed under *T. obscura*. The leaf characteristics of *T. phytonii* are remarkably consistent at disjunct locations. For example, *Tsai 59874* from Yunnan and *Wilson 11154* from Taiwan appear almost identical not only in their leaf shape but also in their leaf color and in their leaf anatomy in which papillae are positioned marginally on midrib cells and in which stomata occur in 11–12 rows per band. *Ludlow & Sherriff 3719* from northeastern India also has these features, while differing slightly in papillae extending entirely across the abaxial leaf surface, instead of just 2–4 cells from the margin.

Taxus phytonii shows affinity to *T. wallichiana* by the relatively long narrow leaves that spread nearly parallel to each other, and also to *T. chinensis* by the yellowish tinted branchlets and by leaves that have broad elliptical epidermal cells as seen in transverse section. Additionally, the branchlet color and phyllotaxy of *T. phytonii* are similar to that of the North American *T. globosa*, which differs by longer leaf epidermal cells near the abaxial margins, also appearing quadrangular in transverse sections.

Etymology.—The epithet *phytonii* is in tribute to an achievement by a company named Phyton (formerly at Ithaca, NY, now in New Jersey) for the commercial production of the anticancer drug taxol by tissue culture; their production facility is located in Germany. Their commercial methodolgy hopefully will eliminate the harvest of wild plants to obtain the taxoids.

9–11. *Taxus* spp. undescribed, aff. *T. chinensis*. The following proposed species need further study.

9—Taxus REH (*T. rehderiana* ined.)**;** Vietnam, China (Taiwan), Indonesia (Sulawesi).
Taxus “REH” (*Taxus* aff. *chinensis*, Spjut in adnot. GH, P), recognized from five specimens, differs from the preceding two species (*T. obscura, T. phytonii*) by the longer leaves showing less of a contrast in color between the two surfaces, particularly in the paler green color on the adaxial surface, and also by the abaxial leaf surface having a wider marginal zone (smooth cells) except for two specimens from Vietnam that have a relatively narrow leaf margin (4 cells wide). Generally, the specimens resemble *T. wallichiana* in the long linear leaves but have more features in common with *T. chinensis* as seen in the pale yellowish green color of the branchlets, the minute scales at the base of branchlets, the elliptical shape of the leaf epidermal cells in transverse section, and in the tapered seeds. In my 1996–1997 annotations, the specimens from Vietnam were identified as *Taxus* aff. *chinensis*, while those from Sulawesi and Taiwan were referred to *T. phytonii*. Additionally, a specimen by *Purdom s.n.* (GH) from northern China: (Shaanxi: Tai-pei-shan *fide* Rehder & Wilson in Sargent 1914) is similar in the gross features of branching and color, and also in the leaf anatomical feature of marginal papillae on the abaxial midrib epidermis; however, it is referred to *T. biternata* by the relatively fewer stomata rows (7 rows per band), and by the persistent dark spreading scales at the base of branchlets. A specimen from the Philippines, *Loher 7129*, as discussed earlier under *T. obscura*, may also belong here.

10–11. Taxus spp. aff. **chinensis. 10—Taxus “OCR”** **(***T. ocreata* ined**.** Spjut in adnot**.,** A, BM**);** China (Yunnan, Sichuan), rocks, 1500 m. **11—Taxus “SCU”** **(***T. scutata* ined**.** Spjut in adnot., A, BM) China (Yunnan, Sichuan, W Hubei), 1200–1400 m.
These proposed species are similar to *T. chinensis* except for conspicuous persistent bud-scales at base of branchlets, in which they differ from one another by the bud-scale characteristics. *Taxus* SCU has persistent scales, numbering 10–20 or more, loosely attached with a shape like overgrown toenails that are ready to fall off. The scales in *Taxus* OCR, in contrast, tightly adhere to branchlets and look more like teeth.

Taxus OCR shows remarkable similarity at two disjunct locations, *Cheng 2890* from Sichuan and *Feng 11937* from Yunnan, but there are also intermediates in duplicates of *Cheng 2890*. It is not clear, however, whether these came from the same plant. Additionally, Feng also collected at the same site in Yunnan on two occasions where his first collection (*Feng 11937*) was from a tree and his second (*Feng 12105*), just nine days later, was from a shrub that was also indicated to be common. Collectors do not always pick from the same plant when assigning collections to the same number. It is also apparent from genetic studies in other species of *Taxus* that unique genotypes exist within populations (El-Kassaby & Yanchuk 1995).

Taxus SCU is also similar to *T. wallichiana* that differs by the fewer scales and longer leaves; however, occasional specimens from the Himalayas and China also appear intermediate by the presence of fewer scales and shorter leaves, or by longer leaves and more scales.

The combination of characters for *Taxus* OCR and SCU appear, on one hand, worthy of taxonomic distinction, and especially necessary for taxonomic clarification of related species—*T. wallichiana* and *T. chinensis*, while on the other hand, it would seem prudent that field studies be conducted to evaluate variation in the bud-scale character features at a particular location.

II. *SUMATRANA* GROUP

The *Sumatrana* Group is characterized by leaves having a relatively broad region of marginal cells adjacent to the stomata bands, usually from 8–36 cells across. This is often evident in dried specimens by a glossy reddish discoloration. The epidermal (accessory) cells in stomata bands are further differentiated from marginal and midrib regions by their shorter length and broader width. Leaves in the other species groups usually have stomata bands bordered by fewer cells, or they are less differentiated by color and development of papillae. The *Sumatrana* Group (Spjut 1998b, 2000c) is generally found at lower elevations on mainland Asia, below 1700 m (Hu 1964), or below 1200 m (Li & Fu 1997), than *T. wallichiana*, which usually occurs above 2300 m.

The taxonomy of this *Sumatrana* Group is difficult due to overlapping character traits among the species and varieties that follow. Previous taxonomists have recognized only one taxon in this group, either as a variety (Cheng & Fu 1975, 1978; Li & Fu 1997) or as a species (Florin 1948a; Handel Manzzetti 1929; Hu 1964), but they have not applied the correct name. *Taxus sumatrana* has been the name applied to all yews in southwest Asia (de Laubenfels 1978), but this is antedated by *T. wallichiana*. This very broad concept of *T. wallichiana* leads to difficulty in distinguishing between *T. cuspidata* and its allies in the *Baccata* Group. Farjon (1998, 2001) indicated that *T. sumatrana* occurs only in Indonesia and the Philippines, but his interpretation, as also stated elsewhere, is without taxonomic support.

Thus, I have found it necessary to recognize more than one species in the *Sumatrana* Group—based on differences in the leaves. Within the *Sumatrana* Group, I distinguish *T. mairei* by the narrow elliptic to oblong leaves tapering to an acute to obtuse apex and by the raised midrib on the abaxial surface, appearing truncated to channeled with relatively short trapezoidal, somewhat inflated (mammillose) epidermal cells (Spjut 1998b; and as indicated in crude illustrations that accompanied my annotations: A, GH in June 1996; BM in April 2005). Leaves of *T. sumatrana* differ by the linear to lanceolate shape tapering to an acuminate apex and by the nearly rectangular shape of abaxial epidermal cells. *Taxus mairei* var. *speciosa* differs from typical *T. mairei* in features of rigidity of branches and leaves, branching pattern, phyllotaxy, and color (in dried specimens), but differences overlap in many of the character attributes. One new species, *T. kingstonii*, is recognized by its slightly larger persistent bud-scales at base of branchlets, and by leaves that are rigid, evenly tapered to base and apex, and by the rusty orange color in the herbarium, especially along the stomata bands. Differences in seed shape and color are also evident among these taxa, but field studies are needed to better evaluate the taxonomy of seed characteristics.

Although the width of the abaxial leaf marginal zone varies in *Taxus*, this, nevertheless, appears to have partial correlation to species within the *Sumatrana* Group. For example, among 15 specimens cited for *T. celebica* (Spjut 2007, Fig. 6), which has the widest leaf margin (that borders the stomata band) of any species of *Taxus*, 11 specimens were found to have 27 or more marginal cells. Two specimens with 22 and 24 bare cells across the abaxial leaf margin are within the range commonly found for *T. mairei*, while two others with a narrower marginal border fall within the range of *T. kingstonii*. Whether more taxonomic emphasis should be placed on the number of cells across the abaxial marginal region needs further study.

A wide range in variation for shape and length of epidermal cells has been observed in juvenile foliage of *T. mairei*, whereas the mature leaves are distinguished by the inflated, short wedge-shaped epidermal cells (1–3× l/w) on the abaxial midrib. Juvenile and adult foliage may differ in conifers such as *Podocarpus*, in which species cannot be differentiated by their juvenile foliage (de Laubenfels 1969). Leaf shape and development of papillae in *Taxus* may also vary with exposure on the same plant as noted for plants in Taiwan and Indonesia (de Laubenfels 1978, 1988). Differences in mature and juvenile leaves of *T. mairei* are noted in this study in which mature leaves are oblong and taper to an acute apex, while immature leaves may appear elliptical and acuminate to apex.

12. Taxus celebica (Warb.) H.L. Li, Woody Fl. Taiwan 34. 1963. (**Fig. 25**). *Cephalotaxus celebica* Warburg, Monsun. 1:194. 1900. Type: INDONESIA. Sulawesi (Celebes): southern, Gipfel des Wawo-Kraeng [one of the summits of G. Bonthain], on the forest-clad summit, 2800 m [Nov 1888], *Warburg 16889* (holotype: S photocopy!; isotype: B-destroyed). Only one specimen was cited by Warburg, although he did not specifically indicate that it was the type. The S specimen is a fragment of the original collection at B. Warburg distinguished his *C. celebica* from *C sumatrana* Miq. and excluded *Podocarpus celebicus* Hemsl.

Podocarpus celebicus Hemsley, Kew Bull. 39. 1896. Type: INDONESIA. Sulawesi (South Celebes): Bonthain Peak, 7000–10,000 ft, Sep 1895 *A.H. Everett 35* (holotype: K!).

Common name.—Celebes Yew.

Distribution and ecology.—Nepal, Bhutan, NE India, South Vietnam, China (Tibet, Yunnan, Sichuan), Indonesia (Sulawesi); forest margins below 1530–3100.

Taxus celebica is recognized by the relatively large, glossy, often pale green, lanceolate plane leaves that taper to an acuminate apex and by the narrow stomata bands relative to a broad marginal zone of long (>10× l/w) rectangular cells, (18–)24–36 cells across. The stomata rows generally number (8–)12–14 per band, compared to (11–)14–19(–21) rows in *T. mairei*. Variation in number of marginal cells (Spjut 2007) appears partially correlated to the region of the leaf where sections are obtained as the leaf blade is strongly tapered from base to apex.

Leaf stomata bands of *T. celebica* often appear distinct from other species in the genus by the short wedged-shape (<3× l/w) accessory cells that have relatively small (minute) medial papillae, appearing more distantly spaced from one another, in contrast to papillae covering the entire surface of the epidermal cells in other species. Examples are specimens from Yunnan (*Forrest 7798*), Sichuan (*H. Smith 10401*, Plate 6 in Florin 1948a), South Vietnam (*Schmind s.n.*), Bhutan (*Cooper & Bulley 2833*), Khasia (*Clarke 38308*), and Tibet (*Kingdon Ward 19324*).

Intermediates between *T. celebica* and *T. mairei* var. *speciosa*, however, are apparent. My 1996–1997 annotations of *T. celebica* were based on leaves having most of the following taxonomic features: long linear to lanceolate shape, acuminate apex, long epidermal cells, obscure palisade layer of parenchyma cells, and appearing flattened in T-section. Recently, it was decided that taxonomic weight should be given to the lanceolate shape of the leaf tapering to an acuminate apex (Spjut 2007). Examples that were formerly annotated *T. celebica*—but subsequently referred to *T. mairei* var. *speciosa*—are from Fujian (*Price 1258b*), Guizhou (*Steward et al. 328*), Sichuan (*Wang 20541*), Guangdong (*Nanling Expedition 1838*), and Ningxia Huizu (*Chao 1223*). Other plants of var. *speciosa* with similar but more distant phyllotaxy are cultivated at the Royal Botanic Gardens at Kew and at Edinburgh (photos in Krüssmann 1985, plate 133; van Gelderen and van Hoey Smith 1996), and juvenile leaves received from Phyton Inc. (as *T. chinensis*). The cultivated plants were reportedly grown from seed of *Wilson 1265*. It is interesting to note that herbarium specimens of the wild plants collected in China and of a plant cultivated at the Kew Gardens appear very similar (www.worldbotanical.com).

13. Taxus kingstonii Spjut, sp. nov. (**Figs. 26–27**). Type: CHINA. Taiwan: Arisan Prov., Kagi, 2833 m [Mt. Alishan], tree 25 ft × 2 ft, only one seen, 2 Feb 1918, *Wilson 9738* (holotype: A! [with male cones; leaves with 10–11 stomata rows per band, abaxial margins of 8 smooth, thick-walled, trapezoidal, anticlinal to periclinal arranged cells across, followed by 5 rows of papillose cells, midribs 12 cells wide, mostly smooth, papillose on outer 2 rows]; isotypes: BM! [leaves with 13 stomata rows and 9 marginal smooth cells, midribs mostly smooth except upper third of leaf, papillose on outer 2 rows of cells], K!, US p.p.!).

Similis a *T. sumatrana* et affnibus, praecipue differt folias coloris ferruginibus vel calendulibus; folia obliquata disposita, rigida, oblonga

Fig. 25. *Taxus celebica*, distinguished by the relatively flat leaf with a broad abaxial marginal zone and narrow stomata bands; Indonesia, Sulawesi, *Everett 35* (holotype, *Podocarpus celebicus*, K).

ad elliptica vel sublanceolata; ventralibus epidermae cellulae quasi rectangularis, inflatus proximus marginalis, costa interdum papillosa, proparte papillosa versas de marginali, sine papillae (7–)8–12(–20) cellulae marginales latis; stomata 11–15 seriata/zona.

Shrub or tree to 12 m high, bole to 65 cm diam; branchlets unequally (type) to equally divided, yellowish green and gradually becoming yellowish with tint of either red, orange or brown; bud scales mostly persistent, 3–4 seriate, turgid, ovate, concave, carinate near apex on upper scales, tan to chestnut brown, lower bud-scales ca. 1.5 mm long. *Leaves rigid, spreading usually at less than right angles to branchlets, not parallel to one another, more evenly tapered to base and apex than in T. mairei*, lanceolate, narrowly elliptical to oblong (type), or linear in other morphs, *evenly tapered to an acute, sharply pointed apex, recurved and/or twisted downwards*, 1.5–2.5 cm long, 3.0–3.5 mm wide, 0.35–0.50 mm thick, dark green and convex above to rounded midrib, the adaxial midrib somewhat acute in lower half, often not evident near apex, paler green to yellowish green and convex below, or plane to concave below to rounded or flush midrib, often with orange tint in the herbarium, or dull rusty brown in the herbarium, thickened and liplike near margins, or plane and slightly revolute near margins; adaxial epidermal cells in T-sect. wider than tall, nearly wide rectangular, or elliptical in T-sect., usually 20–25 um tall and 25–30 um wide, thin-walled, slightly inflated; abaxial epidermal cells similar in T-sect. but not as large, 15–25 um tall, 20–30 um wide, slightly inflated near margin in 2–5 rows, more nearly rectangular in 7–11 cell rows near stomata bands, usually relatively short on midrib, 1–4(–10)× l/w, sharply 4–6 angled, often wider and more slanted at one end (trapezoidal), not inflated (in T-sect) as in *T. mairei*, papillose to ca. (7–)8–12(–20) rows of cells from margins, typically without papillae on midrib (except young leaves), or partially papillose on outer midrib; papillae submarginal to medial in 2–3 irregular rows across each cell. Stomata bands broader than the non-stomatal region, olive green in fresh material; yellowish orange in dried leaves; stomata continuous in 11–15 rows, separated by 1–2 rows of accessory cells, stoma often with a blackish halo. Male cones globose, ca. 4 mm diam, yellowish green, scales generally 4-seriate; pollen sacs mostly 6, pale pink with reddish mid region and patchy resinous areas.

Figs. 26-27. *Taxus kingstonii*, distinguished in part by leaf blades twisted and tapered to base; herbarium specimen and illustration, China, Taiwan. 26 (top). *Wilson 9738* (holotype, A). 27 (bottom left). H-I. Li., *Woody flora of Taiwan* (1963, Fig. 2).

Female cone in bud subcylindric, ca. 2 mm long, greenish, scales mostly 5-seriate, conduplicate at base, maturing on 1^{st} yr branchlets; seeds ovoid, dull, tan or purplish, stained by aril, angular where tapering to apex, or not angled, to 7 mm long, 4 mm wide.

Common name.—Kingston yew.

Distribution and ecology.—India (Khasi Hills), Myanmar, China (Tibet, Gansu, Shaanxi, Sichuan, Yunnan, Taiwan); forest margins or summits, 2450–2833 m in Taiwan, to 800 m on mainland Asia.

Additional specimens: **INDIA. Khasia:** *Hooker L77* (PH), *1337* (K); *Simmons 484* (P), Nungluai, 5000 ft, *Mann* (K, P). **MYANMAR (Burma):** Bernsrdmyo, Ruby Mines, 5600 ft (K). **CHINA. Tibet:** Oriental, Haut Mekong, Tsekou to Nekou, *Soulie1411* (P: 2 sheets). **Gansu:** *F. N. Meyer 1790 ex USDA* (P). **Shaanxi (Shensi):** Tsin-lin au Lao-lin, 3000 m, year 1872 *Davis s.n.* (P). **Sichuan:** Tachienlu *Cheng 1001* (BM), *Cheng 1475* (P). **Yunnan:** Shweli-Salween Divide, 10,000 ft, 25°20 N, shrub 10–20 ft, open shady thickets, *Forrest 11789* (BM, K), Salween, *Forrest 12087* (K, S: C-2093), *Forrest s.n.* (A); Ma-Chang-Kai, valley, 25°30 N, 6000 ft., shrub, 20–30 ft., in thickets, Dec 1918, *Forrest 9462* (A, K), *Forrest 15945* (BM, K); Salween E of Tengyueh, to summit of Shwell, Shwelli River, *Rock 7587* (US). **Taiwan:** Paseian San [Pahsienshan], *Hsi 165* (PH); *Liu et al. 437*, (M, T, US; Fig. 3 in Li, Woody Fl. Taiwan,); Mt. Ammachan, *Liu 0389* (A, K), Arizan, Nitak (PH); Mt. Ammashan, Taichung Hsien, *C.C. Tseng s.n.* (BH); *C-j. Chang* without locality data, *Tongshi #6*, 4 Mar 1993 (wba).

Taxus kingstonii is recognized by its relatively turgid recurved leaves (twist and curve downwards along their blades) that taper rather evenly to apex, and by their rusty orange color on the abaxial leaf surface (dried specimens). In herbarium specimens, the leaves often crisscross, especially near apex of branchlets. In other species of the *Sumatrana* Group, leaves are more reddish or greenish in color and evenly two-ranked and tightly adpressed to branchlets. The Kingston yew often has tightly adhering, strongly nerved bud-scales at the base of young branchlets, whereas scales in related species are similar to those of *T. chinensis*—generally smaller, less imbricate, or often not evident. The Kingston yew generally occurs at elevations between that of *T. mairei* (below 1200 m) and *T. wallichiana* (above 2300 m).

The Kingston yew tends to have the narrowest abaxial leaf margin among species of the *Sumatrana* Group, while this does not appear to be offset by wider stomata bands as most specimens were found to have 12–13 stomata rows per band (Spjut 2007). The width of the marginal region shows two patterns, one occurring around (6–)8–9 cells wide as seen by plants from Myanmar and Taiwan, and another ranging from (10–)12–16(–20) cells wide as seen in plants from Yunnan, Gansu, and Sichuan. This is in contrast to leaves of *Taxus mairei* that show a wider range in variation in which most specimens have14 stomata rows per band and 14–24 marginal cells without papillae. This indicates a higher density of stomata in leaves of *T. mairei*. Variation in leaf anatomical data for *T. kingstonii* may be due to hybridization with *T. wallichiana* in northeastern India, with *T. chinensis* and *T. mairei* in Shaanzi, Gansu and Sichuan, and with *T. celebica* in Yunnan.

Taxus kingstonii includes specimens from Yunnan, India, and Taiwan that have been considered a distinct species by their long narrow, wide spreading leaves tapering to an acuminate apex as recognized by the epithet in regard to the acuminate leaf (Spjut unpublished, key to species of *Taxus*, USDA Memorandum 1995). They have the characteristic pale to rusty orange color on the abaxial leaf surface, but differ in the broader marginal zone of trapezoidal to short rectangular epidermal cells, a feature that is seen more in *T. mairei*. However, the abaxial midrib and marginal epidermal cells have thicker walls in contrast to bulging (mammillose) cells of *T. mairei*; the epidermal cell walls of *T. mairei* are often so thin that they appear transparent to the chloroplast of the spongy parenchyma cells. The character attribute of the acuminate leaf is similar to that of *T. celebica* and *T. sumatrana*; the latter distinguished by dried leaves appearing blood red along the midrib and marginal zones in sharp contrast to the yellowish green stomatal bands, the former by larger and more flattened leaves with a pale green color on the adaxial surface. Some specimens from India were annotated during 1996–1997 as *T. celebica*; however, in further study of a large number of specimens obtained by Professor C-j Chang (Purdue University) from Taiwan, the concept of *T. kingstonii* was broadened to include the specimens from northeastern India and Yunnan.

Despite the similarity of *T. kingstonii* to other species in the *Sumatrana* Group, it will probably be confused most often with *T. chinensis*. A number of specimens at BM, K and P, which I annotated *T. chinensis* (Oct 1997) at the time of my visit to these institutions—based on examination of leaves under a dissecting scope—were later discovered to belong to *T. kingstonii* as a result of examining leaf sections under a compound microscope and discovering that papillae were lacking along the abaxial midrib and marginal zones. These specimens, including the type from Taiwan, appear closely related to *T. chinensis* by the leaf epiderimal cells appearing larger on the adaxial surface than the abaxial surface as seen in transverse sections, and by the abaxial leaf surface having a rounded keeled midrib.

Taxus kingstonii is named in honor of David G. I. Kingston, a chemist who has done extensive work on elucidating and summarizing the taxane chemistry of the genus (e.g., Kingston 1996, 2005; Kingston et al. 1990). Taxol, from which the drug paclitaxel is marketed and used to treat ovarian and other cancers, was originally isolated from dried bark of *T. brevifolia*; however, fresh leaves of many species of *Taxus* have proved suitable for obtaining taxoids. Taxol was first characterized by Monroe Wall's group (Research Triangle Institute, Wani et al. 1971). They also discovered other significant antitumor agents such as camptothecin and holacanthone (Wall et al. 1972).

14. Taxus mairei (Lemée & H. Lév.) S.Y. Hu ex T.S. Liu, Illustr. Native & Introd. Lign. Pl. Taiwan 1:16. 1960. (**Figs. 28–29**). *Tsuga mairei* Lemée & H. Léveillé, Monde des-Pl. sér. 2, 16:20. 1914. *Taxus chinensis* Rehder var. *mairei* (Lemée & H. Lév.) W.C. Cheng & L.K. Fu, Fl. Hupehensis 1:28. 1976 (also indicated as comb. nov. in Fl. Reipub. Pop. Sin. 7:443. 1978). *Taxus wallichiana* Zucc. var. *mairei* (Lemée & H. Lév.) L.K. Fu & Nan Li, Novon 7:264. 1997. TYPE: CHINA. YUNNAN: Dongchuan, 700–800 m, May 1912, *Maire s.n.* (HOLOTYPE [fide Rehder 1936]: E; ISOTYPES: A [fragment from E]!, BM!, P!).

Rehder (1936) reportedly found a holotype for *Tsuga mairei* at the Royal Botanic Garden at Edinburgh (E); however, it is not clear whether the Maire type at E was the only specimen "used" by the authors (ICBN Art. 9.1) since Lemée and Lévéille (in Léveillé 1914) did not cite specimens, and I have seen duplicates of Maire specimens at the Museum of Natural History in London (BM) and at the Museum of Natural History in Paris (P). The duplicate material at BM, although not from the Lévéille Herbarium, was also from E, presumably distributed after they purchased the Léveillé Herbarium in 1919 (Stafleu & Cowan 1979). Additionally, a fragment of the holotype of *T. mairei* is preserved in the Arnold Arboretum (A). The ICBN (Greuter et al. 2000) regards a fragment of a holotype as an isotype if the holotype was designated (Art. 8.3, Ex. 5), but in my opinion a distinction such as merotype should be made because other duplicate specimens at other institutions (isotypes) may have come from different plants.

Taxus mairei is distinguished from other species of the *Sumatrana* Group by the two ranked leaves spreading at nearly right angles, by the abaxial surface of leaves having a truncated but elevated midrib with epidermal cells larger in diameter than those on the adaxial surface (as seen in T-section), appearing mammillose. The midrib is usually channeled, especially in the mid region of the leaf.

Taxus mairei, like *T. chinensis*, has a long history of nomenclatural confusion. As indicated previously, the original authors thought they had a species of hemlock (*Tsuga*). Rehder (1936), upon discovering that *Tsuga mairei* Lemée & H. Léveillé (Léveillé 1914) belonged to *Taxus*, treated it as a synonym of *T. chinensis*; however, the ICBN (Art. 11.4) requires the earlier epithet, *mairei*, be adopted (S.Y. Hu, in Liu, Illustr. Nat. Ind. Lign. Pl. Taiwan 16. 1960). Cheng and Fu (1978) also made the illegitimate combination—*T. chinensis* var. *mairei*—which has since been transferred—*T. wallichiana* var. *mairei* (Lemée & H. Lév.) Fu & Li (in Li & Fu 1997). It must be emphasized that "in no case does a name have priority outside the rank in which it is published" (Art. 11.2); the epithet *chinensis* was employed at the varietal rank by Pilger (1903), and also by Florin (1948a). Rehder recognized *T. chinensis* as a species in 1919; whereas the epithet *mairei* was not used for a variety, but as a species epithet by Lemée and Léveillé in 1914, five years earlier; therefore, *mairei* has priority over *chinensis* in choice of epithet for a species, but has no priority whatsoever as a variety.

Regardless of the nomenclatural misapplications of the name, the taxonomic application in recent years has been to treat yews in subtropical China under the epithet "*mairei*" if their leaves lack papillae on the abaxial midrib (Fu et al. 1999). The species epithet *sumatrana*, an earlier available name, was not applied because botanists in China had not seen its type (Cheng & Fu 1978; Hu 1964; Li & Fu 1997); instead, they selected *mairei* for the varietal epithet—placing it under *T. wallichiana*.

Two varieties are recognized by differences in rigidity, branching, and phyllotaxy.

14a. Taxus mairei var. mairei

Common name.—Maire yew.

Distribution and ecology.—China (Sichuan, Yunnan, Anhui, Guizhou, Guangxi, Jiangxi, Fujian, Hunan, Guangdong, Zhejiang, Taiwan); forest margins, 300–1300 m.

Taxus mairei var. *mairei* is identified by zigzag branching, by the complanate leaves—arranged neatly in two-ranks in which the margins of adjacent leaves along one side of the branchlet are closely parallel—and by the mammillose (enlarged) cells on the abaxial midrib. Leaves also appear sessile; i.e., they are adpressed to the branchlet at the base of the blade, and spread at right angles as they bend and twist. Leaves of var. *speciosa* are similar in shape but often larger in size, more unequally spaced along one side of a branchlet, differ only slightly in anatomy, but often differ in color—by remaining green when dried. Specimens of var. *speciosa* tend to have less dichotomous branching, or a more distinct monopodial branch.

The zigzag branching of *T. mairei* is perhaps an ancestral trait. This branching is seen mostly in southeastern China along coastal provinces as far north and inland as Hunan. Yews further north near Vladvostok, Russian Federation (*Palczevski 3601*), South Korea (*Wilson 9332*), and Japan (*K. Muijabe* 17 Sep 1910, A) show other dichotomous branching treated under *T. umbraculifera* var. *microcarpa*, which is also recognized by crowded (overlapping) leaves oriented in ± decussate ranks. It may be noted that leaves of *T. umbraculifera*, *T. chinensis*, and *T. kingstonii* are relatively thick with a rounded (keeled) midrib, in contrast to thinner leaves in *T. mairei* that have a truncated to channeled midrib. *Taxus biternata*, a common species in temperate E Asia, easily recognized for its much-divided branchlets, has a phyllotaxy that is more similar to *T. sumatrana* than to other species of the *T. cuspidata* Alliance.

Occasional specimens of *T. mairei* are recognized to have an abaxial leaf epidermis of the *T. chinensis* type—as seen by the development of papillae on the midrib and along the marginal zone to ca. 8 cells from margin. Examples are *Ching 1676* (A, P) from Zhejiang at "2600 ft," and

Figs. 28–29. *Taxus mairei* var. *mairei*, distinguished by the isodichotomous branching and the closely parallel leaf arrangement. **28 (top).** N Yunnan, *Maire s.n.*, photo of specimen at E (holotype) with fragment at A (isolectotype). **29 (bottom).** *Maire 131* (BM).

Chiao & Fan 464 (A, P, US) from Sichuan at "200 m." These specimens also lack the enlarged mammillose midrib cells that characterize *T. mairei*, and the specimen from Zhejiang further differs in having rectangular shaped epidermal cells in transverse section. These specimens may be hybrids, or perhaps they are relicts of a *T. florinii*-*T. chinensis* complex from which *T. mairei* may have evolved. Leaves of *T. engelhardtii* from an Oligocene deposit in Europe are remarkably similar to these specimens of *T. mairei* in leaf arrangement, shape and anatomical details (Spjut 2007).

14b. Taxus mairei (Lemée & H. Lév.) S.Y. Hu ex T.S. Liu var. **speciosa** (Florin) Spjut, comb. et stat. nov. (**Fig. 30**). Basionym: *Taxus speciosa* Florin, Act. Hort. Berg. 14(8):382. 1948. Type. CHINA. Guizhou: [Fanjing Mts.] Kiangkow, 450 m, in light woods, tree 8 m high, fruit red, 8 Dec 1930, *Y. Tsiang 7525* (holotype: S; isotypes: A!, BM!, K!, NY photocopy!, US!).

Common name.—Special yew.

Distribution and ecology.—China (S Shaanxi, Sichuan, NE Yunnan, Guizhou, N Guangxi, Hunan, Guangdong, W Hubei, Jiangxi, Zhejiang, Fujian, Taiwan); forest margins, near streams or open areas on hillsides, 100–750(–1600) m.

Taxus mairei var. *speciosa* is recognized by having alternate branchlets along a common branch, and by leaves appearing greenish and unequally spaced along branchlets in dried specimens. It appears to occur more frequently in the interior provinces of China, in contrast to var. *mairei* being found more along coastal provinces; however, exceptions include the type for *T. mairei* from N Yunnan and other specimens from Sichuan.

Taxus speciosa was described by Florin to distinguish a yew in China by the leaves having a smooth midrib from one other in China that he recognized to have a papillose midrib, which he had determined to represent *T. wallichiana* var. *chinensis* based on study of its type. The taxonomic feature of a smooth midrib was also erroneously described for *T. chinensis* by Handel-Mazzetti (1929). Florin (1948a) correctly realized that *T. chinensis* was closely related to *T. wallichiana* even though he only mentioned the type for *T. chinensis* and not *T. wallichiana,* although he had studied a duplicate specimen of the original material (*Wallich 6054A*). However, Florin incorrectly provided another name for the species that he distinguished by the absence of leaf papillae on the abaxial midrib; he cited not only an earlier name—*Cephalotaxus celebica*, but also its type (*Warburg 16889*). Other authorities soon realized this error (Cheng & Fu 1978), and Florin's name was replaced by *T. mairei* S.Y. Hu (Liu 1960), who had also distinguished it from *T. chinensis* according to Florin taxonomy as evident by her 1955 annotations of Harvard specimens (Hu 1964).

Notwithstanding, *T. mairei* was soon replaced by an earlier name *T. celebica* (Warb.) Li (1963), who recognized only one species in China even though Hu (1964) indicated she adopted *T. mairei* because the type for *Cephalotaxus celebica* Warb. might differ based on one specimen she saw from Sulawesi that had a papillose midrib. She might have further assumed that the Berlin type of *C. celebica*.was destroyed; however, as noted previously, Florin took a fragment of the Berlin type to Stockholm. It is surprising that an earlier name mentioned by Pilger (1903), *C. sumatrana*, had been neglected, until finally applied by de Laubenfels (1978). Although *T. speciosa* was founded upon nomenclatural error, it can still be recognized if its type can be shown to belong to a distinct species; however, in this study, the epithet is retained for a distinct variety.

15. Taxus sumatrana (Miq.) de Laubenfels, Kalikasan, Philipp. J. Biol. 7:151. 1978. (**Fig. 31**). *Cephalotaxus sumatrana* Miquel, Fl. Ind. Bat. 2:1076. 1859. Type: INDONESIA. Sumatera: western, Fort de Kock, 3000 m, without date, *Teysmann s.n.* (holotype: U!).

Common name.—Sumatera yew.

Distribution and ecology.—E Nepal, India (Khasia) Thailand, China (Zhejiang, Taiwan), The Philippines, and Indonesia (Sulawesi, Sumatera); mossy forests, 650–3000 m.

Taxus sumatrana is distinguished by the relatively thin (flaccid) leaves that taper to an acuminate apex and pucker on drying, curling inward along margins, often drying dark shiny green above (adaxial surface) and reddish green along margins and midrib below (abaxial surface). The abaxial surface has long rectangular epidermal cells, but are shorter in about 4 rows nearest the margin, and often half of the marginal cells are papillose towards the stomata band. The papillae develop in ±several opposite rows on each cell in contrast to alternately arranged papillae in the *Chinensis* Subgroup.

Fig. 30. *Taxus mairei* var. *speciosa*, distinguished by the predominant monopodial branching, Guizhou, China, *Tsiang 7525*, isotype (A).

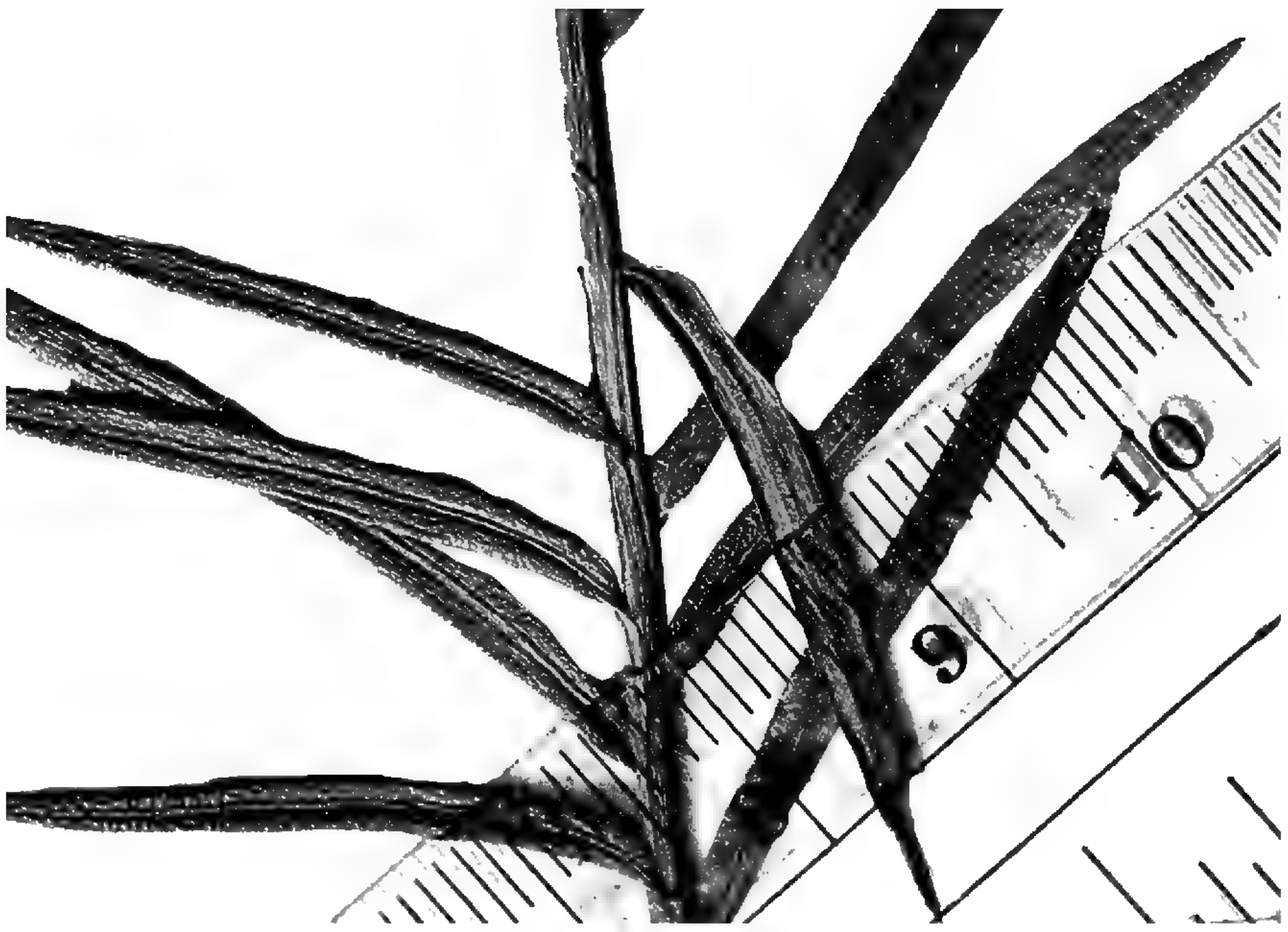


Fig. 31. ***Taxus sumatrana*, distinguished by the puckered leaf tapering to an acuminate apex, and by the abaxial leaf surface having an elevated and truncated midrib that is darker in color (and also the marginal zones) than the stomata bands; Sumatra, *Teysmann s.n* (holotype, U).**

Leaves from two specimens, one from Taiwan (*de Laubenfels P670 & P671*), and another from the Philippines (*de Laubenfels P650*), have relatively narrow marginal zones without papillae. These specimens may key to species in the *Chinensis* Subgroup, but they are clearly related to *T. sumatrana* by the reddish discoloration along the abaxial midrib and marginal zones (as seen under low magnification, 10×), and by the rectangular shape of the abaxial epidermal cells and puckered leaf blades, which are more strongly curled inwards in upper third.

Three varieties of *T. sumatrana* are apparent. They differ in leaf size and color. The typical one—occurring in Indonesia, the Philippines, Thailand, and Jiangsu—has relatively smaller leaves with a dark green adaxial surface, and relatively long epidermal cells on the abaxial midrib and marginal zones (±3–12× l/w). Another with larger paler green leaves, either with shorter epidermal cells (±1–5× l/w), or with both longer and shorter cells, occurs in Nepal and Khasi, and a third in Taiwan, Luzon, and Sumatera has dull olive colored leaves.

III. *BACCATA* GROUP

The *Baccata* Group is divided into two species alliances based on leaf anatomical features of the stomata band as defined by its width and stomata density: (1) the Euro- Mediterranean *Baccata* Alliance and (2) the E Asian *Cuspidata* Alliance.

Differences in stomata density are evident by the number of stomata rows in a band relative to the absence of papillae on marginal cells. The *Baccata* Alliance has fewer stomata in slightly wider bands—at least by 4 cells—in which the stomata bands and their adjacent papillose cells usually extend to 4 cells from the margins, whereas the *Cuspidata* Alliance has a higher density of stomata in narrower bands, most often bordered by a marginal zone of 8–18 smooth cells across.

Other differences in the leaves between these species alliances include the arrangement of accessory cells, the prominence of papillae, and the number of the marginal papillose cells. In the *Baccata* Alliance, the accessory cells are often fusiform with papillae usually covering most of the cell. Their arrangement is diamphicyclic (Florin 1931) except for a narrow straight line of cells between stomata rows. A transitional region of fusiform papillose cells extends to a marginal zone of shorter rectangular or trapezoidal cells that lack papillae. Stomata bands in the *Cuspidata* Alliance, in contrast, usually have ± pentangular to quadrangular or triangular accessory cells with concrescent papillae. Their stomata rows are not separated by a line of cells; rather, stomata often share the same stomata pit.

A third type of stomata band is found in *T. canadensis*, which is included in the *Cuspidata* Alliance even though it occurs in northeastern North America and the Euro-Mediterranean. Stomata bands of *T. canadensis* are much narrower (Nicolosi 1982)—bordered by at least 11 epapillose marginal cells across. Its stomata aperture and the irregular alignment of stomata rows are similar to *T. baccata* (Kvaček 1984), while the absence of papillae across a broad margin indicates a close relationship to *T. cuspidata*.

The distinction of these stomata band types may be correlated with molecular data. Collins et al. (2003) recognized three distinct DNA chloroplast types based on specimens identified as *T. baccata*, *T. cuspidata* and *T. canadensis*. They further suggested that these species probably evolved over a long period of time.

These basic types of stomata bands (*baccata, canadensis, cuspidata*)—as measured by the width of the band relative to the marginal region, 4, 8, and 12 cells in from the margin—are each postulated as an ancestral type. Hybrids, however, are apparent not only between species of these band types, but also with the *Sumatrana* Group as evidenced by the wider leaf margins—generally 16, 24 and 32 cells across. Various combination of other leaf anatomical feature—position and size of papillae on cells, shape of chloroplast, color of chloroplast and cell walls when dried, and shape and arrangement of parenchyma cells—also seem best explained by hybridization. The anatomical features appear independently inherited of gross morphological features such as habit, branching, and phyllotaxy.

IIIA. *Baccata* Alliance.—*Distribution and ecology*—Europe, N Africa, SW Asia (Euro-Mediterranean) and NW Himalayas; the Euro-Medierranean plants in various hardwood and mixed mesophytic forest types, sea level to 500 m in the northern range, to 2000 m in S Europe, or to 2500 m in the Atlas Mountains of N Africa. In hardwood forests with beech (*Fagus orientalis* Lipsky), basswood (*Tilia* spp.), elm (*Ulmus* spp.), oak (*Quercus* spp.) and ash (*Fraxinus* spp.), or mixed hardwood-conifer with beech and spruce [*Picea abies* (L.) Karsten] (Browicz & Zieliński 1982; Duffey 1980) and occasional black pine (*Pinus heldreichii* Christ; Voliotis 1986). Around the Black Sea in beech-fir-spruce forests [*Abies nordmanniana* (Stev.) Spach, *A. cilicica* (Ant. & Kotschy] Carr., *Picea orientalis* (L.) Link], or spruce absent (Browicz & Zieliński 1982), or in the British Isles, forming single dominant woodlands with a closed canopy lacking understory shrubs and herbs (Thomas & Polwart 2003).

Yew plants of the *Baccata* Alliance are characterized by falcate or recurved leaves that overlap or criss-cross when branchlets are pressed, and by the abaxial surface of leaves having a transitional zone of papillose epidermal cells between stomata bands and a narrow bare marginal border, usually 4–7 cells wide.

One species of *Taxus* has been generally recognized in the Euro-Mediterranean region, *T. baccata*; however, leaf anatomical data clearly indicate two, *T. canadensis* and *T. baccata*, and additional species, *T. fastigiata* and *T. recurvata,* and varieties are evident by other morphological differences. The species allied to *T. baccata* and *T. cuspidata* are most distinct in Europe and eastern Asia, respectively, and least distinct in the Caucasus Mountains. *Taxus canadensis*, which has been traditionally known from eastern North America, is also recognized to occur in the Caucasus Mountains, Scandinavia, Estonia, and southwestern Mediterranean.

Taxus baccata has included numerous varieties or forms (Beissner 1891; Carrière 1855a, 1867; Elwes & Henry 1906; Gordon & Glendenning 1858; Gordon 1875; Knight 1850; Krüssmann 1985; Lawson et al. 1851; Loudon 1844; den Ouden & Boom 1965; Pilger 1903, 1916), recognized mostly from horticulture. The more distinct taxa have been treated in Bailey (1923, 1933), Carrière (1855a, 1867), Elwes and Henry (1906), Gordon and Glendenning (1858), Gordon (1875), and Pilger (1903, 1916). Prior to Beissner (1891) and Pilger (1903), these were often considered varieties; Rehder (in Bailey 1902, 1923, 1933), for example, initially treated them as varieties but later as "garden forms" (Rehder 1940, 1949). As evident in these publications, names for many yews in the horticultural trade were not clearly differentiated (taxonomically) prior to 1855.

Those in Carrière (1855a); therefore, are given priority in the present treatment except where earlier legitimate names can be applied. Nothing is known about his types or the existence of his herbarium material (Stafleu & Cowan 1976), and I would assume that his knowledge of yew taxonomy was based on descriptive information in literature and study of living material at gardens in France. Authors who have later described more taxa (e.g., Carrière 1867; Gordon & Glendenning 1858) have not always followed priority. And it should be noted that although horticultural material may exist in gardens, valid names cannot be based on living material; preserved specimens are required. Moreover, plants brought into cultivation from the wild must retain the names that were applied to the wild specimens.

Many specimens collected in the wild compare favorably with varieties described during the 19th century, while other varieties described later, as summarized in Chadwick and Keen (1976), Krüssmann (1985), and den Ouden and Boom (1965), appear to be only minor variations in color and habit that probably originated from hybridization and selection of existing garden plants. Molecular data by Collins et al. (2003) indicate that many cultivars are genetically distinct.

It is also conceivable that many introductions could have originated before the yew horticultural trade developed—in the late 16th century (Mitchell 1974); the presence of *Homo sapiens* in the British Isles dates back to 5500 yr. For instance, "the oldest wooden artifact" used by man in the British Isles is a yew spear, which has been found in elephant remains 4600+ yr old (Godwin 1975), while in later times yews have been planted and harvested for the construction of long bows (Hageneder 2007; Mitchell 1974; Thomas & Polwart 2003). The existence of old yew trees in many churchyards (Loudon 1844; Lowe 1897) is also evidence of a long history of yew associated with religious beliefs, and Tittensor (1980) has suggested that yew woodlands in southern England originated from trees that marked "parish boundaries."

In selecting neotypes, the available varietal names were considered based on priority of publication, current usage, and information in the original description, but not all varietal and cultivar names are accounted for in this treatment. This paper mentions those that appear more common and widely distributed. Unfortunately, it has not been possible to evaluate their character features in the field, and to determine to what extent yew populations may show polymorphisms and introgression, while it may be further noted that much of the yew habitat has already been destroyed by human activities (Heinze 2004). Nevertheless, molecular investigations are being undertaken to assess the genetic variability in various countries such as the United Kingdom, Spain, Portugal, Austria, Germany, Slovakia, and Switzerland as evident from various abstracts and reports on web sites.

16. Taxus baccata Linnaeus, Sp. Pl. 1040. 1753. (**Figs. 32**). Lectotype, designated by Jonsell & Jarvis in Jarvis et al. 1993: Clifford Herb., 464, Taxus No. 1 (BM!).

Of eleven varieties of *Taxus baccata* proposed by (Spjut unpublished, www.worldbotanical.com), five, in addition to the typical variety, are mentioned below. All are widely distributed in the Euro-Mediterranean region.

16a. Taxus baccata var. baccata

Common name.—European yew.

Distribution.—Euro-Mediterranean.

Taxus baccata var. *baccata* is characterized by having equally divided horizontal to pendulous branchlets with leaves ± spreading in the same plane along opposite sides of a branchlet (two-ranked), the adjacent leaves parallel to slightly overlapping or crisscrossing in dried specimens. In most other varieties leaves curve upwards on horizontal branchlets. *Taxus baccata* var. *washingtonii* (Hort. ex Richard Smith) Beissner, which is thought to have originated in horticulture, is possibly of hybrid origin with *Taxus canadensis* as one of its parental types (Gordon 1875); however, a number of specimens from eastern Europe also appear to be natural hybrids between *T. canadensis* in Europe and *T. baccata*.

16b. Taxus baccata L. var. **dovastoniana** Leighton, Fl. Shropshire 497. 1841. (**Figs. 33–35**). Type: ENGLAND. Salik Co.: "Raised by John Dovaston in Westfelton near Shrewbury in 1777" (Loudon 1844), 1863, *Westfelton ex Herb. Bidwell*, annotated "*T. dovastonianum* Leighton," with seed (neotype designated here: BM! [leaves with stomata in 10 rows per band, abaxial marginal border of 4 smooth cells]). Related material, BM: "original tree at Westfelton" *communic. Jackson s.n.*, without seed, with galls [10 stomata rows per band, 4–5 abaxial smooth marginal cells]; other material at K. Original herbarium material unknown; however, the neotype is from the original tree that was recognized and illustrated by Loudon in 1838 by common name, and noted to have been "56 ft" tall in 1836. Leighton (1841) made specific reference to Loudon's illustration ("*p. 2083, fig. 1990*"), which was of the whole tree; this "cannot be critically identified for purposes of the precise application of the name of a taxon" (ICBN Art. 9.7).

The Dovaston yew is distinguished by relatively long undivided pendulous branchlets from ascending to horizontal branches and by the oblong leaves that spread vertically and horizontally. The type has dark green leaves with lateral and lower leaves spreading along two sides of branchlets and uppermost leaves spreading upwards. The female cones of the Dovaston yew often develop near ends of branchlets that apparently have terminated growth, and arillocarpia develop in pairs as noted by Leighton (1841). *Taxus baccata* var. *glauca* can be difficult to distinguish; it is recognized by the recurved branchlets that are more evenly distributed along the main branch.

Figs. 32A–B. ***Taxus baccata*, distinguished by the isodichotomous branching and leaves spreading mostly parallel to each other. A (top). Lectotype (BM). B (bottom). Close-up of branchlet with leaves and mature male cones (lectotype).**

16c. Taxus baccata L. var. **elegantissima**. [Hort. ex] [Ravenscroft] [C.]Lawson et al., Abietineae—List Pl. Fir Tribe No. 10, 82. 1851. (**Fig. 36**). *Taxus baccata* L. f. *elegantissima* Beissner, Syst. Eintheil. Conif. 23. 1887. *Taxus baccata* L. (var.) *argentea* Loudon ex Gordon & Glendenning, Pinetum 312. 1858. Type: SPAIN. Baleares: 1600 m, 15 Mar 1917, *Bianor-Maire s.n.* (neotype designated here: BM! with male cones [abaxial surface of leaves with 9 stomata rows per band, lacking papillae across 5–9 rectangular cells near margin]). Original herb rium material and origin unknown; horticultural form developed in the Handworth Nursery (den Ouden & Boom 1965).

Figs. 33–35. ***Taxus baccata*** **var.** ***dovastoniana*****, distinguished by the terminally digitate long pendant branchlets (in the type). 33 (top left). Specimen from original tree (K). 34 (top right). Specimen at BM (neotype), branch with arillocarpia, from the original tree, with annotation—*Taxus dovastonianum* Leighton. 35 (lower left). Illustration reproduced from Carrière (1861).**

The elegant yew is recognized by long linear leaves tapering gradually to an acute or acuminate apex, and by the leaves often appearing in hair-like tufts near apex of branchlets. The dried leaves are dark—almost blackish green above (adaxial surface)—and rusty orange below (abaxial surface), but on live plants—in cultivation—leaves have been described as "striped pale yellow, later whitish" (Lawson et al. 1851; Rehder 1940), or under more shady conditions, leaves may appear green to golden in sunlight (den Ouden & Boom 1965). Occasional herbarium specimens have these features (preserved).

PLANTES DES BALEARES
Taxus baccata. L.
Montagnes, entre les rochers.
Puig Mayor, 1400m.
1917, 15 Mars.
F.re Bianor-Marie
Recd 1951 with 8 [illegible] plants

Fig. 36. *Taxus baccata* var. *elegantissima*, distinguished by the linear leaves appearing two ranked and in hair-like tufts near apex of branchlets; Spain, *Bianor-Maire* (neotype, BM).

The cv. 'Repandens'—that is common in cultivation in the eastern United States—appears related to this variety. Its low shrubby habit with a flat-topped crown may have been derived from a plant similar to what has been described for *T. baccata* var. *washingtonii*.

16d. Taxus baccata L. var. **glauca** Jacques ex Carrière, Traité gén. Conif. 519. 1855. (**Fig. 37**). *Taxus baccata* L. (f.) *glauca* (Carrière) Beissner, Handb. Nandelholzk. 175. 1891. Type: ARMENIA: Tschunakuchi, horticulture—*ex Herb. Petropolitani*, [year 1899] *Szovich 610* (NEOTYPE designated here: S: C-2072!), [with seed (leaf with 10 stomata rows per band, abaxial margin 4 cells across without papillae, midrib papillose)]; ISONEOTYPE: P! [with seed (leaf with 9 stomata rows per band, abaxial margin—4 smooth cells, papillose midrib)]. Related material: Hort. *Ex Hillier Arboretum, England, 22* Mar 1976, "BM (NH) 1247," in adnot. *T. baccata* 'Glauca' ("Nigra"), "Blue John" (BM!). Original herbarium material and origin unknown.

Taxus baccata var. *glauca* is distinguished by the leaves that overlap parallel to each other while pointing upwards (erect secund), especially near apex of recurved or horizontal branchlets, and by appearing yellow in dried herbarium specimens, and by abruptly tapering to an obtuse apex. The branchlets are yellowish orange and recurved in many specimens. The Dovaston yew, which overlaps with the glauca yew in character attributes of color and pendulous branchlets, differs by the darker leaf color as seen in dried specimens, and by the uppermost leaves often directed towards apex of branchlets.

Variety *glauca* includes at least three horticultural forms. (1) The cv. 'Glauca' or 'Nigra' or 'Blue John', based on a specimen from the Hillier's Arboretum (BM), has long recurved branchlets with oblong glaucous (caesious) leaves, lacking in the yellowish color. (2) A second one, f. *horizontalis* (Carrière), allegedly a cultivar that originated in France, is known for its long horizontal branches (Knight 1850; Callen 1977), while it may be distinguished by its golden color (f. *semperaurea* Dallimore; Rehder 1940, 1949). (3) A third—that is typical—has pendulous branchlets, and includes a specimen from horticulture under the name f. *pendula* as recognized by C. Baenitz indicated on annotation label of a herbarium specimen (US: 1395580).

16e. Taxus baccata L. var. **pyramidalis** [Hort. ex] [Ravenscroft] [C.] Lawson, Abietineae—List Pl. Fir Tribe No. 10, 83. 1851. (**Fig. 38**). *Taxus baccata* L. [f.] *pyramidalis* Beissner, Handb. Nadelholzk. 175. 1891. *Taxus communis pyramidalis* Nelson, Pinaceae 172. 1866. *Taxus pyramidalis* Severin in Möller's Deutsch. Gärt.-Zeit. 41:227. 1926. Type: FRANCE: Lananau Mutohir (Girandi), along marsh, 1 Sep 1930, *Tidestrom 12814*, with seed (NEOTYPE designated here: US!). Origin of material in horticulture unknown; original herbarium material unknown.

This variety is recognized by the equally divided flexuous branchlets that have a yellowish orange color and are often without leaves by the 3rd year and by leaves diverging widely from younger branchlets. It appears related to var. *elegantissima* by the paucity of cones. A specimen from Norway (*Gamble*) has darker metallic leaves instead of the more common yellowish green color. Leaves generally lack papillae across 4–6 cells near margins and are partly to entirely papillose across the midrib. Plants with more distinct radial orientation of leaves, which appear intermediate to var. *glauca*, may be distinguished as var. *ericoides* and var. *erecta* (Spjut unpubl., worldbotanical.com).

16f. Taxus baccata L. var. **variegata** Weston, Bot. Univ. 1:292, 347. 1770. (**Fig. 39**). *Taxus baccata* var. *foli-variegata*, Loudon, Arbor. Brit. 4:2068. 1838, "*T. b. 6 foliis variegates*." (nom. illeg. superfl.). *Taxus baccata* (var.) *variegata aurea* Carrière, Traité gén. conif. 518. 1855 (nom. illeg. superfl.); *Taxus baccata* (var.) *aurea* Carrière, Traité gén. conif. 734. 1867 (nom. illeg. superfl.). *Taxus baccata* subf. *aureo-variegata* Pilger, Pflanzenreich 18 (iv, 5):114. 1903 (nom. illeg. superfl.). *Taxus baccata* f. *aurea* (Carrière) Pilger, Mitt. Deutsch. Dendrol. Ges. 25:11. 1916 (nom. illeg. superfl.). *Taxus communis aurea* [Nelson] Pinaceae 172. 1866 (nom. illeg. superfl.). Type: FINLAND: Ålandia, Lemland, *Florström s.n.* (NEOTYPE designated here: BM! [leaf with 11/12 stomata rows per band and an abaxial marginal area of 4 rows of rectangular, smooth cells]). Original material and origin unknown.

Taxus baccata var. *variegata* is recognized by stiffly spreading branchlets with erect leaves that are mostly dull olive green. The plants appear to be mostly shrubs. Tree forms that appear evident with more wide spreading branches may be referred to as var. *jacksonii* (Spjut unpublished, worldbotanical.com). These varieties, as well as a specimen from Iran referred to as var. *subpyramidalis* (Spjut unpubl., worldbotanical.com), are similar to *T. cuspidata*.

17. Taxus contorta Griffith, Not. Pl. asiat. 4: 28. 1854. "*Taxus contortus*? Vide Itinerary Notes, p. 351, No. 116." See also Itin. pl. Khasyah mts., II:351. (1847–) 1848 (Book III, Chapter II, "Affghanistan Flora,

Figs. 37A–B. ***Taxus baccata*** **var. *glauca*, Armenia, *ex Herb. Petropolitani, Szovich 610* (neotype, S). A (left). Shows characteristic recurved branchlets, pinnately arranged. B (right). Close-up of branchlets showing reflexed cones with seed.**

Second year Kafiristhan.116. *Taxus*?"] (**Fig. 40**). Type: AFGHANISTAN: W of Kabul, "Bharowul, in woods, 7000–7500 ft" (locality data from Griffith nos. 112-114 in Itin. pl. Khasyah mts, collected during 1839–1841), *Griffith 5002* (lectotype designated here: K [lower right specimen of three on a single sheet, with label indicating it was collected from Afghanistan, distributed by Royal Gardens, Kew, 1862–3, accompanied by another label in handwriting with two words, Kafiristan, Griffith; the other two specimens evidently belong to another single collection by another collector from another location with a handwritten note on a label indicating that the bark was used in a tea in Ladakh, det. by Spjut as *T. contorta*]. Original material at K, a single specimen, *Griffith 5002*; however, the same number was used by Griffith for specimens he collected at other locations; e.g., *Taxus wallichiana* from Assam. No specimens cited, but locations from where specimens were reportedly collected are sequentially numbered in Griffith's Notes 1847–48. Griffith, in his earlier publication, noted "Arbor, foliis alternis linearibus compressis, sulcato univeniis basi ½ tortis. Brought from Kafiristhan with the preceding [*Pinus*], the undersurface of the leaves subsequently becomes uppermost from torsion of the base. The change takes place gradually judging from the slight obliquity of young leaves. Stomata blocked up, with a brown curious cuticular substance." Griffin later published the name *Taxus contorta* in Not. Pl. Asiat. 4:28. 1854 ("*Taxus contortus*? Vide Itinerary Notes, p. 351, No. 116").

Taxus fuana Nan Li & R. R. Mill in Li & Fu, Novon 7:263. 1997.—Type: CHINA. TIBET (XIZANG): Jilong, 3000 m, *Qingzhang Expedition 7032* (holotype: PE!).

Taxus orientalis Bertoloni, Mem. Acad. Sci. Bologna ser. 2, I, 229, pl. 2. 1862. No specimens cited, illustration provided, other original material consists only of a single specimen at BOLO. Type: INDIA. Northeastern India, western Sikkim ["Stim"], 8000 ft, without collector's name, without collection number, filed separately in the herbarium of A. Bertoloni, with two labels, handwriting with locality data the same as that published by A. Bertoloni (holotype: BOLO [BOLO0007756!], leaf fragments!). Bertoloni also decribed this taxon in Misc. Bot. 23:17, Tab. 2. 1862.

Two varieties are distinguished by leaf spread and length.

17a. Taxus contorta var. contorta

Common name.—West Himalayan yew.

Distribution and ecology.—Mixed coniferous-hardwood forests of W Himalayas, 2300–3500 m; Afghanistan, Pakistan, India, W Nepal, and China (SW Tibet). Noted to be common in the Garhwal and Kumaon regions at elevations near 8500 ft (Gamble 1922; Gordon 1875), where clouds often hang in oak-conifer forests of *Quercus semecarpifolia* Sm., *Abies pindrow* (D. Don) Royle, and *Rhododendron arboreum* Sm. (Freitag 1971; Rau 1974). In the Uri Range closely associated with *Abies pindrow-Picea smithiana* (Wall.) Boiss. forest (Sapru 1975), a vegetation type common to the higher ranges in the W and C Himalayas of India and Nepal

(Champion & Seth 1968; Rau 1974). In the Kumaon and Nepal regions mostly on N side of the Himalayas in hemlock (*Tsuga dumosa* [D. Don] Eichler) forests with spruce (*Picea smithiana*) as a common associate (Rau 1974), especially near Rara Lake in W Nepal (Stainton 1972).

Taxus contorta is easily identified in the herbarium by the relatively long and straight narrow leaves that are generally crowded along stems in nearly two ranks, which in the typical form generally do not spread more than 60° from branchlets. The leaf mesophyll contains distinctive parenchyma cells (idioblasts) that in the herbarium slowly develop a yellowish to reddish color, as determined in part from 1-year old specimens (*Amin 25025, 25045, 25149* from Pakistan, KIB) that show only minor discoloration of cell walls. The idioblasts occur predominantly across the mid region of the leaf mesophyll and around the diffusion area of the vascular bundle. The cell walls have striations that may suggest a type of sclerenchyma cell, but this appears to be a secretory product—a terpenoid compound—in the cell that when dried becomes deposited on the cell walls. Rao and Malaviya (1965) described what they called "osteo-sclereids" in leaves of one of four varieties of *T. baccata* they reportedly studied from cultivated specimens in Sri Lanka and India; however, their illustrations of leaf sections show thicker-walled cells that are sclereids. I have not seen these "osteo-sclereids" in yew leaves, while I have observed similar cells in Asian species of *Torreya*.

The spongy parenchyma cells of many *T. baccata* specimens have similar idioblasts as seen by their spherical shape and dark color, but lack striated cell walls, and do not fall out when sectioned. Species in the *Cuspidata* Alliance (E Asia) generally have a leaf mesophyll largely of loose spherical to ellipsoidal cells connected together by short cylindrical cells without idioblasts.

Taxus contorta is more related to *T. baccata* than to *T. wallichiana* by the relatively low number of leaf stomata rows per band—usually 7–8, by features of the leaf parenchyma cells as just described, and by the green to olivaceous color in leaves of dried specimens. The leaf mesophyll of *T. wallichiana* has periclinally oriented cells connected in a skeletal-like net; in longitudinal sections these cells appear like bones. It is interesting that *T. baccata* shows more variation (in Europe) than *T. contorta* (in the Himalayas) in branching, leaf arrangement and leaf anatomy. Of particular relevance is the occurrence of papillae on the abaxial midrib of leaves—that in *T. baccata* can be densely papillose (e.g., lectotype), or entirely smooth (e.g., *Curic s.n.*, from Bosnia, K), whereas *T. contorta* always has a densely papillose midrib.

The close relationship between the European *T. baccata* and Himalayan *T. contorta* was recognized by Handel-Mazzetti (1929) and by Florin—who, in his annotations of specimens at Stockholm (S), treated it as a subspecies of *T. baccata*, adopting the epithet of *T. orientalis* Bertol., a later name.

Other botanists have independently recognized *T. contorta* as distinct from *T. baccata* and *T. wallichiana*, but by names that are not always in accordance with the ICBN. For instance, Handel-Mazzetti (1929) correctly realized that *T. wallichiana* could be based on *Wallich 6054A*, but referred the Northwest Himalayan yew to *T. orientalis*. He was also aware of *T. contorta*, which he considered a nomen nudum; however, Griffith (1854) referred back to his earlier 1848 publication (see nomenclature citations above); thus, *T. contorta* is not a nomen nudum (Art. 32.3, 32.4, 34.1), and predates *T. orientalis* Bertoloni (1862). Franco (1964), who reviewed Taxaceae for *Flora Europaea*, also recognized the west Himalayan yew (*T. contorta*) as a distinct species, but he annotated specimens (BM) by another name (*T. angustifolia* Franco, ined., dated 1956) that if published would have been illegitimate; more recently, Nan Li and R. R. Mill (Li & Fu 1997) reached a similar conclusion, but did publish their superfluous name, *T. fuana*. Occasional collections by Polunin et al. (e.g., No. *432*, BM) had been correctly determined, while most herbarium collections of this species have been misidentified as *T. wallichiana*.

It is not clear to what extent Wallich and Griffith had distinguished yews in the Himalayas. Wallich's (1826) *Tentamen Florae Nepalensis* recognized only one species, determined as *T. wallichiana* by Zuccarrini (Siebold & Zuccarini 1843); however, Wallich specimens of *Taxus* numbered 6054, differentiated by letters A-E, suggest they were distinguished—at least by collectors and location, and may include an annotation *T. virgata* Wall. (nomen nudum), which I have identified as *T. wallichiana* (*Blinkworth s.n.* BM, reportedly from Kumaon, but probably from Nepal), or *T. baccata* (young shoot on sheet with 3 other specimens of *T. contorta*, *Wallich 6054*, *ex* Herb. Gordon, with "*b*" indicated lightly in pencil, K; probably added for comparison). Most

Figs. 38A–B. *Taxus baccata* var. *pyramidalis*, distinguished in part by wide spreading, often isodichotomous, branchlets, France, *Tidestrom 12814* (neotype, US). **A** (top). Herbarium specimen. **B** (lower left insert). Close-up of branchlet showing seed and persistent bud-scales.

FIGS. 39A–B. ***Taxus baccata*** **var.** ***variegata*****, distinguished by the rigid pinnate branching and lack of glaucous color, the abaxial surface of the leaves appearing rusty orange; Finland,** ***Florström s.n.*** **(neotype, BM). A (left). Herbarium specimen. B (top right). Close-up of branchlet with terminal male cones.**

Wallich 6054A (from Nepal) belong to *T. wallichiana*, whereas most *Wallich 6054B* (from Kumaon) are *T. contorta*. Griffith, who worked with Wallich on occasion (Burkhill 1965), also assigned mixed collections of *Taxus* to the same number with different data; the type, for example, is from Afghanistan, but other labels with this number (*Griffith 5002*) indicate the specimens were collected in the eastern Himalayas. Griffith (1854) recognized possibly two species from Bhutan, distinguished by "axillary" and "terminal" "inflorescences" and

Fig. 40. Herbarium sheet at K with three specimens, all are *Taxus contorta*, the one on right from Afghanistan, *Griffith 5002*, lectotype, the species distinguished in part by the relatively straight leaf blades in contrast to the falcate leaf in *T. wallichiana*.

a third "3. *Taxus contortus*?" by reference to his collection from Afghanistan. I have noted that three species of *Taxus* are represented in Griffith collections, and also from J. D. Hooker in the Gray Herbarium (*J. D. Hooker 77, 87,* GH) with three different species (*T. contorta, T. kingstonii, T. wallichiana*) all on one herbarium sheet reportedly from Khasia, 5000–6000 ft, and from other locations in India.

Although *T. contorta* appears quite distinct from *T. wallichiana*, hybrids seem evident by the respective higher and lower counts of stomata rows where geographical ranges of these species overlap in central and east Himalayas. This includes the type for *T. orientalis* (BOLO!) from Sikkim. In several leaves studied of the *T. orientalis* type, the parenchyma cells were found to be those of the *T. contorta* type, whereas the slightly larger epidermal cells (20–25 µm tall, 25–35 µm wide) along with the higher stomata counts (10–11 rows per band) indicate affinity to *T. wallichiana*. Additionally, the absence of bud-scales at the base of branchlets, and the strongly revolute linear leaves (illustrated by Bertoloni 1862) are other features I associate with *T. contorta*. Specimens of *T. wallichiana* var. *yunnanensis* from Sikkim were found to have fewer stomata rows (e.g., 13 rows, *Kurz s.n.* A; 14 rows, *J. D. Hooker & Thomson* A, GH, K) compared to specimens from other regions.

17b. Taxus contorta Griff. var. **mucronata** Spjut, var. nov. (**Fig. 41**). *Taxus mucronata* Spjut ined. in adnot. (BM [Oct 1997], A [Jun 1996]). TYPE: BHUTAN (Eastern). HA: 27°22' 89°18', 9,000 ft, tree 15 ft, 11 Apr 1949, *Ludlow et al. 16035*, with male cones (HOLOTYPE: A!; ISOTYPE: BM!).

Differt a var. *contorta* folia breviora valdes divaricatis, 5–10 longiora quam latiora.

Tree to 3 m or more; leaves sharply bent at base of blade, 1.5–2.5 cm long, ca. 2 mm wide; abaxial margin up to 23 cells across, the epidermal cells irregularly quadrate in up to 6 rows nearest the margin, becoming long fusiform to rectangular towards the stomata band and on midrib, mostly 3–7× l/w, papillose on more than half of the marginal cells—to within 8 (-5) cells across from margins and entirely on midrib; stomata bands greenish, or yellowish green, narrower than the marginal region, with 9–11 rows of stomata; spongy mesophyll with idioblasts. Male cone scales 4–5 seriate; sporangiophores 8, united into a ribbed column ca. 2 mm long, thickened at apex of column, separating into 8 umbrellalike segments, each with 5–8-cuculately lobed microsporangia ca. 1 mm diam. Seed in one specimen globose, reddish.
Common name.—Mucronate-leaved yew.

Distribution and ecology.—Nepal, Bhutan; upper forest region, 2300–3100 m.

Additional specimens: **NEPAL.** *Dobremez 2106* (BM); Marayandi Valley, 3100 m, *Wraber 514* (BM); ridge S of Bhahwe Sekh, 9000 ft, *Polunin et al. 1873* (BM); Dhawalagiri Zone, Mustang Dist., Ghasa, 2300 m, *Mikage et al. 9550282* (BM).

I annotated one specimen from the Arnold Arboretum Herbarium (A) as "*Taxus mucronata* Spjut (ined.)" in June 1996, designating it as type. Other specimens at the Museum of Natural History in London (BM) and the Kew Herbarium (K) were later discovered and similarly annotated (Oct. 1997), including an isotype at BM. An illustration in Cheng and Fu (1978) for *T. wallichiana*, redrawn for the English edition of the *Flora of China* (Fu et al. 1999) as representative of *T. fuana*, was thought to have originally been drawn from the type specimen for *T. fuana* as reported on the WBA website (2003–2006); however, upon study of the images of the PE *Taxus* collections that were made available online during 2006, the holotype for *T. fuana* was found to belong to the typical variety. Although *Taxus fuana* was not described until Nov 1997, all specimens I saw at K (Oct. 1997) bearing the annotated name *T. fuana* by Nan Li and R.R. Mill belonged to var. *contorta*, whereas specimens I recognized as "*T. mucronata* Spjut ined." were not annotated by Nan Li and R. R. Mill. Additionally, Farjon (1998) indicated *T. fuana* to occur only in Tibet, but the basis for his decision on this and other species he recognized in *Taxus* is without taxonomic merit. In a review of specimen images of *Taxus* on the PE virtual herbarium, other specimens of *T. contorta* var. *contorta* were found listed under *T. wallichiana*, and also erroneously identified as *T. wallichiana*, while I might add that none of the specimens I studied in herbaria outside China had specimens of *T. contorta* from China.

Variety *mucronata* is distinguished from the typical variety by the relatively shorter and more sharply reflexed leaves—more at base of blade than near junction with branchlet. Leaves also differ from most

Fig. 41A-B. ***Taxus contorta*** **var.** ***mucronata*****, distinguished in part by the relatively short reflexed leaves. A (left). Herbarium specimen (holotype, A). B (right). Close-up of branchlets with male cones.**

specimens of the typical variety by their abaxial surface having a smooth marginal border of 5–8 irregularly quadrate epidermal cells, and 9–11 stomata rows per band. Despite these differences, occasional specimens from Nepal are difficult to assign to either variety. An analysis of the leaf arrangement in *T. contorta* specimens shows that leaves increasingly diverge at wider angles going from west to east in the Himalayas. This also appears correlated also with an increase in number of stomata rows per band (Spjut 2006). The higher stomata counts and wider angle of divergence in leaves of *T. contorta*, however, are characteristics of *T. wallichiana*, whereas the wider leaf margin and reflexed leaves are also characteristics of *T. umbraculifera*. Nevetheless, the apparent hybrids between the two varieties of *T. contorta* would seem to justify varietal status for var. *mucronata*.

18. Taxus fastigiata Lindley, Syn. Brit. Flora 241. 1829. (**Fig. 42**). *Taxus baccata* L. (var.) *fastigiata* (Lindl.) Loudon, Arbor. frutic. britt. 4:2066. 1838. *Taxus baccata* L. f. *fastigiata* (Lindl.) Pilger, Planzenreich 18 (iv, 5):115. 1903. *Taxus baccata* L. var. *hibernica* Hooker ex Henkel & Hochstetter, Syn. Nadelhölzer 356. 1865 (nom. illeg. superfl.). Type: IRELAND: from Florence Court, *ex Herb. Jackson*, Sep 1890, *Stewart s.n.* (neotype designated here: K!). No specimens cited, none reported in the Lindley Herbarium. Original material unknown. Ireland, "mountains of Fermanagh" Parish of Killesher near Aghenteroark, *George Willis*, without herbarium specimens; fide Veitch et al. (1881)—quoting from manuscript by Lord Kinnarid with further reference to Rossie Priory, 8 Sep 1867—transplanted to Florence Court ca. one hundred years ago; thus originally collected in 1767, or as early as 1740 fide internet sources.

Common name.—Irish yew.

Distribution.—British Isles—United Kingdom (Ireland, Scotland, England), Sardinia?

The Irish yew (*T. fastigiata*) has long been considered distinct from other yews; yet, most authorities have treated it as a synonym of *T. baccata*. Its radial orientation of leaves is similar to east Asian *T. umbraculifera* in bending downwards (recurved) and to *T. caespitosa* in the imbricate arrangement, and it is also similar

Fig. 42. *Taxus fastigiata*, distinguished by the erect to ascending branches and by the imbricate arrangement of dark green leaves with blades that curve downwards from base to apex; Florence Court, *ex Herb. Jackson, Stewart s.n.* (neotype, K).

to a Euro-Mediterranean variety of *T. baccata* from Morocco. The Euro-Mediterranean plants with radial spreading leaves, which occur near the western continental distribution limits of the genus, are relatively rare. The columnar habit, associated with radial orientation of leaves, would seem to be an adaptation to open habitats such as bogs, fens, lake shores, or areas along sea coasts.

Taxus fastigiata is known primarily from two plants that once grew in the Cuilcagh Mountains in Fermanagh County, Ireland. A farmer named George Willis dug up two female plants; one was planted in his garden, the other was given to his landlord, Lord Enniskillen, who planted it at Florence Court (Veitch et al. 1881). Willis's yew died in 1865, but the Florence yew prospered, and subsequently has become the source for many horticultural varieties (Veitch et al. 1881). Additionally, male plants appear evident at North Mundham in Sussex, England (Bean 1953), and specimens from Tweeddale in Scotland may also be native. Irish yew is common in cultivation in the United States, especially in the west where it can be maintained in hot and dry climates, temperatures often exceeding 100°F as evident at Redding, CA.

The common "English yew," which I recognize as *T. recurvata*, is distinguished from typical *T. baccata* by the arcuate leaves that curve downwards. Specimens from the British Isles show a more radial orientation of leaves compared to specimens from central and Eastern Europe. The leaves of *T. recurvata* from the British Isles also appear to develop closer together on branchlets and are darker green in color as seen in *T. fastigiata*. This includes a specimen from Neopath Castle Scotland (K) that in my opinion is a hybrid between male *T. recurvata* and female *T. fastigiata*; the collectors Bean and Hill indicated it was a "distinct variety" by its "plumose growth."

Several varieties of Irish yew are proposed (www.worldbotanical.com). One appears to be a low shrub in the British Isles and possibly on Sardinia; the other, a tree, is known only from Scotland and England. The Scotland plants, which are from Lock Lomond, differ from the typical Irish yew in the branches ascending more widely. The relationships of the proposed varieties require more study.

As mentioned elsewhere in this paper, and in Spjut (2007), the *Cuspidata* Alliance includes plants with a similar phyllotaxy to that of the Irish yew, particularly in specimens from the islands of Sakhalin, Hokkaido, and Honshu. I annotated one specimen from Sakhalin Island (*Dvorakovskaia & Bokina*, A) as *T. fastigiata* in June 1996 because the recurved leaves with a purplish green color seemed characteristic of the Irish yew; however, I now regard it as *T. caespitosa* var. *latifolia*. Another specimen of this variety from Sakhalin Island, *Flanakan & Kirkham 203* (K), resembles *T. baccata* var. *glauca* in the upturned leaves with a yellowish green color. The Asian *T. caespitosa* is usually distinguishable by the spreading leaves that bend or curve more along their petioles instead of along their blades.

19. Taxus recurvata Hort. ex [Ravenscroft] [C.] Lawson, Abietineae—List Pl. Fir Tribe No. 10, 83 ("A handsome and distinct species with recurved branchlets and leaves mostly directed upwards"). 1851. (**Fig. 43**). *Taxus baccata* L. [var.] *recurvata* (Hort. ex C. Lawson) Carrière, Traité gén. Conif. 520 ("Branches étalées, divariquées, alongées, peu ramifies, le plus souvent réfléchies"; "feuilles longues et étroites, falquées-countour-nées, involutes." "Cette variété ne peut être confondue avec acune autre"). 1855. TYPE: ENGLAND: SUSSEX: Bury Hill, near summit on chalk, 24 Aug 1933, *Hubbard s.n.* (NEOTYPE designated here: K! [with mature seed; leaf with 8 stomata rows per band and abaxial marginal border of 4 smooth cells]. Original material unknown.

Common name.—English yew.

Distribution.—Europe, SW Asia (Caucasus Mts.).

This species is recognized by plants having most of the following characteristics in common: arcuate leaves, i.e. the leaves are recurved (turned downwards), the leaves crisscross more than parallel each other along one side of a branchlet, the adaxial leaf surface appearing strongly convex, leaves discolorous, and prismatic seeds developing on branchlets of the current season. *Taxus baccata* differs by paler green leaves with the blades facing in the same plane as that of branchlets, and with leaves along one side of the branchlet overlapping more than crisscrossing each other, and also curving upwards instead of downwards.

Taxus recurvata has intermediate phyllotaxy between the radial type of *T. fastigiata* and the distichous-like arrangement of *T. baccata*. In the British Isles, *T. recurvata* is common to chalk downs where "yew woods" form a climax community as evident from specimens that correspond to literature (Watt 1926; Rodwell

Figs. 43A–B. ***Taxus recurvata*, distinguished by the recurved branchlets, crisscrossing leaves with sharp contrast in color between the abaxial and adaxial surfaces; England, *Hubbard s.n.* (neotype, K). A (left). Herbarium specimen. B (above). Close-up of leaves and seeds.**

et al. 1991—as *T. baccata*). Drawings and photos in Loudon (1844), Watt (1926), and Rodwell et al. (1991) show the twisted branches that characterize this species. Specimens from Ireland identified as *T. baccata* var. *glauca* may be an introduction as yew is generally rare in Ireland; however, one record is known to occur with *Arbutus unedo*, a species more commonly found in the Mediterranean flora. The natural occurrence of yew in Scotland has also been considered rare (Godwin 1975; Mitchell 1974)—where two different varieties of *T. fastigiata* are proposed, one from Inchcailloch Island (Loch Lomond) and another from near Tweeddale. A large tree—with a circumference of 16 m, from near Fortingall—is thought to be the oldest living yew in Europe, estimated at 3000 yr (Voliotis 1986) to 5000 (–9000) yr on internet sources. I have not studied specimens of this plant but photos on the web show the isodichotomously divided branches from the trunk that suggests *T. baccata*, and one fuzzy photo showing leaves on pendant branches that further suggest *T. baccata* var. *dovastoniana*.

Plants with less distinct radial orientation and more distant leaves are proposed as distinct varieties (Spjut, unpubl., www.worldbotanical.com). They differ by leaf length. One with long narrow linear leaves, which includes specimens from Madeira, British Isles and Romania, is difficult to distinguish from *T. contorta*.

IIIB. *BACCATA* GROUP, *CUSPIDATA* ALLIANCE

Yews of this alliance are recognized by leaves spreading from branchlets more by bending of their petioles than by curving of their blades, and by having a relatively broad abaxial margin zone of epidermal cells without papillae, usually from 8–24 cells across. Another less obvious distinction is that the epidermal cells are slightly wider and shorter than those of the *Baccata* Alliance, except for *T. canadensis*. Five species and 15 varieties are recognized.

Figs. 44A–B. *Taxus biternata*, distinguished by the much-divided thin branchlets, leaves pinched inwards ca. two-thirds up from the base, and by cones maturing on branchlets of the current season; South Korea, *Wilson 10688* (holotype, A). **A** (top). Herbarium specimen. **B** (bottom). Branchlets and leaves with two arillocarpia.

The taxa are very difficult to distinguish as they intergrade; *Taxus biternata* and *T. caespitosa* var. *caespitosa* are most distinct.

20. Taxus biternata Spjut, sp. nov. (**Figs. 6, 44**). Type: SOUTH KOREA. Kyog[sang] Prov.: Kyongsan, Nemon-rei, common or abundant, 15 Sep 1917, *Wilson 10688* (holotype: A! with arillocarpia (abaxial leaf with marginal zone of 8–9 smooth cells, 9 papillose cells, stomata 9 rows per band, midrib lacking papillae); isotypes: K! (leaf with marginal zone of 6 cells across without papillae followed by 8 rows of papillose cells, 7 stomata rows, and midrib with marginal papillae), US!).

Taxus microcarpa (Trautv.) Spjut ined. (in adnot.: A, BH, BM, GH, K, NA, P).

Taxus canadensis affinis, a qua imprimis differt arbor, ad 30 m alta, arillocarpia maturibus ramulus primus et stomata (7–)9–13(–16) seriata/zona; ramis anisodichotomis horizontalibus, ramulis diffusibus biternatifidibus; folia pectinatum disposita, patentia, linearia, 1.5–2.5 cm longa, 1.5–2.5 mm lata, acuta ad acuminata, 0.150–0.300 mm crassa, supra ramis petiolibus contorta, supra convexa, subtus concava ad plana, cellulas epidermis supra 0.8–25 µm alta, 20–30 µm lata, quasi elliptica in sectione transversala; ventralibus epidermae cellulae quasi rectangulara, non inflata proximus marginalia, costa interdum papillosa vel laevis, proparte papillosa versas de maginalia, sine papillae (6–)8–12(–19) cellulae marginales latis.

Trees or shrubs with erect trunks and horizontal branches, to 30 m high; *branchlets often short and much-divided*, subpinnately arranged but unequally divided, appearing ternately divided or with short delicate tertiary branchlets, horizontal or weeping, yellowish green when young, yellowish orange with age; bud-scales closely overlapping in 3–4 ranks, mostly persistent to the 3rd yr, thick, deltoid, concave, medially recurved and incurved towards apex to form a cusp, with an obscurely thickened midnerve, ca. 1 mm long, spreading from base of branchlets. Leaves persistent on older twigs, or lacking, green upon drying, in two-ranked like arrangement to apex, linear, straight to slightly falcate, 1–2 cm long, 1–2 mm wide, 150–250 µm thick, pale green and convex above to a rounded midrib that forms a channel along the base of the midrib, pale yellowish green and concave below to a rounded midrib, revolute near margins 30–90° in dried leaves, more notably revolute at upper one-third of leaf; adaxial epidermal cells in T-sect. elliptical, 10–15 µm tall, 25–40 µm wide; abaxial epidermal cells similar or larger, 10–15 µm tall, 15–25 µm wide, numbering 11–18 between margin and stomata band, mostly rectangular, or sinuous near the stomata band, 3–7× l/w except quadrate in 1–3 rows near margins, epapillose entirely across the marginal region, or marginal region often partially papillose, often epapillose on (6-) 8–18 cells in from the margins, occasionally with obscure papillae on midrib, papillae usually more prominent on marginal cells bordering stomata band, in 2 opposite rows; stomata bands broader than the marginal region, with 7–13(–16) stomata rows per band. Male bud cones globose, ca. 1 mm diam.; scales 4-seriate; sporophylls ca. 14, united into a terete, smooth or obscurely ribbed column, thickened at apex, spreading shortly above, each branch bearing 8–10 lobed, cucculate sporangia. Female cone scales 4–5 seriate; aril red or pink with tinge of white, with a deep cup, drying dark purple; seed subglobose, obscurely angled where tapering to apex in upper half, 4 mm long, 2–4 mm diam.

Common name.—Delicate branch yew.

Distribution and ecology.—China (NE, Manchuria), Russian Federation (SE Region), North Korea, South Korea, Japan; forests, 800–1400 m. In NE China dominant in "mixed broad-leaved deciduous and needle-leaved evergreen forests" (Hou 1983). On N Hokkaido (Japan), "fairly common" within a mixed conifer hardwood forest of *Picea jezoensis* (Siebold & Zucc.) Carrière, *P. glehnii* (F. Schmidt) Mast., *Abies sachalinensis* (F. Schmidt) Mast., *Populus maximowiczii* A. Henry, *Kalopanax septemlobus* (Thunb.) Koidz., *Ulmus japonica* Siebold, and *Acer pictum* Thunb. ex Murray (Wilson 1916, as *T. cuspidata*). Common in cultivation, including Cv. 'Capitata' and shrub forms misapplied to *T. media* Rehder. At the Secrest Arboretum, apparently spreading by seed among native deciduous hardwoods.

Additional specimens. **RUSSIAN FEDERATION. Far East Region:** Pryanyk For. Div., Zalese Village, silver fir-cedar-broad-leaved forest, *B. Cerereu* (in Russian, A). **Manchuria:** Northern, Sochintzest, forest, small trees 20 Sep 1931, *Skvortzov s.n.* (A). **CHINA. Jilin** (Kirin), 5 Sep 1931, *C. H. Chen 539* (A); Mandshuria SE, *ex herb. hort. bot. Petropolitani*, 1860, *Maximowicz*, iter secundum (A, US); Northern China {**Shaanxi**: Tai-pei-shan *fide* Rehder & Wilson in Sargent 1914], *Purdom s.n.* (GH). **[South] Korea**. Kyog[sang] Prov.: Kyongsan, Nemon-rei, common or abundant, *Wilson 10519* (A, BM, US), *Wilson 10688* (A, BM); N. Heian Prov., O.G.M. Co. Mines, Pukchin & Takkari, 833–1000 m, not uncommon in moist forests, *Wilson 8685* (A, K, US); Shinkabachin Heizanchien to Ehoshin, Kankyo-N Heian divide, rare, 5 Sep 1917, *Wilson 9097* (A); Seoul, East Palace Park 24 Sep 1905, *Jack s.n.* (A). **JAPAN. Hokkaido:** Cosl Mines, Utishini, tree , 20 Sep 1892, *Sargent s.n.* (A); Aza-akaigawa in Morin-machi, 42°0'N 140°39'E, near stream in open woodland, 200 m, tree 20 ft, seeds embedded in reddish aril, *Meyer et al. 19261* (NA); Teshikaga-Machi, 3.2 km SE of Lake Kusharo, road 243, Kawakami-gun, Kushiro, 43.35 N, 144.23 E, *Meyer et al. 19112* (NA); Hokkaido, Kitami prov., common in moist woods, tree 15 m × 1.5 m, 17 Aug 1914, *Wilson 7399* (A). **Honshu:** Sernja prov., Yamanaka on Fuji-san, abundant, tree 6–3 m × 1.5-2.6 m, *Wilson 7778* (A, K); Kai prov., around village of Nakaihinsen, common hedge, *Wilson 7544* (A); Nagano-ken, Okmachi, *Uno 2611* (A, BH); Yokohama, *ex Herb. Hort Petro., Maximowicz* (P); Kamikawa, *Nitzelius* (S: C-2111); Tokyo Pref.: Oizuni, Nepymawku *Makino 43775* (S: C-2111); Mt. Kiyosumi, *Makino 43779* (S: C-2122); Sapporo, Yezo, 21 Jun 1903, *Arimoto s.n.* (A).

Taxus biternata is easily identified by its tree habit with an erect bole and horizontal diffuse branching, and by the much divided slender branchlets with a two ranked leaf arrangement. The tree habit not only distinguishes it from *T. cuspidata*, which differs by long ascending or recurved branches, but also from a shrub yew originally described as *T. baccata* var. *microcarpa*. A detailed study by Kolesnikov (1935) showed that the tree variety (*T. biternata*)—which he referred to *T. cuspidata*—and shrub yew were parapatric with distinct morphological and ecological characteristics. The shrub yew, *T. umbraculifera* var. *microcarpa*, is also similar to *T. canadensis* in layering, but differs in its flat-topped radial growth—as illustrated by Kolesnikov (1935), and by the much smaller paler seed, shaped like a "Hershey Kiss."

Occasional specimens of *T. canadensis* from North America (e.g., *Travis 119,* Maine, PH), Estonia (e.g., *Lundström 742*, S), and others from Europe (e.g., *Handel Mazzetti,* Mt. Olympus, Greece, K) and SW Asia (e.g., *Davis 13667,* Turkey, K) are similar to *T. biternata* in the linear leaves spreading in two ranks with more strongly revolute margins in the upper third as seen in dried specimens. While most specimens can be distinguished by branching, the 3rd yr branchlets of *T. canadensis* have a purplish tint, in contrast to yellowish orange in *T. biternata*. A Maack specimen without number from Manchuria, mounted with the type with *T. baccata* var. *microcarpa* (GH), however, has a leaf spread and color that is hard to distinguish from *T. canadensis*. The female cone scales appearing on the current season growth compare more favorably with *T. biternata*. *Taxus canadensis* seed often mature on 2nd yr or older growth as seen in herbarium specimens; while I also recognize that field studies are needed throughout the range of the species to further substantiate the taxonomic value of this character.

In southeastern Manchuria, *T. biternata* appears to hybridize with *T. umbraculifera* var. *microcarpa* and var. *umbraculifera*. Plants with linear leaves (10× l/w or more) that are strongly recurved in upper third are referred to *T. biternata*. Those with relatively short leaves (oblong, 5–8× l/w) are considered var. *microcarpa*.

21. Taxus caespitosa Nakai, Ch[Ty]ôsen Sanrin Kaihô (J. Kor. For. Soc.) 158:40. 1938. (**Figs. 8, 45**). *Taxus cuspidata* Siebold & Zucc. var. *caespitosa* (Nakai) Q.L. Wang, Clavis Pl. Chinae Bor.-Or., ed. 2:73. 1995. TYPE: JAPAN: 15 Jul 1922, *Sawada s.n.* (LECTOTYPE designated here: TI!). The reference to the type specimen in the typographical format quoted from Nakai (1938) is interpreted here as belonging to either of the two specimens cited; the other, *Kimura s.n.*, Aug 1924 (TI), is here identified as *Taxus umbraculifera* var. *nana*. TOPOTYPES: *Wilson* (A!), *Makino 43792* (S!).

Taxus umbraculifera subsp. *latifolia* (Pilger) Spjut ined. (in adnot. A).

Three varieties are recognized.

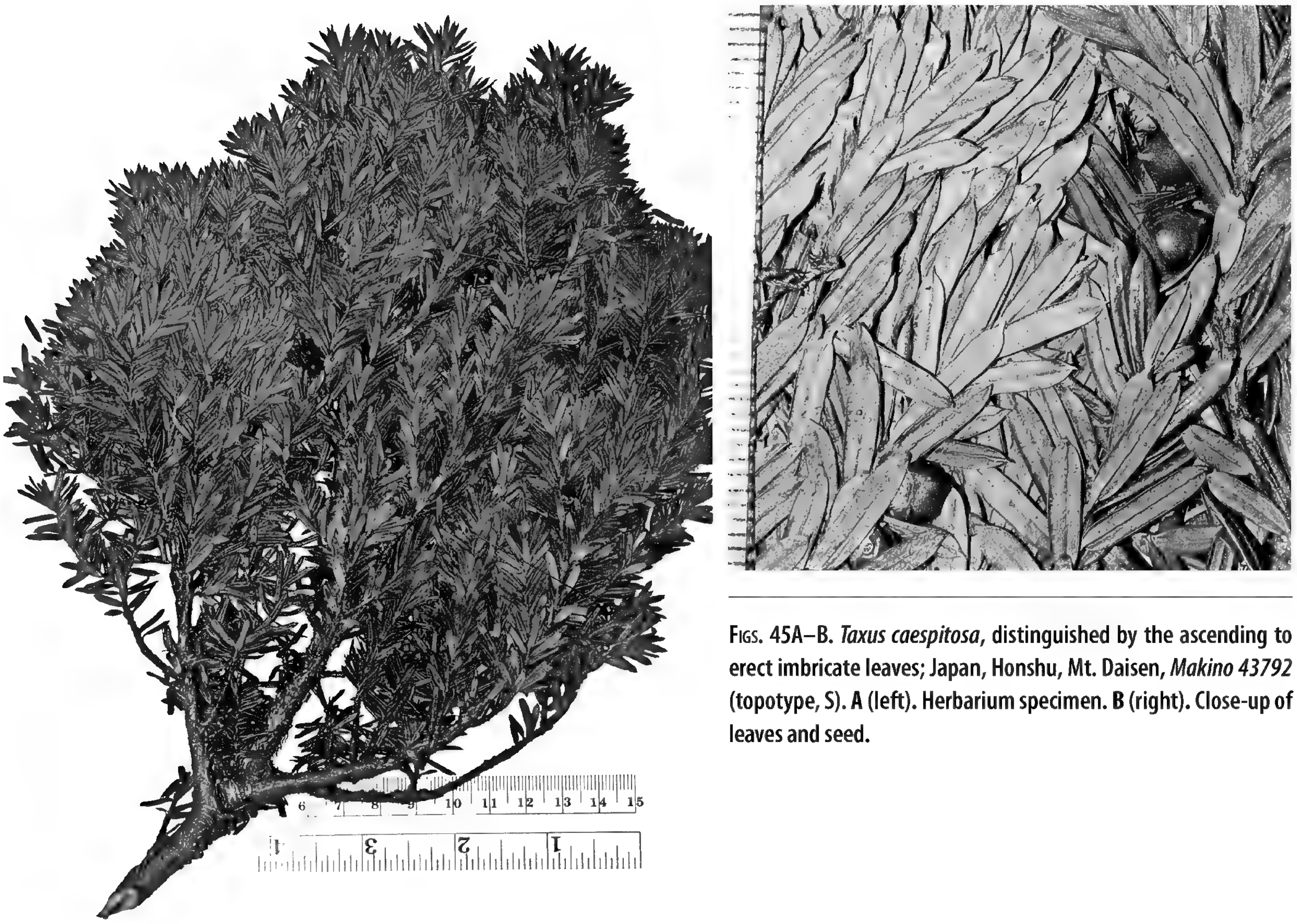
21a. Taxus caespitosa var. caespitosa

Common name.—Caespitose yew.

Distribution and ecology.—Russian Federation (Sakhalin Is.), Korea, Japan.

Additional specimens: **RUSSIAN FEDERATION. Sakhalin Is.:** *Schmidt s.n.* (GH). **KOREA.** In forest, Aug 1907, *Faurie 1512* (A, BM, E). **JAPAN. Honshu:** Niigata, Yuzawa-machi, Minamiuonuma-gun, in *Pinus pumila* scrub, 1650 m, evergreen shrub 0.8 m high, fr red, 3 Oct 1979, *Taoda 3887* (A); Hakkada, windswept slopes, 1000–2000 m, bush 1–1.5 m, rare, 4 Jul 1914, *Wilson 7133* (A); Mutsu Prov., Mt. Hakkoda, *Mizushima 1985* (A); Ohobu near Kobe Calta, 19 Mar 1955, *Muroi 1058*, annotated *T. cuspidata* var. *ambraculifera* (A). **CULTIVATION. OHIO. Secrest Arboretum:** 'Colean', *A30-131*; 'Dwarf Japanese Yew' *A30-163*; 'Hill Anglo-Japanese Yew' *A30-264*.

Taxus caespitosa var. *caespitosa* is identified by the crowded branches and radial distribution of leaves that have an erect orientation. The leaves appear more imbricate than decussate, and curve upwards along the petioles and the blades in the same direction they spiral. Wilson (1916) described plants he saw in Japan as having prostrate branches (from which erect branchlets apparently arise). This is evident in herbarium specimens by the one-sided development of branchlets, which includes specimens from the type locality, Mt. Daisen,



Figs. 45A–B. *Taxus caespitosa*, **distinguished by the ascending to erect imbricate leaves; Japan, Honshu, Mt. Daisen,** *Makino 43792* **(topotype, S). A (left). Herbarium specimen. B (right). Close-up of leaves and seed.**

obtained by Wilson and by Makino. However, cultivars that I have seen as belonging to this variety are not prostrate shrubs, and do not show the small seeds seen in herbarium specimens of wild plants.

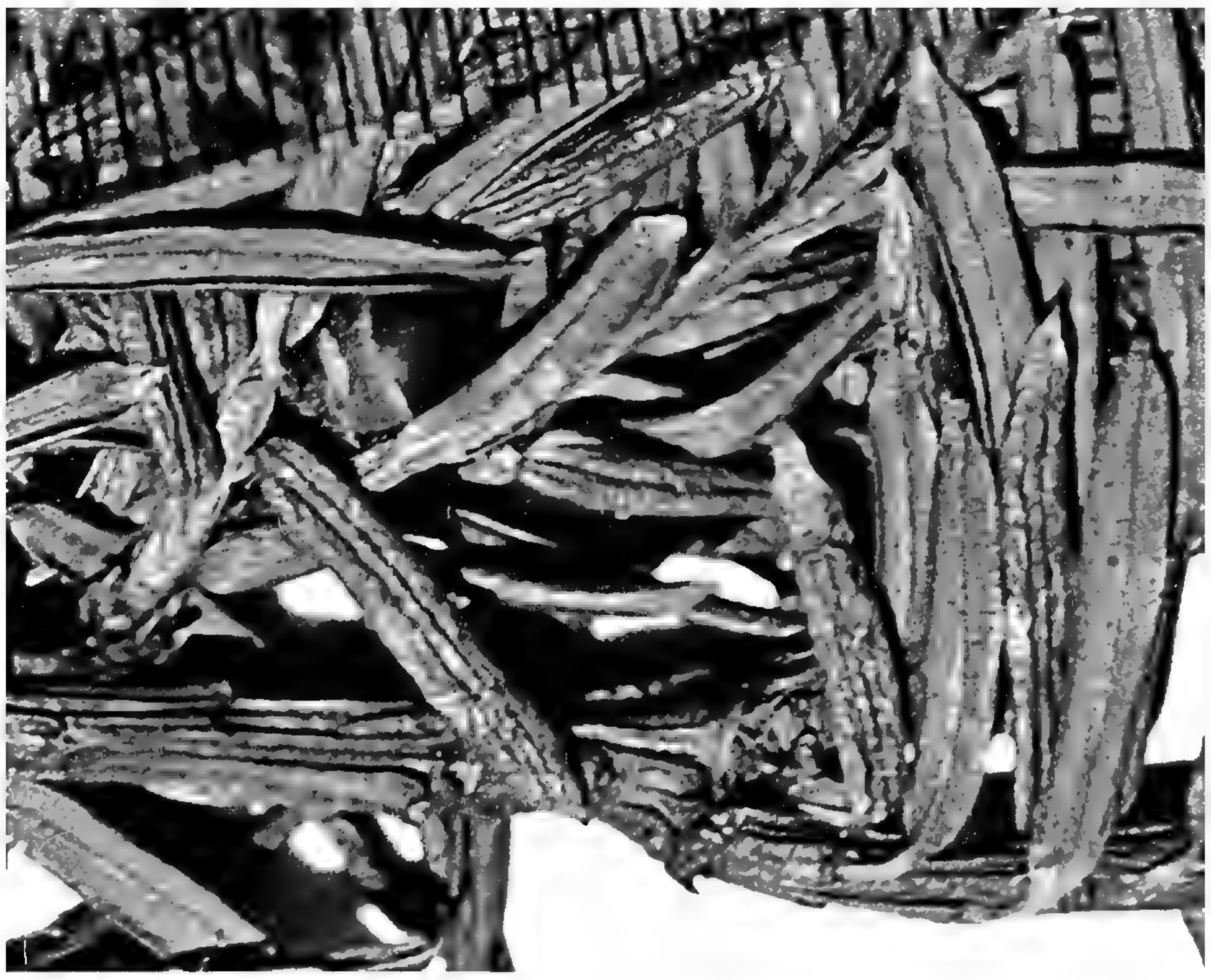
In E Asia where shrub yews show evidence of considerable diversity in habit and in phyllotaxy, the one sided branching and secund leaves of var. *caespitosa* are postulated as ancestral traits allegedly retained in plants with ascending to erect basal branches; these plants are referred to var. *latifolia*. Kolesnikov (1935) regarded the presence of yew in the Manchurian flora as an archaic element having little historical relationship to the rest of the vascular flora, while shrub yews in other regions have been noted to occur in environments that are distinct from their tree relatives such as reported by Elias and Korzhenevsky (1992) for shrub yews in Ukraine and Georgia. Two other distinct shrub types are also recognized in North America, *T. brevifolia* var. *reptaneta* in the Pacific NW has a characteristic habit with a distinct ecology, and *T. canadensis* in NE America has long been know for its shrubby monoecious habit.

21b. Taxus caespitosa Nakai var. **angustifolia** Spjut, var. nov. (**Figs. 46–47**). Type: JAPAN. Prov. Kozuke: Oze-ga-hara, "shrubby habit, "leaves dark green," "yellowish green beneath," 26 Aug 1950, *Mizushima 401* (holotype: A! [leaves with a double row of palisade parenchyma cells, a marginal zone of 14 cells across lacking papillae, 9–10 stomata rows per band; seed]).

Varietas nova frutex, var. *caespitosa* proxima, cujus ramis primus prostratus, ramulosus numerosus, erectus; folia pectinatum disposita, patentia, linearis, 1.5–2.0 cm longa, 1.5 mm lata, acuta, ±0.200 mm crassa, ±disticha; semen ovata, purpurascens, 5 mm longa.

Apparently prostrate, bearing numerous erect reddish orange branchlets, persistent bud-scales few, cuspidate, ca. 1 mm. long; leaves mostly distichous, spreading from erect branchlets, erect on horizontal branchlets, reportedly dark green above, yellowish below, becoming reddish green in the herbarium, revolute along margins when dried, 1.5–2.0 mm long, ca.1.5 mm wide, lacking papillae entirely across 14 marginal cells and on and midrib; with 9–10 stomata rows per band. Seed near base of branchlets, ovoid, purplish, tapering to sharp apex.

Common name.—Ground cover yew.



Figs. 46A–B. *Taxus caespitosa* var. ***angustifolia*,** **distinguished in part by the one sided branching—apparently from a prostrate stem (branch) with erect branchlets—and by the relatively thin, linear leaves that are revolute along margins when dried; Japan,** ***Mizushima 401*** **(holotype A). A (above). Herbarium specimen, showing an apparent prostrate branch and erect branchlets. B (left). Close-up of leaves and seed.**

Distribution.—Korea, Japan.

This variety is recognized by the relatively thin, narrow leaves as in *T. biternata*, but apparently has the habit of *T. caespitosa* var. *caespitosa* as shown in Fig. 50, reproduced from the Illustrated Encyclopedia of Fauna & Flora of Korea (Chung 1965). In this reference, the species is reported to be a shrub that is distinguished by layering.

Additional specimens: None. Known only from the type and illustration.

21c. Taxus caespitosa Nakai var. **latifolia** (Pilger) Spjut, comb. nov. (**Fig. 48**). Basionym: *Taxus baccata* L. [subsp. *cuspidata* (Siebold & Zuccarini) Pilger] var. *latifolia* Pilger, Pflanzenreich 4(5):112. 1903. *Taxus cuspidata* var. *latifolia* (Pilger) Nakai, J. Kor. For. Soc. 158:39. 1938. Type: JAPAN: Hokkaido: Hakodate, [with two labels, one dated 30 Dec 1890 and another dated 1888], *Faurie 6345* (lectotype designated here: P! [with male cones (abaxial leaf with 18 smooth marginal cells followed by a stomata band with 11 rows of stomata, and a smooth midrib]); isolectotype: K fragment!). Syntypes: from E Russian Federation and Japan.

Additional specimens. **RUSSIA FEDERATION. Sakhalin Is.:** 46°37'N, 142°53'E, Prigarodne, mixed conifer (*Abies, Picea*)/broadleaved (*Betula, Sorbus*) woodland, 150 m, to 1.8 m high, *Flanakan & Kirkham 203* (K). **Korea**: in forest, 800 m, 19 Jul 1910, *Taquet 4455* (A); without locality data, *Faurie 117* (P), *3406* (P), *5975* (P). **JAPAN. Hokkaido:** Shiribeshi Prov., Shiribeshi-san, branches wide spreading, 1–2 m, common, 1300–2000 m, 27 Jul 1914, *Wilson 7265* (A). **Honshu:** Mutsu Prov., Mt. Hakkoda, erect tree, 8 Jul 1952, *Mizushima 1989* (A). without locality data, *Faurie 5114* (P: 2 sheets). Locality unknown: *Folley s.n.*, identified *T. cuspidata 'nana'* (K).

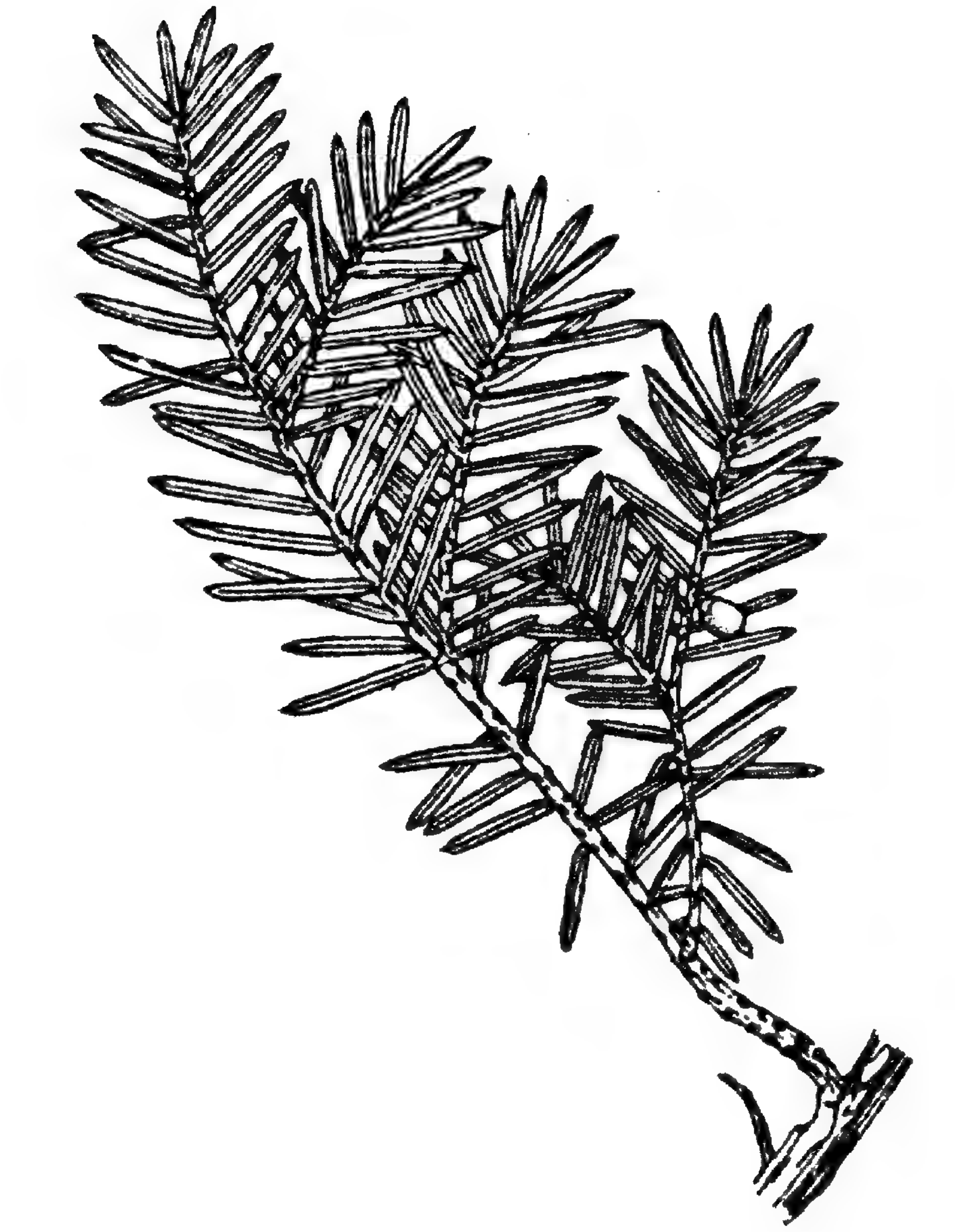


Fig. 47. ***Taxus caespitosa*** **var.** ***angustifolia*****, reproduced from Illustrated Encyclopedia of Fauna & Flora of Korea (Chung 1965, as** ***T. caespitosa*****). Description of plant in that reference indicated that it reproduces by layering.**

Variety *latifolia* is best distinguished by the flexuous branchlets with overlapping erect leaves; however, it varies widely in habit. It may produce a single main branch that creeps along the ground and layers as evident in *Faurie 5114* from Japan, *Faurrie 3406 & 5975* from Korea, *Flanagan & Kirkham* from Sakhalin Is., and *Folley* from cultivation. Erect forms are recognized by branches and leaves that develop primarily on one side of the plant. Wilson (1916) described plants from Shiribishi-san in Japan as either "prostrate on the ground" or as a "broad shrub, 1–2 m high." The prostrate form could be treated as another distinct variety. Chang (pers. comm.) found significant differences in taxane ratios in specimens that I identified as two forms of *T. caespitosa* that were reportedly grown under similar conditions in a greenhouse.

Pilger (1903) distinguished var. *latifolia* from var. *cuspidata* by the densely branched habit, relatively wide leaves (to 2 mm wide), and small, depressed globose seeds. His description partly agrees with that given by Trautvetter (in Maximowicz 1859) for an earlier name *T. baccata* var. *microcarpa*; however, two lectotypes—as applied to two different varietal names—were selected from four syntypes (*Faurie 5975, 6345, Maack* s.n., *Schmidt* s.n.) as cited by Pilger (1903). *Faurie 6345* at P was selected as lectotype for var. *latifolia* because it is a whole specimen mounted alone, and because it has cones (male), compared to other Faurie specimens that were usually sterile and mounted with other specimens on a single sheet as seen in other herbaria. *Maack* from Heilongjiang at GH is the lectotype for *T. baccata* var. *microcarpa* (bottom specimen of two mounted on one sheet). A specimen by *Schmidt* from Sakhalin Island at GH, referred to in the present study as var. *caespitosa*, is a reddish specimen mounted among several other greenish specimens on the same sheet—regarded as *T. umbraculifera* var. *nana*—possibly collected by Augustiowoz. Nakai (1938) also distinguished var. *latifolia* by leaves 3–4.5 mm wide and indicated that var. *nana*, an earlier name, was known only in horticulture; however, var. *nana* has been recognized to occur naturally in Japan (Ohwi 1965).

22. Taxus canadensis Marshall, Arbust. Amer. 151. 1785. (**Fig. 49**). *Taxus baccata* L. var. canadensis (Marshall) Gray, Man. Bot. N. United States, ed. 2, 425. 1856. *Taxus baccata* L. subsp. *canadensis* (Marshall) Pilger, Planzenreich 18 (iv, 5):113. 1903. Type: U.S.A. Vermont: 1877, *C.G. Pringle s.n.* (neotype designated here: US! [leaf with abaxial marginal region of 16–18 smooth cells, stomata bands papillose throughout with stomata in 6 irregular rows per band]). Original material unknown.

A specimen at the Museum of Natural History in London (BM) collected by Joseph Banks in 1766 refers to "Marsh. Hb.," which suggests a possible type. However, the existence of material used by Marshall is unknown. His publication (Marshall 1785) was related to his sales catalogue (Silber & deWolf 1970). A neotype was selected based on a cone-bearing specimen that showed the most common morphology.

Figs. 48A–B. *Taxus caespitosa* var. *latifolia*, distinguished by the spreading branchlets with ascending to erect, imbricate leaves; Japan: *Faurie 6345* (lectotype, P). A (left). Herbarium specimen. B (below). Close-up of branchlets with leaves and male cones.

Figs. 49A–B. *Taxus canadensis*, neotype. U.S.A., Vermont, Pringle, yr 1877 (US). A (left). Herbarium specimen. B (below). Close-up of branchlet showing mature male cones. Var. *canadensis* distinguished by the linear acute leaves spreading horizontally along two sides of a branchlet.

Taxus canadensis is distinguished by leaves having relatively narrow stomata bands bordered by 8 or more marginal cells. Stomata usually number 5–7(–9) rows per band in American plants, or from 4–11 rows per band in Euro-Mediterranean plants. The marginal zone along the abaxial surface of the leaf varies from 12–18 cells wide in specimens from North America, and from 8–24 cells wide in specimens from the Euro-Mediterranean. American plants have papillae confined to stomata bands, sometimes only along a stomata row. Except for one specimen from Ithaca NY, the Euro-Mediterranean plants also differ by more conspicuous papillae in stomata bands with papillose cells sometimes extending into the adjacent marginal zone. The European plants could be referred to fossil species *T. inopinata* Givulescu or *T. grandis* Krausel. The consistent absence of papillae along the abaxial leaf margin in American plants clearly indicates that development of epidermal papillae is genetically fixed.

Taxus canadensis has also been distinguished from related species by its monoecious habit in which plants often creep along the ground and spread by layering (Allison 1991; Bannan 1942), but these characters are rarely reported on labels of herbarium specimens. Nevertheless, *T. canadensis* is not always monoecious (Allison 1991), and perhaps tree forms exist; a specimen I cited from Sainte Baume (France) is where the oldest yew trees are known in France, "attaining a girth of 11½ feet" (Elwes & Henry 1906), and where yew was once abundant (Elwes & Henry 1906). Layering in European yew is thought to be rare, but nevertheless known from Scandinavia (Elwes & Henry 1906) where I have also identified *T. canadensis* from herbarium specimens. The occurrence of *T. canadensis* in Scandinavia is further evident in a photograph of a plant on Saaremaa Island in Estonia that clearly shows a low sprawling plant in a forest understory (of spruce, *Picea abies* [L.] H. Karst; Korpela's Index, website), which I have further identified as *T. canadensis* var. *adpressa*.

Two other character features that reinforce identification of *T. canadensis* outside North America are bud-scales at base of branchlets and color of leaves. In the Canada yew, bud-scales remain rather loosely attached at base of branchlets, and are usually keeled or folded along the mid-nerve, often appearing incurved or cuspidate above the mid region as in *T. biternata* (see Cope 1998 for illustrations of bud-scale features). This is in contrast to scales of the *T. baccata* and its allies that show various other combinations of character attributes. In *T. baccata* var. *baccata*, bud-scales at base of branchlets are loosely attached, but still thick and obtuse, not at all incurved or cuspidate, or other varieties of *T. baccata* have similar thickened obtuse scales more tightly adpressed to branchlets, or in the related *T. recurvata*, bud-scales are thickened cuspidate but not tightly adpressed to branchlets. The other character feature of *T. canadensis* is the dark green color of leaves as determined from general observation and from under the microscope. Most specimen leaves of *T. baccata* differ by a yellowish green, olive green, or glaucous green color. Exceptions occur in specimens from eastern Europe and southwestern Asia where color and anatomical differences overlap between *T. canadensis* and *T. baccata*.

Three varieties of *T. canadensis* are recognized. The typical variety is frequently isodichotomously branched with leaves in pressed specimens appearing crisscrossed in pairs along one side of a branchlet. The leaves are broad linear and spread from branchlets at their petioles in which the blades are relatively straight. Variety *adpressa* differs by irregular alternate branching and by having oblong and truncated leaves near apex, which is acute or obtuse, while var. *minor* is recognized by the crowded erect (secund) leaves. In further studies additional varieties may be distinguished; an example is *Hayek & Hayek s.n.* (BM) from Styria Superior in Austria that is similar to var. *minor* except for the branchlets that appear more recurved with narrower erect leaves, features that are seen more in *T. cuspidata*.

22a. **Taxus canadensis** var. **canadensis**

Common name.—Canada yew.

Distribution and ecology.—E North America (Manitoba near Lake Winnipeg south to Indiana, Newfoundland south along the Appalachian Mts. to NW North Carolina and Tygarts Creek, Kentucky), NW Africa, Europe, W Asia; shady wet places, benches above rivers, or among rocks or soil in bottomland forests of mixed hardwoods and conifers, especially hemlock and beech, 300–1500 m.

Fig. 50. ***T. canadensis*** **var.** ***adpressa*****. Reproduced from Carrière (1855b), neotype. Var.** ***adpressa*** **distinguished by the oblong, obtuse leaves generally spreading along two sides of a branchlet, overlapping slightly.**

22b. Taxus canadensis Marshall var. **adpressa** (Hort. ex Carrière) Spjut, comb. nov. (**Fig. 50**). Basionym: *Taxus* [*baccata* var.] *adpressa* Hort. ex Carrière, Rev. Hort., sér 4, 4:93, fig. 8. 1855 (and Traité gén. conif. 520. 1855). *Taxus baccata* L. [var.] *adpressa* (Carrière) Carrière, Traité gén. conif. 731. 1867. Type: Described from horticulture, original material unknown (neotype designated here: Illust. Fig. 8 in Carrière, Rev. Hort., sér 4, 4:93. 1855).

Cephalotaxus tardiva Siebold *ex* Endlicher, Syn. conif., 239. 1847. *Taxus tardiva* (Siebold ex Endl.) Hort. ex Knight, Syn. conif. pl. 52 (1850); *T. tardiva* (Siebold ex. Endl.) Hort. ex Lindl. & Gordon, J. Hort. Soc. 5:227. 1850. *Taxus baccata* f. *tardiva* Pilger, Pflanzenreich 18 (iv, 5):114. 1903.

Common name.—Rigid-leaf yew.

Distribution.—E North America, Europe, W Asia.

The name for this taxon has been confused in the literature. If recognized as a species, the correct name would be *Taxus tardiva*, but as a variety, the epithet *adpressa* has priority. Carrière referred to it both ways in 1855, as a species in *Revue Horticole*, and as a horticultural variety in *Traité Général des Conifères* under the bionomial name, *Taxus adpressa,* with many synonyms listed, including *T. baccata adpressa* with reference to his earlier journal publication (Carrière 1855b). The ICBN (Art. 11.2, 11.4) indicates that priority is determined by the "final epithet," which "*Taxus adpressa*" was indicated to be a variety, and although in a binomial format, the epithet has priority as variety over *Cephalotaxus tardiva* that was first recognized as a species.

This variety is generally known in horticulture where it was thought to originate as a natural seedling in a nursery at Chester, England in 1826 (Bean 1953; Elwes & Henry 1906; Pilger 1916; Wilson 1916), but also recognized to occur occasionally in the wild (Krüssmann 1985). Others have reported it native to China and Japan (Endlicher 1847; Koch 1873), and still other reports mentioned it as occurring in California, in association with sugar pine, ponderosa pine, Douglas fir and other species (Revue Horticole 1848, 1849).

22c. Taxus canadensis Marshall var. **minor** (Michx.) Spjut, comb. nov. (**Fig. 51**). Basionym: *Taxus baccata* β *minor* Michx., Fl. Bor. Amer. 2:245. 1803. *Taxus minor* (Michx.) Britton, Bull. Torrey Bot. Club 4:167. 1893, no specimens cited. Original Material at P, a single specimen. Type: CANADA. ex Herb. *A. Michaux* (holotype: P!).

Common name.—Minor yew.

Distribution.—NE U.S., E Canada, Portugal (Madeira), Austria.

This differs from var. *canadensis* by the more densely leafy branches with the leaves tending to be obtuse and falcate-secund.

23. Taxus cuspidata Siebold & Zucc., Abh. Königl. Bayer. Akad. Wiss., Math.-Phys. München, III, 801. 1843 (in footnote: ref. to Siebold and Zuccarini, Fl. Jap. II. tab. 128 and to [a description] *T. baccata* in Thunberg (1784, Fl. Jap. 275, "foliis solitariis, linearibus, cuspidatis, approximatis"). (**Figs. 7, 52**). No specimens cited. *Taxus baccata* L. (var.) *cuspidata* Carrière, Coniferae 733. 1867; *T. baccata* subsp. *cuspidata* (Siebold & Zucc.) Pilger,

Fig. 51. *Taxus canadensis* var. *minor*. Canada, *ex Herb. A. Michaux* (holotype, P). Var. *minor* distinguished by spreading to recurved branchlets with ascending (secund), closely overlapping, leaves.

Figs. 52A–C. ***Taxus cuspidata*, Japan, original material (M). A (left). Herbarium specimen with lectotype, the specimen on the right (lower) with branchlets that may have been pendant. B (top). Close-up of persistent cuspidate bud-scales at base of branchlet. C (above).Close-up of leaves and male cones where the two specimen overlap, showing adaxial and abaxial surface of leaves uniformly recurved leaf margins and male cones.**

Planzenreich 4(5):112. 1903. Original material at M. Type: JAPAN: (lectotype designated here: M!, sheet with the following data on labels "*Legit in Japonia et Communicavit de Siebold, anno 1842*," Herbarium Regium Monacense," "Herb. Zuccarini," and "Herbar. Univ. Ludov. Maximil.," the specimen on the right of two mounted on the same sheet, with mature male cones; the left specimen also identified as *T. cuspidata*; isolectotypes: M!, K!, apparently from the same plant as lectotype but with other data on labels).

Taxus cuspidata is possibly native to Hokkaido, Japan, but apparently rare except perhaps in arboreta. Two specimens that were collected by Jack from Hokkaido (A) are clearly related to the type as seen in phyllotaxy, color, and leaf anatomy. The leaf anatomical data in Spjut (2007) show the specimens to have a wider abaxial margin, 16–24 cells wide, compared to a margin of 8–15 (-18) cells across in all other specimens from the Sino-Japanese Region. These three specimens appeared to have the most conspicuous persistent bud-scales of all yews in that region, a character trait that reinforces the choice of the lectotype.

The authorship and publication date for *T. cuspidata* have been confused in the literature. The official date of the volume for Siebold and Zuccarini's Flora Japonica, in which *T. cuspidata* was intended to be described as a new species, did not appear until 1870; yet, reference to this publication, including a figure (Tab. 129 instead of Tab. 128), was first made by Siebold and Zuccarini (1843) 27 years earlier at which time they cited the name in footnote with further reference to a description in Thunberg (1784, *Flora Japonica*). Siebold and Zuccarini's (1846) synopsis of plant taxa in Japan, which many authorities cite as the valid publication date (e.g., Farjon 1998; Fu et al. 1999), does not provide a plant description of *T. cuspidata*; only an indirect reference to *T. baccata* in Thunberg, Flora Japonica (1784). Aside from Siebold and Zuccarini (1843), the first direct description of *T. cuspidata* appeared in Endlicher (1847). Others have since also provided a description for the species (e.g., Carrière 1855a; Lawson et al. 1851; Parlatore 1868) before Miquel published

Siebold and Zuccarini (1870), in which these earlier references were noted. However, Siebold and Zuccarini's (1843) earlier reference to a description in Thunberg (1784) satisfies the requirement for valid publication of "*Taxus cuspidata Sieb. & Zuccar.*" (Art. 32.1), indicating also the origin of the epithet ("cuspidatis").

The leaves of *T. cuspidata* overlap along branchlets with an orientation that varies according to the direction of the branchlet, appearing partially erect and slightly radial as in *T. umbraculifera*, or two-ranked as in *T. biternata*. Indeed, the phyllotaxy of the type appears intermediate between that of *T. umbraculifera* and *T. biternata*. Other specimens assigned to *T. caespitosa* var. *latifolia* are similar to *T. cuspidata* in their long flexuous branchlets (e.g., *Makino 43769* from Honshu, *Maximowicz* from Manchuria, *Dvorakovskia & Bokina* from Sakhalin Is.).

Cultivars that I have studied at the Secrest Arboretum in Ohio (Chadwick & Keen 1976) are identified as belonging to this species by the dome-like to pyramidal crown with a definite leader, and by the branches also with a definite leader that ascend upwards from which hang many long simple branchlets. In other cultivars the branchlets are stiff and recurved. The habit is reminiscent of the European Dovaston yew (*T. baccata* var. *dovastoniana* Leighton)—recognized for its weeping branches—and to other European plants known in horticulture as *T. baccata* var. *glauca* Carrière (US: 1396503 "f. *glauca* = f. *subglaucescens* Jacq.;" *ex Hillier's Arboretum* BM; *ex Herb. Petropolitani, Szovich 610,* S; *C. Baenitz* US, "f. *pendula*"). Thus, I wonder if *T. cuspidata* is of horticultural origin. Wilson (1916) commented that he was not sure whether the yew plants he saw in Japan were natural or cultivated, and since Siebold and Zuccarini (1870) noted that yew there occurred in horticulture, in cultivation around temples, and spontaneously in the mountains, it is possible that the original material came from horticulture. Also, it is interesting to note that Carrière (1861) thought that the Dovaston yew was native to Japan.

This problem is complicated by naturally occurring intermediates between the *Baccata* and *Cuspidata* Alliances as evident from anatomical data and other key characters. Examples of intermediates that are included in the *Baccata* Alliance are from Sweden (*Bjornstrorn, ex Mus. Stockholm*), Finland (*Finlandee Exsic. 419* K, p.p., bottom specimen), and the Caucasus Mountains (*Busch s.n.*). These are not easily distinguished from occasional ones in the *Cuspidata* Alliance such as from Hokkaido (*Makino 43769*), Korea (*Faurie s.n.* A, *Wilson 9484*), and Sakhalin Island (*Dvorakovakaia & Bokina*). Being able to discern the key differences among these problematic Eurasian specimens requires considerable familiarity with *Taxus*.

Another example is *Hayek & Hayek s.n.* (BM), discussed earlier under *T. canadensis*, from Styria Superior in Austria (Spjut 2007, appendix), that seems to differ from *T. cuspidata* only by its dull olive green color, in contrast to a yellowish orange color on branchlets in the E Asian specimens. From a taxonomic point of view, the majority of the specimens fall within the *Baccata* and *Cuspidata* Alliances. However, in further consideration to the distribution of *T. canadensis* in the Euro-Mediterranean Region and eastern North America, the *Baccata* and *Cuspidata* Alliances were possibly derived from an ancestral boreal complex that was perhaps distributed from northeastern North America to northeastern Asia. Thus, these intermediates could be relicts of that former complex.

24. Taxus umbraculifera (Siebold ex Endl.) [Ravenscroft] [C.] Lawson, Abietineae—List Pl. Fir Tribe 10:80. 1851. (**Figs. 9, 53–54**). *Cephalotaxus umbraculifera* Siebold ex Endlicher, Syn. Conif.239. 1847. *Taxus cuspidata* Siebold & Zucc. var. *umbraculifera*, Makino in Makino & Nemoto, Cat. Jap. pl. 407. 1914 (Also, Illus. Fl. Nippon. 1925 typographical error, spelling "ambraculifera," see ICBN Art. 61 and corrected spelling by Makino, Illus. Fl. Nippon 910, fig. 2730. 1931). Type: JAPAN: (neotype designated here: illust. in Makino, Illus. Fl. Nippon, fig. 2730. 1931.). Epitype designated here: JAPAN. Honshu: Hyogo Pref., Mt. Hyonosen, 30 Aug 1948, *Muroi 30*, ex Herb. Hiroshi Muroi, Kobe, identified by Muroi as *T. cuspidata* var. *ambraculifera* Makino (A!). Original material unknown.

The origin of the name *T. umbraculifera* may be horticultural (Gordon & Glendenning 1858, Gordon 1875); however, *Cephalotaxus umbraculifera* was attributed to Siebold by Endlicher (1847) who provided a detailed description but expressed doubt as to whether the species was distinct from *Taxus cuspidata*. Ravenscroft is recognized in Stafleu and Cowan (1983) as the contributor for Lawson et al. (1851), who attributed *C. umbraculifera* to Siebold and Zuccarini, and indicated it was a synonym of *T. cuspidata*; however, the authority for the name is indicated to be Lawson because lack of internal evidence in Lawson et al. (1851) for

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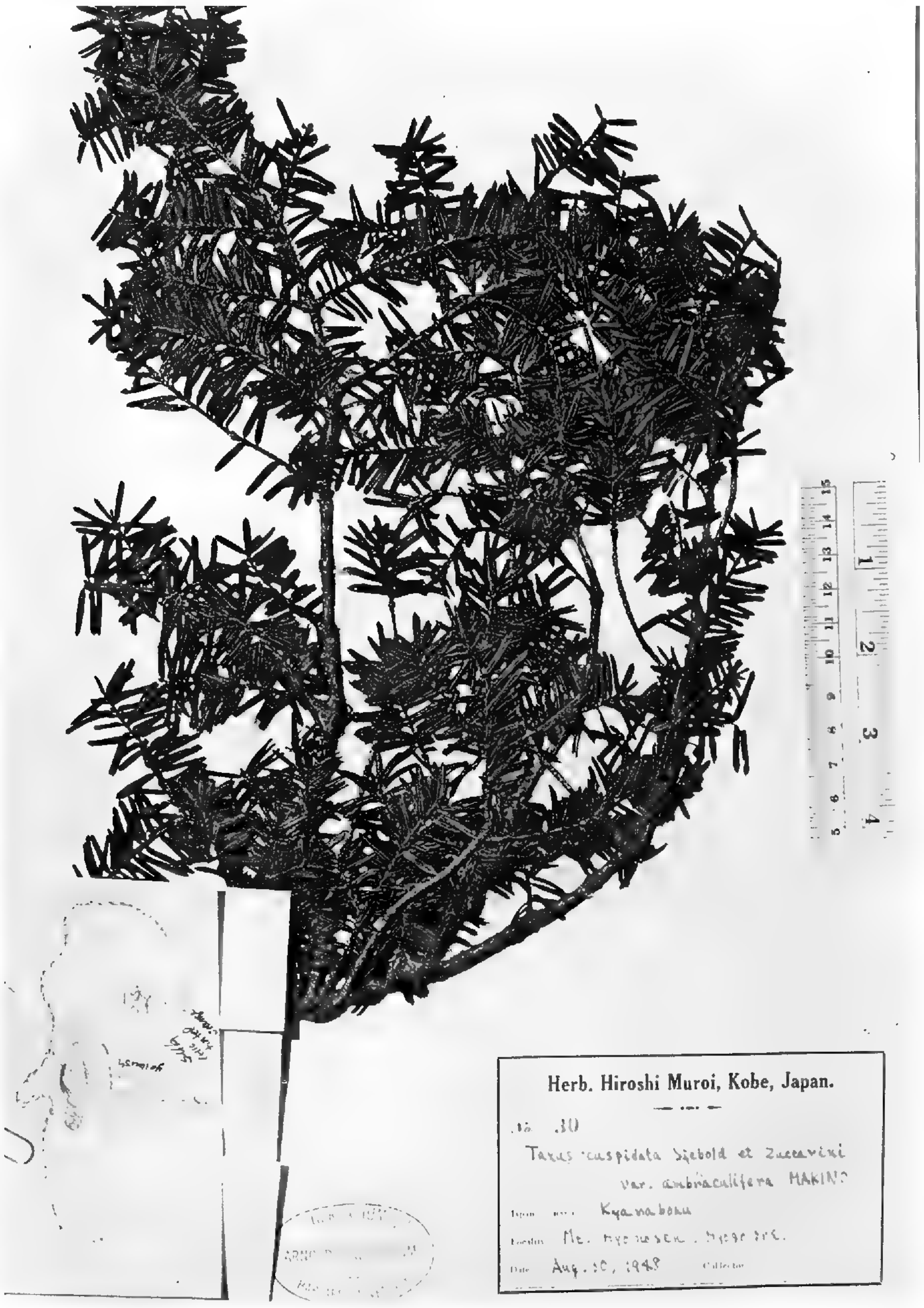
Taxus cuspidata *Sieb. et Zuc*
var. umbraculifera *Makin*
(=**Cephalotaxus umbraculifera** *Sieb.*;
C. tardiva *Sieb.*; **T. adpressa** *Gord.*;
T. cuspidata *S. et Z.* **var. nana** *Rehd.*)

伯耆大山ノ山頂ニ多ク自生シテ密ニ繁茂シ又
ノ山ニ少シク野生スレドモ、多クハ觀賞樹トシ
ニ愛植セラルル常綠灌木ニシテ常ニ叢生ノ
シ横方ニ廣ガレリ。幹ハ一般ニ直立セズシテ地
斜スルヲ常トシ、高サ約1–2mアリ、幹ノ直徑
達スル者アリ。葉ハいちゐト相同ジク線形ヲ
鋭尖頭ヲ成シ深綠色ニシテ質稍厚ク無毛
枝上ニ互生シ略ボ二列生羽狀ノ狀ヲ呈セリ。
ニシテ花ハ春月小枝ノ葉間ニ出デ細小ニシテ
ト相同ジク、雄花ハ黄色ヲ呈セリ。果實ハ
成リ、假種皮ハ杯狀ヲ成シテ綠色ノ種子ヲ
テ液汁多シ。和名伽羅木ハ此樹ノ材ヲ香料
樹卽チたかとうだい科ノ Excoecaria Agallo
ニ擬セシ者ナリ。



Herb. Hiroshi Muroi, Kobe, Japan.

No. 30
Taxus cuspidata Siebold et Zuccarini
var. umbraculifera MAKINO
Japan. name Kyanaboku
Locality Mt. Hyonosen, Hyogo Pref.
Date Aug. 10, 1948 Collector

Figs. 53–54. ***Taxus umbraculifera*** **var.** ***umbraculifera*****. 53 (top). Neotype, Makino, Illus. Fl. Nippon (1931, Fig. 2730). 54 (above). Epitype, Japan, Honshu,** ***Muroi 30*** **(A). Var.** ***umbraculifera*** **distinguished by spreading to ascending branchlets with leaves sharply bent downwards at petiole, the leaves also appearing in a decussate arrangement when looking down from apex of branchlet.**

24a. Taxus umbraculifera var. umbraculifera

Common name.—Umbrelliform yew.

Distribution.—Japan, Russian Federation—Manchuria.

Ravenscroft as the authority, ICBN Art. 35.5. The epithet suggests an umbrella-like leaf arrangement (Fig. 59), not the two-ranked leaves as described by Endlicher (1847). Ravenscroft (Lawson et al. 1851), who treated the species in section *Cephalotaxus* of *Taxus*, indicated that branches are verticillate with "distichous" branchlets. I have not seen any original material, and herbaria that I have contacted in this regard for Siebold specimens reportedly have none. Nevertheless, an illustration in Makino (1931) clearly depicts the umbrelliform leaf arrangement that is distinctive for this species. In later manuals on the flora of Japan (e.g., Ohwi 1965), var. *nana* Rehder (1902) became the name for this taxon, but this is antedated by var. *microcarpa* Trautvetter (in Maximowicz 1859); however, these names are applied to different (and distinct) taxa in the present study.

The leaves of *T. umbraculifera* appear in star-like (almost decussate) manner when looking down the branch from apex, and unlike *T. caespitosa*, the blades of *T. umbraculifera* will face different directions. Leaves appear perpendicular to the plane along one side of a branchlet and in the same plane along another side of branchlet. This is not easily determined in pressed specimens; however, the crisscrossed blades partly reflect this, which is in contrast to the radial orientation of leaves in *T. caespitosa* that all twist in the same manner, appearing imbricate when observed from above the apex of the branchlet. The leaves of *T. umbraculifera* are also sharply reflexed at their petioles, in contrast to bending upwards (erect) in *T. caespitosa*; this difference accounts for the two-ranked appearance in *T. umbraculifera*, in contrast to the secund appearance in *T. caespitosa* often seen on older branchlets.

Four varieties of *T. umbraculifera* are recognized by differences in habit and leaf arrangement.

Additional specimens: **JAPAN. Honshu:** Kanagawa Pref., Mt. Ooyama, shrub 2 m high, cult., 25 Oct 1952, *Suzuki 499003* (A); Shunane Pref., Mt. Sentsu-zan, *Naito s.n.* (A). **RUSSIAN FEDERATION.** Mandshuria SE: Ex herb. hort. bot. Petro. yr 1860, *Maximowicz* (S).

Variety *umbraculifera* appears mostly arborescent with wide spreading branches. It is recognized by the radial distribution of leaves on erect branchlets, especially near apex, and the appearance of a decussate to nearly two-ranked arrangement on horizontal branchlets.

24b. Taxus umbraculifera (Siebold ex Endl.) Ravenscroft var. **hicksii** (Hort. ex Rehder) Spjut, comb. nov. Basionyn: *Taxus media* Rehder f. *hicksii* (Hort.) Rehder ["*T. cuspidata* hicksii Hort." in synon.], J. Arnold Arbor. 4:108. 1923. *Taxus cuspidata* var. *hicksii* (Hort. ex Rehder) Bailey, Cult. Evergreens 189. 1923. Type: U.S.A. New York: horticultural specimen from Hicks Nursery, Westbury, Long Island, 28 Sep 1922, *Arnold Arboretum 8036* (holotype: A!). Bailey (1923) attributed the combination to Rehder even though it has not been determined whether Bailey's publication predates that of Rehder (8 May 1923). All conditions for valid publication are met in Rehder (1923) but not in Bailey (1923); therefore, the name in Rehder (1923) is considered the basionym (see ICBN Art. 45.1) even though Rehder cited a synonym used in horticulture without reference to an authority or publication and implied that it was a basionym.

Common name.—Hicks yew.

Distribution.—Endemic to Japan.

Additional specimens: **JAPAN. Iwate-Pref.:** Asagishi, Muroi 3593 (A). Nagano Pref.: Kamikochi, Muroi 3715 (A). **Gifu- Pref.:** Takayama, Muroi 3698 (A). **Hyogo Pref.:** Kumatugi, Mikata-gun, Muroi 5603 (A); Mt. Hatibuse Muroi 5424 (A); Wakasugi, Muroi 5648 (A). **CULTIVATION: Maryland:** Laurel, residential area, 8495 Imperial Drive, *Spjut s.n.* (wba); Arnold, residential area, 757 Dunberry, 1 Aug 1999, *Spjut s.n.* (wba).

Variety *hicksii* is distinguished by its columnar habit with erect branchlets and erect linear leaves that spread in a radial arrangement. The leaves may appear two-ranked on lower branchlets, but if the branchlets are turned over, the underside will be seen to have some of the leaves reflexed.

Although described from horticulture, this variety appears to occur naturally in Japan, based on four specimens from there that are remarkably similar to the type. It also raises the question as to whether the variety independently evolved there as a hybrid, or whether it may have been introduced into Japan from North America, since the specimens cited above were collected during the mid 1950s—after the Hicks yew was described by Rehder (1923). The Hick's yew supposedly originated from seed of "*T. cuspidata* 'Nana'" sometime around 1900 (den Ouden & Boom 1965). Molecular data in Collins et al. (2003) placed the Hick's yew with *T.* × *media* Rehder; however, their study did not include morphological characters.

24c. Taxus umbraculifera var. **microcarpa** (Trautv.) Spjut, comb. nov. (**Figs. 55–58**). Basionym: *Taxus baccata* L. var. *microcarpa* Trautvetter in Maxim., Mem. Acad. Sci. St. Petersb. Sav. Etrang. 9:259 (Prim. Fl. Amur.). 1859. *Taxus cuspidata* Siebold & Zucc. var. *microcarpa* (Trautv.) Kolesnikov, Bull. Far E. Branch Acad. Sci., USSR 13:43, fig. 2. 1935. *Taxus cuspidata* Siebold & Zucc. var. *microcarpa* (Trautv.) S-Y. Hu, Taiwania 10:21. 1964 (nomen comb. superfl., illegit.). Type: CHINA. Manchuria: Heilongjiang, Exped. Soc Geogr., 1 May 1855, *Maack s.n.* (lectotype designated here: GH!, lower of two specimens; isolectotype: P!, upper of two specimens on one sheet). Original type not specified; original material (syntypes) from several locations, one from Manchuria (1 May 1855, reportedly sterile, GH! P!), and another from Sakhalin Is. (Weyrich, Sep. 1853, with fruit, KFTA?).

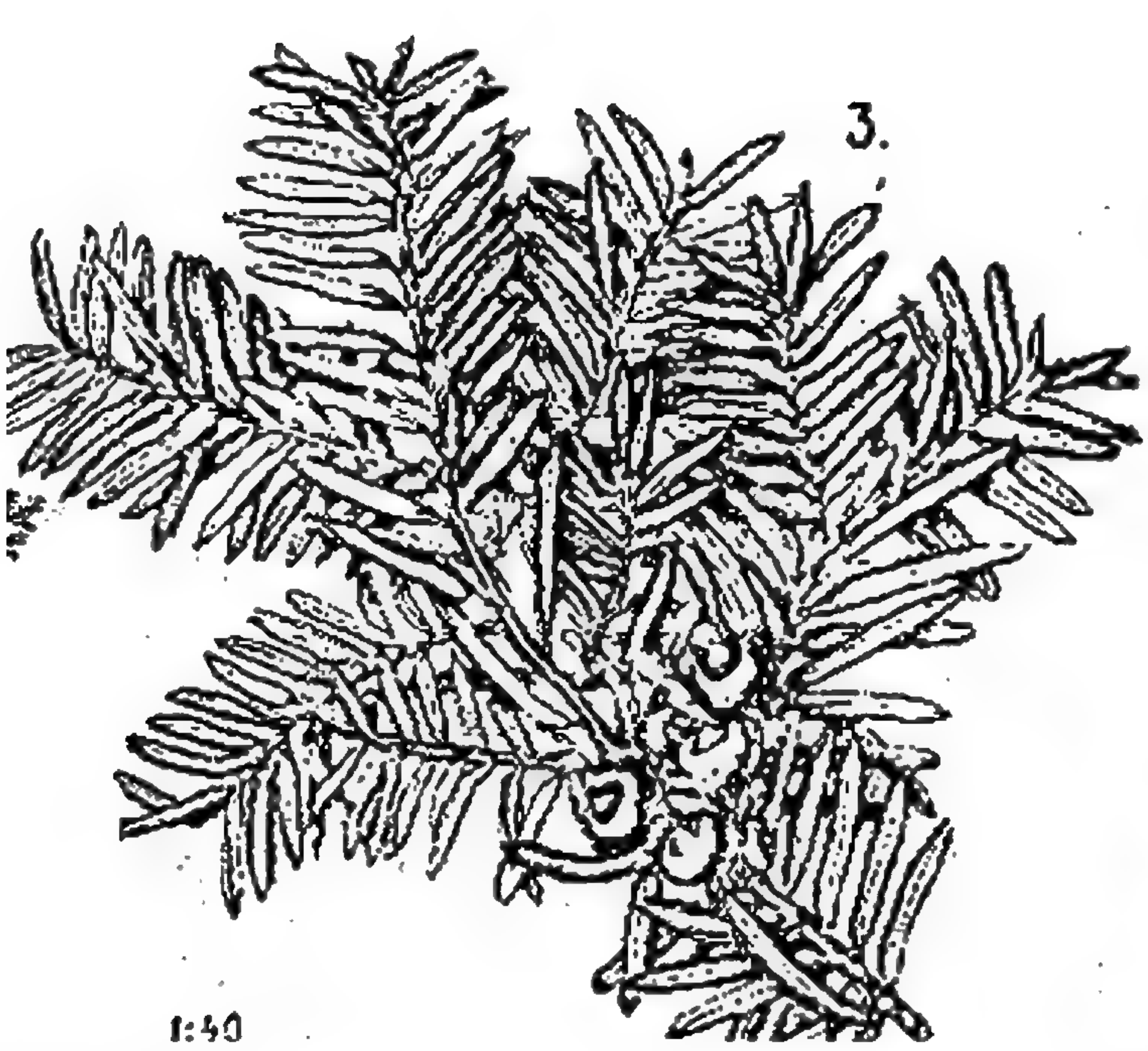
Taxus umbraculifera subsp. *laxa* Spjut ined. Type: KOREA. Ooryong-too (Oagelet Island), 0–900 m, bush or small tree, common, *Wilson 8538* (holotype: A!; isotype: US!).

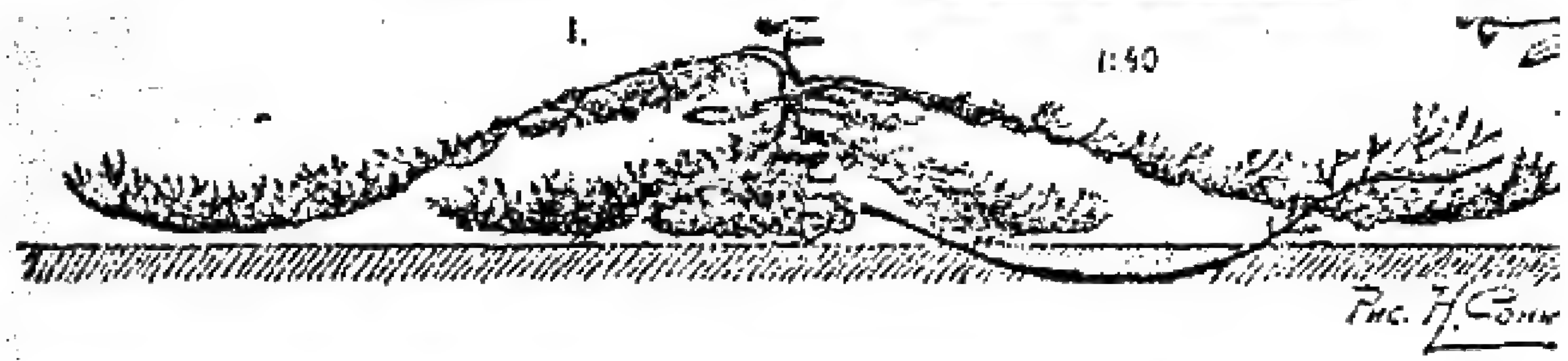
Common name.—Small seed yew.

Distribution.—NE temperate Asia.

Additional specimens. **RUSSIAN FEDERATION. Primorie [Primorskiy] Prov.:** vicinity of Vladivostok, *Palczevsky 3601* (A, K, US); Bay of Peter, the First Sea Reserve, Island of Stenin, 26 Apr 1979, *Kypehinova s.n.* (in Russian, A). **Manchuria Region:** Korea septentrionalis provincia Pen-nian Muorum Jahn…Frajectus Lpatan-ien, 27 Jun 1897, *Komarov 88* (A); Rossica, Aultzo Prov., Ussuri [Ussuzieusis] insula Afnold, Komarov 88 (P); Manchuria: Rossica *Palczevsky [Komarov] 88* (BM, K, US [ex Herb. Baenitz]). **SOUTH KOREA:** Nemon-rei, Kyongsan, tree up to 50 ft, common, 12 Oct 1917, *Wilson 9332* (A); Herb. Lugd. Batv. (P); *Zuccarini 593*, in adnot. *T. baccata* (M). **JAPAN. Hokkaido:** Ishikasi Prov., Apr 1884, *K. Muijabe s.n.* (A). Nanokwa, Tosa, 18 Apr 1888, *Watanabe s.n.* (A); Sapporo, *Agric. College, 15 Jun 1885* (A), *Jun 1878* (A); Sapporo, *Siebold, ex Herb. Zuccarini* (GH); Mt. Nantai, Lake Chuzenji, 20 Aug 1904, *Mochizuki s.n.* (A). **Honshu:** Yokohama, yr 1862, *ex Herb. USDA 1888* (US: top specimen); Japan, no locality or collector data (US 1311889); Hida, Takayama, 17 Sep 1910 (A); Yokohama, yr 1862, *ex Herb. USDA 1888* (P, p.p.; US, lower of 2 specimens); no locality data, *Kiaraboku s.n.* (US 1311889).

This variety is best recognized by isodichotomous branching, the oblong leaf shape (ca. 8× l/w) and crisscross





Figs. 55–58. Comparison of illustrations with herbarium specimens of *Taxus umbraculifera* var. *microcarpa*. **55** (upper left). Illustration from Kolesnikov (1935, as *T. cuspidata* var. *microcarpa*). **56** (upper right). Herbarium specimen, Manchuria, *Palczewski ex Herb. Baenitz* (US). **57** (center). Illustration showing habit of plant from side view (Kolesnikov 1935), appearing radial in outline from top view (not shown). **58** (right). Type herbarium sheet in the Gray Herbarium, *Maack Exped. 1855* (GH). The upper specimen annotated by S-y. Hu—*T. cuspidata* var. *microcarpa*—the type for her illegitimate combination (Hu 1964); however, the specimen that best compares with Trautvetter's description of *T. baccata* var. *microcarpa* (basionym), a low shrub with a small seed, illustrated by Kolesnikov (1935), is the lower specimen (lectotype). The upper specimen is identified in this publication as *T. biternata*, described as a new species, a tree with diffuse branching, and a relatively large seed.

leaf arrangement. Trautvetter (in Maximowicz 1859) distinguished var. *microcarpa* from *T. baccata* by the smaller—wider than tall—seed (Pilger 1903), and Kolesnikov (1935) further indicated it was a low rounded shrub—0.5–1.5 m high and 5–7 m in diam.—that reproduced by layering (Fig. 68). Kolesnikov (1935) had recognized two morphological different varieties (tree and shrub yews) occurring in different habitat types in southeastern Russian Federation.

In my 1996–1997 annotations (*Taxus microcarpa* [Trautv.] Spjut ined.; *Taxus umbraculifera* subsp. *laxa* Spjut ined.), I had concluded that a specimen annotated by S-y. Hu in GH was the type for *T. baccata* var. *microcarpa* (see Fig. 66 and Hu 1964), but upon later reviewing the illustrations in Kolesnikov (1935), reproduced here in Figs. 63–64, it was quite clear this was not its type but rather a specimen below it on the same herbarium sheet. The interpretation of the taxon by Kolesnikov (1935), based on Trautvetter (in Maximowicz 1859), must be preserved; therefore, *T. biternata* is described as a new species, and "*T. umbraculifera* subsp. *laxa* Spjut" will remain an unpublished name.

24d. Taxus umbraculifera var. **nana** (Rehder) Spjut, comb. nov. (**Figs. 59**). Basionym: *Taxus cuspidata* var. *nana* [Hort. ex] Rehder in L.H. Bailey, Cyclopedia Amer. Hort. 1773. 1902. *Taxus cuspidata* f. *nana* (Rehder) Wilson, Conif. Taxads Japan 13. 1916. Type: JAPAN. Honshu: Pref. Hyogo, Mt. Hyonosen, 1100–1400 m, in *Fagus* forest with sasa thicket, on ridge, shrub 2 m, fr red, 11 Aug 1983, *Murata 44671*, det. as *T. cuspidata* var. *nana* Rehder (neotype designated here: A!). Described from horticulture, no specimens cited and original material unclear.

Common name.—Dwarf yew.

Distribution.—E Russia (islands), China (Shanxi), Japan.

Additional specimens: **RUSSIAN FEDERATION. Far East:** Primorskiy Region, Sea Reserve, Island Bolshoy Pelis, *Borzova s.n.* (in Russian, A); Sakhalin, *ex herbario horti Petropolitani, Augustinowiez, T. baccata* var. *microcarpa, Schmidt*, p.p., with *T. caespitosa* var. *caespitosa* (A). **CHINA. Shanxi:** ("Schenhsi merid"): Taipei-schan, 1936, *G. Fenzel 972* (A). **JAPAN.** Mt. Fujiwara Mie pref., *Muroi 1969* (A); Mt. Himekami, Iwate pref, 14 Sep 1955, *Muroi* 5933 (A); Japan, no additinal data, *Faurie s.n.* (P). **CULTIVATION. U.S.A. Ohio:** Secrest Arboretum, cultivars 'Newport,' 'Hatfield.'

The epithet "*nana*" implies a dwarf plant, and Rehder (1902) described *T. cuspidata* var. *nana* as a "dwarf compact form with shorter leaves" in regard to a horticultural plant. Rehder (1949) later considered it only a form. Nevertheless, others applied the varietal name to native plants in Japan. The plants were characterized as low shrubs with a radial orientation of leaves, found mostly along the seaside of Japan (Ohwi 1965).

Variety *nana* is a low, densely branched shrub with oblong leaves that are mostly radial and crisscrossing in herbarium specimens, appearing dark glossy green above (adaxial surface) and paler below (abaxial surface).

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Figs. 59A–B. ***Taxus umbraculifera*** **var.** ***nana*****, Mt. Hyonosen, Japan (neotype, A). A (left). Herbarium specimen, all specimens appear to be from the same plant. B (right). Close-up of top specimen showing leaves and arillocarpium.**

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BOOK REVIEWS

Robert H. Mohlenbrock. 2006. **The Illustrated Flora of Illinois Flowering Plants: Flowering Rush to Rushes. Second Ed.** (ISBN 0-8093-2687-6, hbk.). Southern Illinois University Press, P.O. Box 3697, 1915 University Press Drive, Carbondale, IL 62902, U.S.A. (**Orders:** http://www.siu.edu). $65.00, 328 pp., b/w line drawings, glossary, index, 5½" × 8½".

Flowering Plants: Flowering Rush to Rushes is an updated flora by Mohlenbrock that includes many of the monocot families from Illinois. The flora includes information on 16 families including: Butomaceae, Alismaceae, Hydrocharitaceae, Juncaginaceae, Potamogetonaceae, Ruppiaceae, Zannichelliaceae, Najadaceae, Araceae, Lemnaceae, Sparganiaceae, Typhaceae, Xyridaceae, Commelinaceae, Pontederiaceae, and Juncaceae. *Flowering Plants: Flowering Rush to Rushes* is a second edition, and is part of a six flora series entitled *The Illustrated Flora of Illinois*. A second part of the series will be a flora containing the other half of the monocot families.

The author starts out by showing the reader how to use the keys; this allows the reader to determine the family of the plant they are interested in. The keys used for this flora are very straightforward. This flora also includes a glossary, so this book will be usable for novices as well as those with more plant identification experience. The author has provided general descriptions of the order as well as descriptions for all families included under that order (for Illinois). These descriptions include general morphological traits and other notable traits for order, family and genera within the family. Dichotomous keys follow each family description and allow readers to determine genus followed by species within each genus.

Each species contained in the flora includes information on that species' morphological traits, common name, habitat, range, some known collection data and other helpful information. There are 125 black and white line illustrations of various species (108 from the first edition and 17 new illustrations for this edition). These images provide readers with details of the plant habit, leaves, inflorescence and/or fruit. Each species description also presents a distribution map by county of that species within Illinois.

This flora concludes with an explanation of why certain species were excluded from this second addition, and also contains an appendix that discusses revisions from the previous edition (1970). Mohlenbrock has provided readers with a succinct summary of the taxa included in this volume, a glossary, references and an index by plant names, both common and scientific.

Flowering Plants: Flowering Rush to Rushes by Mohlenbrock is a usable flora that would make a nice addition to the library of any person interested in the identification of Illinois area plants (as well as anyone working with aquatic plants). This flora is a second edition and has been updated over the earlier versions by the addition of new species as well as corrected plant name information. The black and white drawings provided in the text are helpful in showing the major identification traits of the species. The keys are straightforward and the flora does contain a glossary for any unfamiliar terms. The description for each species is thorough and identification hints help the reader conclude that he/she has determined the correct species. *Flowering Plants: Flowering Rush to Rushes* is another well-written and user-friendly flora from Robert Mohlenbrock.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

V.B. Price and Bakes H. Morrow. 2006. **Canyon Gardens: The Ancient Pueblo Landscapes of the American Southwest.** (ISBN 13: 978-0-8263-3859-4, pbk.). University of New Mexico Press, MSC04 2829, 1 University of New Mexico, Albuquerque, NM 87131-0001, U.S.A. (**Orders:** www.unmpress.com, 800-249-7737) $39.95, 217 pp., 36 halftones, 40 line illustrations, 2 maps, 6 ⅜" × 9 ⅝".

With today's concerns about global warming and climate change, this two-part anthology is very timely. Part One examines how the Ancestral Puebloans used their vast storehouse of practical knowledge to live in, and with, the desert and to adapt to changing natural and historic circumstances. Part Two proposes ways in which modern urban societies can learn from these ancient pragmatists. Although aimed at contemporary landscape architects, urban planners, architects and builders, this book will be thought-provoking for anyone interested in the natural world and especially for who make laws and regulations on the local, state and national levels. As V.B. Price states in the prologue:

> We believe that in times of global climate change, water scarcities, and upheavals in energy sources and technologies, an observant sensitivity as to how the natural environment works and a mastery of its demands could prove to be immensely useful in designing and retrofitting urban environments in the future.

"Design with nature," Ian McHarg famously argued in the 1960's. *Canyon Gardens* offers some insights into how the Puebloans did just that and some examples of how we today can also.

Contributors to this outstanding anthology include an architect/teacher/writer, two archaeologists, the curator of anthropology at the U. Colorado Museum, a paleoethnobotanist, a National Park Service historian, a lyrical writer/poet, a landscape historian/landscape architect, and a writer/architectural historian who is a member of the Santa Clara Pueblo. The two editors—a writer/poet/columnist and the founding director of the Master's Program in Landscape Architecture at UNM—are contributors as well. Each has his/her individual voice and point of view. All invite the reader to consider the lessons of the past in shaping the world of tomorrow.—*Penny McCook, Volunteer, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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A PHYTOGEOGRAPHICAL ANALYSIS OF *TAXUS* (TAXACEAE) BASED ON LEAF ANATOMICAL CHARACTERS

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ABSTRACT

A phytogeographic analysis of 845 *Taxus* specimens is presented based on leaf anatomical characters for the number of stomata rows in a stomata band and the number of epidermal cells that lack papillae between the leaf margin and stomata band. The specimens are arranged by continent, country, state or province, and species, and represented geographically on three maps: (1) North America, (2) the Euro-Mediterranean, and (3) Asia. *Taxus* is least diverse and most distinct taxonomically in North America, and most diverse and least distinct taxonomically in southwest China. Stomata data show several clines in North America, an obvious south to north decrease for the Mesoamerican yew (*T. globosa*) and Pacific NW yew (*T. brevifolia*) populations combined, and a less obvious reverse cline for the Canada yew (*T. canadensis*). The results are discussed in review of other paleobotanical data. It is suggested that *Taxus* immigrated to North America from Asia across a Pacific land connection during the Cretaceous, and from Europe to North America across North Atlantic land bridges during the Tertiary. The low diversity of *Taxus* in North America is suggested to be the result of the K/T extinction event. In the Euro-Mediterranean, evolution of *Taxus* is suggested to have been impacted more by extinction as a result of climatic changes during the Tertiary, and by hybridization during the Pleistocene. The greater diversity in SW China is indicated to be the result of less extinction there and more frequent hybridization during the Pleistocene, not only among authochtonous species, but also allochtonous species as a result of the Himalayan uplift.

CHINESE ABSTRACT

基于每一条气孔带内气孔列数目以及叶边缘和气孔带之间缺乏乳突的表皮细胞数目的解剖特征，本文对 845 份红豆杉属 *Taxus* 标本进行了植物地理分析。标本按洲、国家、州或省以及种来排列，其地理分布显示在 3 幅地图上：（1）北美，（2）欧洲—地中海，（3）亚洲。红豆杉属在北美的多样性最低且分类上区别最明显，而在中国西南部的多样性最高且分类上区别最不明显。气孔数据显示红豆杉属在北美有几个渐变群，中美洲红豆杉 *T. globosa* 和太平洋西北红豆杉 *T. brevifolia* 的居群由南向北明显减少，加拿大红豆杉 *T. canadensis* 由北向南减少得不太明显。综合考虑了古植物学资料，这些结果支持以下一些假说。红豆杉属在白垩纪和第三纪分别从亚洲和欧洲穿过太平洋陆地连接和北大西洋陆桥迁移到北美。白垩纪—第三纪界线绝灭事件造成了红豆杉属在北美低的多样性。第三纪气候变化造成的绝灭和更新世发生的杂交对欧洲—地中海地区红豆杉属的演化影响更大。由于喜马拉雅山的抬升，红豆杉属的土著种和外来种在更新世的杂交比较频繁，而且在中国西南部绝灭较少，所以该属在中国西南部的多样性较高。

INTRODUCTION

The genus *Taxus* has included eight geographically defined species: (1) *T. baccata* L.—Europe, N Africa and SW Asia (Franco 1964), (2) *T. cuspidata* Siebold & Zucc.—temperate E Asia (Krüssmann 1985; Ohwi 1965), (3) *T. wallichiana* Zucc.—Himalayas (Krüssmann 1985), (4) *T. sumatrana* (Miq.) de Laub.—S China, Philippines, Taiwan, Sulawesi, and Sumatera (de Laubenfels 1988), (5) *T. globosa* Schltdl.—N Central America to Mexico (Ferguson 1978), (6) *T. brevifolia* Nutt.—NW North America (Ferguson 1978; Hils 1993), (7) *T. floridana* Nutt. ex Chapm.—W Florida (Ferguson 1978; Hils 1993; Price 1990), and (8) *T. canadensis* Marshall—NE North America (Ferguson 1978; Hils 1993; Price 1990). Except for *T. sumatrana*, these were also recognized by Pilger (1903, 1916, 1926) as subspecies of *T. baccata*.

These eight geographically defined taxa—generally accepted as species (Bailey 1933; Farjon 1998; Hils 1993; Krüssmann 1985; Rehder 1940; Silba 1984)—have not been clearly distinguished (Ferguson 1978; Price 1990), including several other species and varieties that have been recently recognized (Farjon 1998, 2001; Fu et al. 1999); however, I will show that this traditional geographical classification is distorted to recognizing more species where diversity in the genus is least (North America) and less species where

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diversity is greatest (SW China). This will be based on quantitative leaf character attributes for the number of stomata rows (SR) in a stomata band, and the number of marginal cells (MC) across an abaxial marginal zone without papillae. These data will be summarized on geographical maps of North America, Euro-Mediterranean, and Asia, and analyzed in the results section of this study. This is followed by a discussion of phytogeographical relationships. Data for all herbarium specimens studied are provided in an appendix according to continental and political regions and taxonomy.

MATERIALS, STANDARDS AND METHODS

MATERIALS.—The materials of *Taxus* include 845 specimens of fresh and dried branchlets with leaves from throughout the natural range of the genus (Appendix), and an undetermined number of specimens from cultivated plants in Australia (1), England (~50), France (~20), and the United States (~300), and from miscellaneous other sources, the main one was Phyton, Inc (~65), now Phyton Biotech, a commercial company specializing in producing taxol from tissue culture of *Taxus*.

STANDARDS.—The genus *Taxus* Linnaeus (Taxaceae Gray) is defined by cone and leaf morphology (Florin 1931, 1948c, 1951) in relationship to other "taxad" genera, characterized by producing an arillocarpium (Spjut 1994)—a type of cone in which the seed is subtended by a fleshy arillate bract (Airy Shaw 1973; Cheng & Fu 1978; Florin 1948a; de Laubenfels 1988).

Taxads include both extant and extinct taxa; the extant genera, in addition to *Taxus*, are *Amentotaxus* (5–6 spp., China, Vietnam), *Torreya* (6 spp., E Asia, N America), *Austrotaxus* (1 sp., New Caledonia), *Cephalotaxus* (8–11 spp., E Asia), and *Pseudotaxus* (1-2 sp., China) (Fu et al. 1999). Molecular studies employing ribosomal RNA (Chaw et al. 1993, 1995), chloroplast DNA (Tsumura et al. 1995), or RAPD (T. Wang et al. 2000), suggested *Amentotaxus* and *Torreya* to be more closely related to each other than to *Cephalotaxus* or *Taxus*, and that *Cephalotaxus* is basal to two clades, (1) *Torreya*/*Amentotaxus* and (2) *Taxus*/*Pseudotaxus*/*Austrotaxus* (Cheng et al. 2000); however, whether these clades should be treated in separate orders, families, subfamilies, or tribes, is controversial (Hill 1998).

Cones.—*Pseudotaxus* and *Taxus* produce a terminal seed on a lateral (secondary) short shoot (André 1956; Dupler 1920; Miller 1988) that is only partly surrounded by a loose cupular bract, whereas in other genera the seed is more fully and tightly covered by the aril (Florin 1948b; Sahni 1920). *Cephalotaxus* is distinct for its biovulate cone scales from which usually only one ovule matures (Singh 1961). *Amentotaxus* differs for its terminal, "racemose" male shoots (Cope 1998; Fu et al. 1999). The *Austrotaxus* cone was regarded as isolated from other taxads based on anatomy of the seed coat (Bobrov et al. 2004).

The closely related *Pseudotaxus* (1–2 spp., China, Fu et al. 1999) differs from *Taxus* by a white arillocarpium (Cheng 1934), and additional sterile scales in male cones (Florin 1948c).

Leaves.—*Taxus* leaves are differentiated from those in other taxad genera by **papillose** cells that define the "stomatic apparatus" (Dilcher 1969; Florin 1931, 1948c, 1951, 1958). This apparatus includes 4–8 small subsidiary papillose cells that encircle each stoma (Florin ring) and adjacent (accessory) papillose cells (Figs. 1A, 1B, 1C). Stomata develop in longitudinal rows (periclinal) in a stomatal region divided into two bands by a midrib (e.g., Fig. 1A). The midrib and marginal cells vary in size, shape, and development of papillae. Further details—with photomicrographs—can be found in Ferguson (1978), Florin (1931, 1951), Jinxing and Yuxi (2000), Kvaček (1984), and Kwei and Hu (1974).

Mammillae, not to be confused with papillae (Bertrand 1874), develop singly over most of the cell's surface as large lens like bumps. Under a dissecting scope (30×) they appear most conspicuous along leaf margins, less so on the epidermal surfaces (adaxial or abaxial). Papillae, by contrast, are smaller and numerous on a cell—like pimples. They develop in 1–3 distinct or concrescent rows, generally discernible only under a microscope—at least 100×, and only on the abaxial surface. Papillae are always present in stomata bands, gradually diminishing in prominence outside the bands towards the leaf margins, and may develop entirely or partially or not at all on midrib cells.

The development of stomata in rows and their differentiation by papillose accessory cells, which together make up the stomata band, are the most distinguishing features of *Taxus* relevant to data in this study, compared to other extant genera of taxads (Florin 1931, 1951). For example, *Pseudotaxus* has glaucous stomata bands (Cheng 1934; Florin 1931, 1948b, 1948c, 1948d) devoid of papillae, except on subsidiary cells, and more stomata rows per band—23–28 rows (Florin 1948c), in contrast to 4–21 rows in *Taxus* (Appendix). *Amentotaxus* and *Torreya* (Amentotaxaceae) have papillose glaucous bands largely of subsidiary cells (periclinally arranged), rather than accessory cell types (Florin 1951, 1958). *Austrotaxus* (Austrotaxaceae; Nakai 1938; Florin 1958), which also differs conspicuously by its long-linear leaves—comparable to some *Podocarpus* spp.—has stomata evenly scattered across the entire abaxial surface without clear differentiation of rows and bands in which the epidermal cells are similar to those on the adaxial surface—irregularly quadrate (or pentagonal) as in *Taxus*. These differences, and the presence of other features such as sclereids and resin canals in leaves of *Torreya* (Bertrand 1874) and *Cephalotaxus*, would seem to support classification of the taxads in different families (Amentotaxaceae, Austrotaxaceae, Cephalotaxaceae, Taxaceae).

The features of the stomata band that distinguish *Taxus* from other extant taxads do not apply to extinct taxads, however (Florin 1951, 1958; Harris 1976a, 1976b; Kvaček 1984; Miller 1977). Photomicrographs of many taxad fossils from Jurassic deposits presented by Florin (1958) show remarkable detail that are strikingly similar to extant *Taxus* in leaf epidermis (Kvaček 1984; Meyen 1984), except for narrower stomata bands with fewer stomata rows (Kvaček 1984). Indeed, some leaves, which included twigs and arillocarpia, were assigned to *Taxus*; these are *T. bornholmiensis* Florin with 4–5 stomata rows, *T. harrisii* Florin with 5 stomata rows, and *T. jurassica* Florin with 3–5 stomata rows; however, none of these appear to belong to the genus *Taxus*. Harris (1976a, 1976b), for example, transferred *T. jurassica* to *Marskea*, an extinct genus characterized by opposite-decussate leaves (Florin 1958; Harris 1976b), which are clearly evident in Florin's (1958) photograph of *Marskea jurassica*. Jurassic taxads include many other extinct genera (Florin 1958) that may have existed since the Triassic (Florin 1951; Meyen 1984).

Epidermal cells adjacent to leaf stomata bands, the midrib and marginal areas, are usually papillose in part. Epidermal cells on the abaxial surface nearest the leaf margin appear to have evolved in some species by extension (folding) of the upper (adaxial) surface to the lower (abaxial) surface; leaves of many specimens are revolute along their margins in which the abaxial epidermal cells are often more similar to those above than to the adjacent cells below (Nicolosi 1982).

The comparative morphological relationships of *Taxus* to other extant taxads (Florin 1931, 1948c; Appendix) indicate that the ancestral *Taxus* leaf had a partially differentiated abaxial epidermis in which stomata developed in definite rows but not in distinct bands. Evidence for this can be seen in *T. wallichiana* and allied species in the E Himalayas and SW China. Their leaf stomata occur not only in stomata bands, but also on the abaxial midrib; essentially, stomata develop across the entire abaxial leaf surface to within several cells of the margin—in up to 21 rows. The abaxial marginal and accessory epidermal cells are all nearly rectangular and papillose—in sharp contrast to the epidermal cells on the adaxial surface that are much shorter, ±trapezoidal-pentagonal, and without papillae.

METHODS

More than 1,000 herbarium specimens (A, BH, BM, BOLO, E, GH, K, M, NA, NY, P, PE, PH, S, U, US; Holmgren et al. 1990) were studied of *Taxus* throughout the natural range of the genus to assess morphological variation in characters that involve branches, bud-scales, leaves, and cones; 845 are cited in the appendix, and additional specimens are mentioned in this paper. Each specimen was photographed with a Nikon camera using 35 mm color film with 35 mm and 60 mm lenses. Stafleu and Cowan (1976–1988) were consulted for location of types, other specimens of historical relevance to this study, and references.

From each herbarium specimen of *Taxus,* one mature leaf was selected for microscopic study of anatomical features. The *Taxus* leaf was soaked in water for 8–16 hrs. The leaf was then transversely sectioned in the mid region as bryologists routinely section leaves of mosses for taxonomic identifications. With a single-edge razor blade and dissecting needle as a guide, 5–10 transverse sections were generally made. Then an abaxial epidermal layer was removed from both remaining leaf portions, generally 0.5–2.0 mm in length, by scraping mesophyll parenchyma from the epidermal layer with a razor blade. Occasionally, the entire abaxial leaf

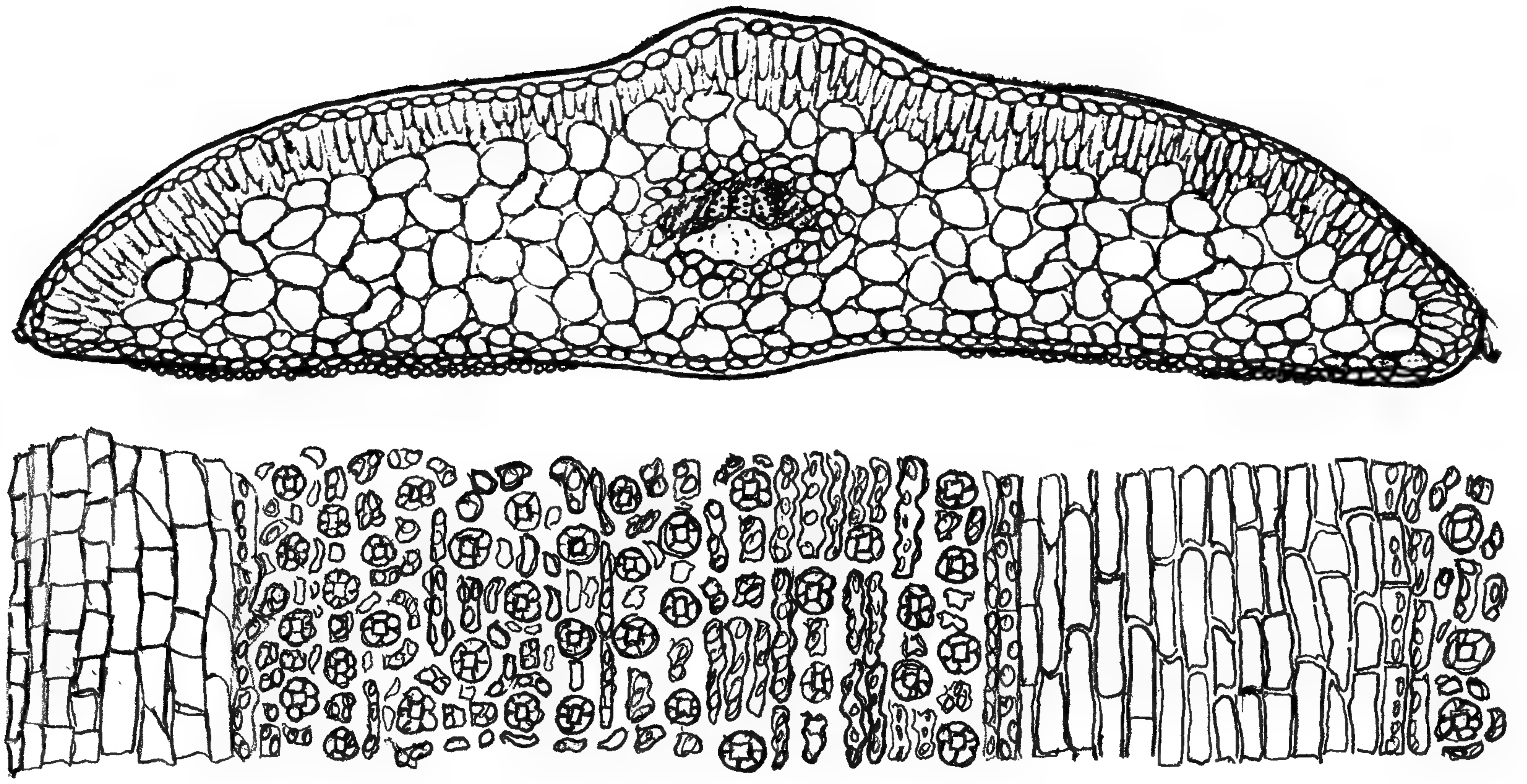

Fig. 1A. Mid leaf sections of *Taxus caespitosa* var. *latifolia*, from a cultivated plant in Maryland, U.S.A, *Spjut 10485* (wba), representative of the *Baccata* Group, *Cuspidata* Alliance. **Top:** transverse section (T-sect.), ~100×, showing elliptical shaped epidermal cells, mesophyll layers of anticlinal palisade layer of parenchyma and spherical parenchyma cells, drawn by Karen Parker. **Bottom:** abaxial epidermal layer from margin (left) to midrib (right), ~250×, showing a marginal border of 8 smooth (non-papillose) cells wide followed by a stomata band with 13 rows of stomata, and a midrib of mostly smooth cells, drawn by R. Spjut.

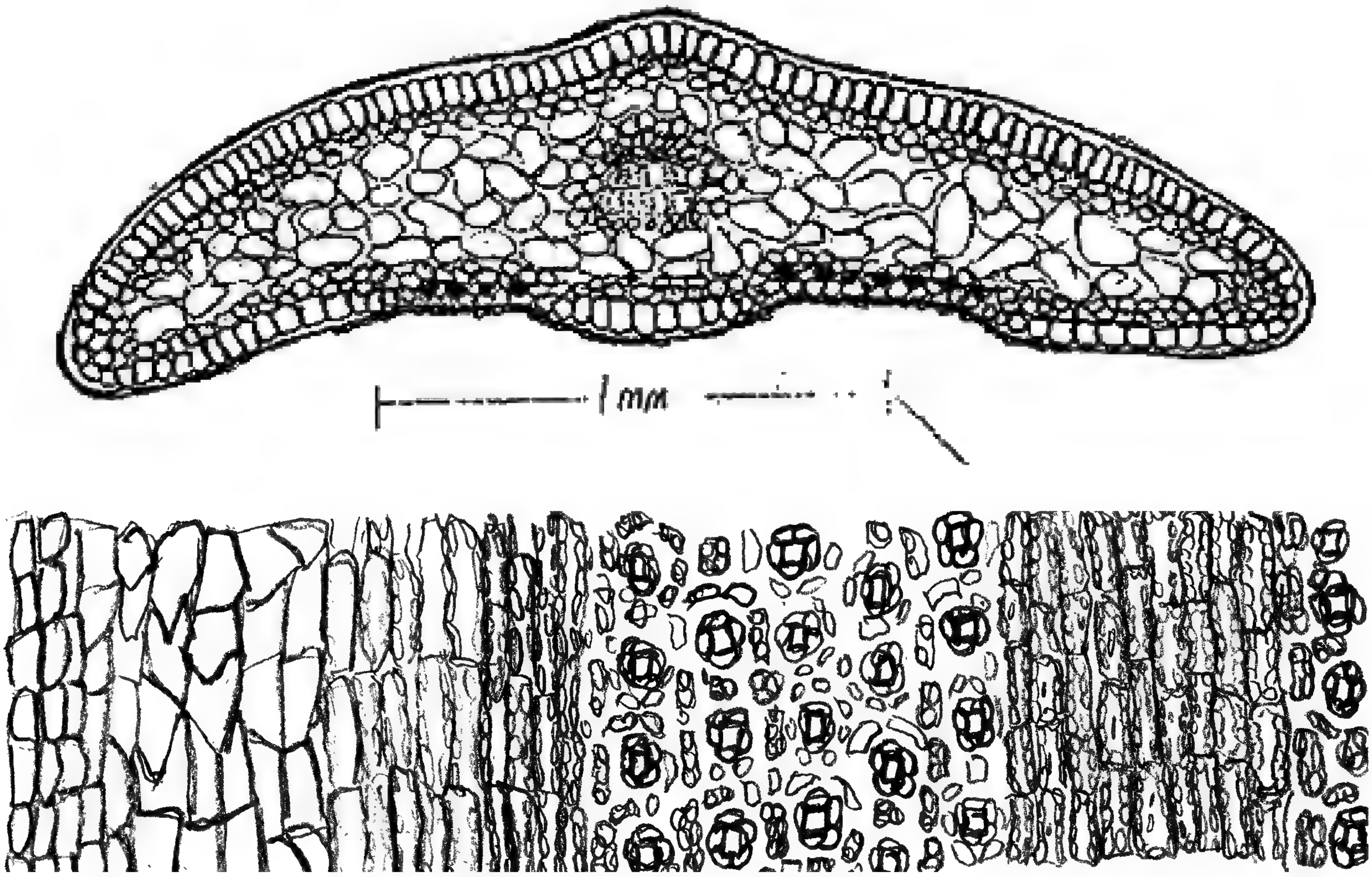

Fig. 1B. Mid leaf sections of *Taxus brevifolia* var. *reptaneta* from Siskiyou Co., California, U.S.A., representative of the *Wallichiana* Group, *R. Spjut & T. Spjut 11835* (wba, type). **Top:** T-sect. ~ 100× shows tall angular epidermal cells, drawn by Karen Parker. **Bottom:** abaxial epidermal layer from margin (left) to midrib (right), ~250×, shows marginal region of 10 smooth cells across of which 6 rows are inflated, followed by 8 rows of papillose cells, 5 stomata rows, and a papillose midrib, drawn by R. Spjut.

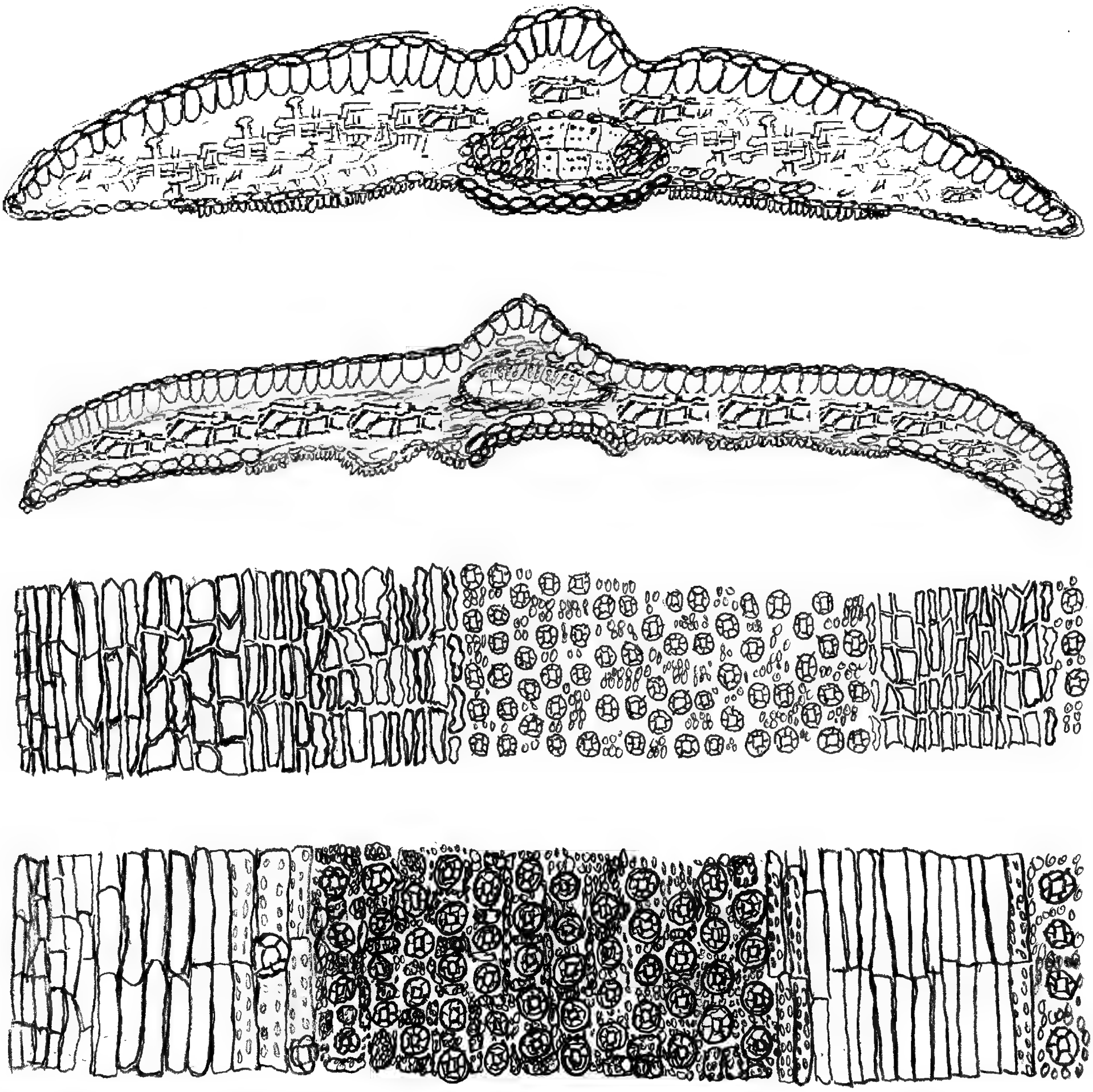

Fig. 1C. Mid leaf sections representative of the *Taxus Sumatrana* Group, drawn by R. Spjut. From top to bottom: **Top:** *T. mairei* var. *mairei* from Guangdong (China), *Tsang 20694* (US), showing elevated and truncated midrib along abaxial surface with enlarged epidermal cells in comparison to smaller elliptical epidermal cells on adaxial surface, the lower T-section, *T. mairei* var. *mairei* from Yunnan, *Maire s.n.*, isotype, showing truncated and channeled midrib with larger spherical parenchyma cells lying against smaller epidermal cells—most conspicuous along midrib and marginal zones. **Lower two sections:** abaxial epidermis from margin to across the midrib; upper most from Guizhou, isotype (A) of *T. speciosa*, showing marginal region of 23 smooth cells in width, a stomata band with 16 rows of stomata, and a smooth midrib; the lowest section from holotype of *T. sumatrana*, showing long rectangular cells and 12–14 stomata rows.

surface and a medial portion of the adaxial epidermis were removed. All sections were examined under magnifications of 100×, 250×, and 400× (Nikon binocular microscope) for cell shape, number of stomata rows, number of cells marginal to stomata bands, and for papillae position and distribution across the abaxial leaf surface. The results were sketched and described on small packets 3 × 5 inches. A temporary slide of the sections and photographs of the herbarium specimen were retained for each packet. Leaves from fresh specimens were also similarly studied throughout the range.

Figs. 1A–1C show diagrammatic leaf sections of the mid region that is representative of three species

FIG. 2A. Number of stomata rows per band (SR) in leaves of *Taxus* plotted from locality data on representative herbarium specimens from North America; see Appendix for specimen data. Specimens from northern Mexico indicated in yellow numbers are not easily distinguished from those in Florida; therefore, these are considered *T. globosa* var. *floridana*.

FIG. 2B. Number of stomata rows per band (SR) in leaves of *Taxus* plotted from locality data on representative specimens from the Euro-Mediterranean; see Appendix for specimen data. Most specimens were found to have 8–10 stomata rows per band as indicated in yellow numbers. Occasional plants with higher counts, 11–15 stomata rows per band, are shown in red. Both yellow and red numbers belong to the *Baccata* Alliance. Numbers in white belong to *T. canadensis*. Most *T. canadensis* have less than 8 stomata rows per band, but a few with higher counts—up to 10 stomata rows per band—are shown.

groups of *Taxus*. These include (1) a complete transverse section and (2) an epidermal portion of the abaxial surface from one margin to across the midrib. As previously indicated, similar sketches were made on 3.5 × 5 inch (8 × 12.5 cm) packets for most herbarium specimens studied except only portions of the stomata and marginal areas were drawn, while number of stomata in a band and number of marginal cells adjacent

Fig. 2C. Number of stomata rows per band (SR) in leaves of *Taxus* for representative specimens in E Asia of the *Baccata* and *Wallichiana* Groups; see Appendix for specimen data. The *Sumatrana* Group, which is common in SE China, is not shown to contrast the difference between the *Wallichiana* and *Baccata* Groups. The *Wallichiana* Subgroup includes *T. suffnessii* in white, *T. florinii* in blue, and *T. wallichiana* var. *yunnanensis* in black. The *Chinensis* Subgroup within the *Wallichiana* Group includes *T. chinensis* shown in purple in mainland China and related species in the *Chinensis* Subgroup in the Philippines, Sumatera, Sulawesi, and Taiwan, and also two species in mainland China, in yellow. The *Cuspidata* Alliance includes four species; *T. cuspidata, T. biternata*, and *T. caespitosa*, in maroon, and *T. umbraculifera*, in black. Note higher counts for *T. contorta* (8–11) and lower counts for *T. wallichiana* (11–14) where the ranges of these taxa overlap in the central Himalayas. The widest range in number of stomata rows was found in N Myanmar to SW China where *T. florinii* is recognized to have 7–12 rows per band, and *T. suffnessii* from 13–20 rows per band.

to stomata bands were recorded. The leaf margin can be difficult to pinpoint when leaves are rounded along margins. This is determined by the smallest cell that is usually mammillose. Both types of leaf sections were examined to determine where papillae develop on cells between the margin and stomata band.

Variation due to mechanical preparation, error in counting, and environmental factors (Deryugina & Nesterovich 1981), were only generally assessed—for practical reasons—from duplicates that were unintentionally included in this study, occasional field collections that were collected at various heights from one or several trees of a population (top, middle, and lower branches of *T. brevifolia* from trees in California and Oregon), and from test cases of selected leaves at various developmental stages from shrubs in cultivation. Practical reasons include damage to herbarium specimens caused by removing a leaf, and the time required to prepare leaf sections and record data, approximately one hour for each specimen.

Herbarium specimens studied are listed in an appendix with data on numbers of stomata rows per band (SR) and numbers of marginal cells (MC) without papillae. Specimen data are arranged by continent, then by country within continents, and finally by taxa, generally from south to north in North America, and from west to east in Eurasia, and then east and south from the Himalayas to Indonesia. Leaf anatomical data are further arranged by decreasing order in number of stomata rows (SR), and by increasing order in number of marginal cells (MC) except for *T. canadensis*, the *Sumatrana* Group, and for duplicate specimens belonging to the same species, or duplicate specimens from the same locality or collection number. Only minimal collection data are cited, although for many specimens data were minimal. If the stomata count varied on each side of the midrib of a single leaf, this is indicated by a slash; for example, *T. canadensis* frequently had 5 stomata rows in one band and 6 in the other (5/6). A dash between numbers indicates a variable range, especially when more than one leaf from the same specimen was studied, or a dash alone indicates absence of data. It should be remembered that these data are a byproduct of an overall taxonomic study of the genus *Taxus* (see Spjut 2007); i.e., they were not compiled with this paper in mind. Additional character features that appeared to correlate with the findings are also noted (e.g., length of epidermal cells/width of epidermal cells or l/w).

RESULTS

Numbers of Stomata Rows (SR).—Figures 2A, 2B and 2C show numbers of stomata rows per band on maps of North America, Europe, and Asia, respectively, for representative specimens listed in the Appendix. Each number represents a count from a single leaf of a herbarium or fresh specimen; the datum is plotted at the general location where it was reported to have been collected. Where the count varied on each side of the leaf midrib, or among duplicate specimens, the highest number was scored.

Stomata data for duplicate specimens, or among specimens from different plants at the same locality, are summarized under five cases as follows:

(1) For 62 duplicates of herbarium specimens included in this study, the same number of stomata rows per band was found in 19 duplicate specimens. Among the remaining 43 duplicates, 17 differed only by 1 row, another 17 differed by 2 rows, 6 varied by 3 rows, and 3 varied by as much as 4 rows. Duplicates that varied by 4 stomata rows appear to have been collected from different habitats within the same general locality. Examples are *Farges 128* from Sichuan, *Tsiang Ying 1425* from Guangdong, and several cases where the same collection number was reported from multiple locations, *Wilson 1265*, from two sites in Sichuan and one in Hubei, and *Wilson 4053* from two locations in Sichuan (Rehder & Wilson in Sargent 1914).

(2) From a single shrub of *T. caespitosa* Nakai var. *latifolia* (Pilg.) Spjut in Maryland, ~35 yrs of age and 3 m in height, 16 leaves were selected from branchlets with various exposures to light and age (1st–2nd yr). With one exception, 15 were found with 13 stomata rows per band; one leaf—plucked from a well-shaded branchlet near the main trunk—had 16 rows.

(3) From trees of *T. brevifolia*, leaves from top, middle, and lower branches had the same count at two sites—one in California, and another in Oregon—but varied by 1–2 rows in leaves from different trees at the same sites.

(4) In Taiwan, individuals of a population collected on five occasions (Appendix) had the same number of stomata rows at one site (Tongshi 7), but varied from 11–14 rows per band at two other sites (Tongshi 5, Tongshi 6).

(5) The age of the leaf was apparently not a factor in 20 leaves studied of one cultivated individual of *T. mairei* (Lemée & Lév.) S.Y. Hu *ex* T.S. Liu var. *speciosa* (Florin) Spjut; 16–18 stomata rows per band were found in all leaves from buds to 3rd yr branchlets.

Generally, the number of stomata rows per band varied by a count of 3 for about half of the individuals or species. In NW North America (*T. brevifolia*), this occurred frequently among different individuals within a population, whereas in Europe (*Baccata* Alliance) leaves of *Taxus* exhibited the same range in variation whether obtained from the same plant or from different plants at the same site. A wider range, 13–18 stomata rows, in the E Himalayas (*T. wallichiana*), and a narrower range, 5–6 or 6–7 stomata rows, in NE North America (*T. canadensis*), were also evident.

Despite this range in variation, the numbers of stomata rows per band in North American *Taxus* (Fig. 2A) show a distinct cline from south to north for the *Wallichiana* Group (Central America to Florida, California). Specimens from Honduras to southern Mexico had 7–11 rows per band (Bertrand 1874); those from N Mexico and Florida had (5–) 7 (–8) rows per band in further contrast to 4–7 (–9) stomata rows per band in the Pacific NW. This northward decline in stomata rows per band is also apparent within the Pacific NW by the highest count of 9 rows found in specimens from California, compared to the lowest count of 4 rows from specimens at more northern locations—in the Rocky Mountains. This cline was also noted to be associated with an increase in length of epidermal cells relative to width (l/w), ranging from an average of ca. 3× l/w to 8× l/w.

A reverse cline, however, is evident in the NE North America by 9 rows per band occasionally found in specimens from Newfoundland, compared to the more common 6 rows per band as reported by Bertrand (1874), which includes specimens from Quebec to Ontario, south to Kentucky (Spjut 1998a, 2000a, 2000b).

In the Euro-Mediterranean, *Taxus* leaves most often had 8–10 stomata rows per band (Fig. 2B); however, notably higher counts and lower counts were found at widely scattered locations (Fig. 2B, red and white numbers; appendix in bold type). Among the higher counts are specimens from the Caucasus Mountains, one with 15 rows (*Princeps Kascelsky, ex. Herb. Hort. Imper. Petro*), another with 13 rows (*Woronowa s.n.*). Occasional specimens with 12 rows are from Bosnia (*Biol. Inst. Dubrovnik 37*), Romania (*Topa, Bot. Mus. Exsic*), Finland (*Florstöm s.n.*), Portugal mainland (*Yoller 61*), Portugal Azores (*Goncalves 4625*), and Algeria (*Swingle s.n.*). Those that were noted to differ in other morphological features are indicated in bold type, including also specimens with 11 stomata rows per band, such as one specimen from England (*Bowden & Hillman 433*) that had globose shaped epidermal cells, instead of the usual elliptical shape; others such as *Hauti 28894* from the British Isles and *Busch s.n.* from the Caucasus Mountains had a broader marginal zone of bare cells, as indicated later under results for marginal cells. A higher number of stomata rows with a wider leaf margin indicate a higher density of stomata as seen in the *Cuspidata* Alliance. The range of variation for the *Baccata* Alliance was greatest in Transcaucasia.

Leaves with fewer than 8 stomata rows per band include seven specimens with 7 rows—from Germany, Austria, Switzerland, Bosnia, and Turkey; these belong to the *T. baccata* Alliance. Those with fewer than 7 rows were relatively rare (1–2% of 196 specimens cited for the Euro-Mediterranean Region), two specimens with 5 rows from Norway and Sweden, and one with 4 rows from Slovenia. These are considered *T. canadensis* as shown later. A cline is not apparent in the Euro-Mediterranean as it is in North America; however, the relative frequent occurrence of stomata in 8–10 rows per band appears significant when compared to a greater range of variation in E Asia (7–21 rows per band, Fig. 2C).

In E Asia, the number of stomata rows per band ranged from 7–16 in the temperate region, and from (5–) 7–19 (–21) in the tropical region with two patterns converging in the Himalayas, one from the west with 5–8 (–11) rows of stomata, and another from the east with 7–21 rows per band.

Number of Marginal Cells (MC).—The absence of papillae nearest the leaf margin, as measured by the number of marginal cells (MC) across between the margin and stomata band, is depicted geographically in Figs. 3A and 3B, and detailed in the Appendix.

Data on marginal cells lacking papillae along the abaxial surface (MC) were recorded less often for North American species because they were distinguishable early in the study (Hils 1993; Spjut 1992, 1993). It was recognized that marginal cells of *T. canadensis* always lacked papillae (Hils 1993, Spjut 1992, 1993, 1998a, 2000b), which has since been determined to vary from 11–19 cells across in North American plants (Appendix); the absence of papillae on the abaxial midrib is in sharp contrast to the papillose midribs of other North American species (*T. brevifolia, T. globosa*).

In the Euro-Mediterranean, the abaxial surface of leaves of most *Taxus* specimens (~75%) lacked-papillae along a relatively narrow marginal zone of 4–7 cells across (Fig. 3A). This included the lectotype for *T. baccata* and two specimens from the Caucasus Mountains that, unlike the lectotype, were found to have a relatively high stomata count as noted earlier—one with 13 stomata rows per band, and one with 15 stomata rows per band—and also one specimen from Bosnia with 12 stomata rows per band. A specimen from the Caucasus Mountains—that had abaxial marginal papillae to within one cell from the margin—lacked papillae on nearly half of the cells across the midrib in the median region (*Woronowa s.n.*).

Leaves of Euro-Mediterranean specimens with a relatively broad zone of bare cells between the margin and stomata band—from 8–24 cells across—were found less frequently (~25%). These are from widely scattered places. Many are indistinguishable from *T. canadensis* in North America—based on additional characters of branching, phyllotaxy, and color (Figs. 4–5); therefore, are referred to *T. canadensis* (Spjut 2000b). In Europe, leaves of *T. canadensis* may include a transitional zone of papillose cells between the stomata band and margin (Fig. 4, specimen from Morocco). These plants may be hybrids between *T. canadensis* and *T. baccata*.

The *Cuspidata* Alliance showed an intermediate range of values for abaxial marginal cells without papillae, (6–)8–18(–24) cells across (Figs. 3B, 6), compared to the *Baccata* Alliance, (1–)4–7(–11) cells across (Fig. 3A) and the *Sumatrana* Group, 8–36 cells across (Fig. 3B, 6). The higher stomata counts in relatively narrower stomata bands for the *Cuspidata* Alliance (see also Dempsey & Hook 2000) and *Sumatrana* Group means in effect they have a higher leaf stomata density, recognizing also that stomata density is related to width of the epidermal cells and the width of the stomata band (Nicolosi 1982), and that a transitional zone of papillose cells is always present in the *Baccata* Alliance but not in the *Cuspidata* Alliance. Data on number of papillose cells across the abaxial margin were not included in this study because this was observed to be highly variable, although the absence of papillae in *T. canadensis* has taxonomic significance in North American species as already indicated (Hils 1993; Spjut 1992, 1993, 1998a, 2000b).

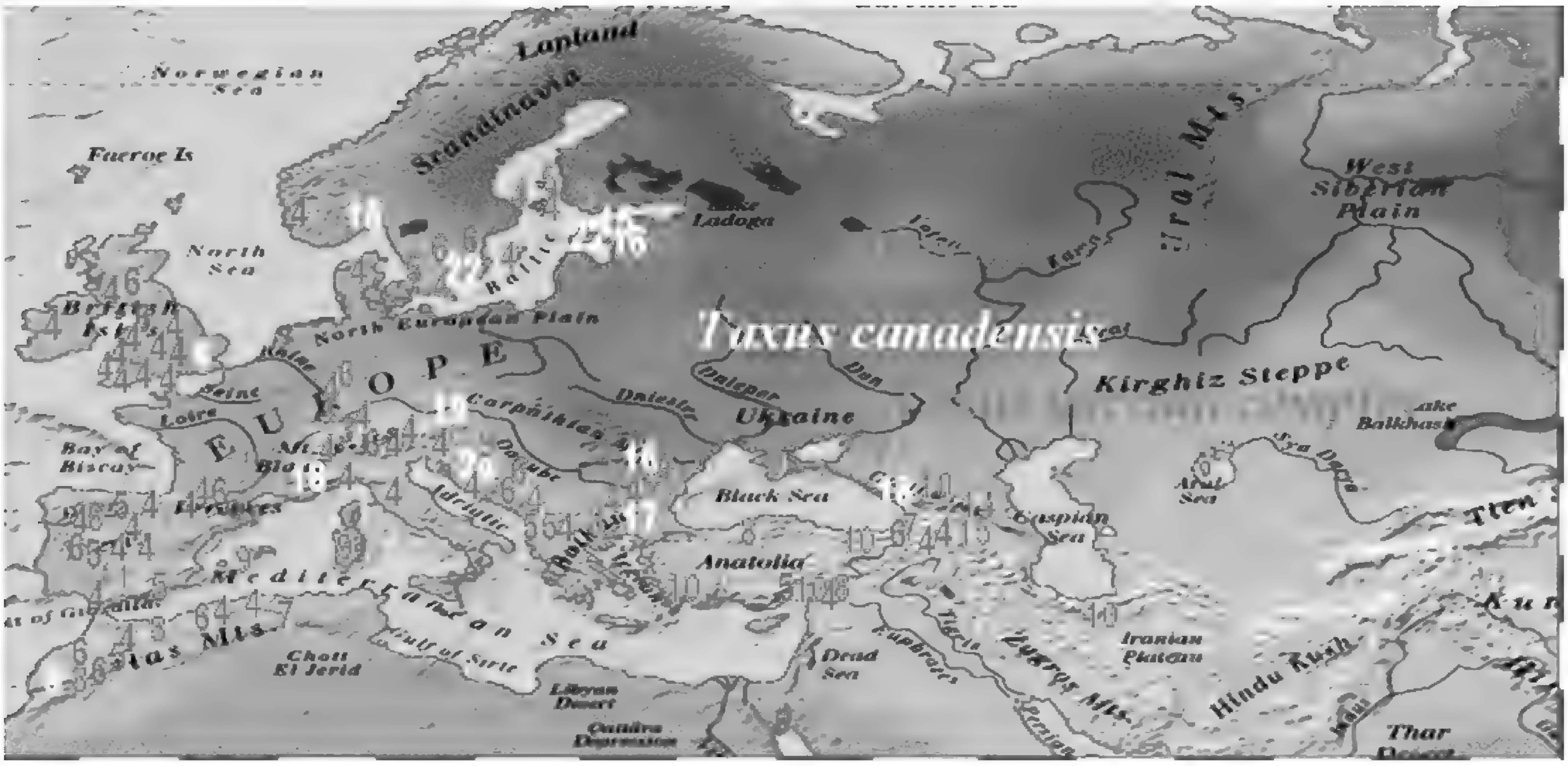

Fig. 3A. Number of epidermal marginal cells (MC) without papillae between the margin and stomata band (abaxial surface nearest margin) for representative specimens of *Taxus* from the Euro-Mediterranean Region; see Appendix for locality data. Numbers in red show the more common range in variation—a leaf margin 4–7 cells across—that corresponds to *T. baccata* and its allies in the Euro-Mediterranean Region. Numbers in white contrasts the higher counts—a leaf margin 6–24 cells wide—that belong to *T. canadensis*. Data in yellow numbers indicate intermediates that are morphologically similar to *T. biternata*, *T. canadensis*, *T. cuspidata*, or T. *contorta*, appearing more frequent in specimens from the Caucasus Mountains (Appendix, data in bold type)..

Fig. 3B. Number of epidermal marginal cells (MC) without papillae between the leaf margin and stomata band for three species groups of *Taxus* obtained from herbarium specimens cited in the Appendix. Data for the *Wallichiana* Subgroup and *T. contorta* (*Baccata* Group) are summarized, and data for the *Chinensis* Subgroup—summarized in Fig.6—are excluded here to further contrast the wide range in variation seen in the *T. cuspidata* Alliance (*Baccata* Group) and the *Sumatrana* Group. The *Sumatrana* Group includes *T. celebica* in maroon, *T. mairei* in black, *T. kingstonii* in white, and *T. sumatrana* in yellow. The *Cuspidata* Alliance includes *T. biternata* in orange, *T. cuspidata* in maroon, *T. caespitosa* and *T. umbraculifera* in red. Note that the widest range in variation occurs in SW China.

Fig. 4. Examples of *T. canadensis* var. *canadensis* as characterized by the regularly isodichotomous branchlets, and acute to acuminate leaves that spread from branchlets more by their petioles than by their blades, arranged in nearly two ranks, and by the abaxial surface of leaves lacking papillae on at least 8 cells across from the margin. MC = Marginal Cells across the marginal zone without papillae. SR = Stomata Rows in one stomata band. The specimen from Morocco has a partially papillose margin, 8–9 of the 18 cells between the margin and stomata band lack papillae. Specimens above left, above right and left: *Bean et al. 19634* (PH), *Lowe 570* (BM), *Font Quer 1928* (BM).

	Nova Scotia	Madeira	Morocco
MC	15	14	8-9(18)
SR	7	11	8

The absence of papillae along the abaxial marginal surface is most variable in E Asia (0–36 cells across, Figs. 3B, 6). This variation is related to taxonomic features that define the species groups and the species themselves as shown in Fig. 6. In Fig. 3B, the numerical data for the *Taxus wallichiana* Group, and for the NW Himalayan species, *T. contorta* (*Baccata* Group), were summarized because leaf stomata bands are consistently bordered by a relatively narrow marginal zone of epidermal cells without papillae—most often 4 cells across (Fig. 6)—as seen also in the *Baccata* Alliance (Fig. 3A, Appendix). Asian plants with a marginal border of fewer than 4 cells across generally belong to *Taxus wallichiana* var. *yunnanensis* (W.C. Cheng & L.K. Fu) C.T. Kuan, or to *T. suffnessii* Spjut, whereas specimens with an abaxial leaf margin exceeding 7 cells in width usually belong to the *Sumatrana* Group and *Cuspidata* Alliance, but there are several notable exceptions. One is *Taxus chinensis* with a leaf margin of 4–12 cells wide that is clearly intermediate between the *Sumatrana* Group and the *Cuspidata* Alliance, corresponding also to its intermediate geographical posi-

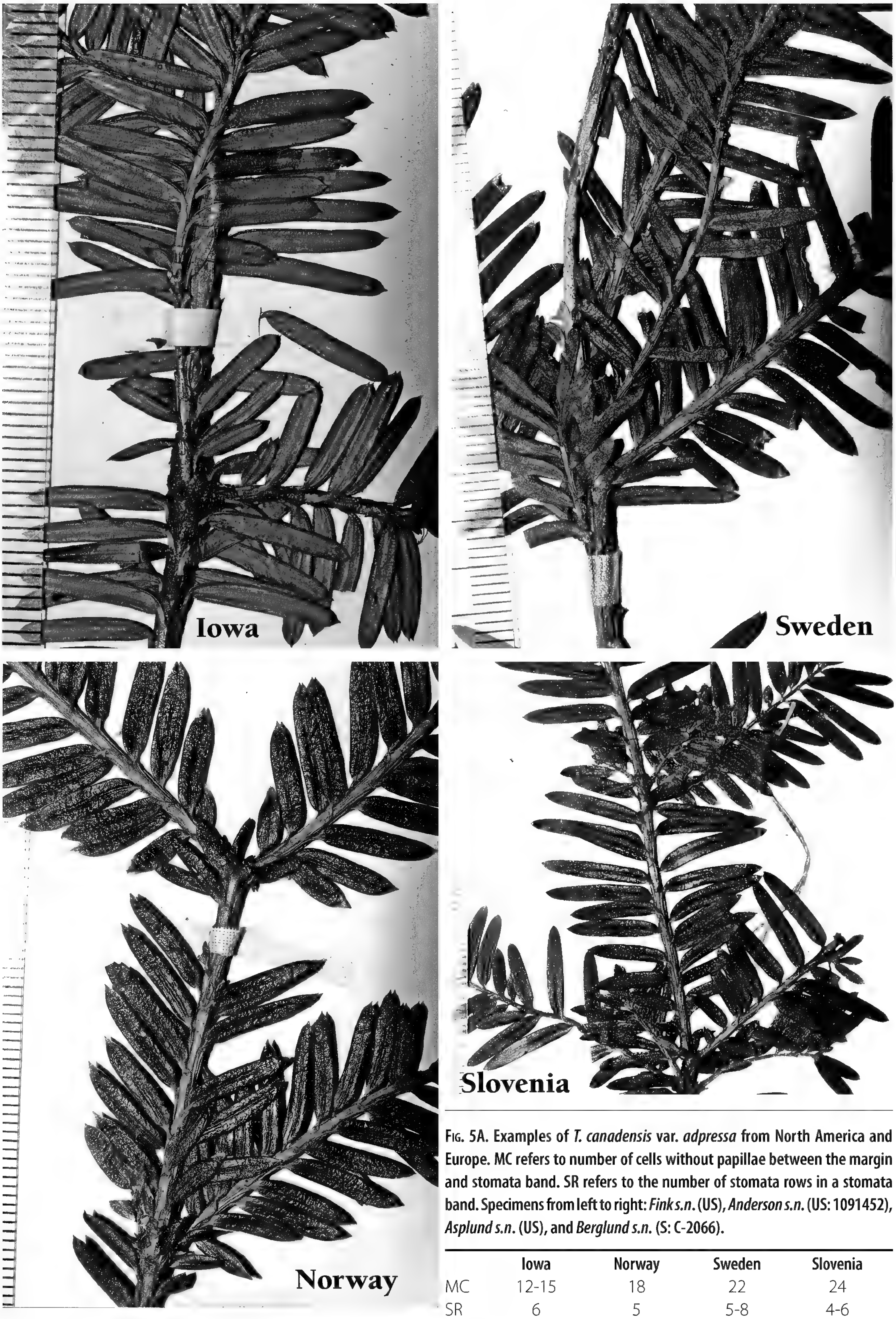

Fig. 5A. Examples of *T. canadensis* var. *adpressa* from North America and Europe. MC refers to number of cells without papillae between the margin and stomata band. SR refers to the number of stomata rows in a stomata band. Specimens from left to right: *Fink s.n.* (US), *Anderson s.n.* (US: 1091452), *Asplund s.n.* (US), and *Berglund s.n.* (S: C-2066).

	Iowa	Norway	Sweden	Slovenia
MC	12-15	18	22	24
SR	6	5	5-8	4-6

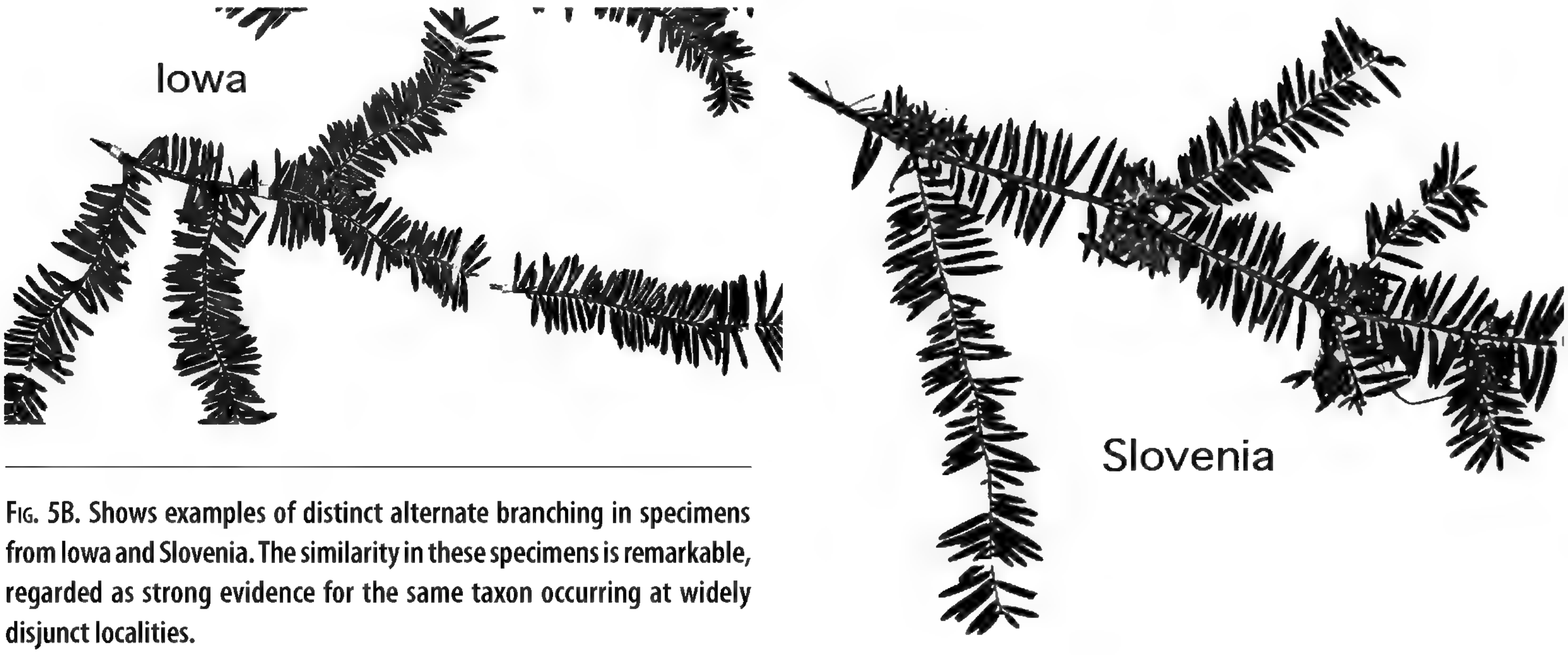

Fig. 5B. Shows examples of distinct alternate branching in specimens from Iowa and Slovenia. The similarity in these specimens is remarkable, regarded as strong evidence for the same taxon occurring at widely disjunct localities.

tion in central China. Another is the central Himalayas *T. contorta* var. *mucronata* Spjut, a variety that is recognized by shorter reflexed leaves as in *T. umbraculifera* (*Cuspidata* Alliance) but also with slightly more stomata rows per band (8–11) and a wider leaf margin (8–10 cells across) than what is usually seen in the typical variety of NW Himalayas.

Data in Figs. 3B and 6 also contrasts the wide variation in the number of marginal cells in the *Sumatrana* Group and *Cuspidata* Alliance with other Asian taxa. The *Sumatrana* Group and *Cuspidata* Alliance share the elliptical shape of epidermal cells as seen in T-section, in contrast to the angular leaf epidermal cells of the *Wallichiana* Subgroup, and also lack of papillae on the abaxial midrib as well as along marginal regions (e.g., *T. sumatrana*, Fig. 1C). This group usually occurs at elevations below 2000 m in contrast to *T. wallichiana* found mostly above 2300 m. One exception, *T. kingstonii* Spjut, in the *Sumatrana* Group, is ecologically and morphologically intermediate between the *Wallichiana* and *Sumatrana* Groups.

Variation in the number of abaxial marginal cells recorded from the same plant, or related plants at the same locality, was assessed similarly to data compiled on number of stomata rows. Among duplicate herbarium specimens, the count was the same in nearly half of the duplicate sets. Most variation within individuals, or within a population of individuals, occurred in the *Sumatrana* Group (*T. celebica* [Warb.] H.L. Li, *T. kingstonii, T. mairei* [Lemée & H. Lév.] S.Y. Hu ex T.S. Liu, *T. sumatrana*; Fig. 3B, Appendix). For example, leaves from duplicate specimens of *T. mairei* from Guangdong often lacked papillae along the abaxial margin on either 14 or 24 cells across. Similar dimorphic differences are evident in specimens from Sichuan and Guizhou, and in *T. kingstonii* from Yunnan. These differences may be due in part to leaves from different plants, or from different ages of shoots, or from different heights on the plant (de Laubenfels 1988), or in *T. celebica*, from slightly different regions of the leaf.

In the case of *Wilson 1265* (A, BM, K, S, US), which was mentioned earlier as having been collected from three different locations (Rehder & Wilson in Sargent 1914), one site in western Sichuan at 600–650 m included duplicate specimens that was found to have either 15 (US) or 21 (A) stomata rows per band, and either 16 (US) or 25 (A) marginal cells. *Wilson* also collected seed (*Wilson 1265*) from Sichuan near Mt. Emei and/or Yachou Fu at 600 m from which leaves in three herbarium specimens obtained from a plant grown from seed (of *Wilson 1265*) at the Royal Botanic Gardens—Kew lacked papillae entirely along an abaxial margin zone, 18 or 28 cells across, while all three had 8–10 stomata rows per band. This plant is not *T. chinensis* as indicated in the literature (Rehder & Wilson in Sargent 1914), but *Taxus mairei* var. *speciosa* (Florin) Spjut that appears atypical by the relatively large greenish distant leaves that are more characteristic of *T. celebica*. Photographs of a very similar plant in cultivation at the Royal Botanic Garden—Edinburgh (probably from *Wilson 1265* seed) are shown in van Gelderen and van Hoey Smith (1996) and in Krüssmann (1985). However, *Wilson 1265**(b)*** does include one specimen I identified as *T. chinensis* that was reportedly obtained from western Hubei south of "Ichang," 600–1300 m.

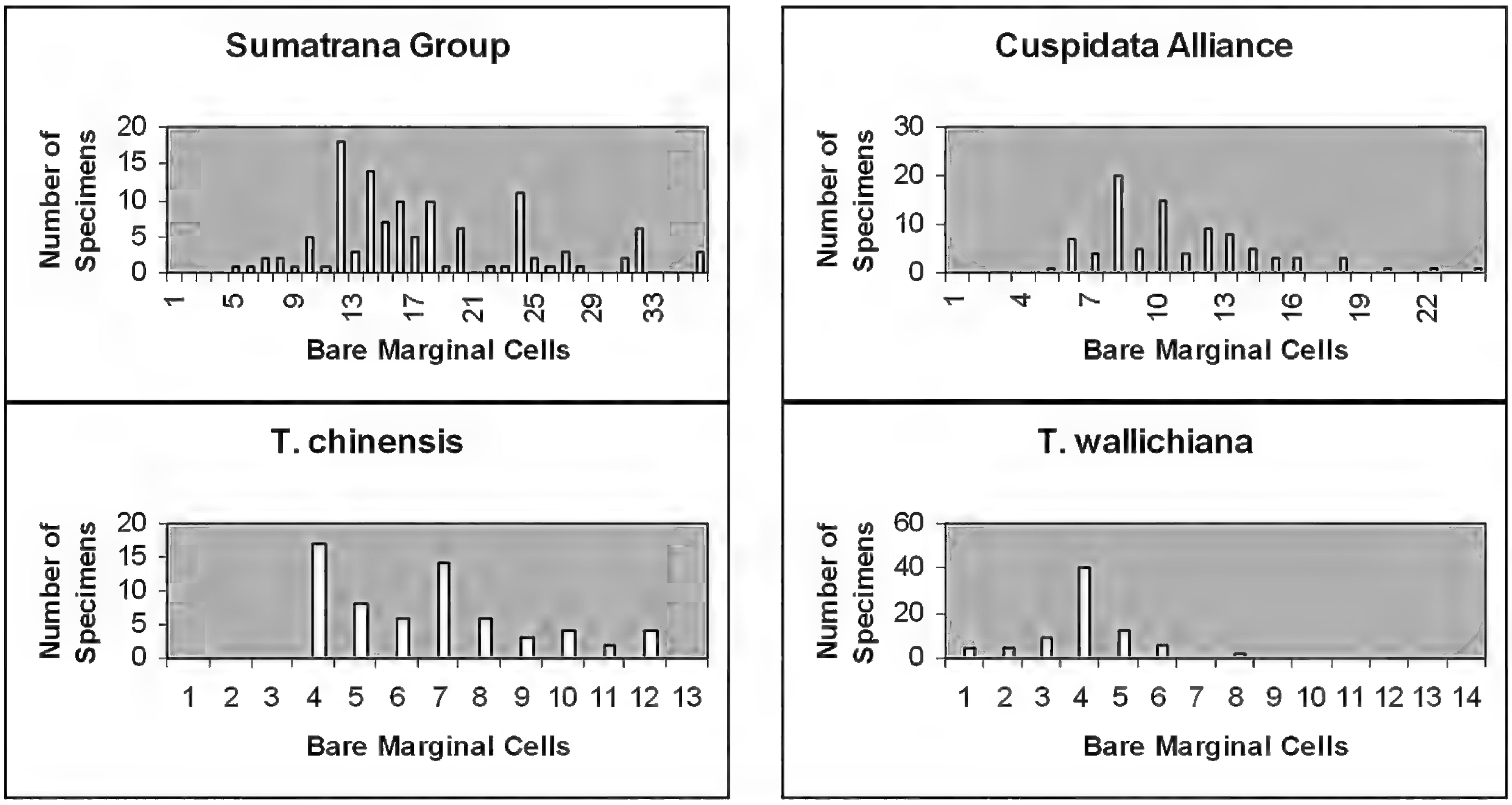

Fig. 6. Number of *Taxus* specimens according to the number of bare (without papillae) cells across abaxial surface of leaves between the margin and stomata band for selected taxa from E Himalayas to China. Note that the *Sumatrana* Group has the widest leaf marginal zone without papillae, and that *T. wallichiana* has the narrowest zone, mostly 4 cells wide (40 specimens).

De Laubenfels (1988), commenting on his field observations of yews in Taiwan, suggested that differences in leaf shape may be seen on the same plant and further implied the same for the presence or absence of leaf papillae.

Leaves of *Taxus mairei* var. *speciosa* that showed considerable variation were also studied from plants cultivated in the United States. An examination of 20 leaves (*Phyton s.n.*)—from apical buds to 3rd yr branchlets—were found to be relatively constant in the number of marginal cells without papillae—9 cells across—and also in having 16–18 stomata rows per band. They were notably variable in shape and length of epidermal cells, especially juvenile foliage.

The abaxial leaf margin in *T. mairei* specimens obtained by C-j. Chang from near Hualien, Taiwan varied by four cells (4–7) at four of six locations (Nos. 2, 4, 9, 10), and by only two cells (0–1 cell) at the two other locations (Nos. 1, 5).

Finally, specimens of *T. celebica* from South Vietnam by Schmid (1974) were found to lack papillae on either (23–) 24 or 32 cells across the leaf margin. Here Schmid (1974) reported that *Taxus* was polymorphic, and among his specimens at the Museum of Natural History in Paris (P), is an apparent hybrid (*Schmid s.n.*) between *T.* aff. *chinensis* (*Poilane 4150*) and *T. celebica*.

DISCUSSION

Phytogeography of *Taxus*.—Data presented for leaf character attributes of *Taxus* (Figs. 2 and 3) show that stomata rows and marginal cell features are most diverse in SW China, while the same number of subspecies (Pilger 1903), or species (Farjon 1998; Silba 1984) have been recognized to occur in both North America and Eurasia; thus, the traditional separation of *Taxus* species (or subspecies) based on these geographic discontinuities is a distorted classification. The phytogeographic data in this study support the taxonomy of yew for only the geographical disjunct occurrences in North America.

In North America, leaf stomata of *Taxus brevifolia* show a cline in number of stomata rows ranging from 9 rows in California to 4 rows in the northern Rocky Mountains, and also in length of abaxial epidermal cells relative to width (l/w) from an average of ca. 3× l/w to 8× l/w. Molecular differences have been reported between coastal and inland yews (El-Kassaby et al. 1994, 1995) at more northern localities. Clinal variation in conifers has been linked to historical migrations and hybridization patterns with the advance and retreat of glaciers since the Pliocene (Wilkinson et al. 1971); however, the cline in stomata data for the North American *Wallichiana* Subgroup, including Mexico, seems best explained by loss of stomata in leaves of *Taxus* as it may have migrated northwards during the Neogene, when the climate may have become increasingly warmer and drier, while the differences within the Pacific Northwest may be a product of more recent climatic changes (Graham 1999).

Also, a geographical species concept that recognizes *T. sumatrana* as widely distributed in SE Asia (de Laubenfels 1988) might conclude that its distribution was achieved from long-distance dispersal by birds, whereas geographical disjunction of *Taxus* in North America has been correlated with paleobotanical data (Graham 1999). This seems paradoxical; i.e. the greater variation in leaf anatomical data of *Taxus* in Asia should also be explained by evolution and paleogeography—perhaps the result of climatic and geomorphic changes that have occurred since the Cretaceous, a period of 130 million years (my). Therefore, the discussion that follows will focus on this latter hypothesis.

Although data on leaf stomata rows in *Taxus* are more variable in Asia than in North America and Europe, relationships become evident when other taxonomic features are taken into consideration (Spjut 2007). For example, in the western Himalayas, the stomata counts that range from 5–8 (–10) or 8–11 stomata rows per band (Fig. 2C) are a characteristic feature of *T. contorta* Griff. This species is also recognized by the long narrow leaves that have idioblasts in the spongy mesophyll (vesicular cells appearing dark red in herbarium specimens), a character trait not seen in the E Himalayan yews. Moreover, these features show a closer relationship to European yews than to Asian yews. In the E Himalayas, *T. wallichiana*—indicated to have 11–19 stomata rows—is recognized by leaves having large angular shaped epidermal cells as seen in T-section, by the persistent bud-scales at the base of branchlets, by the branchlets that show a marked color change in their 2nd yr of growth—from yellowish green to maroon or reddish orange, and by the bone-like parenchyma cells in the spongy mesophyll that connect in a reticulate pattern with rounded to angular intercellular spaces. These morphological features are considered more closely related to yews of SW China than to *T. contorta* of W-C Himalayas.

Data in the appendix take into account variation in *T. chinensis* and *T. wallichiana* on Mt. Emei. Specimens are arranged according to increasing number of marginal cells along the abaxial surface of the leaf without papillae. In *T. wallichiana*, the epapillose marginal cells, which are consistently 4 wide for numerous specimens in the Himalayan Region (see also Fig. 10 in Spjut 2007), appear to show greater variation on Mt. Emei where it was found that two of six specimens had a leaf margin 8 cells wide. Similarly, *T. chinensis* outside of Mt. Emei was usually found to have a relatively narrow leaf margin of 4–7 cells wide, 25 of 30 specimens (83%); only 2 specimens (7%) were found with a leaf margin greater than 8 cells wide, whereas on Mt. Emei, 11 of 30 specimens (37%) had a relatively broad leaf margin (8–12 cells across). The broader leaf margin in *T. chinensis* from Mt. Emei could be the result of recent hybridization with species of the *Sumatrana* Group, or possibly reflects historical introgression with *T. umbraculifera* of NE China. Hybridization might also account for similar variation in *T. chinensis* for three specimens from Guizhou, Shaanxi, and Vietnam.

The development of leaf papillae in *Taxus* along the abaxial marginal zone may be partially correlated with latitude as evidenced by the narrower range of marginal cells without papillae (7–24 cells across, Figs. 3B, 6) for the *T. cuspidata* Alliance in temperate NE Asia, compared to that of the more widely distributed *Sumatrana* Group (8–36 cells across, Figs. 3B, 6) in SE tropical Asia. At increasingly higher latitudes, plants with more papillae on their leaves obviously receive greater protection from ultraviolet rays of the sun—during the longer summer days. The refractivity (protective) effect of papillae on *Taxus* leaves has indeed been mathematically demonstrated (von Frimmel 1911). Nevertheless, hybridization between the tropical and temperate species alliances in E Asia cannot be ruled out.

In the *Cuspidata* Alliance, I have observed that papillae are of lower stature and concrescent near cell walls in which the cell walls appear thicker, examples of which are shown in Jinxing and Yuxi (2000). This may be evidence of introgression with the *Wallichiana* Group from which *T. chinensis* allegedly evolved. As indicated, leaves of *T. chinensis* often have elliptically shaped epidermal cells in T-section, a slightly wider marginal border, ranging from 4–12 smooth cells across (Fig. 6), and midrib papillae often more conspicuous along cell walls. Thus, the *Cuspidata* Alliance, which is undoubtedly related to the *Baccata* Alliance (Collins et al. 2003; J. Li et al. 2001), may have acquired an expanded leaf margin as a result of hybridization with species of the *Sumatrana* Group.

In cultivated individuals related to *T. cuspidata* and *T. mairei*, papillae sometimes were found on midribs of young leaves, but not the older leaves. However, the odd leaf mentioned earlier for one cultivar (*T. caespitosa*) with 16 instead of 13 stomata rows/band was found with low papillae on its midrib, whereas the other 15 leaves had smooth midribs; this odd leaf may have retained juvenile characteristics due to lack of exposure to light. I have also completely "skinned" leaves to evaluate the distribution of papillae from base to apex in specimens from Europe, Taiwan and the Philippines, and have found papillae to develop more in the upper half (towards apex). The presence of midrib papillae on juvenile leaves, thus, may indicate an ancestral trait that should not be treated as a justification for lumping all variation within a geographical area under one species.

This alleged ancestral trait is also evident among specimens that are intermediate between *T. chinensis* and *T. mairei*, and the extinct *T. engelhardtii* (Fig. 7). The characteristics of *T. mairei* include larger (mamillose) epidermal cells on the abaxial midrib and marginal zones, and isodichotomous zigzag branching; those of *T. chinensis* are the marginal papillae on the abaxial midrib [e.g., *Ching 1676* from Sichuan; *Chiao & Fan 464* (US) from Sichuan, and *Tsiang Ying* 1425 (P)]. A study by Kwei and Hu (1974)—that mentioned 30 of the specimens cited in the Appendix—recognized intermediates by a partially papillose midrib; however, Spjut (1992, 1993, 1998a) has since reported other correlative taxonomic characters—such as shape of leaf epidermal cells, development of papillae along the abaxial marginal zone and size of bud-scales—to help further separate these species. It should also be noted that midrib papillae can be consistently present in the W Himalayan *T. contorta* (Kvaček 1984), or consistently absent in the North American *T. canadensis*.

From Myanmar are four specimens found to have leaves almost entirely papillose within a few cells from the abaxial margin. Three of the specimens are recognized as belonging to a distinct species (*T. suffnessii*) by the relatively large and persistent bud-scales at base of branchlets, by the conspicuous papillae on epidermal cells, and by the relatively tall-rectangular epidermal cells as seen in T-section of leaves (Spjut 2007). One of two other specimens from NE India and Bhutan (*Ludlow & Sherriff 18762, 3719*)—that was recorded to be papillose within 2 cells from the margin—differed by having elliptical instead of angular epidermal cells. It would appear, then, that the occurrence of papillae on the abaxial surface of *Taxus* leaves has taxonomic significance even when the numerical differences are relatively narrow as also seen in North American *T. globosa* var. *globosa* and *T. globosa* var. *floridana* in which intermediates are recognized to occur in northern Mexico.

Disjunct Relationships between Eastern Asia and Western North America.—Disjunct geographic distributions in *Taxus* and other genera have long been recognized between temperate North America and Eurasia (Axelrod 1983; Boufford & Spongberg 1983; Good 1964; Graham 1972; Hara 1972; Kornas 1972; H. Li 1952; Tiffney 1985a; Qian 2002; Q. Wang et al. 2006); however, their rate of evolution varies. For conifers this has been considered relatively slow (Prager et al. 1976). In the genus *Abies*, for example, the subalpine fir in W North America [*A. lasiocarpa* (Hook.) Nutt.] appears more closely related to an endemic species of Taiwan [*A. kawakamii* (Hayata) Ito] than to any of the 10 other American species (Farjon 1990; Hunt 1993; Liu 1971). Indeed, recent molecular studies by Suyama et al. (2000) show *A. mariesii* Masters of Japan to be more related to species in North America than to its relatives in Japan. Additionally, species of *Pseudotsuga* (±4 spp., Farjon 1990) in Asia may have been derived from ancestors in North America (Strauss et al. 1989).

The *Wallichiana* Subgroup of *Taxus*—characterized by angularly shaped epidermal cells in T-section—occurs primarily in E Himalayas to SW China (Sichuan, Yunnan) and in North America (Spjut 1998a, 1998b, 2000a). Within this subgroup, leaves of Yunnan and Sichuan plants (*T. florinii*, Spjut) appear indistinguishable from those of the American *T. globosa* (Spjut 1998b, 2000a, 2000c). Other specimens from Myanmar

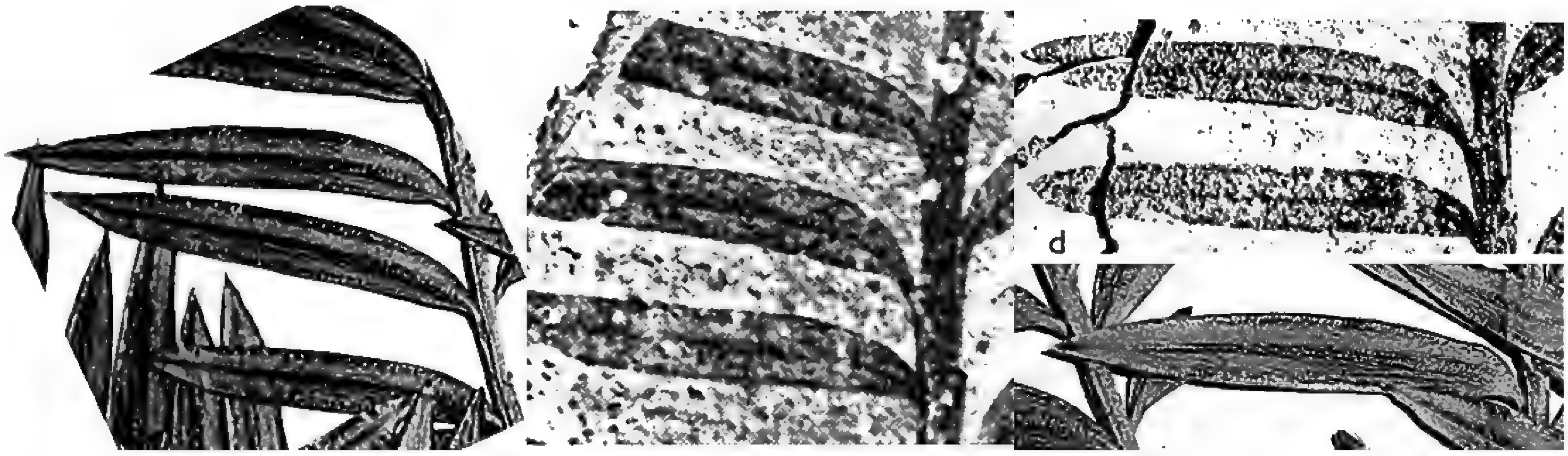

Fig. 7. Comparison of leaves of extant *T. mairei* (clear photos, isotype, P) with extinct *T. engelhardtii* (grainy photos, reproduced from Kvaček 1984), from an Oligocene deposit in Bohemia.

(*T. suffnessii*) are similar to *T. brevifolia* in the relatively large bud-scales and tall rectangular epidermal cells as seen in T-section (Spjut 2000c).

An analogous disjunct relationship is seen among the white pines, *Pinus monticola* Douglas ex D. Don of W North America and *P. wallichiana* A. B. Jackson of Myanmar (Axelrod 1986, *Pinus griffithii* [Hook. f. & Thomson] Parl.). They are remarkably similar in cone morphology and needle chemistry. The antiquity of this relationship is supported by their turpentine chemistry of saturated straight chain hydrocarbons—undecane and heptane, the chemical structures of which are considered more archaic among the terpenoid compounds in pines (Mirov 1953). Additionally, heptane occurs in the Mexican *P. ayacahuite* Ehrenb. ex Schltdl. (Mirov 1953), along with a bicyclic sesquiterpene—cardenine—that has also been found in *P. parviflora* Siebold & Zucc. of Japan (Mirov 1953). The close relationship among these species, which belong to sect. *Quinquefoliae* subsect. *Strobus*, is supported by molecular data (Liston et al. 1999) from which it has been suggested that the ancestors probably originated in the "Old World" (Gernandt et al. 2005).

In angiosperms, it is interesting that Phipps (1983) recognized—among ~145 species of hawthorns—*Crataegus mexicana* Moç. & Sessé, a widely distributed species in Mexico and Guatemala, to have its closest relative in Yunnan, *C. scabrifoliaI* (Franchet) Rehder, and that both are the "most primitive" of a taxonomically complex Laurasian genus, which has numerous species in both Mexico and in Yunnan.

For taxads and other conifers, diversity is greatest in SW China (Figs. 2, 3; Cheng & Fu 1978; Prakash et al. 1995; Qian & Ricklefs 1999). Ancestors related to *Taxus suffnessii* Spjut in Myanmar (Appendix) may have immigrated to North America across a former Aleutian (or Bering) land bridge (Hamilton 1983; Millar 1993)—as suggested for *Crataegus* (Phipps 1983). A logical time for this to occur would have been during the latter half of the Cretaceous (110–100 mya), after Pangaea had fragmented (Graham 1993)—when an epeiric sea (Wolfe 1975) possibly divided the North American continent into distinct west and east floras (Graham 1999; Srivastava 1994; Thorne 1972, 1978). Late Cretaceous fossils related to the Alaska cedar, *Callitropsis nootkatensis* (D. Don in Lambert) Florin, which includes one related sister species in North Vietnam, and is also sister to other species in North America (Little 2006), have been found on Vancouver Island (McIver 1994), and an early Cretaceous fossil, *Chamaecyparis eureka* Kotyk, from Eureka Sound in the Canadian Arctic, is most similar to the extant *Ch. pisifera* Siebold & Zucc. in Japan (Kotyk et al. 2004). Additionally, fossil cones of *Thuja smileya* LePage from Late Cretaceous deposits on the North Slope of Alaska are indistinguishable from modern species (LePage 2003).

As climate temperatures declined during the Cretaceous (Axelrod 1958; Frederiksen 1994; Graham 1999; Novacek 1999; Srivastava 1994), *Taxus* might have retreated southwards, perhaps reaching southern Mexico by the end of the Cretaceous (65 mya); similar retreats have been suggested for other genera (Phipps 1983; Sharp 1966), but for the Tertiary Period (Phipps 1983), not the Cretaceous. A later migration and extinction of *Taxus*, such as in the Tertiary near the Eocene-Oligocene boundary, may seem like a more reasonable time frame for evolution of North American *Taxus*, but there also has to be ample time for diversification of the *Cuspidata* Alliance as well as the alleged migration and extinction of the *Wallichiana* Group across the Sino-Japanese Region.

The end of the Cretaceous is marked by a distinct change in the geochemical and fossil records (McIver 1999; McIver and Basinger 1999; Novacek 1999)—indicating a rapid climatic warming—possibly due to a meteor impact in the Caribbean Sea that might have caused massive volcanic materials to erupt and cloud the atmosphere (O'Keefe & Ahrens 1989)—a 'greenhouse' calamity that could explain evidence for "ecological deserts" (Tschudy et al. 1984)—and mass extinction of major taxa (e.g., dinosaurs, Novacek 1999). This could have extirpated yew north of Mexico; Cretaceous fossils of gymnosperms of the Taxodiaceae (*Metasequoia, Sequoia, Sequoiadendron*), and Amentotaxaceae (*Amentotaxus, Torreya*) are known as far south as New Mexico and North Carolina (Florin 1963) for which *Taxus* has had a long history in association (Florin 1951, 1963; Kvaček 1984) but whose fossils may not always be preserved or identified.

Paleontological evidence indicates that following the Cretaceous a warmer subtropical humid climate (Chaney 1947; Frederiksen 1994; Tiffney 1985a) prevailed over much of North America until the late Eocene (ca. 50 mya; Chaney 1947; Graham 1999; Novacek 1999; Srivastava 1994; Wolfe 1975). Assuming that ancestral *T. globosa* had survived only in Mexico, a northward migration (as the climate warmed) would account for the cline in leaf stomata data of *Taxus* in W North America (Fig. 2A). Other North American conifers with evidence of a southern ancestry include Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco), most likely derived from big cone fir (*P. macrocarpa* (Vasey) Mayr), endemic to S California (Strauss et al. 1989), and pines that may have drifted northwards on the San Andreas rift system (Axelrod 1986)—a system that may have included Vancouver Island originating perhaps from as far south as "lands end" off the cape (Cabo San Lucas) of Baja California (90 mya, Ward et al. 1997). A northward range extension of ancestral *Taxus globosa* may be further correlated with the change in a Rocky Mountain flora from paleotropical (boreotropical) to neotropical elements during the mid Eocene (Leopold & MacGinitie 1972), and later along the Gulf as evident from biogeographical data on fishes and amphibians (Rosen 1975), maples (*Acer saccharum* L. Group; Humphries 1982), and other taxa (Burnham & Graham 1999)—emphasized by Axelrod (1975, 1986).

As the climate became drier with the uplift of the W Cordillera (Chaney 1947; Wolf 1969), the range of *Taxus*, like other Arcto-Tertiary genera, diminished (Axelrod 1975, 1983; Graham 1993, 1999), while other taxa evolved (Axelrod 1958). Fossils of *Taxus* have been reported in Eocene (54–38 mya), Oligocene (38–27 mya), and Miocene (27–10 mya) strata of W North America (Gaussen 1979; Kvaček & Rember 2000, in press; Manchester 1994; Meyer & Manchester 1997) in association with species of *Tsuga, Abies, Lithocarpus, Quercus, Acer, Alnus, Cornus, Carpinus, Castanea, Fagus, Liquidambar, Nyssa, Ostrya, Platanus, Tilia, Ulmus*, and *Cercidiphyllum* (Graham 1999; Whittaker 1961).

Extant species of *Taxus* are still found with these same genera today in mixed mesophytic forests of S Appalachia (Braun 1950), China (Hou 1983), and Japan (Hayashi 1954). *Taxus brevifolia* allegedly evolved from an ancestral *T. globosa* complex as the climate became cooler and drier during the Eocene (56–34 mya; Graham 1999), while closer ties between the Mesoamerican yew and Florida yew were likely maintained until the Pleistocene as evidenced by the close similarity among many shared taxa between the two regions (Sierra Madre Oriental and S Appalachia). It is interesting that specimens of Florida yew appear indistinguishable from those occasionally collected in Veracruz and in Nuevo Leon/Tamaulipas, Mexico (e.g., *Meyer & Rogers 2746*, BM; *Mueller 1337*, BM, PH), where they reportedly occur with *Carpinus caroliniana* Walter, *Cercis canadensis* L., *Frangula caroliniana* (Walter) A. Gray, *Hamamelis virginiana* L., *Liquidambar macrophylla* Oerst, *Magnolia schiedeana* Schltdl., *Prunus serotina* Ehrh, and others also found in S Appalachia, including many lichens and mosses (Culberson et al. 1990; Graham 1973, 1999; Miranda & Sharp 1950). Moreover, it has been shown that the Florida yew and Mesoamerican yew form a clade with the Pacific yew as a sister species (J. Li et al. 2001), and that the Florida and Mesoamerican yew are indeed more closely related (J. Li et al. 2001).

As previously noted, genera found with the Mesoamerican yew also occurred with Pacific yew (Graham 1999), but in the Pacific Northwest many of these genera perished—such as *Carya, Disopyros, Fagus, Hamamelis, Liquidambar, Liriodendron, Magnolia,* and *Morus* (Axelrod 1975, 1983, 1986; Graham 1999; Manchester

1999; Wood 1972). *Liriodendron* is one of many known from fossils in Europe and W North America with relatives now surviving only in E North America and E Asia (Axelrod 1983; Manchester 1999; Schuster 1976). They perhaps were part of a widespread Tertiary "boreotropical" forest (Wolfe 1975; Graham 1999), which may have included *T. canadensis* (Figs. 4, 5).

As conifer diversity declined and grassland vegetation expanded during the Miocene (Axelrod 1976; Jacobs et al. 1999), *Taxus* possibly had attained maximum diversity in geographic and ecological species isolation. McIver and Basinger (1989) found in Eocene deposits cones similar to western red cedar (*Thuja plicata* Donn ex D. Don) that may have been derived from an earlier complex related to the extinct *Thuja polaris* McIver *et* Basinger, which they described from a Middle Paleocene deposit on Ellesmere Island, whereas other cedars related to *Th. occidentalis* L. are not known before the Miocene (McIver and Basinger 1989). Moreover, *Th. occidentalis* is recognized in the fossil record from the late Pliocene (Bennike 1990). The redwood, *Sequoia sempervirens* (Lamb. ex D. Don) Endl., is hardly distinguishable from a former widespread *S. abietina* (Brongn.) Knobloch—known from the Upper Eocene to Upper Miocene (Mai 1998). A species of *Taxus* from a Middle Miocene deposit in N Idaho (Clarkia area Latah Formation) has nearly the same abaxial epidermal features seen in the extant *T. brevifolia* (Kvaček & Rember 2000, in press). Klicka and Zink (1997) concluded from DNA evidence that North American species of song birds had already originated by early Pleistocene, and that subsequent glaciation was more of an "obstacle course" for their survival. Yew species, by comparison, are likely to evolve more slowly as a yew trunk may live 3000 years (Larson et al. 2000; Thomas & Polwart 2003; Voliotis 1986), and still may survive by producing trunks from adventitious shoots (Hageneder 2007; Loudon 1844). The greater diversity of *Taxus* in SW China may also be related to less species extinction there as seen in many plant genera as a result of increasingly drier and cooler climates that had a more profound impact on the vegetation elsewhere since the Middle Miocene (Axelrod et al. 1998; Kubitzki & Krutzsch 1998).

Relationships between Eastern North American and Eurasian *Taxus*.—While the Pacific floristic element of *Taxus* in North America is represented by three disjunct taxa within the *Wallichiana* Group, the Atlantic floristic element has only *T. canadensis,* a species that appears more related to the *Baccata* Group (J. Li et al. 2001; Spjut 2007) than to *T. globosa* by its elliptical shaped epidermal cells in T-section, and by its subcylindrical seed shape (Spjut 1998a, 2000). The lack of papillae on the abaxial leaf surface between the margin and stomata band that characterizes the North American Canada yew is also seen more frequently in yews of temperate NE Asia (*Cuspidata* Alliance) than in the Euro-Mediterranean (*Baccata* Alliance), and its leaf epidermal features are most similar to *T. biternata* Spjut, a species closely allied to *T. cuspidata*. The close relationship between *T. canadensis* and *T. cuspidata* is supported by molecular data (Collins et al. 2003). *Taxus biternata* differs from *T. canadensis* by the 2–3 angled seeds (tapered part) developing on 1st yr branchlets, and by the tree habit (Spjut 2007). The complete lack of papillae along the abaxial leaf marginal zone is a relatively rare occurrence in European yew (<2%), but this character trait may have once been common in that region; for example, three species described by Kvaček (1984) from leaves of fossil assemblages in Europe—dating from Oligocene to Pliocene—all lacked papillae entirely between the stomata bands and margins.

Furthermore, a "*Taxus* (sp. 1," Kvaček 1984; Fig. 8) of Lower Miocene age is, in my opinion, *T. canadensis*. Its leaves are more similar to American plants than to European plants, which differ by the distinctly papillose stomata bands—except perhaps for rare North American specimens (e.g., *Coy & Glen* from Ithaca, New York). These extant European variants could be referred to the extinct *T. grandis* Kräusel or *T. inopinata* Givulescu (1973)—described from Tertiary deposits in Europe (Kvaček 1984). Data for numbers of stomata rows (Figs. 2A, 2B) also support my hypothesis that the North American *T. canadensis* came from Europe, possibly arriving late Paleocene or Eocene when migration across the Atlantic was possible by land (McKenna 1983; Tiffney 1985b), as suggested for the evolution of *Cornus sessilis* Torr. ex Durand (Xiang et al. 2005, 2006). During this period the Gulf Coast flora shows evidence of many immigrants from Europe (Frederiksen 1994, 1995) that included species of *Fagopsiphyllum, Hydrangea, Iodes, Koelreuteria, Langtonia, Nyssa, Palaeophytocrene, Pentoperculum, Platanites, Platycarya, Pyrenacantha, Sargentodoxa, Symplocos, Tapiscia, Tetraclinus*, and *Tilia* (Manchester

Fig. 8. Comparison of *T. canadensis* var. *minor* from Madeira (*Lowe ex Barby s.n.*, US) and Maine (*Fellows 5686*, US) above with close-up on middle left showing seed on 2nd yr branchlet, and below photomicrographs of part of leaf stomata band of var. *canadensis* from Ohio (400×) and of a Miocene fossil from Czech Republic ("*Taxus* sp. 1," Kvaček 1984) with leaf fragment ("d" on right). This variety is recognized by the more strongly falcate leaves that are mostly erect in contrast with the wide spreading obtuse leaves in var. *T. canadensis* var. *adpressa*. Note the medial papillae that are most conspicuous along stomata rows.

1999). It is interesting to note that 10 species (in 9 genera) of lichens recently discovered to occur in E North America—on Mt. Katahdin in Maine—were previously known only from northern and/or central Europe, except for one species that also occurs in Greenland and Siberia (Fryday 2006).

Relationships between the Euro-Mediterranean and Asian *Taxus*.—The European yews have all been considered a single species, *T. baccata*; however, additional species appear evident. The lectotype (of *T. baccata*) has leaves arranged mostly parallel to one other along two sides of a branchlet in a flat spray with 8–10 stomata rows/band and a papillose undersurface—from the midrib to near the margins. The typical European yew is further characterized by isodichotomous branching, pale glaucous green leaves similar in color on both surfaces, and cones maturing on branchlets that have terminated their growth as evident in specimens from England, Germany, Austria, Switzerland, Czech Republic, Spain, Portugal, Algeria, Morocco, Italy, Albania, Bosnia, and Turkey. This is in contrast to another widespread species, *T. recurvata,* that I recognize by a less parallel arrangement to the leaves with a sharper contrast in color between the leaf surfaces—notably yellowish green on the abaxial surface and dark green on the adaxial surface, and by cones developing on branchlets that continue their growth. Both have many naturally occurring varieties based on differences in leaf arrangement, leaf texture and branching, and leaf anatomical differences.

Intermediates include specimens similar to *T. contorta* in the W Himalayas. Examples are characterized by long linear ±distichously arranged leaves that in relative thickness to width (as seen in T-section) are similar to either the W Himalayan *T. contorta* (1.5-2.0 mm wide, < 0.5 mm thick, e.g. *Biol. Inst. Dubrovnik* from Bosnia, *Barabas* from Romania, *Davis 13667* from Turkey), or to the E Asian *T. biternata* Spjut (2.0-2.5 mm wide, 0.25-0.33 mm thick, e.g., *Petrak* from Czech Republic, *Moniz* from Madeira, *Handel-Mazzetti* from Greece, *Anderson 42* from Bulgaria, *Davis & Hedge 32208* from Turkey). The W Himalayan *T. contorta* is distinguished from most Euro-Mediterranean *T. baccata* by the presence of dark red, or sometimes yellowish, parenchyma cells (idioblasts) in the leaf spongy mesophyll (in herbarium specimens); however, European specimens occasionally have idioblasts in the leaf mesophyll. In fresh specimens, the intermediates would probably be difficult to distinguish. Of further significance is that the abaxial leaf midrib of *T. contorta* is always papillose (Kvaček 1984), whereas in *T. baccata*, the abaxial midrib varies from smooth to papillose.

I suggest that ancestral *T. contorta* entered the Himalayas from the north during the Miocene uplift (Krishnan 1974), or earlier (Najman & Garzanti 2000), before it arrived in Europe (Frederiksen 1995). Its leaves would likely have lost stomata in adapting to the rising Himalayas where environmental selection would also likely favor the development of papillae on the abaxial leaf midrib (von Frimmel 1911).

As glaciers advanced during the early Pleistocene (2.5–1 mya), the cooling temperatures may have led ancestral *T. contorta* to also retreat into Europe where it then allegedly hybridized with other species of *Taxus* that may have flourished in a subtropical evergreen laurel-conifer forest (Axelrod 1975; Klaus 1989; Kvaček 1984; Mai 1989; Palamarev 1989), but may have found refuge in ravines and coastal areas. Similar patterns of evolution have been suggested for European species of *Abies* (Fady et al. 1992). The significance of numerous European refugia for conifers was suggested by Fady-Welterlen (2005) to account for their "significantly higher" "within species diversity" "than that of other conifer species worldwide." In this regard, it is interesting to note that the association of *Taxus* with "ancient forests" on limestone cliffs in Iowa and in Europe is partly attributed to the topography of the habitat that offers protection from *Homo sapiens* (Larson et al. 2000), whereas a severe decline in European *Taxus* is generally recognized (Heinze 2004).

Taxus engelhardtii Kvaček, described from a late Oligocene deposit in "NW Bohemia," was associated with a mixed mesophytic forest with prevailing broad-leaved componets (Kvaček 1984; Kvaček & Walther 1998) that included *Laurophyllum* (4 spp.), *Cercidiphyllum, Liriodendron, Acer, Ostrya, Betula, Craigia* and other genera. Its leaf shape and arrangement is much like *T. mairei* in Sichuan, Yunnan (Fig. 10) and Guangdong where similar forest types still occur today. Vegetation in these areas—characterized by a distinct dry season—includes species of *Cercidiphyllum* and *Liriodendron* (Hou 1983) that have since become extinct in Europe. In Vietnam, the closely related *T. celebica* occurs in a laurophyll oak forest from 1000–1600 m in elevation in association with *Cinnamomum obtusifolium* Roxb. ex Nees, *Michelia foveolata* Merr. ex Dandy, *M. mediocris* Dandy, *Castanopsis fissa* (Champion ex Benth.) Rehder & E. H. Wilson, *Quercus bambusifolia* Hance and others (Dung 1996; Schmid 1974.). Extant yews in Europe, however, bear little resemblance to *T. engelhardtii*; therefore, it may not have contributed to hybrid complexes that are now apparent in Europe. Rather it may have simply been extirpated from the Euro-Mediterranean Region due to changes in the climate.

However, another European complex appears to have been derived in part from the Irish yew (*T. fastigiata* Lindley), a possible relict of a former subtropical forest. Known initially from two trees in Ireland—that were transplanted at the time of discovery (~1770; Veitch et al. 1881), it has always been regarded a distinct yew even though taxonomists have included it under *T. baccata* (Loudon 1844; den Ouden & Boom 1965). Its linear dark green leaves that are spirally arranged in whorls seem less evolved. Moreover, such radial phyllotaxy is infrequent among yews—occurring at disjunct locations in the Old World, particularly coastal regions—in Spain, Morocco, British Isles, Honshu, Hokkaido, and Sakhalin. Leaves of the Irish yew in cultivated specimens from widely scattered locations were found to be remarkably similar in lacking papillae along 6–15 cells across an abaxial marginal zone and on the midrib as well; these specimens, which are not included in the Appendix, are from Australia (*Boorman,* New South Wales, A), North America (*Spjut s.n.* Oregon, California, Maryland, wba), and Europe (*Baker,* Yorkshire, BM; *Stewart* Hort., Florence Court, Ireland, K; *Baenitz,* Lusitania, S). Perhaps European yews during the Tertiary were more like those now seen in E Asia but have since acquired more papillae on their leaves through introgression with ancestral *T. contorta*, the alleged replacement species. Many yew specimens with dark metallic green foliage from Great Britain appear intermediate between *T. contorta* and *T. fastigiata;* examples are the "Dovaston yew" (*T. baccata* var. *dovastoniana*) and the English yew (in England, *T. recurvata*).

Evolution within the European *T. canadensis* complex is also evident as seen in leaves of one specimen from the former N Yugoslavia (Slovenia, Fig. 5) by the relatively fewer (4–7) stomata rows per band and inflated epidermal cells. Related plants in Madeira, southern France, Norway, and Sweden have more stomata (5–9 rows/band) and less inflated epidermal cells. Characteristics of the Slovenian yew (obtuse leaf apex, 4 stomata rows/band, wedge-shaped epidermal cells) are evident in a fossil leaf from a Pliocene deposit in Bohemia, Czech Republic ("*Taxus* sp. 2," Kvaček 1984).

The increase in cell size and loss of stomata in leaves of the Slovenian yew may reflect adaptation to changes in a climate from a warm temperate humid type with uniform distribution in rainfall towards a climate with more pronounced warmer and drier seasons. The Yugoslavia region is also one of 33 sites in the Euro-Mediterranean region with "Paleomediterranean" woody taxa known from Oligocene, Miocene, and Pliocene deposits (Palamarev 1989). Thus, the Slovenian yew may be a relict of a former Mediterranean montane flora that included the conifer genera *Pinus, Juniperus, Tetraclinus, Abies, Cedrus, Cupressus*, and *Picea* (Palamarev 1989); some of these are reported with this Pliocene yew (Kvaček 1984).

I also distinguish *T. mairei* from *T. sumatrana* by the relatively short inflated epidermal cells on the abaxial midrib (Appendix; Spjut *in adnot.* and on illustrations of packets, A, GH, Jun 1996; Spjut 1998b, 2007). The occurrence of this species in China corresponds mostly to the "*broad-leaved evergreen forests of the subtropical zone*" of Hou (1983) with a climate marked by "distinct dry seasons"—"on mountains below 1100 m in the eastern humid subtropics, or on mountains between 1500 and 3000 m in the western subtropics of the Yunnan Highland" (Hou 1983). Similarly, *T. brevifolia*, a species confined to the North American Mediterranean climate, has wider and taller marginal epidermal cells and fewer stomata (Fig 1B), compared to its putative ancestor, *T. globosa* (Spjut 1998a, 1998b) that has evidently survived in the montane cloud forests of Mexico and Central America. The evolution towards larger epidermal leaf cells has also been noted between fossils and living species of *Amentotaxus* (Ferguson 1978).

The variation in leaf anatomical data for *Taxus* in SW China is also related to the convergence of different floras in that region (Bartholomew 1999; X-w. Li & J. Li 1997; Zhengyi & Sugong 1998). These include the "Turkmenian" in W Himalaya, Tibetan or "Indo-Chinese", Malayan, and Sino-Japanese (Mani 1974; Rao 1974; Rau 1974). In the W Himalayas *Taxus* is represented by the neoendemic *T. contorta*, usually with 7–8 stomata rows per band, and in the eastern region by the paleoendemic *Wallichiana* Group with 15–18 (-21) stomata rows. The relatively lower numbers for stomata rows in *T. wallichiana* (11–15) and higher numbers for *T. contorta* (9–11)—where these taxa overlap in their distribution—is undoubtedly due to hybridization and introgression (Fig. 2C). Further evidence for hybridization involving *T. contorta* is seen in the wider marginal region of cells along the abaxial surface of leaves (MC, Appendix) and the wider angle of leaf divergence from twigs in plants from Nepal and Bhutan (Spjut 2006).

The wide range in leaf anatomical traits for yews of SW China (Fig. 2C, 3B) is also a product of a long evolutionary history of tropical and temperate vegetation types with possibly less extinction of taxa during glacial climates (Hsü 1983), in comparison to greater glacial devastation to the floras of North America and Europe. The oscillating wet and dry periods during the Pleistocene may have led to many new combinations in *Taxus* between anatomical and gross morphological features that were once distinctly correlated with eco-geographic differences prior to the Pleistocene. Introgression of character traits has been correlated with data on the advance and retreat of glaciers for other conifers—such as between *Picea rubens* Sargent and *P. mariana* (Mill.) B.S.P. (Bobola et al., 1996), between *Picea glauca* (Moench) Voss and *P. engelmannii* Parry *ex* Engelm. (Wilkinson et al., 1971), among species of *Pinus* (Axelrod, 1986), and among species of *Abies* (Fady et al. 1992).

The slow evolutionary rate that I have suggested for yew is perhaps not all that surprising in view of its ability to survive almost indefinitely. Individual yew trunks can live several thousand years or more (Loudon 1844; Larson et al. 2000; Thomas & Polwart 2003), and when they fall, the plant still survives by adventitious shoots, or by layering (Hageneder 2007; Loudon 1844); thus, it may continue to survive until perhaps a change in climate forces it to either adapt or perish. Prager et al. (1976) calculated a rate of change in the amino acid sequence for Pinaceae to occur once in every 7.5 my. In *Taxus* this may be longer. By extrapolation from data in Figs. 2, and from paleoclimatic changes earlier discussed, one may hypothesize that one row of stomata may become lost permanently in the *Taxus* leaf as it adapts to slight changes in climate over a period of 10 my during which time it may also spread a distance of some 3000 km (at the rate of 300 km/my).

APPENDIX

Data for all herbarium specimens studied according to continental and political regions and taxonomy.

	SR	MC
NORTH AMERICA		
Wallichiana Group		
Taxus globosa var. globosa		
EL SALVADOR		
Tucker 1073 (US). 2670 m	10	5
HONDURAS		
Armour & Chable 6083 (US). Cerro Sta. Barbara, 2750 m	11	4
MEXICO		
Phyton Oaxaca	11	4
Phyton Oaxaca	10	4
Meisner (K). Veracruz to Orizaba	10	3
	SR	MC
Sharp 52112 (GH). Tamaulipas: El Cielo to Ojo de los Indios	10	3
Pringle (US). Trinidad Iron Works	9	4
Harteg 438 (BM). Hildalgo: Real Monte	9	4
Ehrenberg 1837 (K: **type**). Hidalgo: Real Monte, C. Nabajas	9	3
Taxus globosa var. _floridana_		
Hernandez 01459 (BM). Veracruz	9	6
Meyer & Rogers 2746 (BM). Nuevo Leon/Tamaulipas: 1690 m	7	2
Mueller 1337 (PH). Nuevo Leon: Sierra Madre Oriental	7	2
Mueller 1337 (BM)	7	2

	SR	MC
U.S.A. Florida		
Mohr (PH). Near Bristol	8	6
*Croom*1833. (K: **type**).Near Aspalaga	5–7	7
Ex Canby Herb. (PH). Rock Bluff	7	5
Blanton 7050 (PH). Rock bluff	7	5
Wherry (PH). Rock bluff	7	9
Phyton. Florida.	7	8
Taxus brevifolia		
California		
Hansen 1682 (US). *Sequoia gigantea* Region	8/9	4
Lemmon 1874 (US). Yosemite	7	2
Lemmon 1874 (US). Yosemite	6/7	2
Sudworth 1899. (US). Stanislaus Forest	7	4
Bolander 186 (US). Forest Hills, Devil Canyon	6	–
Leeberg 5054 (US). Lovelock, 3500 ft.	7	2
Stokes (US). San Mateo Co.	6	2
Heller 5941 (US). Lake Co.	5–7	5
Clark (US). Mendocino Co.	6	5
Yager & Bozovsky (wba). Del Norte Co.: Oregon Mt. Rd., 200 m, 3 trees:		
(1) top branch	5	–
(1) middle branch	5	–
(1) bottom branch	5	–
(2) lower branch	6–7	–
(2) middle branch	6–7	–
(2) top branch	5–7	–
(3) lower branch	7–9	–

	SR	MC
Rose 55089 (US). Trinity Co., Buckhorn Summit, 2600 ft	6/7	–
Spjut 12307 (wba). Salmon Mts., 2000 m	6–8	7
Spjut 12307 (wba). Salmon Mts., 1500 m	5	8
Spjut 10171 (wba). Marble Mts., 2000 m	5	–
Dudley (US). Salmon Mts., Foxtail Ridge	5–6	–
Benson 2228 (US). Shasta Co., Hatchet Creek	5	0
Grant 1281 (US). Shasta Co., Dunsmiur	6	5

Oregon

	SR	MC
Fisher (US). Portland	7	–
Collector, no.? (US). Jackson Co.: Wimer	6/7	2
Walpole 153 (US). Jackson Co.: Ashland	6/7	–
Coville (US). Imnaha Natl. For., Billy Meadows	6	4
USFS (wba). Josephine Co.: above Taylor Creek, Minnow Creek Rd., 650 m		
4 specimens from nearby sites:		
(1)	5	–
(2)	6	–
(3)	4–5	–
(4)	6–7	–
Lankford (wba). Clackamas Co., 1060 m	5–6	–
Lankford (wba). Clackamas Co., 930 m	5	–
Lyall 1860 (K). Columbia River	5	–
Nuttall (K: **type**). Columbia River	5	–
Spjut 12301 (wba). E Cascades E of Portland	4–6	10
Beattie 5046 (US). Josephine Co.: 2270 ft	4–6	–
Cusick 3405 (US). Eastern Oregon	4	3

Washington

	SR	MC
Spjut 12302 (wba). E Cascades E of Seattle	6–7	10–11
Horner (US). Blue Mts.	6	–
Meyer 1589 (US). Thurston Co., Mud Bay	5–6	6
Grant s. n. (US). Cascade Mt.	6	–
Cantwell (US). Orcas Island	4/5	–
Fosberg (US) King. Co., Stevens Pass	4/5	–

Idaho

	SR	MC
Cronquist 6187 (US). 20 mi W of Riggins, French Creek	5/6	–
Shields (wba). Idaho Co.: Allison Creek, 3400 ft.	5	–
Cochrane (wba). Idaho Co.: Nez Perce Natl. For., 5600 ft., 2 plants	6	–
	5	–

Montana

	SR	MC
Donner (wba) Flathead Natl. For., nr. Columbia Falls, 3800 ft.		
middle branch	7	–
Donner (wba)	7	–
Donner (wba)	4–6	–
P. C. Standley 18251 (US). Glacier Natl. Park, 1400–19850 m	5/6	–
Thomas 11031 (US). Lake Co.: 8 mi from Polson, 3850 ft.	5	4
Steven Wirt 100 (MRC, wba). Flathead Co.: shrubs	5–6	–
Steven Wirt 100 (MRC, wba)	5	–
Steven Wirt 100 (MRC, wba)	4–5	–

CANADA British Columbia

	SR	MC
MacMillan (PH). Selkirk, 4300 ft.	6/7	–
Calder & Saville 9982 (US). SE of Nakusp	7	–
Macoun (US). Rocky Mts., Silver City	6	6
Macoun 2340 (US). Vancouver Is., Victoria	6	–

Baccata Group
Taxus canadensis

U.S.A.

	SR	MC
Herb. C. W. Minott (US). Ma: Amherst	7/8	–
Bovin & Blain 753 (PH). Me: Cumberland Co., 425 m	6/7	–
True 164 (PH). Me: Ovis Island, Long Cone	6/7	–
Gilbert 831 (PH). Ky: Carter Co., Cascade Caverns	6/7	–
Allard 12060 (US). Wv: 900–1200 m	6/6	–
Women's College *of Baltimore* (US)	6	12
Palmer & King 205 (US). Va	6	–
Taylor 424 (US). Pa: Bucks Co., Kintersville	6	–
Eames 3432 (US). Ny: Coy Glen, Ithaca	6	–
Spjut (wba) Ny: Ithaca	6	–
Spjut 11778 (wba) Nh:White Mts. Natl. For., Wildriver, 300 m	6	–
Stevenson (US). Vt: Willoughby Lake	5/6	12
Weatherby 5977 (US). Ct: Boston Hollow	6	11
Sheldon (US). Mn: Towers St. Laus	6	12
Fellows 5686 (US). Me: Rockport	6	12
Spjut 12179 (wba). Ohio: Secrest Arboretum	5/6	–
Shreeve 1971 (US). Md: Garrett Co., Bailing Spring	5/6	–
Travis 119 (PH). Me: Cumberland Co.	4–6	–

CANADA: Ontario

	SR	MC
McDonald 223 (US). Ontario: Sagastaweeki Is.	5/6	12
Rouleau 2700 (US). Humber Dist., Twin Lakes	7/7	–

Quebec

	SR	MC
Tae hé & Lepage 332 (PH). Dartmouth River	7/8	–
Asselin 7212. (US). St.-Charles	7/7	–
Pennell 16734 (PH). La Belle Co.	6/7	–
Bartram & Long 649 (PH). Rimousk Co.	6/7	–
Fernald et al. 2404 (US). Gaspé Co., Mt. St. Pierre	6	15
Louis-Alphonse 3547 (US). Baie Missisquo	6	18
Lucien 743 (PH). Laurentides, Bellerive	6/6	–
Louis-Maire 686308 (PH). Mé gantic	5/6	–
Bovin 1268 (US). St.-Catherine	5/6	–
Chas Mohr (US). Montreal	4/5	–

New Brunswick

	SR	MC
Malte & Watson (S: C-2153).	6/7	12–13
Allen 2528 (PH). St. John	5/6	–

Nova Scotia

	SR	MC
Gorham 45139 (US). Halifax Co.: near Halifax, St. Margaret's Bay	7/7	–
Bean et al. 19634 (PH). Yarmouth Co.	7	–
19015 (S: C-2155).	6	19
(S: C-2156). Victoria Co.	6/6	12
Pease & Long 19633 (PH). Cumberland Co.	5/6	–
Bissell et al. 19632 (PH). Digby Co.	5/5	–

	SR	MC
Newfoundland		
Fernald et al. 6738 (PH). Prince Edward Is.	8/9	–
Palmer 1300 (US). Bay Is.	8/9	–
Palmer 1327 (US). Hermitage Bay, Balena	7/7	–
Buochan (S: C-2130).	7/7	18
Rouleau 6545 (US): St. Barbe Distr., E BluePond	7/7	15
*Banks*1766 (BM). Croque	7/7	–
Fernald et al. 26201 (PH). NW Coast	6/7	–
Robinson & Shrenk (US). St. John's	6/7	–
Rouleau 5533 (US). Gander River	5–7	–
Fernald & Wiegand 4414 (PH). Valley of Exploits River	6/6	–
Fernald & Long 27305 (PH). Pistolet Bay	6/6	–
Wiegland & Gilbert 27304 (PH). Highlands of St. John	5/5	–
EURO-MEDITERRANEAN		

Baccata Group

Specimens ranked first by number of stomata rows then by marginal cells for ***Baccata* Alliance,** *T. canadensis* noted separately under each country.

ALGERIA		
Swingle (NA). Chria near Blida	12	4
Reichenbach (K). Atlas, Blida	9	4
Gamble (K). Atlas des Demia	8	4
Olaptin (S: C-2070), Atlas, Blida.	7/8	4
Davis 52628 (BM). Cedrus forest, 1900–1950 m	9	6–7
Univ. Algeria Apr 1912 (NA).Atlas, Blida	9	6
MOROCCO		
Trethewy 85 (K), *pendula*. Ifrane 1400 m	10	6
Lewalle 8670 (BM). Ifrane 1400 m	10	4
Lewalle 8670 (BM).	8	–
Lewalle 9670 (BM). Ifrane 1400 m	9	6
Davis 49209 (BM). Ifrane 1700 m	9	5
Lynes (BM). Mid Atlas, Azrou, 5700 ft	9	6
Haout 938 (BM)	9	5
***Davis 55121* (BM). Ifrane, Cascada, 1580 m**	**9**	**8**

Taxus canadensis

Font Quer 1928 (BM).Kaloa to Tauka, 1500 m	8	7–9
PORTUGAL		
Goncalves 4625 (BM). Azores	12	4
Yoller 61 (BM). Sierra Jerez [Spain]?	12	3–5
Goncalves 4491 (BM). Azores	10	4
ex Herb. Moniz (K). Madeira	10	4
Cyrén (S: C-2058). Ser. Estrela	10	6
Fontee et al. (S: C-2047). Ser. Estrela, 1400 m	10	5
Fontee et al. (S: C-2047–2). Ser. Estrela,	9	5
Meaden 1865 (K). Madeira	9	4
Moller (BM). Serra Gerez: Vidoal	8	4

Taxus canadensis

	SR	MC
Lowe 570 (BM, bottom specimen). Madeira	11	7–14
Lowe with 570 (BM, top specimen)	8	10
Lowe ex Barby (US). Madeira	7	12
SPAIN		
H. Elias 4353 (BM). Burgos: Ser. Obarenes, 1000 m	11	5–8
Modesto Laza Palacios (K). Ser. Tejeda & Almijara, Malacitana Prov.	10	4
no data 1878 (US). Laguna	10	4
Sennen 7087 (BM). Barcelona	10	5
Roivainen (S: C-2075). Guipúzcoa, 900 m	10	5
Sandwith 4452 (BM), Huesca: Ser. Guara	9	4
Heywood & Davis 490 (BM). Ser. Cazoria: Yedra	9	4
Rodriquez (K). Serrania buenia	9	8–11
Bianor-Maire (BM). Baleares, 1600 m	9	5–9
FRANCE		
Fosberg 41055 (US). Jura Mts.	10	4
Endress Aug 1831 (K). Pyrenees	10	6
Endress Aug 1831 (S). Pyrenees	8	5
ex Herb Comby (PH)	9	4
Tidestrom 12814 (US)	9	4
Massonnet (K). Pyrenees	9	5
Herb. Hook., 1867 (K). Pyrenees	8	4
Herb. Churchillanum (K). Corsica	7	–
C. Lagerheim & G. Sjogren Jul 1844 (K). Batsmanshus Paroeciae Elfkarl by Rosalagiae abundans	8/9	5

Taxus canadensis

Herb. Gombault (S). Sainte Baume	9	18
UNITED KINGDOM		
Gamble 19866 (K). Berkshire Dist	11	4
***Bowden & Hillman 433* (BM, globose epidermal cells). Nottinghamshire**	**11**	**3–5**
Gamble 28894 (K). Weltham woods [England SW]	11	5
Albarnes 26 (K). Dorsey: churchyard [England SW], 350 ft	10–11	8
Michaelstone (K). British Isles, England	10	4
Turrill 4903 (K). Leicestershire, Charwood Forest	9/10	4
Ap. ys 77–390 (K). Kent	10	4
Turrill (K). Surrey, Box Hill [England SE]	10	4
Fraser (K). Surrey, Box Hill	10	4
Fraser (K). Surrey, Chalk Pits	10	4
Bean & Hill (K). Scotland: Neopath Castle, Tweedsdale near Peebles	10	4
Ball 1838 (US). Surrey, Jumper Hill	10	4–5
Ex. Herb. Bidwell (BM), *dovastonianum*. Westfelton	10	4
Ex. Herb. Gordon (K), *dovatsonianum*. Westfelton.	10	4
Jackson (BM). Westfelton (Dovaston yew, original)	10	5
Lewis 721 (BM). Monmouthshire	10	5
Jarrell (K). Kent: Shorehane	10	5
Bennett & Croydon 713 (US). Riddlesdown	10	5–6

	SR	MC
Hooker (PH). Kent	9	3
Barron (K). Kent, Buckland	9	4
? (K). Kent, "var. *washingtonianum*"	9	4
Valpy (K). Elsing, Norfolk	9	4
Boswell (BM). Shropshire, Lyth Hill	9	4
Brubaker 1960 (PH). Druids Grove	9	4
Roper 1525 (K). Bristol, Birdhamdown	9	4
Carruthers (K). Ireland: Pollawaddy	9	4
Aug. 1874 (BM). Perth Co.? [filed under Portugal]	9	5
Turrill (K). Yorkshire: 3 mi. from Richmond	8	4
Hubbard (K). Sussex: Bury Hill	8	4
Jackson (BM). Highclere, Saddam	8	4
Turrill (K). Scotland: Loch Lomond	8	4–7

Taxus canadensis var. *adpressa*

	SR	MC
***Summerhayes 2581 (K).* E Kent**	**8**	**4–6**
SWITZERLAND		
Kellermann (US: 518500)	10	3
Herb. A. Gray (K)	9	5
Fr. Castella (US). Le Pissot sur alboue, 1000 m	7	6–7
GERMANY		
Reichenbach fil. (PH). Dresden	11	3
Martius 1831 (PH). Bavaria	9–11	4–6
Martius 1831 (K).	9/10	4
Milchbuder (K). Bavaria	10	4
Petzi 1444 (K).Bavaria	8/9	5
Reichenbach, ex Short Herb. (PH). Dresden	7–8	4
Keller (PH). Darmstadt	7	4
Martius 1831 (K). Bavaria Alps	7	4
POLAND		
Baenitz (US). Silesia: Proskau, 180 m, "*f. dovastonii*"	10	6
Baenitz (US) *epacroides*. Silesia: Breslau, 120 m, "v. *recurvata*"	9	4
Baenitz (US). Silesia: Breslau, 120 m, "f. *epacroides*"	10	4–5
Baenitz (US), *epacroides*. Silesiaca: Breslau, Scheitniger Park 120 m	8	4
Baenitz (US). Silesia: Breslau, 120 m, "f. *erecta*"	9	9–10
CZECH REPUBLIC		
Jirasek & Suza (K). Moravia Centr.: 4–450 m	10	4–6
Jirasek & Suza (US). Moravia Centr.: 4–450 m	10	5–6
Petrakm, Fl. Boeh. & Morav. exsic. 99 (BM)	8	4–5
AUSTRIA		
Ex Pickler Herb. 1895 (US).	11	4
Ex Herb. Pichler (US: 347988, lower specimen). Tirol	10	4
Ex Herb. Pichler (US: 347988).Tirol	8	4
Ex Shulte Herb. 1863 (K)	10	4
Hayer (S: C-2034). Salzburg	10	6
Gander 1869 (K). Tirol	9	6
Gander 1869 (US: 157025). Tirol	9	6
Keck (US)	9	5

Taxus canadensis

	SR	MC
A. Hayek & F. Hayek (BM). Styria superior: Kulmburg	9	17

	SR	MC
HUNGARY		
Herb. Láng (PH)	10	4
Schönach 3084 (S: C-2061A)	10	4
Schönach 3084, Austr-Hungar. (US). 445 m	8	3
Wagriesh (US: 451917). Vorarlbergia, 445 m	8	3
Wagriesh (US: 481917). Dolüa	8	3
Boros (BM). Comit. Boraod. Ohassa, 550 m	9	5
Lémke (S: C-2042). Bakony: Mikl¢spalhazy	9	4–5
Schönach, Aust.-Hungar. (US: 966290), *epacroides* 445 m	8	4–5
Ex Herb. Mus. Nat. Hungar. (S: C-2041), Bakony	8	4
Schönach 3084, (BM). 445 m	9	6

Taxus canadensis

	SR	MC
Schönach 3084 (S: C-2061 R Specimen). 445 m	5–6	19
ROMANIA		
***Topa, Bot. Mus. Exsic.* (US). Bucovina: 400 m**	**12**	**16**
Topa, Bot. Mus. Exsic. (S: C-2024). Bucovina, 400 m	10	3–5
Topa, Bot. Mus. Exsic. (US). Bucovina, 400 m 9	4	
Anderson 102 (K). Balkan Exped., Cajan Pass	9	4
Mititleu & Barabas (BM). Bucovina: Darmanesti, 500 m	8	5
BULGARIA		
Kotschy (P)	8	4
Anderson 42 (K). Sofia: Vitorha	9	4
ITALY		
Herb. Hook. 1814 (K). Montagnes	10	3/4
Levier (BM). Florentino	10	4
Lenander 1933 (S: C-2008). Lago di Garda, Riva, Sydtyrolen	10	4
McDonald: I-37 (US). Cult.	10	5
McDonald: I-37 (PH). Cult.	8	5
Solla (US: 280040).	9	3–4
Baroncini 16 Sep 1893 (US)8/9	5	
Fireuze (BH). Cult.	10	9
Martelli (PH). "Iter Sardoum", Limabara [Sardinia]	8/9	10
[YUGOSLAVIA]		
***Biol. Inst. Dubrovnik 37* (NA). Bosnia: Mt. Trebevic near Sarajevo, 1450 m**	**12/13**	**3–4**
Kosarim (S: C-2065), Macedonia, Petiska	10	5
Baldacci 169 (K). Albania	8/9	5
Rohleana 1908 (BM: 17197). Montenegro	7/8	4–5
Curic 1897 (K). Bosnia	8	9
Biol. Inst. Dubrovnik 136 (NA). Bosnia. Mt. Plasma near Jablanica, 1500 m	6/7	2–4
Woloszczak (K), Tatra	9	6–9

Taxus canadensis

	SR	MC
***Berglund* (S: C-2066; var. *adpressa*). Slovenien: Bled, berget Straza**	**4–6**	**24**
GREECE		
Georginda & Tzanoudakis 631 (BM). Artis: Mt. Tzoumarka	10	6
HGT 884 (K). Hills N of Xant Is	9	4

	SR	MC
Heldreich (S: C-2023). Oeta, 4500–6000 ft.	9	2–4
Greola (PH). "Mts. of Tyrah"	9	4
Guiol 2260 (BM). Mt. Olympus	7/8	3–4
Handel Mazzetti (K). Mt. Olympus, 750–850 m	8–9	8
TURKEY		
Balonsa (BM). Taurus	9	5
Balonsa (P). Taurus	8	5
Davis & Hedge 32208 (BM). Coruh, Savval Tepe above Murgul, 1400 m	7	6
Sintensis 5118 1892 (P) Paphalogonia: Wilajet Kastanbuli	9	8
Sintensis 5118 (K)	7	8
Murray 936 (NA). Between Molla Veyis and Meyden, S of Ardesen, 750 m	8	–
Davis 13667 (K). VA. Jenigli (Caira [Caria ?]) (Denizli, Boz Da, *Davis 13447*), 5000–5500 ft	8	8–10
IRAN		
Koelz 16208 (US, distinct for obconical to 4-lobate seeds). Gozlu, Mazandaran	8–9	7–10
SYRIA		
Haradjían (K). Dúldúl: Mt. Amanos, 5000–7000 ft	10	4
Haradjían 2341 (S). Dúldúl: Mt. Amanos, 5000–7000 ft	8	4
Gesbeldagh (BM)	9	4
Gesbeldagh (US)	10	4
Haradjían 3865 (S). Dúldúl: Mt. Amanos, 1500–2000 m	10	8–10
Delbés (P). 1000 m	9	8
RUSSIAN REGION		
Estonia		
Taxus canadensis		
Lundström 742 (S). Eosl near Karriland	9	16
Lundström 579 (S). Ösel, Sworbe	9	22
Lundström 562 (S). Ösel, Sworbe	7	15
Transcaucasia (Caucasus Mts.)		
***Elias et al. 5615* (NA) Ukraine Crimea, 1150 m**	**9**	**9**
***Princeps Kascelsky, ex. Herb. Hort. Imper. Petro.* (S). Caucayas Hosharia**	**15**	**6–7**
***Busch* (K). Caucasus, Terek**	**11**	**12–14**
***Woronowa* (S: C-2027). W Transcaucasia: Suchum, Petkir (Fl. Madshara)**	**13**	**1**
Dmitrieva (NA). SW Georgia, Black Sea near NE Turkey, Adzharia, 900 m	11	4
Inst. Bot. Acad. Sci. Armenia (US). 22 Mar 1946	10	4
Szovich 610 (S: C-2072). Armenia: Tschunakuchi	10	4
Szovich 610 (P). Armenia: Tschunakuchi	9	4
Ex. Herb. Inst.. Bot. Ac. Sc. URSS (US: 2560106). [Transcaucasia]	9	4
In Russian #75 (P). Azerbaijan [Kura Mts.]	9	8
Herb. Komaróv (US: 1862552). Armenia	7/8	6
***Prilipko* (K). Transcaucasia**	**9**	**10**
Goghika (NA). Caucasas: Azerbaijan, Chanlar, 1800 m	10	8
***Brzhezitzky & Kasumov H196* (US). Azerbaijan**	**10**	**15**
Taxus canadensis		
Kousnetzoff 89 (US: 254512). [Russian Federation] Kuban	10	18
NORWAY		
Gamble 28933 (K). West Dalen	10	4
Taxus canadensis		
Anderson (US: 1091452). Kolsås	5	18
DENMARK		
Herb. Joh. Lange 1866 (K)	10/11	–
Herb. Joh. Lange 1866 (K: Right specimen)	8	4
SWEDEN		
Thedenius (PH), Göteborg	9–10	4
Thedenius (US)	8	4–6
Steinvall 1872 (K). Södermanland	10	6
Henriksson (K). Dalsland:Gunnarans	8/9	6
Holmgren (US: 1276222). Blekinge	8	5
Lindberg 419 (K). Ekerö	11	8
Herb. Bot. Berjianus (S: C-2177), *"washingtonianum"*	10	8
Bjornstrorn, ex Mus. Stockholm (US). Podermanlane? [Södermanland]	10/11	10
Taxus canadensis		
Asplund (US: long-needled specimen). Södermanland	9	20
Asplund (US: short-needled specimen).	8	22
FINLAND		
Florström (BM). Alandia: Lemland	11/12	4
Florström 1909 (K)	10	3–6
Vidlund, Helsinki Exsic. (K). Lemland	8	4
EAST TEMPERATE ASIA		
Cuspidata Alliance		
RUSSIAN FEDERATION		
Taxus biternata		
B. Cerereu (A). Far East Region: Pryanyk For. Div.	11	12
***Taxus umbraculifera* Complex**		
Kypehisnova (A). Primorye Prov.	14	–
Kypehinova (A) Primorye Prov., Bay of Peter, First Sea Reserve, Is. Stenin	10	5
Dvorakovskia & Bokina (A). Sakhalin Is.	11	8
Palczevsky 3601 (K). Primorye Prov.: vicinity of Vladivostok	11	8
Palczevsky 3601 (US)	9	–
Palczevsky 3601 (A)	8	–
Lyubarsky 2 (A). South, Sikhote-Alin, foothills, Mt. Hezalaza, River Beryozovoy	8	7
Esus 203 (K). Sakhalin Is.	8	12–15
MANCHURIA		
Taxus biternata		
Ex herb. hort. bot. Petro. 1860, Maximowicz (P). Mandshuria SE	10	6

	SR	MC
Skvortzov 20 Sep 1931 (A). N Manchuria, Sochintzest, forest, tree	10–11	8
In Russian No. 75 (P). Jilin (Kirin)	9	8
C. H. Chen 539 (A). Jilin (Kirin)	8	6
Maack 1855. (GH: top specimen)	7	7
Purdom (GH). N China [Shaanxi: Tai-pei-shan *fide* Rehder & Wilson in Sargent 1914]	7	13
T. umbraculifera Complex		
Palczevski [Komaróv] 88 (K). Manchuria: Rossica	14	14
Palczevski [Komaróv] 88 (BM)	12	9
Maack 1855. (P)	11	8
Ex herb. hort. bot Petro.1860 (Bunge), Maximowicz (P). Mandshuria SE	12	10
Ex herb. hort. bot. Petro. 1860, Maximowicz (S) Mandshuria SE	12	8
Ex herb. hort. l.c. (P)	10	8
Ex herb. l.c.(GH)	7	–
G. Fenzel (A). Schenhsi merid., Taipei-schan	7	13

KOREA

Taxus biternata

	SR	MC
Wilson 10519 (US). Kyongsan, Nemon-rei	13	15
Wilson 10519 (A)	10	14
Wilson 9484 (A), Hallai-san down to Mushroom House, bush	12	8
Wilson 9097 (A), Shinkabachin Heizanchien to Ehoshin, Kankyo-N Heian divide, tree	11	16
Wilson 8685 (A). N. Heian Prov.: O.G.M. Co. Mines, Pukchin	10–11	12
Wilson 8685 (US)	10–11	12
Wilson 8685 (K)	10	10
Komaróv 1897 (GH). Pen-nian Prov.	10	4–6
Wilson 10688 (US). Kyongsan, Nemon-rei	9–10	6
Wilson 10688 (A)	9	8–9
Wilson 10688 (K)	7	6

Taxus umbraculifera Complex

	SR	MC
Wilson 8538 (US). Oagelet Island, 0–900 m, bush	12	12
Wilson 8538 (A)	12	12
Wilson 9332 (A). Kyongsan Prov.: Nemon-rei, tree	12	10
Faurie 1512 (BM)	9/10	9

JAPAN

Taxus cuspidata

	SR	MC
Ex Herb. Zuccarini (M: **type,** *T. cuspidata*) Japan	11–12	24
Ex Herb. Zuccarini (K: **type,** *T. cuspidata*) Japan	11–12	18
Jack (A). Hokkaido: Sapporo	12	20
Jack (GH). Hokkaido: Sapporo	10–11	16

Taxus biternata

	SR	MC
Makino 43775 (S), Tokyo Pref.: Oizuni, Nepymawku	16	12
*Mujabe*1884 (A). Hokkaido: Ishikasi	14	14
Makino 43779 (S). Chiba Pref.: Mt. Kiyosumi	13	6–8
Uno 2611 (A). Nagano-ken, Okmachi	13	9
Mochizuki (A). Mt. Nantai, Lake Chuzenji	12	10
Wilson 7544 (A). Kai prov., Nakaihinsen, 1200 m, hedge	12	9–12
Sargent (A). Hokkaido, Cosl Mines, Utishini	11	10
Arimoto (A). Sapporo, Yezo	11	13
Nitzelius (S: C-2111), Göteborg cult., from Hokkaido: Kamikawa, Yamabe	11	18
Wilson 7778 (A). Hondo, Sernja Prov.: Yamanaka on Fuji-san, tree	11	–
Wilson 7778 (K)	9	14
Hatusima 13858 (A). Kagoshima Pref., Mt. Takahuma, tree	10	–
Ex herb. horti bot. Petropolitani, Maximowicz. 1862 (P), Yokohama	9	6

Taxus umbraculifera Complex

Taxus caespitosa var. *caespitosa*

	SR	MC
Mizushima 1985 (A). Honshu: Mt. Hakkoda	11	13–18
Wilson 7133 (A), Honshu: Hakkoda, 1000–2000 m, shrub	11	8
Ex herb. horti bot. Petropolitani, Maximowicz. 1862 (GH), Yokohama	10	10
Ex herb. horti bot. Petropolitani, Maximowicz. 1862 (P). Yokohama	10	10
Wilson (A). Honshu: Mt. Daisen (**topotype**), 2000 m, shrub	10–11	9
Makino 43792 (S). Honshu: Mt. Daisen (**topotype**)	10/11	10

Taxus caespitosa var. *latifolia*

	SR	MC
Shimotsake 446 1888 (US, anatomy like *T. mairei).*	15	16
Faurie 6345 (K, **isolectotype**)	14–15	12
Faurie 6345 **(**P, **lectotype)**	11	8
Bataw, Herb. Lugd (P). Honshu: Shimane	14–15	–
Faurie 5114 (P)	13	10
Faurie 5114 (P)	12	6
Makino 43769 (S), Honshu: Akita Pref.	12	7–8
Tomitar ex. Makino 43780 (S), Honshu: Kanagawa, Mt. Imaizumi	11	8
Wilson 7265 (A). Hokkaido: Shiribeshi Prov., 1300–2000 m	11–12	10
Mizushima 401 (A). Honshu: Prov. Kozuke, Oze-ga-hara	9–10	10
Mizushima 1989 (A). Honshu: Mt. Hakkoda	9–10	7
K. Muijabe 17 Sep 1910 (A). Hida, Takayama	9	14
Shimotsake (P). Honshu: Nikko	8	8
Ex herb. horti bot. Petropolitani, Maximowicz. 1862 (P). Yokohama (with *T. biternata*)	11	8
Ex herb. horti bot. Petropolitani, Maximowicz. 1862 (US). Yokohama (top specimen)	10	7
Ex Herb. Zuccarini, 1842, with *ex* Herb. Lugd. Batav. (GH). Japan	8(–11)	12

Taxus umbraculifera

	SR	MC
Ex Herb. Lugd. Batav. (P). Japan	11–14	15

	SR	MC
Suzuki 499003 (A), Honshu: Mt. Ooyhama, Kanagawa-Pr, cult.	14	13
Faurie Dec 1904 (A), [Hokkaido], cult. and in forest	13	13
Muroi 1969 (A). Honshu: Mt. Fujiwara	12–13	14
Wilson, ex. Sakurai (A), Honshu: Kyaraboken, cult. "*nana*"	10	13
Muroi 5933 (A). Honshu: Mt. Himekami	10–12	10
Sapporo Agric. College (PH). Hokkaido: Kitami Prov, Rishiri	11	11
*Sapporo Agric. College*1885 (A). Hokkaido: Niarenai?	9–10	13
*Sapporo Agric. College*1878 (A). Hokkaido	11–13	11
Naito (A), ex. Herb. Kagoshima Univ. Shimane Pref., Mt. Sentsu-zan.	11	8
Hatusima 13858 (A). Kagoshima Pref., Mt. Takahuma, tree	11	8
Shiota 4441 (A). Hondo, Mino Prov., hort.	11	8
Muroi 30 (A), Honshu: Hyogo Pref., Mt. Hyonosen	10	8

Taxus umbraculifera var. *hicksii*

Muroi 5603 (A). Hyogo Pref.: Kumatugi, Mikata-gun	13	14
Muroi 5424 (A). Mt. Hatibuse	12	8
Muroi 5648 (A). Wakasugi	11–12	10
Muroi 3593 (A). Iwate-Pref.: Asagishi	11–12	10
Muroi 3698 (A). Gifu-Pref.: Takayama	11	10
Muroi 3715 (A). Nagano Pref.: Kamikochi	11	8

ASIA: HIMALAYAS

Baccata Group

AFGHANISTAN-INDIA

Taxus contorta var. *contorta*

	SR	MC
Sprague 730 (K). Murree	6	4–5
Aitchinson (K). Kurrum Valley, 7500–9000 ft	6	4
Sinnott et al. 146 (K). Between Gotchbok and Kubkot Valley, 2750 m	7	3–4
Stewart 15343 (US). Murree, 7000 ft	7	–
ex Herb. Schlagintweit (PH). NW of Srinagar	5	–
Stewart 7374 (PH). Sonamarg, 10,000 ft	6/7	4
Mukinji (K). Lada Valley	6	4
Stewart 8414 (US). Kashmir: Pahlgam	5	4
Stewart 8414 (A). Kashmir: Pahlgam	7	3
Stewart 8414 (PH). Kashmir: Pahlgam	7	3
Stewart 12001B (A). Kashmir: Pahlgam 2600 m	7	6
Schlagintweit (P). Kashmir: Báltal to Númner	7	–
Kenyoer & Dugeon (PH). Bureah, 11,000 ft	7	5
Rau 31770 (A). Garhwal to Lake Hemkund, 3200 m	7	–
ex Herb. Falconer 1000 (S: C-1994). Kumaon, Dwali? 8500 ft	7	4
ex Herb. Falconer 1000 (P). Kumaon	7	5
Koelz 10285 (A). Punjab: Kulu, above Bandrole, 8000 ft	7–8	–
Schlagintweit 8941 (GH). Kashmir: Sukhi across Bamsuru and Chaia Pass to Khdrsali, 9000–15400 ft	7–8	3
Rodin 5313 (US). Punjab Province: Rosenhiem, Murree	8	5
Stewart 5931 (A). Kashmir: Pahlgam, 7000–10,000 ft	8	–
Heybrook 29 (K): Kashmir: Pahlgam 2600 m	8	4
Lace 301 (A). Bashahr, Uri Forest	8	–
Stewart (PH: 829196). Dharmkat, Dharmsala, 6000 (ft?)	8	8
Gamble 23507 (K). Jaunsar Dist., 10,000 ft	8	1–3
Stewart 10663A (PH). Gulwarg, 7000–10,000 ft	9	12
Laig Raus (P). Siwalik and Jaunsar Div., 10,000 ft	9	5
Pengelly (K). Chumba	10	4
Bertoloni (BOLO: **type,** *T. orientalis*). Western Sikkim	10–11	3

NEPAL

Baccata Group

Taxus contorta var. *contorta*

Stainton et al. 7832 (BM). Chingnon, 10,000 ft	7/8	4
Polunin et al. 1353 (BM). Dhotar, 9600 ft.	9	4
Polunin et al. 432 (BM). Chankeli Range, 8000 ft	11	5
Polunin et al. 5050 (BM). W of Jumla, Belas Gaejigeth, 10000 ft	9	6
Polunin et al. 1873 (BM). Chatlwe, 9000 ft.	10	5
Gardner 557 (BM). Shios Khola, 8500 ft	9/10	5
Stainton et al. 734 (BM). Lete, S of Tukucha, 8000 ft	10	5
Ottba et al. 8311066 (BM). Marayandi Khola	11	0
Mikage et al. 9550282 (BM). Dhaulagiri Zone, 2405 m	10/11	4
Stainton et al. 5616 (BM). Chingnon, N of Tukucha, Gadaki Valley, 10,000 ft	11	7

Taxus contorta var. *mucronata*

Dobremez 2106 (BM).	8/9	10
Wraber 514 (BM). Hanangi: Karayundi Valley, 3100 m	8/9	10

Sumatrana Group

Taxus sumatrana

Herb. Banerji, 1953, in adnot. T. bounoniana Carr. (A). E Nepal: Khanigaon to Kalanti, 6,000 ft.	12	16

Wallichiana Group

Taxus wallichiana

Wallich 6054A (M: **Original Material**). [Nepal]	15	6
Wallich 6054A (K: Duplicate of Original Material). [Nepal]	14	5
Wallich 6054A (K: Duplicate of Original Material). [Nepal]	12	5
Wallich 6054A (S: Duplicate of Original Material). [Nepal]	13–15	2
[Wallich] (GH: Duplicate of Original Material). Napalia.	15	4

	SR	MC
Beer 25316 (BM). Above Sedua, 9400 ft	14	4
Stainton et al. 1398 (BM). Arun Valley, N of Kutiar, 9000 ft	14	4
Stainton et al. 6601 (BM). Eastern: Duon Kosi, Chaunrikarua, 9500 ft	13	4
Stainton et al. 4496 (BM)	13	4
Griffith 2006. 9000–10,000 ft	13	3
Stainton et al. 5102 (BM)	13	4–5
Tabata et al. 10585 (A). Soluhumbu Dist.: Lamujo to Chumawa, 2450 m	12	4
***Tabata et al. 10585* (BM)**	**11**	**0**
Stainton et al. 8296 (BM). Pembrang?, 10,000 ft	11	3
Williams 458 (BM). 9500 ft	10–11	4/5
Ohba et al. 8310264 (BM). Thulo Kobar to Ran Thanti, 2600 m	9–11	4
Ohba et al. 8310264 (BM)	11	4

Taxus phytonii

Williams 1014 (BM). 9000 ft	16	4

BHUTAN

Baccata Group

Taxus contorta var. *mucronata*

Ludlow et al. 16035 (A). Eastern, Ha: 27.22′ 89.18′, 9,000 ft	11	9
Ludlow et al. 16035 (BM)	9–10	8

Sumatrana Group

Taxus celebica

Cooper & Bulley 2833 (BM). Rinchu Timakha, 6000 ft	13	13

Wallichiana Group

Taxus wallichiana

Ludlow et al. 18672 (BM). Tunle La. near Kinga Rasdah, 11,000 ft	12	2
Ludlow et al. 18672 (A). Tunle La near Kinga Rapden, 11,000 ft	12+	5
Grierson & Long 4417 (A). Thimphu Dist.: summit of Dochong La, 3110 m	12	6
Cooper & Bulley 2600 (BM). 7,500 ft	16	4
Bartholomew & Boufford 3917 (A). Above Motithang, W of Thimphu	10–11	6

NE INDIA & TIBET

Sumatrana Group

Taxus celebica

Kingdon Ward 19324 (BM). "Assam" [**Tibet**]: Rima, 7000 ft	11	32
Clarke 38308 (K). Khasia: Maophlang	9	32

Taxus kingstonii

Mann 1885 (K). Khasia Hills, l.c.	13	20
Mann 1885 (BM), l.c.	15	15
Mann 1885 (P). Khasia Hills, l.c.	13	19
Kingdon Ward 18751 (A). Khasi Hills, Mawphlang, 6000 ft	12	15
Hooker 1337 (K). Khasia: 5000 ft	13	16

	SR	MC
Hooker & Thomson 1855 (P)	11	12
Hooker & Thomson 1855 (P)	10/11	8–10
Hooker & Thomson 1855 (P with seed)	13	10
Simmons 484 (P). Assam: Khasia	13	12

Taxus sumatrana

Mann 1885 (A). Khasia Hills: Nunghuai, 5000 ft	24	12

Wallichiana Group

Taxus wallichiana

Wallich (M: **Lectotype**). Eastern	13	4
Biswas 439 (A). E Himalaya	13	5
Biswas 439 (A). E Himalaya	10–11	5
Kurz (A). Sikkim: Tongloo	13–15	–
Raijada 18919 (A). Cult., Dehra Dun, Bot. Gard. Darjeeling	14	4
Griffith 5002, ex Herb. Griffith. E Himal. (P)	**12**	**0**
Griffith 5002, ex Herb. E India Co (P)	13	4
Griffith 5002, ex Herb. Bunge E Himal. (P)	13	4
Hooker 77 (P). Khasia, 5000–6000 ft	16	4
Hooker 77 (P). Khasia, 5000–6000 ft	16	4
Griffith 2(7)606 Assam (P)	15	4
Kingdon Ward 17271 (A). Sirhoi: 8000 ft	15	4
Kingdon Ward 17271 (BM). Sirhoi: 8000 ft	15	4
Vos et al. 148 (NA). West Bengal: Singalila Range, 8400 ft	15	5
C. B. Clarke 436743 (BM). Khasia: 4500 ft, Vale of rocks	14	4
G. Watt 5955 (A). Manipur: Seriphari, 10,000 ft	15–17	–
G. Watt 5955 (P). Manipur: Seriphari, 10,000 ft	17	4
G. Watt 6493 (P). Manipur: Sirohifarar, 7000 ft	16	4
G. Watt 6208 (P). Manipur: Jakpho, 11,000 ft	18	4

Taxus wallichiana var. *yunnanensis*

Hooker (K). Sikkim: 7000–10,000 ft	14	3
Hooker (K). Sikkim: 7000–10,000 ft	14	3
Kingdon Ward 18990 (BM). Jakpho Range 7300 ft	14	4
Clarke 41238B (K). Jakpho, Naja Hill	11–12	3
Kingdon Ward 7755 (K). Barail Range, Naga, 9000–10,000 ft	13	4
Kingdon Ward 8090 (K). Assam [**Tibet**]: Chiban, Delei Valley, 6000–7000 ft (K)	14	3
Kingdon Ward 8594 (K). Assam: [**Tibet**] Delei Valley, 9000 ft (K)	15	4

Taxus phytonii

***Ludlow & Sherriff 3719* (BM). Pachaksihri, Laluma, 94°15, 27°45, 7000 ft**	**12**	**0**

MYANMAR (Burma)

Sumatrana Group (*Taxus kingstonii)*

Oliver 4 Sep 1894 (K). Bernardmyo, Ruby Mines	15	8
Oliver (K) 14 May 1892, 5600 ft	12	5–6

Wallichiana Group
Taxus obscura (Chinensis Subgroup)

	SR	MC
Oliver (K) Ruby Mines, 6500 ft	13–15	5

Taxus suffnessii (Wallichiana Subgroup)

	SR	MC
Kingdon Ward 21901 (A). West Cental Esakan, 6400 ft	12–15	6
Kingdon Ward 20901 (BM). W Central	18	0
Kingdon Ward 20902 (A: **holotype**) North Triangle, 9000–10,000 ft	12–13	–
Kingdon Ward 20902 (BM, **isotype**)	16	2
Kingdon Ward 13003 (BM). 27°45′N, 97°50′E, 9–10,000 ft	20	0
Hla & Koko (K) Myintkyina: Sumprabum, 8600 ft	15–16	2

Taxus wallichiana var. *wallichiana*

	SR	MC
Kingdon Ward 9214 (BM) Northern, Adung Valley, 97°30–98°30′, 27°30–28°30′, 6000 ft.	17	4
Kingdon Ward 9214 (A)	16	4
Kingdon Ward 9375 (A). N Adung Valley, 97–98°30′ 27–28°30′ 7000– 8000 ft	12–13	4

Taxus wallichiana var. *yunnanensis*

	SR	MC
Kingdon Ward 22819 (BM). Mt. Viatoria, 9000–10,000 ft	16	4
Kernode 17205 (K). Myintkyina: Laikan-Fenshuiling Rd, 8000 ft	12	3

THAILAND

Chinensis Subgroup
Taxus obscura

	SR	MC
Lobb 461 (BM) Malaya	12–14	8

Sumatrana Group (*T. sumatrana*)

	SR	MC
Kerr 20146 (K). Kao Kuading, 1200 m	15	14
Kerr 20146 (BM)	12	14

VIETNAM

Sumatrana Group
Taxus celebica

	SR	MC
Evrard 305 (P). Dalat: ravin buisé an chalet Rimaud	9/10	24
Evrard 1438 (P). Lâm Dông	12	24
Schmind 1960 (P). Dak Tria- Manline, 1400 m	8	32
Schmind 1960 (P). Dalat: Dau Lamghi	9	24
Schmind (P). Dalat: Dak Tria, 1610 m	11	32
*Van Cuong 12891*1960 (P). Dalat: Manline, 1610 m	12	23

Wallichiana Group
Taxus chinensis

	SR	MC
Hiép & Chan 405 (P). Hoa Binh, Mai Chôu, Pà Co, 900–1500 m	13	8–13

Taxus aff. *chinensis*

	SR	MC
Poilane 4150 (P). Phu Khanh: Nha Trang, 1500 m	11	4
Poilane 4150 (A). Nha Trang, 1500 m	10–11	4
***Schmind* (P). Dalat: Dak Tria, 1400 m**	**15**	**8**
Soulie 1523 (P). "Haut Mekong"	15	12

CHINA

Tibet & Yunnan

Sumatrana Group
Taxus kingstonii

	SR	MC
Soulie 1411 (P). "Tackou et Nekou ("Haut Mekong")	11	12

Wallichiana Group
Taxus florinii

	SR	MC
R.C. Ching 21505 (A). Soc. W. Sikiang: Tamichung	10	–
C. W. Wang 65475 (A). Sikang, Me-kong, Tsa-wa rung, 2500 m	8–9	16
Handel-Mazzetti 2602 (K). Ngaitschekou, 2800–3500 m	11	2
Fleigner et al. 1129 (K). Sahlie Valley on Muzhiyan Shan, 2980 m	10	10

Taxus wallichiana var. *yunnanensis*

	SR	MC
Zhang 916 (PE: **type**). Tibet, Zayul, 2100 m	15	3
Kingdon Ward 6292 (BM). Zayul, 7000–8000 ft	15	3

Sichuan

Sumatrana Group
Taxus celebica

	SR	MC
H. Smith 10401 (BM). Huangnipu, Malingtsang, 1000 m	12	36
Wang 20541 (A). South of Kuan-Hsien, 1160 m	11–12	36
Farges 1895–1897 (P). Tchenkéou Tin	20	32
Farges 128 (P). Tchenkéou Tin	14	24

Taxus kingstonii

	SR	MC
Cheng 1001 (BM). Tachienlu	12	18
Cheng 1475 (P). Tachienlu	12	18

Taxus mairei

	SR	MC
Wilson 1265 (A). Western: Nin Ya-chou Fu, 2000 ft	21	25
Wilson 1265 (US)	15	16
Fang 5811 (P). Nanchuan-Hsien	17	12
Fang 5811 (A). Nanchuan-Hsien	-	16
Hwa 229 (K). *Metasequoia* area	16	12
Fan & Class 91 (A). Kuan-Hsien, Chien-Chang-Shan, 1000 m	16	22
Farges 1436 (P). NE	16	15
Farges 100 (P)	15	16
Law 65 (K). Pei pah	15	8–12
Hwa 27 (A). Li-chuan, Jian-Nan-Hsien, Ta-pen-Ying, 3800 ft	15	27
Smith 10402 (A). W region: between Huangnipu and Yaan (Yachou), Malingtsang, 900 m	14	14
Smith 10402 (S)	15	27
Hwa 27 (A)	14	21
Hwa 27 (K)	14	17

	SR	MC
Legendre 586 (P). Pao Shan NE, 600 m	14	17
Fang 3461 (A). Tienchuan Hsien, Tienchuanchow, 2500–3000 ft	14	20
Fang 3461 (P)	13	17
Fang 12205 (A). Kuan-Hsien, Mt. Tsing-cheng, Chengtu and Kuan-Hsien, 1390 m	14	13
Wang 20600 (A). Wah-Hsien, Mou-tao-chi, Metasequoia area, 1390 m	12–14	16
Hu 1563 (A). Shikong: Tien-Chuan Ling-Kwan, 3000 ft	14–16	–
Farges 128 (P). Tchenkéou Tin	14	17
Farges 128 (P). Tchenkéou Tin	12	24
Fang 3442 (A). Tienchuan-Hsien, Tienchuanchow, 2500–3000 ft	11	12
Fang 3796 (A). UnqLing-Hsien, 5000 ft	12	–
Cao 0152 (BM). Jiabigon, Zhao Quing-sheng, 2500 m	12	10
Wallichiana Group		
Taxus chinensis		
Harry Smith 10398 (BM). Tachsiangling, 2600 m	16	6
Peng 502 (Biol. WCUU) (A) Yachow 1600 ft	15	8
d'Legendre (P). 2500 m	14	5
Henry 7155 (US: **type**): E Sichuan: Wushan-Hsien, 2000–3000 m	13	4
Henry 7097 (US)	14	5
Henry 7097 (A)	12	7
Farges 128. NE Sichuan, Tschen-kuu-tin Dist.: (Chenkouting), (P)	13	8
Farges 128 (P)	16	8
Farges 128 (P)	11	7
Wang 1930 (A)	12	4
Wang 22602 (A). Kwang-yun Hsien, 1800 m	12	4
Sichuan (Emei-Hsien: Mt. Emei)		
(*T. chinensis*, by increasing number of bare marginal cells)		
Feng 1941 (A)	16–17	4
Fang 16082. (A)	16–17	4
Yu 667 (A). Mt. slope, 2600 m	15	4
Wilson 6200	14–15	4
Lee 3237. (A)	14	4
Hu 8243. (US)	13	4
Hu 8243. (A)	14	5
Lee 4445 (A)	13	4
Yu 669 (A). 1000 m	12	4
Hu 8786. (A)	14	5
Yu 869 (A). 2500 m	12	5
Fang 18420. (A). 2335 m	12–13	6
Lee 4500 (A).	21	7
Ching 1676 (A). Siachu, 2600 ft	16	–
Ching 1676 (P). Siachu, 2600 ft [rectangular cells, papillose midrib in upper half]	16	7
Wang 23656 (A). 2000 m	14	7
Wilson 479 (A).	12	7
Chiao & Fan. 604 (A). 1000 m	10–11	7
Fang 10940 (A). 1200 m	13	7
Fang 15940 (A)	13	8

	SR	MC
Chiao & Fan 464 (A)	10–11	7
Chiao & Fan 464 (P)	12	8
Chiao & Fan 464 (US)	13	9
Hu 8176 (A)	14	9
Wang 20993 (A). W of Wen-chuan Hsien, 2800 m	11	9
Hu 8497 (A)	–	10
Fang 18310 (A)	13	10
Yu 8166 (A). 2400 m	12	10
Fang 15128 (A)	16	11
Fang 15128 (A)	14	11
Wilson 624 (K). S. Wushan, ravine	12	12
Taxus* aff. *chinensis		
Cheng 2890 (A, *Taxus* OCR, in Spjut 2007) W of Lung-an-fu	13–15	8
Cheng 2890 (P)	12	4
Hu 8619 (A). Emei-Hsien, Mt. Emei	12–13	8
Taxus wallichiana		
Sichuan: Mt Emei		
Hu 8166 (A)	18	4
Y-s Liu 1196 (A)	15	5
Hu 8542 (A)	15–16	4
Feng 3945 (A)	14	8
Lee 4465 (A)	13	8
Wilson 4053 (A). W Pan-lan-shan W of Kuan Hsien, 5000–6000 ft	14	4
Gansu (Kansu)		
Sumatrana Group		
Taxus kingstonii		
Meyer 1790 (P)	14	8–12
Ningxia Huizu		
Taxus celebica		
Chao 1223 (A). Sikong: Lung Dung An, 1000 m	13	36
Shaanxi (Shensi)		
See also *Cuspidata* Alliance, *T. biternata, Purdom s.n.*		
Sumatrana Group (T. kingstonii)		
Davis 1872 (P). Tsin-lin au Lao-lin, 3000 m	13	12
Wallichiana Group		
Taxus chinensis		
Chens 1893 (P). Central	15	10
Yunnan		
Sumatrana Group		
Taxus celebica		
Forrest (A)	11	27
Forrest 7798 Gaoligongshan (K)	14	18
Taxus kingstonii		
Forrest 11789 (BM). Shweli-Salween Divide, 10000 ft	13	12
Forrest 11789 (K)	13	7
Forrest 15945 (K). Schweli-Salween Divide	13	16
Forrest 15945 (BM). Schweli-Salween Divide	12	12

	SR	MC
Forrest 9462 (K). Ma-Chang-Kai, valley, 25°30′N, 8000 ft	10	14
Forrest (A). Yunnan, no other data	12	16
Forrest (A). Yunnan, no other data	-	14
Forrest 12087 (S). Schweli-Salween Divide	15	12–14
Forrest 12087 (K)	13–14	14–20
Forrest 9339 (BM)	13	16–18
Rankin 1913 (K). "Yung Chun"	12	14
Rock 7587 (US). Salween E of Tengyueh, to summit of Shweli, Shweli River	12	9

Taxus mairei

Forrest 15053 (K)	16	12
Maire 131 (BM)	16	15
Maire 1913 (P). Tie'tchang Keol, 700 m	14	28
Maire. (A: **type**). Dongchuan, 700–800 m	13	17

Wallichiana Group

Taxus chinensis

Feng 630 (A). Ta-hon-shan near Ta-koo, NE of Likiang Snow Range	12	–
Cavalerie 7823 (K)	14	7

Taxus florinii

Alpine Gard. Soc. Exped. 309 (K). Zhongdian; haba Shan, 3347 m	10	3
Rock 18502 (A). NW: Mt Ludu, NW of Li-Kiang, W of Yangtze	8	4
Rock 18502 (US)	9–10	4
Forrest 19967 (S). NW: Mekong-Salween Divide	8–9	4
Schneider 2918 (A). 3000–3200 m	7	–
Schneider 2918 (K)	9–10	5–6
Schneider 1429 (A). 3500 m	9	13
Schneider 1429 (K)	7	8
Yu 11076 (A). *sine* locality	7–8	9
Yu 7848 (BM); Dokerla, 3100 m	8	7
Rock 11573 (A). Litiping Range, Mekong-Yangtze divide, E of Weihsi	10–11	–
Rock 11573 (A)	9	–
Ching 21980 (A). Litiping, between Likiang and Weihai	10	–
Feng 1809 (A). S Chungtien, Kung- shiang-shu, Snow Mt to Kai-Lou-wei, Yangtze bank 3200 m	8	16
Wang 67735 (A). Wei-si Hsien, 2500 m	10–11	–
Wang 67414. (A). Lung-pan la Champu fung	10–12	5

Taxus aff. *chinensis*

Feng 11937 (A: type in adnot., *Taxus* OCR in Spjut 2007). Si-chour-Hsien, Faa-doou, 1500 m	16	5
Feng 12105 (A) *l.c.*	14	–
Tsai 59874 (A, *T. phytonii*). Wei-se Hsien 2800 m	12	4
Tsai 58464 (A: type in adnot, *Taxus* SCU in Spjut 2007) Che-tse-lo, 3200 m	14	4
Tsai 58464 (P)	12	6

Taxus wallichiana var. *yunnanensis*

	SR	MC
SB 1981 Exped., Cangshan 0419 (K). W Shangschang, above Yangbi, 2700 m	17	2
Wang 67412 (A). Champu, 2120 m	19	4
1984 SAB Exped 388 (A). Xangbi Xian, W side of Diancang Shan Mt Range, Malultang, Chang Shan, 2700 m, 25°46′ 100°01′	19	6
Handel-Mazzetti 6408 (A). Dji-shan ad boreo-orientem urbis Dali (Talifu), 3200 m	18	4
SB 1981 Exped., Cangshan 0419 (A). W Shangschang, above Yangbi, 2700 m	17	0
SB 1981 Exped., Cangshan 0227 (A). Kiemiu-ingdi above Yangbi, 3000 m	16	4
Wang 72417 (A). Chen-Kang Hsien	15	4
Yu 21036 (A). Salween, Kiukiang Divide, Shawlongwang, 2600 m	14	4

Guizhou (Kweichow)

Sumatrana Group

Taxus mairei

Steward et al. 328 (A). Ta Ho Yen, Kianakou Hsien, 980 m	14	20
Steward et al. 328 (US)	14	12
Steward et al. 328 (P)	13	18
Cheng 7525 (A: **type,** *T. speciosa* Florin). Kiangkow, 450 m	16	24
Steward et al. 154 (US). Liang Feng Yah, Tsunyi Hsien, 900 m	15–16	19
Steward et al. 154 (A)	12	18
Tsiang 8987 (P). Pichish	14	13
Tsiang 8987 (A). Pichish	11–13	–
SAG Exped. 1981 (GH). Songtao Xian, Lengjiaba, Xiaohe and Dahe Rivers, NE Fanjing Shan mt range, 820–1120 m	12	18

Wallichiana Group

Taxus chinensis

Cavalerie & Foriupat 2604 (P)	20	7
Cavalerie & Foriupat 2604 (P)	12	5
Cavalerie & Foriupat 2604 (P)	11	5
SAG Exped. 1981 (US).	12	6
SAGB 1986 Exped. 1854 (A). Yinjiang Xian, Xiapingsho, W Fanjing Shan range, 1 100–1400 m	16–17	10
SAGB Exped.1046 (A). Jiangkou Xian, Daiyenpeng, Kaitu River, SW Fanjing Shan range, 750–1000 m	12	12

Hubei (Hupeh)

Wallichiana Group

Taxus chinensis

Chow 76099 (A). Shenlungkai	15	7
SA 1980 Exped. 1540 (A). S of Jiuhuping Forest along Jizigou canyon, 1900 m	13	6
Wilson 1265b (A). Western: Nin Ya-chou Fu, 2000 ft	13	4

	SR	MC
SA 1980 Exped. 777 (A).Western: Shennongjia For. Dist., NE Guanmenshan, S of Shicao river, 1150 m	13	7
SAB 1980 Exped. 1824 (GH). Shibapan, 1850 m	13	7
SAB 1980 Exped. 1824 (A)	12	6
Wilson 716 (A)	12	7
Taxus* aff *chinensis (*Taxus* sp. SCU in Spjut 2007)		
SA 1980 Exped. 585 (A). Western: Shennongjia For. Dist. 331°30'N 110°30'E, 1200–1400 m	13	8
Sumatrana Group		
Taxus mairei		
Gressitt 2507 (A). *Metasequoia* Area, between Ta-yin-pin & Chunglo, Shui-sa-pa, 900 m	12	14
Anhui (Anhwei)		
Sumatrana Group		
Taxus mairei		
Ching 3168 (A). Southern, Chanen, 300 ft	12–13	12
Wallichiana Group		
Taxus chinensis		
R-C Ching 2622 (A). S Anhui, Clas Hara Shan	17	5
R-C Ching 2622 (US)	13	4
Cheng 4026 (BM). Wangshan	11	6
Henan (Hunan)		
Taxus mairei		
Fan & Li 644 (A). Ma-Ling-Tung, Sinning Hsien, 600 m	15	18
Fan & Li 296 (A). Changning Hsien, Yang-Shan, 680 m	15	–
Fan & Li 296 (BM)	14	12
Jiangsu (Kiangsu, Kiangshi)		
Taxus mairei		
Wang-Te-Hui 445 (A). Ningdu, Yuntungtschi	9–12	25
Y.K. Hsiung 6443 (A). NW, Si-ho, Hwang-kong-shan Mt	-	11
Wang-Te-Hui 458 (A). Lienhwa-shan, 800 m	-	10–12
Chow 80325 (BM). Nanking, 75 m	12	16
Guangxi (Kwangsi)		
Sumatrana Group		
Taxus celebica		
Ching 5976 (US). Bin Long, Miu Shan, N Luchen, border of Kweichow, 4000 ft	15–16	32
Ching 5976 (A)	14–15	31
Taxus mairei		
Chiao 18795 (US). Lu Shan	16	6–10
Wallichiana Group		
Taxus chinensis		
Steward & Cheo 947 (P). 2110 m	15	4
Steward & Cheo 947 (BM). San Chiang Hsien, 2110 m	12	4
Zhejiang (Chekiang)		

	SR	MC
Taxus mairei		
Cheng 3617 (US). Eastern: Tien-Mu-Shang	14–16	10
Keng 317 (A). Taishun-Hsien	13	18
Hu 342 (A). Tien-Tai-Shan, 1300 m	13	15
S. Chen 1063 (A)	12	18
(US: 145110). Tien Tai Shan	12	–
Ching 2489 (A). S: King Yuan, 300–800 m	11	20
Ching 2489 (US)	13	14
Taxus sumatrana		
Hu 1628 (A). Lin-an Hsien, 1200 ft	14	16
Hu 550 (A). Y-Chien Hsien, 1000 ft	12	15
Guangdong		
Taxus celebica		
Nanling Exped. 1838 (A). Ruyuan Xian	-	31
Taxus mairei		
Tsang 20694 (US). Loh Ch'ang Dist., Chong Uen Shan near Kau Fung	13–15	14
Tsang 20694 (A)	-	24
Chiao 14510 (A). Tien-Tai-Shan, 1300 m	12	24
Chiao 14510 (US)	12	14
Tsiang Ying 1425 (A). Hung-mio to Mio- lan, Jui-feng, Lokohong Hsien N.R. Region, 1340 m	12	14
Tsiang Ying 1425 (A, different label)	14	24
Tsiang Ying 1425 (P, specimen does not appear to be the same plant as in A)	13	5–7
Fujian (Fukien)		
Sumatrana Group		
Taxus mairei		
Price 1258b (K). Ing-dan E. Fookma	12	26
Sheng 1544 (K). Naping, 800 m	16	14
Chung 2865 (A). Yeuping, Shih-Sun-Keng, 650 m	13	14
Chung 2865 (K)	12	16
David (P). W: Mts	12	18
Chung 3581 (A). Buong Kang, mt slope, 700 m	9	24
He-Guosheng 1544 (US). Naping, 800 m	16	6
Wallichiana Group		
Taxus aff chinensis		
H.H. Chung 3866 (A). Puchen	11	5
Taiwan		
Sumatrana Group		
Taxus kingstonii		
Hsu 1651 (PH). Mt. Pasein-san, Taichang Hsien	16	8
Liu 389 (PH). Mt. Ammashan, Taichung Hsien	15	8
Liu 389 (A)	14	–
Hsu (PH). Mt. Pasan-shan, Taichang Hsien	14	9
Wilson 9738 (BM, **isotype**). Arisan Prov.: Kagi, 2833 m	13	9
Wilson 9738 (A: **holotype**)	10–11	8
Liu 437 (US). Taiklang, Shih-wan-hsi, Pa-Hsien-shan, 2250 m	12	9

	SR	MC
Nakahara (PH). Arizan Prov.	11	9
C-j Chang, Tongshi 6 (wba)		
27 Sep 93	14	9
26 Nov 93	13	7
06 Dec 93	12	9
09 Dec 93	13	9
27 Jan 94.	13	8
13 Jan 94 (new growth)	13	8
13 Jan 94 (old growth)	11	9

Taxus mairei

	SR	MC
C-j Chang 1–2,4–5, 7–10 (wba). Hua-lien		
1 16 May 94	12	18
1 03 Aug 94	12	18
2 16 May 94	11–12	27
2 03 Aug 94	11–12	20
4 16 May 94	12	21
4 03 Aug 94	12	17
5 16 May 94	10–11	23
5 03 Aug 94	12	24
9 16 May 94	15	19
9 03 Aug 94	12	24
10 16 May 94	12	14
10 03 Aug 94	11	18
7 16 May 94	14	8
7 03 Aug 94	14/15	6
8 16 May 94	16	9
8 03 Aug 94	16	8

Taxus sumatrana

	SR	MC
de Laubenfels P 671 (A). Tai-shu Shan For. Dist., 2000 m (Rt. 210, 7km)	10–11	6
de Laubenfels P 670 (A). l.c.	10	8
C-j Chang		
3 (wba) 16 May 94	11	13
3 03 Aug 94	10–11	12

Wallichiana Group
Chinensis Subgroup

	SR	MC
Wilson 11154D (A: **type** in adnot.). Karenko Prov.: mts W of Karenko	12–13	6
C-j Chang, Tongshi 5 (wba)		
27 Sep 93	14	4
26 Nov 93	12	5
06 Dec 93	11	5
09 Dec 93	12	5
13 Jan 94	11	4
C-j Chang, Tongshi 7 (wba).		
27 Sep 93	14	7
26 Nov 93	14	9
06 Dec 93	14	5
09 Dec 93	14	5
27 Jan 94	14	5
C-j Chang 6 (wba). Hua-lien		
16 May 94	09–10	8
03 Aug 94	11	8–9

	SR	MC
Origin?		
Y. Sugilara, Ex TUS (GH).[arbitrarily placed here]	13	3

THE PHILIPPINES

Sumatrana Group
Taxus sumatrana

	SR	MC
Merrill 4595 (US). Lepanto Dist., Mt. Data	12–13	14
de Laubenfels P650 (GH). Benguet, 58 km N of Baguio, 2100 m	11–13	13
Whitehead 1896 (BM). NW central Luzon: 5000–7000 ft	12	12
Williams 1002 (US). Benguet: Mt. St. Tomas	12–13	10–12
Leano 20672 (US). Benquet Prov. Mt. St. Tomas	11–13	9
Vidal 623 (GH); Mt. Banahao, Pr. Tayabas	11	7

Wallichiana Group
Chinensis Subgroup

	SR	MC
E.C. Leano 25128 (US). Luzon: Benquet Prov., Mt. St. Tomas	16	4
Elmer 6244 (P). Mt. St. Tomas	14	4
Elmer 6244 (US)	12	4
Loher 4850 (K). Luzon: central.	14	4
Loher 4850 (US)	12	4
Curran 5015 (P). Benquet Prov., Mt. Tonglan	14	7
Curran 5015 (PH)	14	4
Jacobs 7171 (K). Luzon: Mt. Pulog, 2200–2300 m	14	2–3
Ramos & Edaño 40234 (K). Luzon: Lepanto, Mt. Data	14	2
Ramos & Edaño 40234 (P)	12	4
Wilkes Exped. 1838–1842 (GH). Luconia: Mt. Mahaihai	13	2
Curran 7911 (US). Luzon: Benquet Prov., Mt. Banajao	12/13	5
Merrill 839 (US). Luzon, Benquet Prov.	12	3–4
Merrill 839 (US)	12	4
Ocampo 27920 (A). Mt. Banajao	11	–
Ocampo 27920 (P)	11	–
de Laubenfels P669 (GH). Luzon: Laguna Prov., Mt. Banajao, 2100 m	11	4
*de Laubenfels P668***.** (GH: **type** in adnot.)	-	4
Herb. Hook. (K). Luconia, 7600 ft	10–11	4
Loher 7139 (US)	-	3
Sulit 2350 (A). Luzon: Benguet Prov., Mt. Pauai, 2450 m	15	8
Alvarey 18369 (BM). Benquet Prov.	12–14	8

INDONESIA

Sulawesi (Celebes)

Sumatrana Group
Taxus celebica

	SR	MC
Everett 35 (K: **type,** *Podocarpus celebicus* Hemsley). Bonthian Peak, 7000–10,000 ft	14–15	22

Taxus sumatrana

	SR	MC
Teysmann 14190 (U). Bonthian	11–13	16

	SR	MC
Wallichiana Group, Chinensis Subgroup		
Neth. Ind. For. Serv. bb:19577 (A). Ond. Malili 1800 m	12–15	12
Neth. Ind. For. Serv. bb:20887 (K). Goua Lambaja, 2000 m	11	4

Sumatera

	SR	MC
Sumatrana Group		
Taxus sumatrana		
Teysmann s.n. (U: **type**). Sumatra: western, Fort de Kock, 3000 m	12–14	12
de Voogd 1503 (K). Palembang, Dempo, 1000 m	13	10
Wallichiana Group, Chinensis Subgroup		
Boschprochation 7709 (U). Tharolanden, 1400 m	14	4

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NOTES ON THE *GAYLUSSACIA DUMOSA* COMPLEX (ERICACEAE)

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ABSTRACT

Four taxa in the *Gaylussacia dumosa* complex are reviewed, using morphologic and habitat characters. Most morphologic characters overlap to some degree, but all taxa are readily separable by using character suites. *Gaylussacia dumosa* is widespread; the other three taxa have relatively narrow ranges and are separated geographically, but each is partly sympatric with G. dumosa. There is no overlap in habitat; syntopy is unknown. We recognize all four of these entities as full species: *G. dumosa* (Andrews) Torr. & A. Gray, *G. mosieri* Small, *G. orocola* (Small) Camp, and **Gaylussacia bigeloviana** (Fern.) Sorrie & Weakley comb. nov.

RESUMEN

Se revisan cuatro taxa del complejo *Gaylussacia dumosa*, usando caracteres morfológicos y del hábitat. La mayoría de los caracteres morfológicos tienen algún grado solapamiento, pero todos los taxa son fácilmente separables usando series de caracteres. *Gaylussacia dumosa* es una planta común; los otros tres taxa tienen areales relativamente pequeños y están separados geográficamente, pero todos son parcialmente simpátricos con G. dumosa. No hay solapamiento en el hábitat; la sintopía es desconocida. Reconocemos a las cuatro entidades como especies: *G. dumosa* (Andrews) Torr. & A. Gray, *G. mosieri* Small, *G. orocola* (Small) Camp, y **Gaylussacia bigeloviana** (Fern.) Sorrie & Weakley comb. nov.

INTRODUCTION

The *Gaylussacia dumosa* complex includes four related taxa of dwarf to one-meter tall shrubs of eastern North America. These taxa may be distinguished from other members of the genus by the persistent inflorescence bracts longer than the pedicels (vs. early-deciduous and shorter than the pedicels) and by stipitate-glandular sepals, pedicels, bracts, and leaves (vs. sessile-glandular). *Gaylussacia dumosa* (Andrews) Torr. & A. Gray was described in 1843 (Torrey & Gray 1843); *G. dumosa* var. *bigeloviana* in 1911 (Fernald 1911); *G. mosieri* Small in 1927 (Small 1927), originally named *G. dumosa* var. *hirtella* Chapman (Chapman 1860); and *G. orocola* (Small) Camp in 1935, originally described as *Lasiococcus orocola* Small (Small 1933). While the first three taxa have been recognized by many authors, the very locally distributed *G. orocola* has met with less general acceptance and has often been synonymized within *G. dumosa* by authors of floristic treatments.

Camp (1935, 1941) recognized *Gaylussacia dumosa* (including "*bigeloviana*" without rank), *G. mosieri,* and *G. orocola* at species level. In his monograph of the genus *Gaylussacia*, Sleumer (1967) followed Camp's taxonomy, using morphologic characters. Authors of northeastern floras, such as Fernald (1950) and Gleason and Cronquist (1990), recognized *bigeloviana* as a variety within *G. dumosa*. Southeastern authors, such as Radford, Ahles, and Bell (1968), included var. *bigeloviana* as a synonym of *G. dumosa*, if they mentioned it at all. Radford, Ahles, and Bell also synonymized "*orocola*" without rank within *G. dumosa*. In the most recent study, Floyd (2002) analyzed DNA and morphologic characters genus-wide. She recognized three species within the *G. dumosa* group: *G. dumosa, G. mosieri,* and *G. orocola*. However, she did not collect specimens of *G. orocola* for DNA sampling. Also, Floyd apparently elected not to recognize var. *bigeloviana*; she did not discuss it and it is unclear if she included specimens of that variety within her analyses of *G. dumosa*. These omissions are unfortunate, for the inclusion of var. *bigeloviana* in her work may have helped to resolve its taxonomic position, and the absence of DNA data from *G. orocola* weakens her conclusion that it stands apart from *G. dumosa* and *G. mosieri*.

Overall, the *G. dumosa* complex ranges from Newfoundland south to Florida and west to Louisiana, inland to the Appalachian Mountains and Cumberland Plateau. The distribution and habitats of *G. mosieri* and *G. dumosa* have been fairly well worked out, but problems have remained regarding *G. orocola*, due to

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a paucity of specimens and due to imprecise knowledge of the taxonomic limits between it and *G. dumosa* var. *bigeloviana*. Problems also have remained between G. *dumosa* var. *bigeloviana* and var. *dumosa,* because of imprecisely described taxonomic limits and alleged hybridization within a broad area of sympatry (Fernald 1950; Gleason 1952; Gleason & Cronquist 1990). In this paper we set forth criteria for distinguishing these taxa, present a taxonomy of the group, and provide county-level distribution maps.

METHODS

We examined over four hundred herbarium specimens from CLEMS, DUKE, IBE, NCSC, NCU, USCH, VA, VPI, and WILLI, and selected specimens from GH. We assessed morphological characters that have been traditionally used in *Gaylussacia*, such as glandular hairs on the calyx, as well as new characters, such as corolla length. Five measurements were made of each character per specimen, from at least ten specimens across the range of each taxon. The distribution maps were prepared from herbarium specimens plus records from the following sources: Alabama—Clark (1971), Florida—atlas of Florida vascular plants (http://www.plantatlas.usf.edu), Georgia—Duncan and Brittain (1966) and Jones and Coile (1988), Tennessee—Chester et al. (1997). Maps of Delaware, Maryland, New Jersey, New York, and Pennsylvania were prepared from specimens plus data from state Natural Heritage Program botanists (see discussion under Distribution below).

RESULTS AND DISCUSSION

Distinguishing characters

Our analyses revealed several useful morphological characters (Table 1). These are: plant height, corolla length, anther length, density and length of glandular hairs on the hypanthium, density and length of non-glandular hairs on the leaf margin, and presence of sessile glands on the upper leaf surface. Habitat, when accurately described on specimen labels, is a valuable distinguishing character. Other characters have been used by various authors, but are not utilized here. For example, the more-or-less virgate and relatively few branches of *G. dumosa* var. *dumosa* (vs. numerous spreading branches in the other three taxa), while useful in the field, can be difficult to apply to herbarium specimens. Small's description of *G. orocola* states that the leaves possess stellate hairs; this is a unique character when present, but we found such hairs to be so sparse (completely lacking on many leaves) that its use as an identification character was untenable. Size of mature fruit may be a useful character in living plants, but the squashed fruits on dried specimens are highly variable in dimensions.

Table 1 compares morphological characters of the four members of the *Gaylussacia dumosa* complex. We briefly discuss each character.

1. Plant height. *Gaylussacia dumosa* var. *dumosa* is the only dwarf shrub of the group, seldom exceeding 0.3 m. The other three taxa usually exceed 0.5 m and may reach 1 m tall. However, var. *bigeloviana* may occasionally overlap var. *dumosa* in height, and presumably short-statured plants have caused identification problems in the purported area of overlap from Virginia to New York.

2. Corolla length. *Gaylussacia mosieri* and var. *bigeloviana* have distinctly longer corollas than the other two taxa. *G. orocola* is unique in combining tall plant height with small corolla and anther size.

3. Anther length. This character follows that of corolla length: two taxa with long anthers and two with short anthers.

4. Hypanthium glandular hairs. The greater density and length of glandular hairs on *G. mosieri* (1.0–1.5 mm, twice as long as in other taxa) are obvious on dried specimens as well as on living plants. *G. dumosa* var. *dumosa* has the least dense and shortest hairs (0.2–0.3 mm), although some individuals may be difficult to distinguish from var. *bigeloviana* and *G. orocola* (0.3–0.5 mm).

5. Leaf margin hairs (non-glandular). *Gaylussacia orocola* and var. *bigeloviana* clearly have denser marginal hairs than the other two taxa: 6–9 hairs per mm of leaf margin and 7–10 hairs, respectively, vs. 1–2 hairs per mm in *G. mosieri* and 2–5 hairs per mm in *G. dumosa*. Leaf margin hairs are nearly or entirely absent in many *G. dumosa* and *G. mosieri* plants.

6. Sessile glands on upper leaf surface. *G. mosieri* is unique in lacking them, while the other three taxa usually have large numbers.

Taxonomy

Based on original morphological and ecological analyses, we recognize all four taxa at species rank. In doing

Table 1. Comparison of characters among four North American taxa of *Gaylussacia.*

	G. mosieri	*G. bigeloviana*	*G. orocola*	*G. dumosa*
Plant height	0.5–1.0(–1.5) m	(0.2–)0.4–1.0 m	0.4–1.0 m	0.1–0.3(–0.4) m
Corolla length	7.0–8.5 mm mean 7.41 mm SD = 0.80	6.5–8.0 mm mean 7.06 SD = 0.46	5.5–6.5 mean 5.96 SD = 0.47	5.3–6.5 mean 5.78 SD = 0.53
Anther length	3.3–4.3 mm mean 3.88 mm SD = 0.28	3.2–4.2 mean 3.73 SD = 0.35	2.5–3.2 mean 2.85 SD = 0.26	2.8–3.1 mean 3.02 SD = 0.07
Density and length of glandular hairs on hypanthium	very dense; 1.0–1.5 mm	dense; 0.3–0.5	moderate to dense; 0.3–0.5	moderate; 0.2–0.3
Density and length of non-glandular hairs on leaf margin	1–2 per mm of leaf margin; up to 0.5 mm long	7–10 per mm; up to 0.3 mm long	6–9 per mm; up to 0.3 mm long	2–5 per mm; up to 0.3 mm long; often absent
Sessile glands on upper leaf surface	none	numerous	numerous	numerous; sometimes absent
Habitat	seepage bogs, wet flat woods, baygalls, ecotones of streamheads	peat bogs, boggy cedar-maple swamps, peat-based pocosins within Carolina bays	montane sphagnous bogs, seepage over granite	xeric to dry pine-oak uplands and sandhills, dry to wet pine savannas and flatwoods, oak barrens, oak heaths

so, we parallel the work of Luteyn et al. (1996), who treated the three members of the *Gaylussacia frondosa* (L.) Torr. & A. Gray group at species rank. In the *G. frondosa* group, there is a relatively widespread coastal plain/piedmont species plus two southeastern coastal plain endemics. In the case of the *G. dumosa* group, there is one widespread "core" species, *G. dumosa*, with three other species that, while well separated from each other, are partially sympatric with *G. dumosa* (Figs. 1–4). Each of the three segregates is sharply separated from *G. dumosa* by habitat, and in the case of *G. orocola*, mostly by elevation as well.

We have had little difficulty in identifying herbarium specimens, whether flowering, fruiting, or simply vegetative, by utilizing a suite of characters (see Table 1 and above discussion) that renders each species unique. Some poorly-collected specimens with vague habitat data can be difficult to identify. By employing several characters per specimen, identification errors are greatly reduced. Moreover, we refute the assertion that there is a broad zone of intermediacy (Long Island, New York to Virginia) involving *G. dumosa* and *G. bigeloviana*; instead, our data suggest that identification characters used in previous works were inadequate or were partly based on misidentified specimens.

The choice to treat the complex as four species deserves some comment. *Gaylussacia mosieri* has generally been accorded specific distinction from the other three, while *G. dumosa* var. *dumosa* and var. *bigeloviana* have generally been regarded as only varietally distinct from one another. *Gaylussacia orocola* has often been included in *G. dumosa* var. *dumosa*. Two characters appear to separate *G. mosieri* from the other three taxa: length and density of hairs on the hypanthium and absence of sessile leaf glands on the upper leaf surface. However, other characters suggest variable and shifting groupings of the taxa (see Table 1). For example, corolla size and anther length would ally *G. mosieri* and *G. dumosa* var. *bigeloviana* on the one hand and *G. orocola* and *G. dumosa* var. *dumosa* on the other. Habitat and stature would suggest that *G. dumosa* is the outlier from the other three, being the shortest and occupying the driest habitats. We therefore conclude that the most practical treatment is to consider the four taxa to have equal taxonomic rank. Some taxonomists may suggest that the taxa should be given varietal status, because they may view the morphological characters as relatively subtle, because some of the taxa have traditionally been treated at that level or not recognized at all, and because of the existence of occasional ambiguous herbarium specimens. However, the differences exhibited between taxa is greater than that usually accorded varieties, which normally involves only one or two minor morphological traits and often a geographical component (Grant 1981). Here, the four taxa are differentiated by combinations of habit, corolla and anther size, vestiture, presence/absence of sessile glands on upper leaf surface, habitat, and range. The *Gaylussacia* taxa treated here fit the morphological, or taxonomic, species concept (Grant 1981; Stuessy 1990). While we suspect that the four taxa probably represent distinct evolutionary lineages, thus fitting the concept of phylogenetic species, the data of Floyd (2002) are inconclusive. Moreover, additional evidence from biochemical and crossing studies are desirable.

Names at species rank exist for three of the taxa; here we raise *G. dumosa* var. *bigeloviana* Fernald to species status.

Gaylussacia bigeloviana (Fernald) Sorrie & Weakley, comb. nov. BASIONYM: *Gaylussacia dumosa* (Andrews) Torr. & A. Gray var. *bigeloviana* Fernald, Rhodora 13:95–99. 1911. Type: U.S.A. MAINE. Washington Co.: heath at base of West Quoddy Head, Lubec, 26 Jul 1909, *M.L. Fernald 2038 with K.M. Wiegand* (HOLOTYPE: GH!).

KEY

1. Plant ≤ 3 dm high.
   2. Corollas 6.5–8.0 mm long, averaging 7.0 mm; anthers 3.2–4.2 mm long, averaging 3.7 mm; glandular hairs on hypanthium dense, 0.3–0.5 mm long; non-glandular hairs on leaf margin dense; plants usually 4–10 dm high, rarely less than 3 dm; plants of wet boggy habitats; northeastern range, south to DE, disjunct to NC and SC ____ **G. bigeloviana**
   2. Corollas 5.3–6.5 mm long, averaging 5.8 mm; anthers 2.8–3.1 mm long, averaging 3.0 mm; glandular hairs on hypanthium moderately dense to relatively sparse, 0.2–0.3 mm long; non-glandular hairs on leaf margin sparse to absent; plants occasionally up to 4 dm high; plants of xeric to moist habitats; southeastern range, north to VA (rare MD) and scattered inland to n AL, n GA, c TN, w SC, w NC, and s WV ____ **G. dumosa**
1. Plant > 4 dm high, ranging up to 10 dm, occasionally to 15 dm.
   3. Sessile glands on upper leaf surface absent; glandular hairs on hypanthium 1.0–1.5 mm long; East Gulf Coastal Plain endemic, sw GA-n FL-s AL-s MS-se LA ____ **G. mosieri**
   3. Sessile glands on upper leaf surface numerous; glandular hairs on hypanthium 0.3–0.5 mm long; ranging from SC northward.
      4. Corollas 6.5–8.0 mm long, averaging 7.0 mm; anthers 3.2–4.2 mm long, averaging 3.7 mm; plants of peat bogs, raised bogs, peat-based pocosins, and Atlantic white cedar-red maple swamps; ranging from Newf. to DE, and as a rare disjunct in the Coastal Plain of NC and SC ____ **G. bigeloviana**
      4. Corollas 5.5–6.5 mm long, averaging 6.0 mm; anthers 2.5–3.2 mm long, averaging 2.9 mm; plants of montane bogs and seepage over rock; rare endemic of southern Appalachians of w NC____ **G. orocola**

Habitat

Gaylussacia dumosa normally inhabits much drier sites than the other three species. It is most abundant in xeric to mesic pine-oak sandhills, pine-oak-hickory woodlands, and oak barrens, but also occurs in moist to seasonally wet longleaf pine savannas and flatwoods.

Gaylussacia mosieri inhabits seepage bogs (often called hillside bogs), margins of streamheads and baygalls (often with Atlantic white cedar, *Chamaecyparis thyoides* (L.) B.S.P.), and wet pine flatwoods. These seepages are minerotrophic and do not accumulate peat; therefore they are best termed poor fens. *Gaylussacia mosieri* may occur in disturbed habitats (roadside scrapes, borrow pits) that superficially appear dry, but which are underlain by a claypan.

From Delaware northward, Gaylussacia bigeloviana inhabits peat bogs (including ombrotrophic raised bogs), sphagnum-shrub bogs, and boggy red maple (*Acer rubrum* L.)-Atlantic white cedar swamps. It may also occur in disturbed habitats (roadside scrapes, borrow pits) that superficially appear dry at some seasons, but which are underlain by high water tables. In North Carolina, *G. bigeloviana* occurs in several large pocosins, which are peat-based ombrotrophic bogs dominated by ericaceous shrubs and scattered pond pines (*Pinus serotina* Michx.). These pocosins occur in the outer coastal plain within Carolina bay depressions and in extensive interstream flats (Weakley & Schafale 1992). In South Carolina, *G. bigeloviana* inhabits a seepage wetland dominated by Atlantic white cedar.

The primary habitat of *G. orocola* is peaty montane bogs at moderate elevations in the southern portion of the Appalachians, notably the bogs of the East Flat Rock area, Henderson and southern Buncombe counties, North Carolina; these wetlands have been largely destroyed and few remnants remain (Weakley & Schafale 1994). Specimen label data suggests that *G. orocola* may also occur in seepage over sloping exposures of granitic rock. These bogs harbor endemic taxa as well as disjuncts from the Coastal Plain. Among the endemics are *Sarracenia jonesii* Wherry and *Sarracenia purpurea* Linnaeus var. *montana* Schnell & Dietermann. Coastal plain disjuncts include *Chamaedaphne calyculata* (L.) Moench, *Myrica gale* L., *Helonias bullata* L., *Juncus caesariensis* Coville, and *Eriocaulon decangulare* L.

Distribution

Gaylussacia mosieri is endemic to the East Gulf Coastal Plain from Coffee County, Georgia, and Taylor County, Florida, west to Tangipahoa Parish, Louisiana (Fig. 1). One outlying record is from Duval County, Florida (Curtiss 1660 GH, mixed sheet with *G. dumosa*). All populations occur within 250 km of the Gulf of Mexico.

Gaylussacia orocola is endemic to the Southern Appalachian Mountains of western North Carolina, in Buncombe, Henderson, Jackson, Macon, and Transylvania Counties (Fig. 2, Appendix 2). This area supports a concentration of "southern Appalachian bogs," many now altered or destroyed.

Gaylussacia bigeloviana is distributed on the Atlantic seaboard from Newfoundland south to Delaware, disjunct to North and South Carolina (Fig. 3). Extreme inland records—maximum 120 km from saltwater—are in York County, Pennsylvania, and Prince George's Counties, Maryland, but these are near Chesapeake Bay, a major estuary of the ocean. Specimens at USCH collected from Atlantic white cedar swamps in Lexington County in central South Carolina, were annotated by Wilbur and Whitehead to *G. dumosa* var. *bigeloviana*; we concur. The specimens have unusually large leaves (ranging from 1×2.5 cm to 2×5 cm), possibly a result of growing in shady conditions. Corolla length, anther length, and leaf margin hair density are typical for *bigeloviana*, but hypanthium glandular hairs are longer than usual, ranging from 0.6–1.0 mm.

Gaylussacia dumosa occurs from Virginia and West Virginia to south Florida, west to East Feliciana Parish, Louisiana (Fig. 4). We have seen one specimen from Maryland (cited below). Although predominantly a species of the coastal plain, there are many inland records from the piedmont and even montane provinces of northern Alabama, central Tennessee, etc. We list selected inland records in Appendix 1. Various manuals have ascribed a range north to Long Island, New York, but we have seen only one correctly identified specimen of *G. dumosa* from north of Virginia. Fernald (1911, 1950) and Gleason (1952) suggest that there is much intermediacy between *dumosa* and *bigeloviana* in the region from Long Island to Virginia. For example, Gleason (1952) states that "Intermediate plants are plentiful between Va. and Long Island." In contrast, we have observed virtually no intermediacy in specimens from this region. Here we discuss the status of *G. dumosa* in these states.

New York. Mitchell and Tucker (1997) synonymized "*bigeloviana*" within *G. dumosa* without discussion; the inclusive *G. dumosa* has been documented only on Long Island and Staten Island. Stephen Young of the New York Natural Heritage Program has observed and collected only *G. bigeloviana*, all in boggy habitats (pers. comm.).

New Jersey. The inclusive *G. dumosa* has been documented from Monmouth County south to Cape May and Cumberland Counties (Stone 1911). Stone stated that "I fail to distinguish the variety *bigeloviana*, proposed by Prof. Fernald..." He could hardly come to another conclusion, since there is no verified specimen of *G. dumosa* sensu stricto from New Jersey; all specimens we have seen are *G. bigeloviana*. David Snyder of the New Jersey Natural Heritage Program has observed and collected only *G. bigeloviana*, all in boggy habitats within the Pine Barrens (pers. comm.).

Pennsylvania. Rhoads and Klein (1993) listed *G. dumosa* without synonymy and mapped it in Lancaster, Montgomery, Northampton, and York Counties. The habitat is given as "moist, acidic woods and

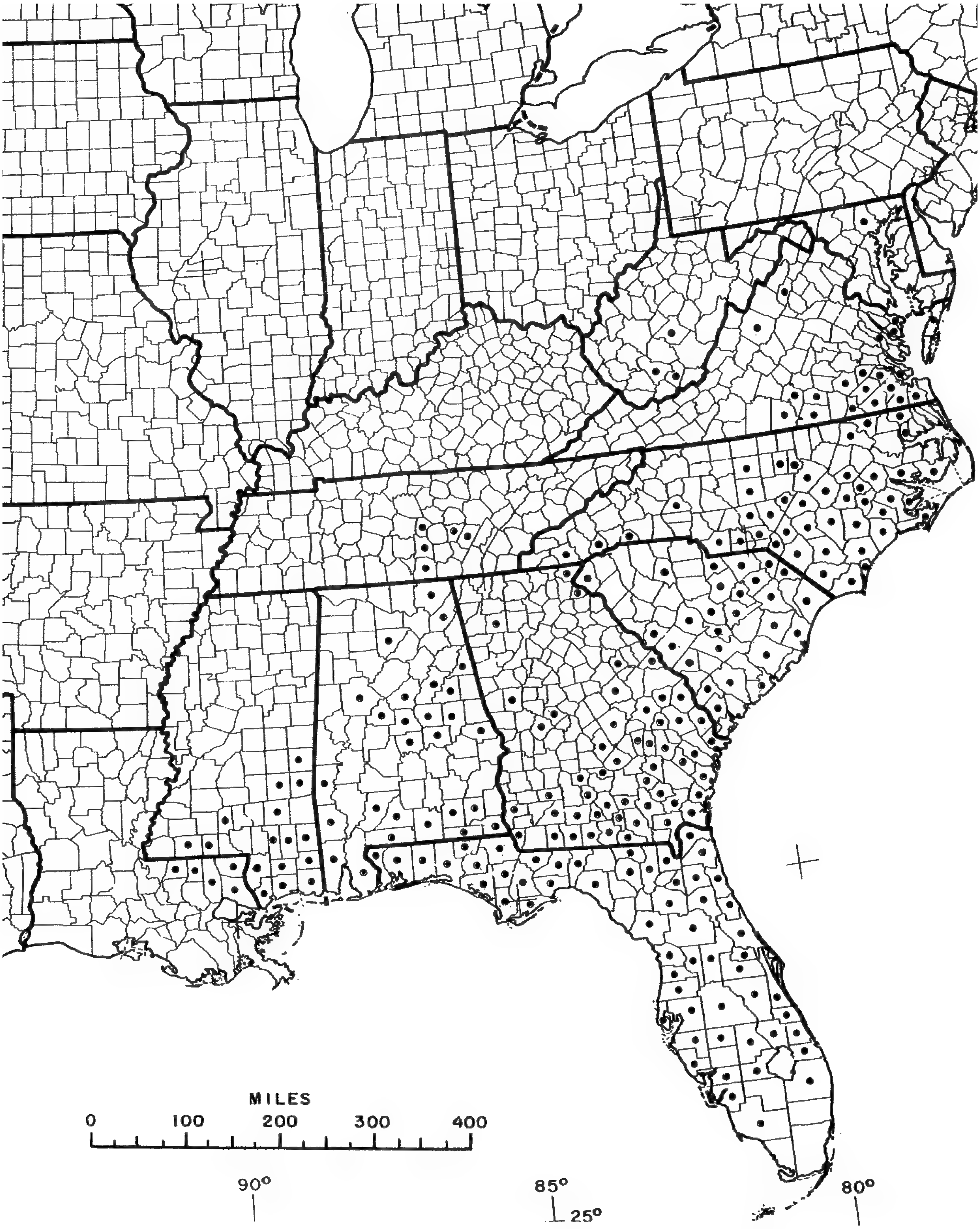

Fig. 1. County level distribution map of *Gaylussacia dumosa,* based on specimens and selected sources.

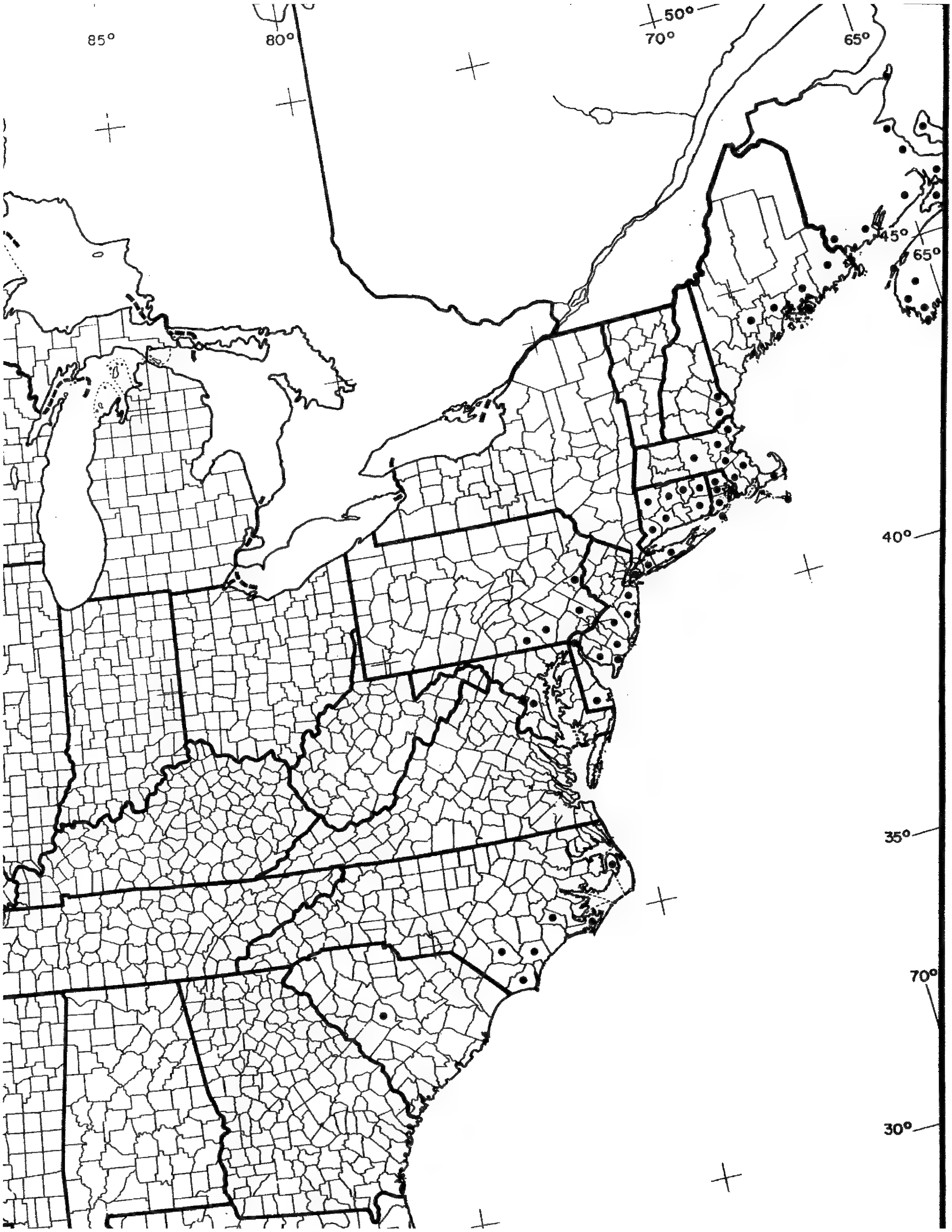

Fig. 2. County level distribution map of *Gaylussacia bigeloviana,* based on specimens and selected sources.

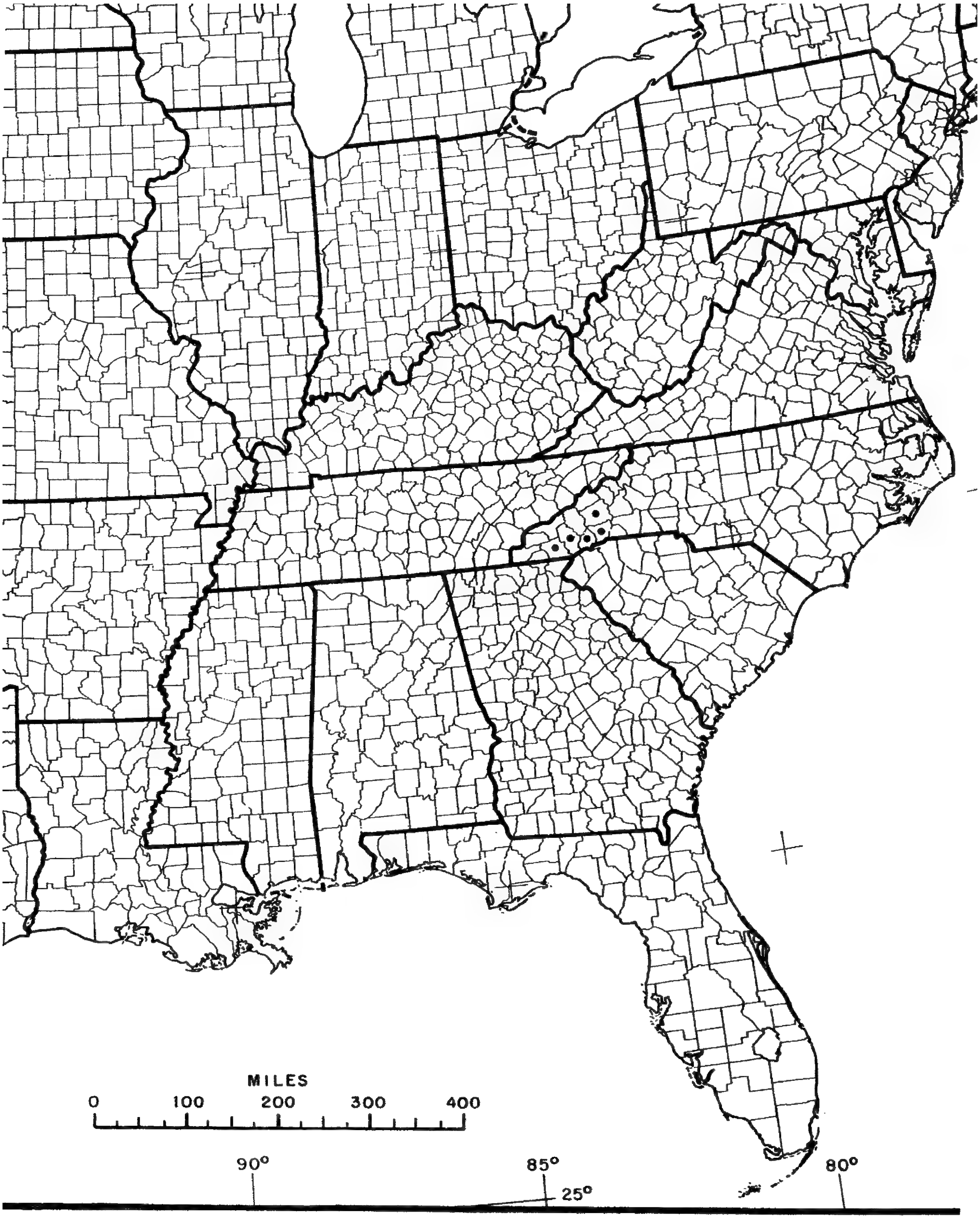

Fig. 3. County level distribution map of *Gaylussacia orocola,* based on specimens and selected sources.

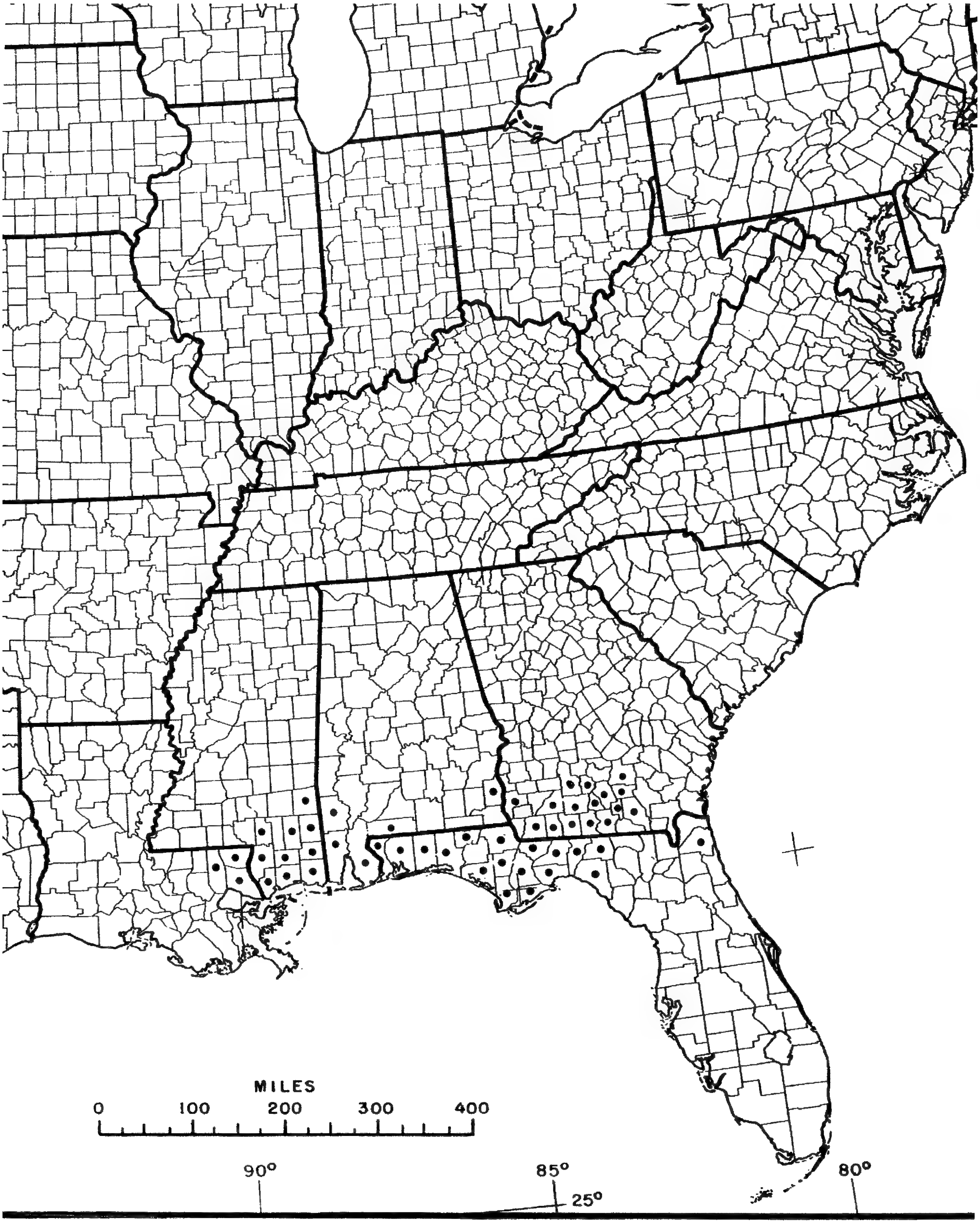

Fig. 4. County level distribution map of *Gaylussacia mosieri*, based on specimens and selected sources.

swamps." Small (1894) also reported Pennsylvania plants from wet habitats: "At the Pennsylvania localities the plant grows in swamps, and at Smithville [Lancaster County] is actually in the water..." We believe that all Pennsylvania records refer to *G. bigeloviana*.

Maryland. Brown and Brown (1992) listed *G. dumosa* without synonymy and state that it inhabits "Moist to dry, sandy soils of the Coastal Zone; recorded from the Mountain Zone by Shreve." The text description appears to be a composite of both *dumosa* and *bigeloviana*. A specimen from Baltimore County—glade of transmission line east of Pulaski Highway, Baltars 1824 (DUKE)—is *G. dumosa*. The Maryland Native Plant Society website (www.mdflora.org/survey_data/JMPMontCoPlantsAddendum.html) lists old records from Takoma (Montgomery County) and Powdermill Bogs (Prince George's County), adjacent to the District of Columbia; no variety is indicated. In May of 2006, two specimens from Prince George's County were examined by Chris Frye of the Maryland Natural Heritage Program and verified as *G. bigeloviana*: Suitland Bog, 10 June 1966, Mazzeo and Dudley 1394 (NA); Airport Bog, 13 July 1945, Hermann 11547 (NA). We believe that both *G. dumosa* and *G. bigeloviana* occur in Maryland but are very rare.

District of Columbia. We have seen one specimen apparently from this region: low woods, Steele 119 (DUKE); label pre-printed with "Plants of Washington D.C. and Vicinity." It is *G. bigeloviana* due to plant height and dense non-glandular hairs on leaf margins.

Delaware. Tatnall's (1946) species account is ambiguous, but it appears that he listed records for both taxa from New Castle and Sussex Counties. McAvoy and Bennett (2001) listed only *bigeloviana*—from the same two counties—and gave its habitat as Atlantic white cedar swamps. It is historical in the state. We believe that all Delaware records are *G. bigeloviana*.

Virginia. The online Atlas of the Virginia Flora (http://www.biol.vt.edu/digital_atlas) maps records of *G. dumosa* sensu lato from the coastal plain plus three montane counties: Augusta, Carroll, and Page. The Carroll County record is erroneous (T. Wieboldt pers. comm.). Carr (1938) cited specimens of *G. dumosa* var. *bigeloviana* from two locations in Augusta County; we have examined Carr 409 (GH, VA) and it is *G. dumosa*. We have not located Carr 138 (supposedly at VA), nor the Page County specimen. Nonetheless, we believe that all current Virginia records are *G. dumosa* but believe that *G. bigeloviana* may yet be found in the Dismal Swamp or a similar habitat in the southeastern sector of the state.

APPENDIX 1

SELECTED INLAND RECORDS OF *GAYLUSSACIA DUMOSA* SENSU STRICTO

There are many specimens and literature reports from the piedmont region of Virginia, the Carolinas, Georgia, etc.; we will not repeat them here. Instead, we focus on records from montane regions. **ALABAMA. Clay Co.:** Emory's Gap, 2000 ft, specimen at NCU. DeKalb Co.: Little River Canyon parkway, specimen at IBE. The draft Atlas of Alabama Flora maps G. dumosa in several counties in the hill country of east-central Alabama and N to Cullman, DeKalb, and Jackson Cos. **GEORGIA. Bartow Co.:** specimens at FSU and NCU. **Rabun Co.:** sandy slopes of Thomas Bald, 2500–3000 ft, reported by Small (1894); Rock Mountain, vicinity of Tallulah Falls, *A.B. Seymour 110* (DUKE). **NORTH CAROLINA. Catawba Co.:** hillside near Hickory, elev. nearly 2000 ft, reported by Small (1894). **Macon Co.:** Satula summit, Highlands, *T.G. Harbison s.n.* (NCU); top of Mt. Satulah, *M.B. Wilson 1860* (DUKE) [this is 4700 ft]. **Polk Co.:** dry ground, Tryon, *J.R. Churchill s.n.* (GH). **Transylvania Co.:** Horsepasture Gorge, pine woods, 2000+ ft, *C.L. Rogers 61341a* (NCU). **SOUTH CAROLINA. Oconee Co.:** several collections at CLEMS, NCU, USCH, from relatively low elevations in blackjack oak woods, xeric mixed oak woods, dry rocky slopes up to 1200 ft. **TENNESSEE. Coffee Co.:** Tullahoma, 1070 ft, *H.K. Svenson 10091* (DUKE, FSU, IBE). The Atlas of Tennessee Vascular Plants (Chester et al. 1997) maps it also in **Bledsoe, Cannon, Franklin,** and **Van Buren cos.,** all on the Cumberland Plateau. **VIRGINIA. Augusta Co.:** Shenandoah Acres, vicinity of Stuarts Draft, *L.G. Carr 409* (GH, VA). **WEST VIRGINIA. Raleigh Co.:** Flat Top Mountain. This record is discussed in detail by Strausbaugh and Core (1977) and is from a dry habitat with other species of coastal plain affinity. Harmon et al. (2007) map it also in **Nicholas** and **Summers cos.**

APPENDIX 2

RECORDS OF *GAYLUSSACIA OROCOLA*

NORTH CAROLINA. Buncombe Co.: swampy places, Biltmore, 25 May 1896, no collector (NCU), orig. det. dumosa. **Henderson Co.:** King Creek Bog, end of Mine Gap Road, montane sphagnum bog with dense woody vegetation and small openings, uncommon, 21 May 1993, *B.A. Sorrie 7306 with A.S. Weakley, B. Van Eerden, M.J. Russo* (NCU); near Brickton. n.d., *W.W. Ashe s.n.* (NCU); edge of Devil's Fork swamp, 2.5 mi E of Hendersonville, 18 Jun 1947, *G.W. McDowell 408* (DUKE); in swamps near East

Flat Rock, J.K. Small (NY), Type of *Lasiococcus orocola* Small, cited in Sleumer (1967); East Flat Rock, E.J. Alexander (NY), cited in Sleumer (1967); Flat Rock, 30 May 1886, *E.R. Memminger s.n.* (NCU); in bog 1 1/2 mi S of East Flat Rock, on rte. 176, 10 Oct 1937, W.C. Coker and party (NCU, 2 sheets); in a bog at East Flat Rock, near Hoot's Nursery, 6 Jun 1936, *D.S. Correll 5143 with H.L. Blomquist and K.H. Garren* (DUKE); Hoot's Swamp, *D. Samson 719* (NY), cited in Sleumer (1967). **Jackson Co.:** very top of Big Yellow Mountain, plants taller than on coast, 21 Aug 1936, *W.C. Coker s.n.* (NCU). **Macon Co.:** Satulah Mtn., Highlands, 21 Jun 1924, *W.W. Ashe s.n.* (NCU). **Transylvania Co.:** oak-hickory woods on rock outcrop, 2 mi N of Cedar Mt., 2 Jun 1952, *A.E. Radford 6090* (GH, NCU) [we believe there is a mis-labeling here; there are bogs two mi N of Cedar Mountain that support *Sarracenia jonesii, S. purpurea* var. *montana* and *Arethusa bulbosa* and other associates of G. orocola]; 1 mi NE of Frying Pan Gap, 23 Sep 1957, O.M. Freeman 57831 (NCU), mixed sheet with G. *baccata*; by creek in bog behind Pisgah Inn, 24 Jun 1955, *L. Walton 3551* (DUKE).

ACKNOWLEDGMENTS

We wish to thank the curators of the following herbaria for specimen loans or for providing access: CLEMS, DUKE, GH, IBE, NCSC, NCU, USCH, VA, VPI, and WILLI. Botanists from several Natural Heritage Programs, cited above, provided critical information regarding species within their states. Two anonymous reviewers considerably improved the manuscript.

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REINSTATEMENT OF *SAGITTARIA MACROCARPA* (ALISMATACEAE)

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ABSTRACT

Sagittaria macrocarpa J.G. Sm. is here restored to full species status. A narrow distribution, the rarity of specimens available for study, and morphological similarity to closely related taxa has contributed to this species being overlooked or misidentified for a century. Recent research in population genetics, molecular sequencing, and morphology support the hypothesis that *Sagittaria macrocarpa* is distinct from congeners. In addition, the taxon occupies a unique range of habitats and apparently a limited distribution.

RESUMEN

Se restaura aquí a *Sagittaria macrocarpa* J.G. Sm. al status de especie. Una distribución restringida, la rareza de los especimenes disponibles para su estudio, y la semejanza morfológica con taxa relativamente próximos ha contribuido a que esta especie sea pasada por alto o se identifique erróneamente durante un siglo. Investigaciones recientes en genética de poblaciones, secuenciación molecular, y morfología apoyan la hipótesis que *Sagittaria macrocarpa* es diferente de sus congéneres. Además, el taxon ocupa un único rango de hábitats y aparentemente una distribución limitada.

INTRODUCTION

Recent field and herbarium studies have documented specimens referable to *Sagittaria macrocarpa* J.G. Sm., a name long misapplied and in synonymy under *S. graminea* Michx. Morphological and molecular studies lend significant support for designating *S. macrocarpa* a distinct taxon. In this paper we provide evidence for reinstating *S. macrocarpa* to specific status. *Sagittaria macrocarpa* J.G. Sm. was described in 1894 (Smith 1894). He cited only the holotype, a specimen collected by M.A. Curtis from "margin of ponds" in South Carolina (undated, *Curtis s.n.* MO!). Bogin (1955) cited an isotype of *S. macrocarpa* at GH; while correctly identified, this specimen is almost certainly not an isotype (see discussion ahead). Until now, these two are the only specimens known of *S. macrocarpa* sensu J.G. Sm.

Small (1909) misapplied the name *S. macrocarpa* to plants that were later to be named *S. fasciculata* by Beal (1960). This misapplication was apparently based on the large achenes of *S. macrocarpa* and *S. fasciculata*, which are markedly larger than other taxa of the *S. graminea* complex. In a later publication, Small (1933) again included *S. macrocarpa* in his text and provided habitat and range statements that are consistent with *S. macrocarpa* of J.G. Sm. However, Small's description does not exclude plants later to be named *S. fasciculata* Beal, particularly those with 3–5 whorls of flowers.

Bogin (1955) reduced *S. macrocarpa* to varietal status, as *S. graminea* Michx. var. *macrocarpa* (J.G. Sm.) Bogin. At the same time, Bogin misapplied the name *macrocarpa* to plants that later were named *S. fasciculata* Beal.

Beal (1960) correctly recognized plants of North Carolina montane bogs and sluggish streams as *S. fasciculata* Beal, based on spatulate emersed leaves, broad basal phyllodia, and narrow distribution. He placed *S. macrocarpa* in synonymy with *S. graminea* var. *graminea*, stating that *S. macrocarpa* "differs from typical *S. graminea* var. *graminea* in no way except the size of achenes which are as much as 3 mm in length in contrast to the usual length of 1.5–2.0 mm of var. *graminea*. However, specimens of var. *graminea* collected by the author [Beal] in the coastal plain of North Carolina exhibit a range in achene size including 3 mm. Therefore, *S. macrocarpa* J.G. Sm. must be relegated to synonymy." During our research, however, we have not seen any *S. graminea* with achenes approaching 3 mm. Wooten (1973) and Haynes and Hellquist (2000) followed Beal (1960) in placing *S. macrocarpa* in synonymy under *S. graminea*. In their treatment for Flora of North America, Haynes and Hellquist (2000) use subspecies rather than variety to designate infraspecific rank within *Sagittaria graminea*; we will do so henceforth.

REDISCOVERY AND SPECIMENS

During a botanical inventory of Fort Bragg Military Reservation, North Carolina, specimens initially determined as *Sagittaria isoetiformis* J.G. Sm. were collected and discussed by Sorrie et al. (1997). These plants possess leaves with slender distal blades and/or bladeless (phyllodial) leaves; they have since been annotated to *S. macrocarpa* based on achene and floral morphology. Other plants collected on Fort Bragg possess somewhat wider blades and were originally determined to be *S. graminea*, but based on achene and floral morphology these specimens also belong to *S. macrocarpa*. All of these plants occur in blackwater streamheads, beaver ponds, and artificial impoundments; none occur in natural depression ponds or Carolina bays, habitats occupied by *S. isoetiformis*.

Once the salient characters of *S. macrocarpa* were determined, the senior author found additional populations and historical specimens elsewhere in the Sandhills region of North and South Carolina. The following list represents all known vouchers. ITAM stands for the herbarium at the office of Integrated Training and Management on Fort Bragg, North Carolina; WEWO stands for the herbarium at Weymouth Woods State Nature Preserve, North Carolina; the other acronyms follow Index Herbariorum (2006).

NORTH CAROLINA. Hoke Co.: Fort Bragg, Field Branch, boggy portion of formerly impounded blackwater stream, S of firebreak 11 and west of Turkey Road, 18 Sep 1993, *Sorrie 7558* (NCU, pers. herb.); Fort Bragg, Calf Branch at Southern Pines Road, open streamside disturbed by siltation, 11 Aug 1993, *Sorrie 7545 with B.Van Eerden and R. Kral* (pers. herb.); Fort Bragg, Gum Branch at Chicken Road, margin of blackwater stream, sandy bottom with some mud and clay, 20 Jul 1993, *Sorrie 7566* (NCU, pers. herb.); same location, 16 Sep 1981, *J. Carter III 1497* (WEWO); Fort Bragg, Puppy Creek at Plank Road Cutoff, with *Scirpus etuberculatus, Sparganium americanum, Potamogeton diversifolius*, 2 Jun 1995, *T. Crawford and P. Crutchfield B1329* (ITAM); Fort Bragg, NE shore of McArthur Lake, with *Mayaca aubletii, Eleocharis flavescens, Nymphaea odorata*, 29 Sep 1992, *P. Crutchfield and M. Jones B652* (ITAM). **Hoke/Moore Cos.:** Fort Bragg, Johnsons Millpond, a large beaver pond dotted with peat islets, locally common in shallow pools and where inlet streams enter, with *Sagittaria engelmanniana, Eleocharis robbinsii*, 9 Oct 1991, *Sorrie 5969 with A. Weakley, J. Carter III* (NCU, pers. herb.); same location, sandy substrate at east shore, 18 Aug 1993, *Sorrie 7557* (DUKE, GH, NCU, pers. herb.); same location, peaty-sandy shore, 16 Aug 2002, *Sorrie 10981 with J. Gray* (US, pers. herb.). **Moore Co.:** Aberdeen Recreation Lake, 4 mi NE of Pinebluff, Chloride 1.6 ppm, 16 Jun 1960, *E. Beal 5592* (DUKE, NCU); same location, southern shores, 30 May 2004, *Sorrie 11262* (GH, UNA, NCU); Pinebluff Lake, impounded blackwater stream with stressed *Nyssa biflora* at head end, with *Panicum hemitomon, Juncus debilis*, 28 May 1997, *Sorrie 9252* (NCU, pers. herb.); same location, 21 Jul 2000, *Sorrie 10571* (pers. herb.); margin of Powell's Pond at intersection of Fort Bragg-Aberdeen Hwy. and Saunders Blvd., 28 Jun 1979, *T. Howard s.n.* (WEWO); submerged just below beaver dam, Weymouth Woods State Nature Preserve, 23 Oct 1965, *H. Ahles 63085* (WEWO); Weymouth Woods, partially submerged in old beaver pond, 9 Aug 1976, *J. Carter III s.n.* (NCU, WEWO); Weymouth Woods, along Pine Island Trail near crossing of James Creek, 28 Sep 2002, *Sorrie 11016* (pers. herb.); Moore County without location, 27–28 Jun 1897, *W. Ashe s.n.* (NCU). **SOUTH CAROLINA. Aiken Co.:** infrequent in wet portion of herb-dominated sandhills seepage bogs in high voltage powerline clearing between Vaucluse and Graniteville above Flatrock Pond, Horse Creek, 26 Jun 2001, *P. McMillan 5447 with R. McCartney, H. Shealy* (CLEMS). **Chesterfield Co.:** just above hot water discharge of power plant, W margin of Lake Robinson, 1/2 mi S of Hwy. 346 bridge, 15 Sep 1986, *C. Aulbach-Smith 4200* (USCH), 4192 (NCU, USCH). **County unknown:** "margin of ponds S. Car.", undated, *M.A. Curtis s.n.* (MO)–Type; "S. Carolina," undated, *M.A. Curtis s.n.* (GH).

STATUS OF CITED ISOTYPE

A second Curtis specimen was cited by Bogin (1955) as an isotype of *S. macrocarpa*: "S. Carolina", undated, *M.A. Curtis s.n.* (GH). On the sheet J.G. Smith wrote "This plant…is intermediate between *S. teres* and S. macrocarpa." In all respects this specimen matches *S. macrocarpa*, except for the achenes, which are 2.0 mm long and 1.5 mm wide. However, the achenes appear to be immature and apparently not fully developed. The labeling of this specimen differs from the type collection in several particulars and we believe it not to be an isotype. First, the lettering is printed by machine, not in longhand as on the MO type label. Second, the paper used for the label is different from that of the MO label. Third, there is no mention of habitat ("margin of ponds") as on the MO label. For these reasons, we suggest that Curtis collected the GH specimen at a different place and date than the type at MO. Based on evidence and discussion above, we believe this specimen is not an isotype of *S. macrocarpa*.

GENETIC STUDIES

Edwards and Sharitz (2000) investigated the genetic structure of *S. isoetiformis* and *S. teres* S. Wats. One population in their study gave divergent results: "We were surprised to discover a population (NCJM) [Johnsons Millpond, Fort Bragg, North Carolina] that was monomorphic at two loci for alleles not found in any other population of either *S. isoetiformis* or *S. teres*. There are several possible explanations for this phenomenon: (1) we did not sample enough populations to detect the alleles elsewhere; (2) the NCJM population has been repeatedly misidentified as *S. isoetiformis*, but actually represents a known species in the *Gramineae* section of the genus; (3) the NCJM population represents a cryptic species that has not been morphologically distinguished from *S. isoetiformis*, or (4) the NCJM population is *S. isoetiformis*, but contains remnant genetic input from past introgression with another species." As a result of our research, all specimens at Johnsons Millpond previously assigned to *S. isoetiformis* have now been correctly assigned to *S. macrocarpa*; therefore, choices 2 and 3 of Edwards and Sharitz apply to the present situation.

Keener (2006) investigated most of the genus utilizing sequences of the nuclear ribosomal DNA nontranscribed spacer (5S-NTS) in a systematic analysis. His findings indicated a rather strong sister relationship of *S. macrocarpa* with *S. cristata* Engelmann, a taxon of the extreme north central United States and south central Canada. A reasonable hypothesis is yet to be formed as to how these sister taxa came to have such a large disjunct gap in their distributions.

MORPHOLOGICAL CHARACTERS

The following is a description of *S. macrocarpa*, expanded on Smith (1894). **Plant:** perennial, monoecious herbs, glabrous, emersed from shallow water or stranded during flowering and fruiting, to 40 cm tall. Rhizomes absent; **corms present**; stolons often extending from **corms** but usually broken or lost during collecting; tubers unknown; roots septate. **Leaves:** narrowly bladed and petiolate, or phyllodial. Leaves ascending to erect, (6.5–)8.0–22.2(–28.2) cm long, slender, when petiolate dilated distally into linear blades (0.8–)1.0–3.1(–4.0) mm wide, lacking sagittate processes; margins entire; apex acute. **Scapes:** often 1 but range up to 4, erect, (11.4–)14.3–27.2(–33.8) cm long, exceeding leaves; inflorescences racemose, bearing1–3 nodes; lowest node bearing 1–2 carpellate flowers and 1–2 staminate flowers; upper nodes bearing staminate flowers; nodal bracts scarious, connate at base for more than 1/4 to 1/3 total length, ovate, tips blunt or acute, (1.9–)2.1–2.7(–3.0) mm long. **Flowers:** pedicels ascending; receptacles convex; sepals spreading to recurved, 3.0–3.5 mm long, translucent, shorter than petals; petals 3, white, (4.2–)4.6–6.4(–7.3) mm long, entire. Carpellate flowers: carpels numerous, apocarpous, ovules 1, styles terminal. Staminate flowers: stamens 8–10, filaments distinct, moderately dilated basally, sparsely to fairly densely short-pubescent, 0.4–0.7 mm long, anthers 0.9–1.0 mm long, yellow. **Fruiting heads:** 8–10 mm in diameter; achenes obovate, 2.0–2.7 mm × 1.3–2.0 mm, compressed, beaked, adaxially keeled, keel margin entire to scalloped; abaxially slightly keeled, keel margin entire; faces ridged, ridges horseshoe shaped, margins scalloped to entire; resin canal 1, rarely 2; beak laterally attached, obliquely emerging, 0.5–1.0 mm long. Figure 1 depicts the salient features.

Table 1 compares several key characters among *Sagittaria macrocarpa, S. isoetiformis, S. graminea* ssp. *graminea,* and *S. fasciculata*. Although no single character uniquely identifies any one of the four taxa, a number of combinations will do so effectively. The thick rhizome of *S. graminea* ssp. *graminea*, when present, will positively distinguish that entity from the others; however, Godfrey & Wooten (1979) state that in young plants (through the first year or so of blooming) the rhizome is not yet well developed.

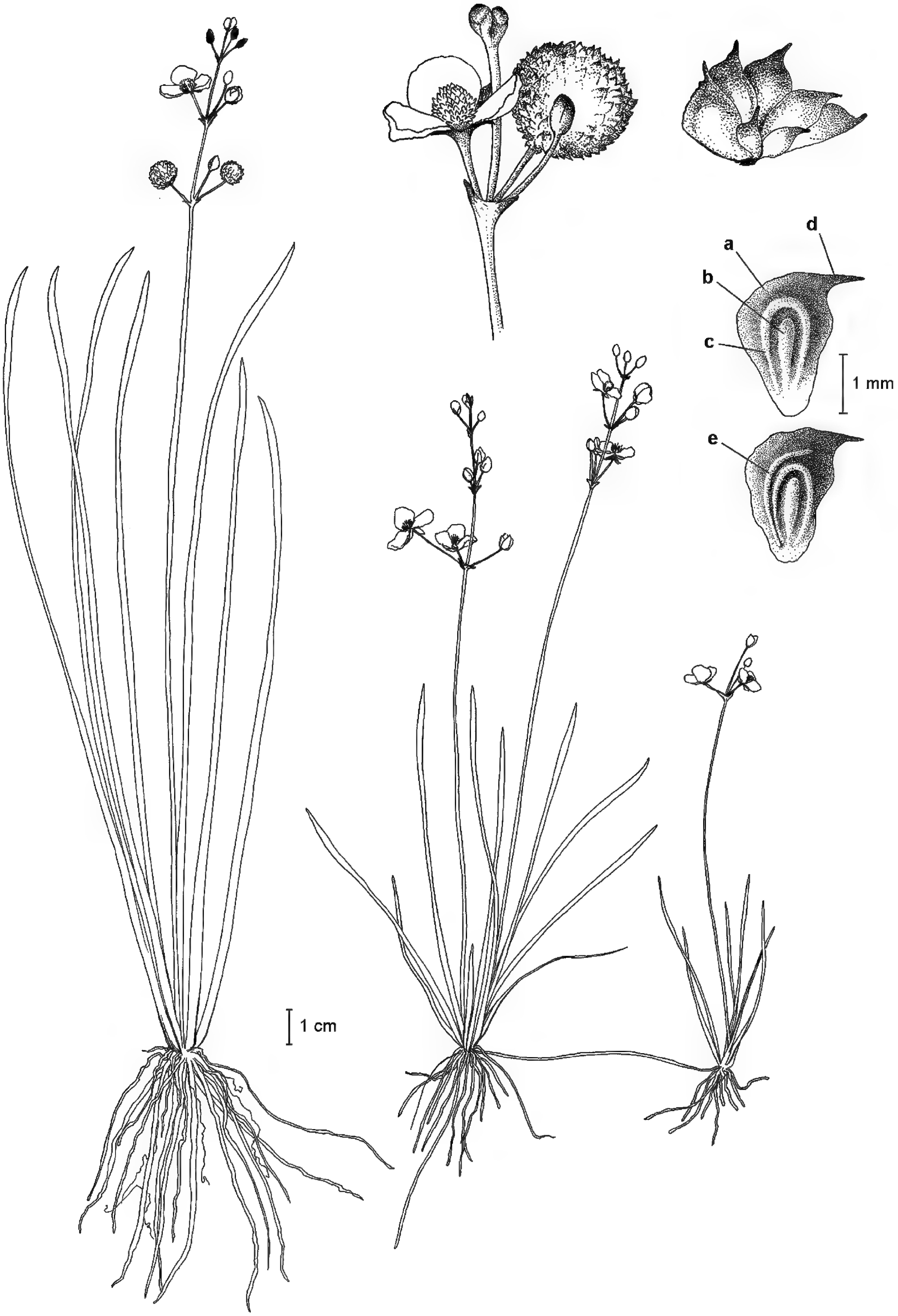

Fig. 1. Two plants of *Sagittaria macrocarpa* (one with offshoot from stolon), with detail of inflorescence and achenes. **a.** achene keel. **b.** resin canal. **c.** facial ridge. **d.** beak. **e.** secondary facial ridge.

Table 1. Comparison of selected morphological characters of *Sagittaria macrocarpa, S. isoetiformis, S. graminea* ssp. *graminea,* and *S. fasciculata.* Measurements in millimeters. FNA refers to Haynes & Hellquist (2000); Beal refers to Beal (1960); otherwise, measurements are from original work. * = A. Edwards unpublished data.

	macrocarpa	*isoetiformis*	*graminea*	*fasciculata*
Achene length	(2.2–)2.4–3.0	1.5–2.0(–2.5)	1.4–2.0	2.5–3.0 FNA 2.5–3.5 Beal
Achene width	1.3–2.1	0.9–1.2(–1.5)	0.9–1.2(–1.5)	1.2–1.5 FNA 1.3–2.0 Beal
Beak length	0.5–0.9	0.2–0.6	0.2–0.4	ca. 0.5
Achene face	resin canal 1(–2), flanked by 2(–3) low ridges	resin canal 2-3, flanked by 2–3 low ridges	resin canal 1, surrounded by 2 high ridges	resin canal 1, flanked by 2 low ridges
No. of inflorescence whorls	1–3	1–5	1–7	2–5
Bracts connate	up to 2/5 of length	at least 1/2	1/3–2/3	1/4
Leaf blade width	1.0–4.3	<1–2.2	3.0–15.0	5.0–21.0
Rhizome present and thickness	no or very slender	no or very slender	yes, thick	no
Corms produced	no	yes*	no	yes
Stolons present	yes or no	yes, but usually not collected	no	yes

A KEY TO THE NARROW-LEAVED MEMBERS OF THE *SAGITTARIA GRAMINEA* COMPLEX

The following key will serve to identify narrow-leaved members of the *Sagittaria graminea* group occurring in the southern Atlantic region of the United States. *Sagittaria graminea* ssp. *weatherbiana* (Fernald) R.R. Haynes & Hellquist is a much coarser plant with blunt-tipped leaves at least 1 cm wide.

1\. Leaves phyllodial.
  2\. Achenes 1.5–2.0(–2.5) mm long; achene with 3 or more facial ridges and 2 or more resin canals; inflorescence bracts connate for more than half of entire length **S. isoetiformis**
  2\. Achenes (2.2–)2.4–3.0 mm long; achene with 2–3 facial ridges and 1–2 resin canals; inflorescence bracts connate for less than 40% of entire length **S. macrocarpa**
1\. Leaves petiolate.
  3\. Carpellate pedicels distinctly thicker in cross section than staminate pedicels, recurved in fruit **S. platyphylla**
  3\. Carpellate pedicels more-or-less equal to staminate pedicels in diameter, ascending in fruit.
    4\. Rhizomes coarse; achene with markedly raised facial ridges, forming an elliptical bowl-like structure.
      5\. Inflorescence racemose **S. graminea** ssp. **graminea**
      5\. Inflorescence paniculate **S. graminea** ssp. **chapmanii**
    4\. Rhizomes absent or slender; achene with slightly raised facial ridges (markedly raised in *S. graminea*).
      6\. Leaf blades at least 5 mm wide and anthers about 0.6–0.7 mm long **S. fasciculata**
      6\. Leaf blades less than 4.5 mm wide and anthers about 0.9–1.1 mm long.
        7\. Achenes (2.2–)2.4–3.0 mm long, beaks 0.5–0.9 mm long **S. macrocarpa**
        7\. Achenes 1.4–2.0(–2.5) mm long, beaks 0.2–0.6 mm long.
          8\. Achenes with markedly raised facial ridges, forming an elliptical bowl-like structure; leaf blades at least 3.0 mm wide **S. graminea** ssp. **graminea**
          8\. Achenes with slightly raised facial ridges; leaf blades less than 2.3 mm wide **S. isoetiformis**

HABITAT AND DISTRIBUTION

Sagittaria macrocarpa inhabits very shallow water of beaver ponds, impoundments, slow-moving streamhead creeks, and occasionally in adjacent wet seepage slopes, all within the longleaf pine (*Pinus palustris* P. Miller) ecosystem. These are blackwater drainages with dark tannin-stained water, low pH, and low nutrient content. Substrates are sands or clayey sands of the Middendorf Formation (Upper Cretaceous). Peat mosses (*Sphagnum* spp.) are common associates, along with members of *Juncus, Eleocharis, Scirpus, Panicum, Dichanthelium, Lachnanthes, Nymphoides, Nymphaea, Sparganium, Potamogeton,* and *Mayaca*. Ericaceous shrubs are often prominent around the margins of these wetlands. Within the genus *Sagittaria*, only *S. engelmanniana* J.G. Sm. and *S. graminea* (rarely) have been found growing with *S. macrocarpa,* based on personal observations.

To date, all populations occur in the rolling Sandhills Region (inner coastal plain) of North and South Carolina. Although documented from only four counties in two states, there is abundant potential habitat in the region as beaver continue to reclaim former range and as humans continue to create streamhead impoundments.

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VARIATION IN *PETRADORIA PUMILA* (ASTERACEAE: ASTEREAE)

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ABSTRACT

Populations of *Petradoria pumila* with linear-filiform leaf blades, primarily in Arizona and northwestern New Mexico, are treated as *P. pumila* var. *graminea*. They are interpreted here to be distinctive variants at the southern extremity of a north-south cline with the gradient breaking sharply at the southern end. Formal taxonomic recognition can be maintained for var. *graminea*, although intermediates are common and the taxon probably is artificial, especially if enclaves of linear-filiform variant populations in central Utah are identified as var. *graminea*. Clusters of populations from Clark, Nye, White Pine, and Elko cos., Nevada, along the western margin of the geographic range, differ from others of the species (var. *pumila* and var. *graminea*) in disc floret number. In these populations (9 populations, 15 plants), disc florets per head range 5–10, averaging 7.0. Over the rest of the range of the species (n = 125 plants, outside of Nevada), disc florets range 2–4(–5), averaging 3.3. There is no evidence that the high floret number populations in Nevada represent a single lineage.

RESUMEN

Las poblaciones de *Petradoria pumila* con láminas foliares linear-filiformes, de Arizona y noroeste de Nuevo México, se tratan como *P. pumila* var. *graminea*. Aquí se interpretan como variantes diferenciables del extremo Sur de una variación clinal Norte-Sur con el gradiente que se rompe netamente en el extremo Sur. Se puede mantener el reconocimiento taxonómico formal de la var. *graminea*, aunque los intermedios son comunes y probablemente el taxon es artificial, especialmente si los enclaves con poblaciones variantes linear-filiformes en Utah central se identifican como var. *graminea*. Los grupos de poblaciones de Clark, Nye, White Pine, y Elko cos., Nevada, a lo largo del borde Oeste de su areal geográfico, difieren de otros de la misma especie (var. *pumila* y var. *graminea*) en el número de flósculos del disco. En estas poblaciones (9 poblaciones, 15 plantas), los flósculos del disco por capítulo varían de 5–10, con una media de 7.0. En el resto del areal de la especie (las plantas n = 125, fuera de Nevada), los flósculos del disco varían de 2–4(–5), con una media de 3.3. No hay pruebas de que las poblaciones con alto número de flósculos en Nevada representen una línea simple.

The genus *Petradoria* Nutt. was treated by Anderson (1963) to include two species: *P. pumila* (Nutt.) Greene and *P. discoidea* L.C. Anderson (= *Chrysothamnus gramineus* H.M Hall). He later reinstated *P. discoidea* within *Chrysothamnus* (Anderson 1983), but molecular evidence subsequently has shown that species to be phylogenetically remote from both *Chrysothamnus* and *Petradoria* (Beck et al. 2004; Roberts & Urbatsch 2004). *Chrysothamnus gramineus* has now been segregated as the monotypic genus *Cuniculotinus* Urbatsch et al. (Urbatsch et al. 2005), and *Petradoria* has reverted to its monotypic status (Urbatsch et al. 2006). *Petradoria pumila* is morphologically distinct from *Stenotus* Nutt., its closest relative, in having many, few-flowered heads with vertically aligned phyllaries, functionally staminate disc florets, and glabrous cypselae.

Petradoria pumila is a common plant of pine forests, pinyon-juniper woodlands, and shrub communities in the southwestern U.S.A. The distribution is centered around Utah and includes northern Arizona, San Bernardino Co., California, western Colorado, southeasternmost Idaho, northwestern New Mexico, Sweetwater Co., Wyoming, and eastern Nevada (Fig. 1). A single collection from the "Truckee Mts."cited and mapped by Anderson (1963) as originating from Washoe Co., Nevada (2 May 1868, *S. Watson 557*, [US]) is out of range for the species. Two other 1868 collections by Watson, however, both numbered "557," have locality data placing them in Elko Co., Nevada. It is probable that the specimen with the "Truckee Mt." label also was collected in Elko Co.

In Anderson's monograph, largely followed by Urbatsch et al. (2006), *Petradoria pumila* comprises two infraspecific taxa (treated as subspecies by Anderson, as varieties by subsequent authors): var. *pumila* occurs over most of the range; var. *graminea* (Woot. & Standl.) S.L. Welsh is mostly restricted to the southernmost portion of the range. Urbatsch et al. (2006) distinguished the two taxa by the following contrasts:

1. Leaves usually 1(–3)-nerved, 1–2 mm wide; involucres 1.3–2 mm wide; ray florets usually 1, laminae 0.7–1.5 mm wide; disc florets 2–3 ____ var. **graminea**

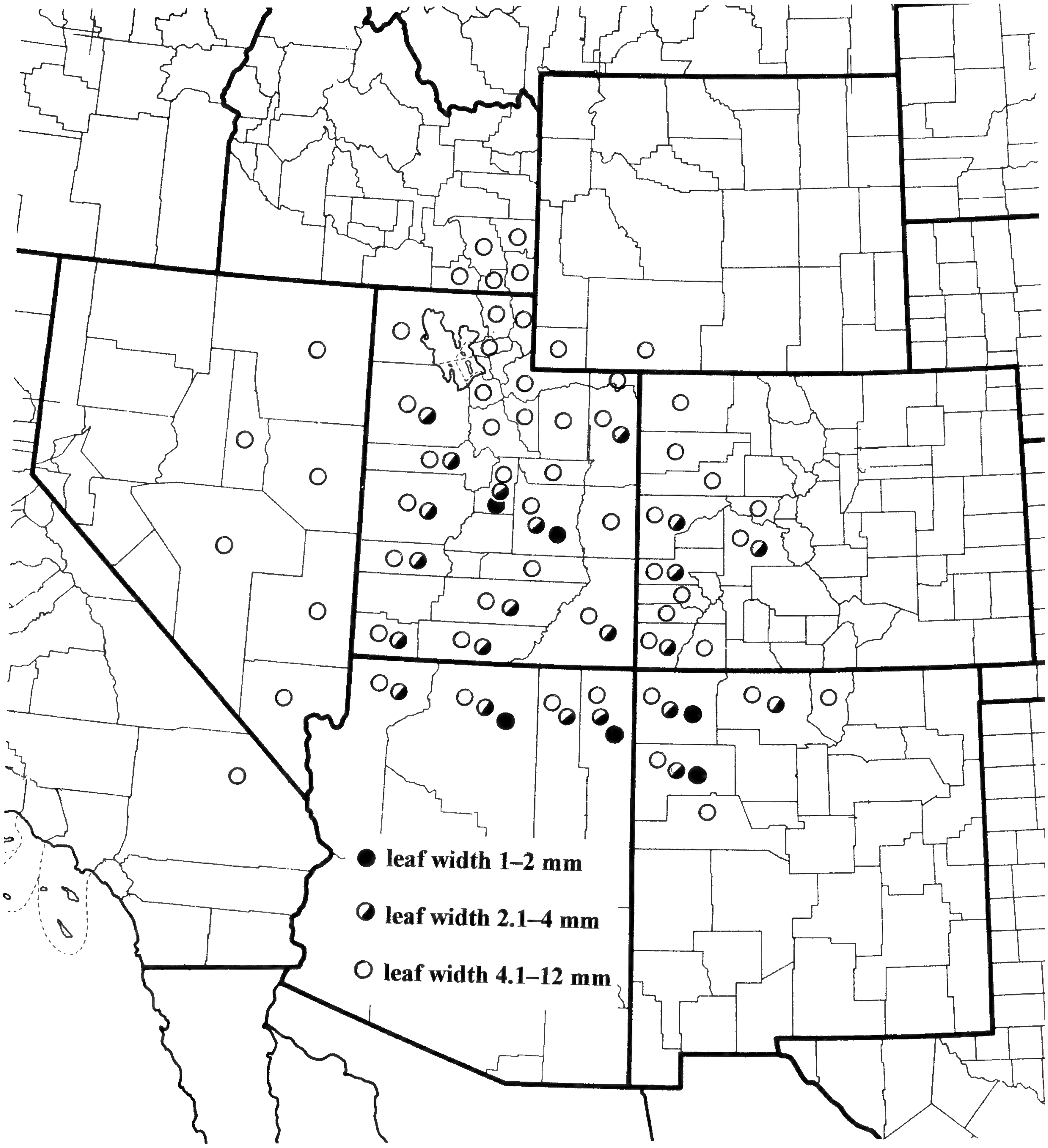

Fig. 1. Variation in leaf shape in *Petradoria pumila*. Linear-leaved plants (var. *graminea*) are concentrated mostly in the southernmost portion of the range but they also appear in more northern localities. The typical form occurs throughout the range of the species.

1. Leaves usually 3–5-nerved, 2–12 mm wide; involucres 1.9–3 mm wide; ray florets usually (1–)2–3, laminae 1–2.4 mm wide; disc florets 2–4(–5) ______ var. **pumila**

The present study reexamines taxonomically significant characters. Our observations generally agree that linear-leaved variants are concentrated in Arizona and New Mexico although evidence suggests that they do not represent a single lineage. We also document previously unrecognized variability in disc floret number.

Leaf morphology and other clinal variation

As cited and mapped by Anderson (1963), var. *graminea* occurs in Mohave, Coconino, and Apache cos., Arizona, and San Juan and McKinley cos., New Mexico. Using his criteria for identification, we add Navajo Co., Arizona, and Sanpete and Emery cos., Utah, to the distribution of var. *graminea*. Welsh et al. (2003, p. 218) also noted that "a few specimens from Emery and Garfield counties seem to be clearly allied to var. *graminea*." A county-level map of collections showing intermediate-width leaves (Fig. 1), however, suggests that variation in leaf width (and number of veins, which is correlated) is continuous, if intermediates between var. *pumila* and var. *graminea* are considered to have leaves 2.1–4 mm wide. Linear-leaved plants tend to be concentrated in southern populations but plants of typical morphology and intermediates are common in the same region. Disjunct enclaves of linear-leaved plants (var. *graminea)* in central Utah are hardly distinguishable from southern linear-leaved plants, and it seems likely that populations with linear leaves have arisen independently.

Anderson (1963) observed that var. *pumila* occurs at higher elevations where it occurs sympatrically with var. *graminea*. We are not able to test this, but our data suggest that there is no overall distinction in elevation: 20 collections from Arizona in our study referable to var. *graminea* occur at a range of 5000–8500 ft, averaging 7020 ft; 46 collections from Arizona referable to var. *pumila* or intermediates between the two varieties occur at an elevational range of 4600–8500 ft, averaging 6350 ft. Plants of var. *pumila* have been collected at a range of (4000–)5000–8300(–10,000) ft in Utah, Colorado, and New Mexico. *Petradoria pumila* in San Bernadino Co. (and one collection from Tulare Co.), California, occurs at 3500–7000 ft.

Anderson (1963, p. 681) noted with respect to var. *pumila* that "much of its variation is clinal along the north-south axis of its range," these trends illustrated in his figs. 44 and 45. Figure 1 of the present study indicates that a similar clinal trend is reflected in leaf width. Figure 2 indicates that there are no discontinuities in leaf width in each of four areas within the range of the species.

Anderson's Figure 45 shows geographic variation in involucral width, ray width and number, and disc floret number—measurements for each of these features decrease in a north-to-south direction. Fig. 44 shows geographic variation in the number of involucral bracts per head; number of bracts slightly increases southward in var. *pumila* (overall range 10–21) but bract number in plants identified as var. *graminea* ranges 11–15. We did not make a detailed analysis of involucral bract number, but whatever differences may exist do not appear to be significant. We counted 20 bracts in several plants from northern Utah.

In summary, the linear-leaved plants may justifiably be treated without formal rank, since it seems likely that many of the populations are independently derived, especially if those in Utah are identified as var. *graminea*. But a final clinal step in reduction of leaf width gives these plants a distinctive appearance, and they are concentrated at the southern extremity of the range of the species. The name var. *graminea* is available for those who wish to use it, although the taxon probably is largely artificial.

Floret number

Over the range of the species, excluding Nevada, we confirm that numbers of florets per head are essentially as reported for the species by Anderson (1963): ray florets 1–3, disc florets 2–4(–5). We also note that heads completely lacking ray florets occur at a low frequency, sometimes on plants with rayed heads. In counts from a total of 125 collections from all states in the range except Nevada, ray florets per head range (0–)1–2(–3, rarely), while disc florets range (1–)2–4(–5). For these same populations, ray florets average 1.4, while disc florets average 3.3. The modal number of ray florets per head is 1 in Colorado, New Mexico, Utah, and Arizona. Number of ray florets does not distinguish var. *graminea*.

In contrast to the normal situation, in a series of populations along the western extremity of the range in Nevada (Fig. 3; 9 collections, 15 plants), disc florets per head range 5–10, averaging 7.0. Ray florets per head range 1–3, as elsewhere in the range. In most other Nevada localities (38 collections, 66 plants), disc florets per head range (1–)3–5, averaging 3.8. Except for slightly broader involucres, the higher-number plants differ in no other apparent features from the lower-number ones.

Cited here are collections mapped with high numbers of disc florets. Floret numbers are in square brackets [ray,disc]; multiple plants are separated by a backslash. **NEVADA. Clark Co.:** Charleston Mts., Lee Canyon, 8000 ft, 28 Jul 1913, *Heller 11015* [2,8/2,6] (DS, MO, NY, UC, US); Charleston Mts., near Griffith Peak, *Windham 97-117* [2,7] (MO). **Elko Co.:** Angel Lake, ca. 13 km SW of Wells, 2600 m, *Lowry*

	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
ARIZ (n=27)	8	5	5	4	2	2	1	0					
NMEX (n=30)	1	4	9	6	4	2	3	0					
UTAH (SnJn Co.) (n=33)		0	3	2	3	5	4	2	3	3	6	2	0
IDA-NEV (n=30)			0	2	1	4	3	7	5	3	4	1	1

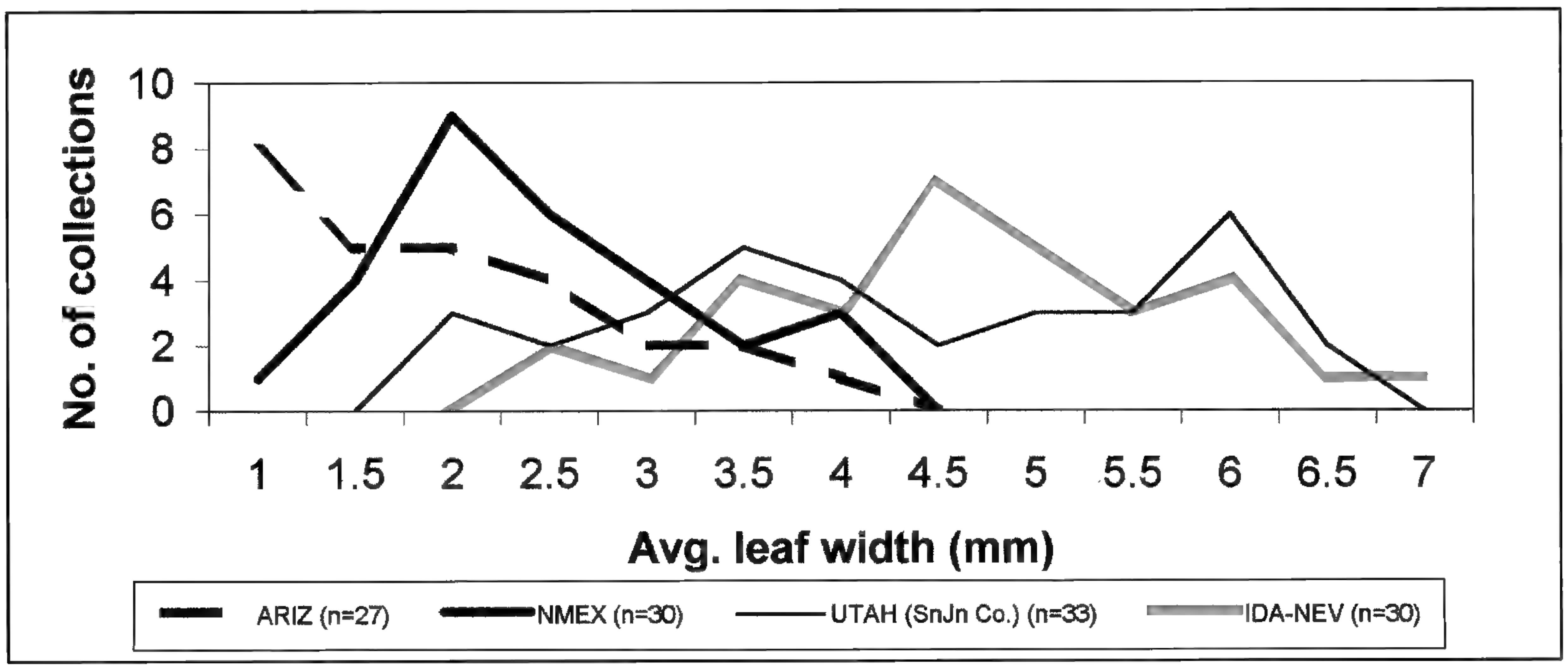

Fig. 2. Variation in leaf width in *Petradoria pumila*. Data points represent average width of basal leaves, one measurement per sheet, with some duplicate sheets measured. Arizona (4 counties), New Mexico (5 counties), Utah (San Juan Co.), and Idaho and Nevada (8 counties).

4630 [2,7] (MO); Ruby Mts, N slope of Verdi Peak, 9000 ft, 13 Aug 1941, *Mills & Beach 1543* [3,6/2,5/3,5] (BRIT, UC). **Nye Co.:** between Haystack Canyon and Mosquito Creek, 8800 ft, 22 Jul 1984, *Atwood et al. 10516a* [3,9/3,8] (BRY, NY); S flank of Mt. Jefferson, SE side of Toquima Range, 10,000 ft, 2 Aug 1976, *Williams 76-95-7* [1,6/3,5] (CAS, NY, UTC). **White Pine Co.:** Snake Range, W of Baker, ridge E of Lehman Creek, 10 Aug 1963, *Breedlove 5821* [1,7] (SMU); summit of Cave Mt., 16 mi due E of Ely, 18 Jul 1997, *Hess et al. 7624* [1,9/2,7] (BRIT, MO); Schell Creek Range, ca 1 mi S of Success Summit on NV Rte 486, 8600 ft, 16 Jul 1981, *Pinzl 4406* [2,10] (MO).

In the Charleston Mountains of Clark Co. and a few other localities, considerable variation in disc floret number per head apparently occurs within some populations. Studies of population structure in the Charleston Mountains and in the Snake Range might reveal whether such variation actually occurs continuously within populations or whether sampling by collectors included plants from adjacent, genetically different populations. From the Prospect Ridge area of Eureka Co., other collections have been only of plants with low floret numbers. Cited below are vouchers for collections with duplicates and multiple plants in which counts of disc florets per head (1 count per plant) are in both low and high ranges. Clark Co.: Charleston Mts., ridge S of Deer Creek, 2700 m, 31 Jul 1935, *Clokey & Clokey 5644* [1,7/2,6/2,6/2,6/2,5/3,4/2,4/2,4/2,4/1,4/2,3] (LL, MO, RM, RSA, TEX); Charleston Mts., gravelly wash with juniper and pine, 2270 m, 12 Jul 1936, *Clokey 7345* [2,6/1,6/1,5/2,3] (MO, TEX, UC). Eureka Co.: Prospect Ridge, SW part of county, on Relay Station Rd, 8700 ft, 19 Jul 1983, *Williams & Tiehm 83-108-4* [2,8/1,5] (NY). White Pine Co.: Snake Range, Mt. Washington, S slope at head of canyon, 10400 ft, 14 Aug 1964, *Holmgren & Reveal 1657* [1,6/2,4/1,4] (NY, TEX).

Vestiture variants

Plants of one population from the Clover Mountains of Lincoln Co., Nevada, produce densely hirsutulous-puberulent stems and leaves (*Tiehm & Crisafulli 11415* [BRY, CAS, COLO, NY, ORE, RM, RSA, TEX]). Otherwise, these specimens are similar to specimens referable to var. *pumila*, which mostly are completely glabrous. Plants of another population from Lincoln Co. ("Deer Lodge," *Train 2521* [MO, UC]) have very sparsely hirsutulous leaves. Other plants from scattered localities in the range also produce a sparsely hirsutulous indument, *e.g.*, Coconino Co., Arizona (*Clover 4320* [TEX]; *Parker 6188* [LL]); Emery Co. (*Hatch s.n.* [UTC]), Garfield Co. (*Richards 14962* [GH, UTC]; *Foster 5399*, BRY]), and Millard Co. (*Brooks 20353* [KANU, RM]; *Cottam 5660* [LL]), Utah.

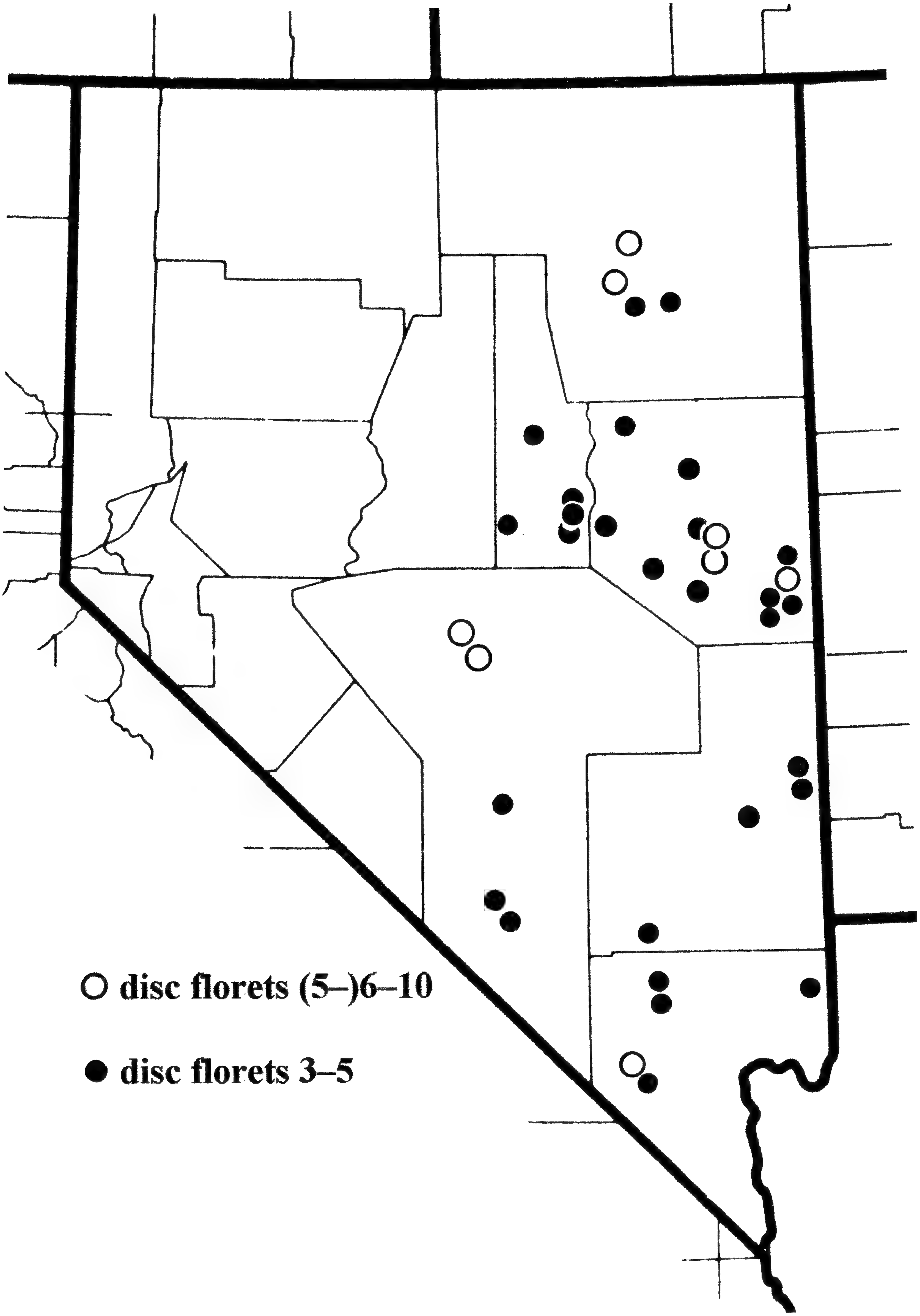

Fig. 3. Distribution of *Petradoria pumila* in Nevada. Plants with high numbers of disc florets per head occur in clusters along the western boundary of the species.

Chromosome number

Diploids and tetraploids have been reported within *Petradoria pumila* (Anderson 1963). Diploids are from Arizona, Nevada, and Utah; tetraploids are from Kane Co., Utah, and Coconino Co., Arizona. No morphological differences between diploids and tetraploids were reported by Anderson, nor do we observe any.

Taxonomy

Petradoria pumila var. pumila

Petradoria pumila (Nutt.) Greene, Erythea 3:13. 1895. *Chrysoma pumila* Nutt., Trans. Amer. Philos. Soc., n.s. 7:325. 1840. Type: U.S.A. [Idaho. Bear Lake Co.:] "In open situations, on shelving rocks toward the western declivity of the Rocky Mountains" [protologue], 1834, *T. Nuttall s.n.* (holotype: BM!, photo-US!). In June of 1834, Wyeth's expedition (with Nuttall as naturalist) was in Sweetwater Co., Wyoming, but slightly north of the known localities for *P. pumila*. After crossing the Green River, they continued to Ham's Fork in Lincoln Co., Wyoming (Graustein 1967). Leaving Ham's Fork in early July, they traveled northwestward into Bear Lake Co., Idaho, and continued toward Soda Springs in Caribou Co., where they stopped from 8–10 July. Because the leaf morphology of the type specimen is closely matched in recent collections from Bear Lake Co., we believe that Nuttall collected the type there, at the northernmost point of the range of the species, apparently the only place where he would have encountered it. Anderson (1963) also concluded that the type collection was made in "southeastern Idaho." In the description, Nuttall noted "Discal florets three; rays usually two."

Petradoria pumila var. *petiolaris* A. Nels., Bull. Torrey Bot. Club 26:482. 1899. Type: U.S.A. Wyoming. Sweetwater Co.: North Vermilion Creek, southern portion of the county, abundant on stony hillsides, growing with typical forms of the species, 17 Jul 1897, *A. Nelson 3581* (holotype: RM!; isotypes: BM!, BRY!, COLO!, GH!, MO!, NY!, UTC!). In the protologue, Nelson noted that "The narrow leaves and their much greater relative length give the variety a very different aspect, but I think the difference can hardly be considered specific." The MO isotype has 2 ray and 5 disc florets.

Petradoria pumila var. **graminea** (Woot. & Standl.) S.L. Welsh, Great Basin Naturalist 43:324. 1983. *Solidago graminea* (Woot. & Standl.) Blake, J. Washington Acad. Sci. 21:326. 1931. *Petradoria pumila subsp. graminea* (Woot. & Standl.) L.C. Anderson, Trans. Kansas Acad. Sci. 66:682. 1964. *Petradoria graminea* Woot. & Standl., Contr. U.S. Natl. Herb. 16:183. 1913. Type: U.S.A. New Mexico: "N. Mexico" [as on label], "northwestern New Mexico" [in protologue], 14 Jul 1883, *C.C. Marsh 209* (holotype: US!, internet image, photo-UC!). The type presumably was collected either in San Juan Co. or McKinley Co., New Mexico.

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THE IDENTITY OF CULTIVATED *PHELLODENDRON* (RUTACEAE) IN NORTH AMERICA

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ABSTRACT

The identity and cultivation of the two species of *Phellodendron* (Rutaceae) in North America are reviewed. *Phellodendron amurense* is known to have escaped and naturalized in North America, especially in the northeastern USA. *Phellodendron chinense* is cultivated in gardens and arboreta, but has not escaped or naturalized yet. The differences between the two recognized species are provided, and the variability of the bark is also discussed. In addition, representative accession records of the cultivated specimens of *Phellodendron* in gardens and arboreta are provided.

RESUMEN

Se revisa la identidad y cultivo de dos especies de *Phellodendron* (Rutaceae) en Norte América. *Phellodendron amurense* se sabe que ha escapado y se ha naturalizado en Norte América, especialmente en el noreste. *Phellodendron chinense* se cultiva en jardines y arboreta, pero aún no se ha escapado o naturalizado. Se aportan las diferencias entre las dos especies reconocidas, y también se discute la variabilidad de la corteza. Además, se aportan citas de accesiones representativas de especimenes cultivados de *Phellodendron* en jardines y arboretos.

INTRODUCTION

Phellodendron, Rutaceae, is a small genus of ornamental, deciduous trees, with only two species, endemic to East Asia (China, Japan, the Korean Peninsula and the Russian Far East, Ma et al. 2006) where the bark and oil from its fruit are used medicinally (Huang Bo). Nearly 150 years have passed since *Phellodendron* was first introduced to the West in 1850–1860 (Rehder 1940; Read 1974; Bean 1976). Nonetheless, the nomenclatural status of the genus, especially in the horticultural field, is still confused today (Dirr 1998). For this study, published records of cultivated species of the genus were reviewed, available specimens were examined, major characters in cultivated specimens were analyzed, and the status of the alien species of *Phellodendron* in North America was clarified.

HISTORICAL REVIEW

The genus *Phellodendron* was completely revised first by Sargent (1905) based on the specimens at A and GH, and the living collections at the Arnold Arboretum of Harvard University; and a total of three species was accepted with fine illustrations of *P. amurense* Rupr. (Manchuria; Mongolia; C China), *P. sachalinense* (F. Schmidt) Sargent (Korea; Hokkaido, Japan) and *P. japonicum* Maxim. (Japan; Hubei and Sichuan, China). Sargent's revision has been cited as the classical history of the genus. However, because not enough specimens from the native area were available to his study, Sargent could do no better than earlier researchers; and, in fact, he created further confusion by identifying specimens from central China as both *P. sachalinense* and *P. japonicum*, a later described species (see below). Sargent also raised *P. amurense* var. *sachalinense* F. Schmidt to specific status as *P. sachalinense* (F. Schmidt) Sargent because he believed that it differed from *P. amurense* Rupr. in the darker color of the branchlets; the thinner, not corky, bark; the rufous, rather than silvery pubescent, winter buds; the leaflets not lustrous adaxially and glabrous along the margins; and the glabrous inflorescences. The species, *P. sachalinense* (F. Schmidt) Sargent, however, was treated as a synonym of *P. amurense* Rupr. in the modern *Flora of Japan* (Ohwi 1984; Ohba 1999).

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In Rehder's Manual (Rehder 1940), an authoritative guide in the field of horticulture, five species of *Phellodendron* were recorded: *P. amurense* Rupr. from N China, Manchuria, introduced to North America in 1856, and cultivated in Hardiness Zone III; *P. sachalinense* (F. Schmidt) Sargent from Sghalin, Korea, N Japan, and W China, introduced to North America in 1877, and cultivated in Hardiness Zone III; *P. lavallei* Dode from C Japan, introduced to North America in 1862, and cultivated in Hardiness Zone V; *P. japonicum* Maxim. from C Japan, introduced to North America in 1863, and cultivated in Hardiness Zone IV; and *P. chinense* C. K. Schneid. from C China, introduced to North America in 1907, and cultivated in Hardiness Zone V. This work was completely adopted by another important horticultural manual (Bailey 1949), with fine illustrations of the leaves; and also adopted by the recent monumental work, *Garden Flora of Europe* (de Vries 1997). Based on these standard horticultural references for North America and Europe, different names have been used for living specimens in various gardens and arboreta, rather than the two names accepted here. Some were *P. piriforme* E.L. Wolf (e.g., Morton Arboretum record of 2004, #539-38, Arnold Arboretum Inventory of 2003, #1242-57 & 21607, Royal Botanic Gardens, Kew, Living Collection Database, #1938-13701, searched on March 28, 2003), which has never been effectively published (Ma et al. 2006), or *P. insulare* Nakai (e.g., Holden Arboretum Living Collection Database, #81-285, Royal Botanic Gardens, Kew, Living Collection Database, #1988-4479, searched on March 28, 2003, and Cornell Plantations Living Collections Database, #82-177, searched on March 25, 2004), which has never been accepted (Ma et al. 2006), or *P. lavallei* Dode (e.g., New York Botanical Garden Living Collections Database, #220/72, searched on March 27, 2004, Royal Botanical Garden Edinburgh Catalogue of Plants 2001, #19190039, Cornell Plantations Living Collections Database, #01-130, searched on March 25, 2004, Brooklyn Botanic Garden Living Collections Plant Inventory of 2004, #25008, 25009 & X00316, *The Plants of Pennsylvania*, Rhoads & Block 2000 and *Garden Flora of Europe*, de Vries 1997), which has never been accepted in its native flora of Japan (Ohba 1999) and worldwide revision (Ma et al. 2006). Some were even wrongly reported as *P. sachalinense* (Rhoads & Block 2000; McNamara and Pellett 2000 - the report, however, has been denied by the Junior author (Harold Pellett, pers. comm.). Pellett stated that "We do not have any *Phellodendron sachalinense* that we are confident of their identity. We think that the trees that we have in the Minnesota Arboretum are probably hybrids with *P. amurense* or some other species."

DIFFERENCES BETWEEN BARK OF NATIVE AND CULTIVATED TREES

There should not be much difference between the bark of the woody plants in cultivation and in their native habitats. However, this indeed happened in *P. chinense*. From measurements and observations of trees in their native habits, the two layers of bark of the two species could be easily distinguished (Ma et al. 2006): the outer bark of *P. amurense* is nearly 10 × (1.12/0.37 to 0.13/0.33) thicker than those of *P. chinense*. However in this study, all of the data of *P. chinense* from cultivated trees in northeastern North America are basically similar to those of *P. amurense* in its native habitat (see Table 1).

The ratio of outer to inter bark of *P. chinense* in cultivation is 1.56 to 0.92 (i.e., 1.7: 1), much larger than natural, wild populations (0.38: 1, Ma et al. 2006), approximately one half of the bark of *P. amurense* in wild (3.1: 1). Because *P. chinense* was from central and southwestern China where the weather is much warmer and wetter than the sites where it is in northeastern North America, the bark likely thickened in response to the colder temperatures, especially the outer layer, to protect the cambium. This indicates the plasticity of bark thickness of *P. chinense* in response to the environment (similar to Hedge et al. 1998s finding of variable bark thickness in response to disturbance in the western Ghats of India). However, no such change occurred in *P. amurense*, with its already thick, fissured bark (insulated from extreme temperatures, see Nikolai 1986) and grows in an area of East Asia, similar in climatic conditions to northeastern North America.

TAXONOMIC TREATMENT

Tree, deciduous, dioecious, 15–35 m high, 40–60(–100) cm in diam., usually with secretory cavities containing aromatic ethereal oils scattered throughout parenchymatous tissues. Bark corky, generally in two layers: phloem (inner part), yellow, usually thickened with age, and cork (outer part), gray, usually thickened, dark, deeply striped or fissured along main truck; lenticels white, slightly expanded on young branches; pith present, white or light brown to brown, round, continuous, sometimes spongy. Buds solitary, small, always hidden beneath leaf petiole, naked after leaves have fallen, pubescent, 2 per node, opposite. Leaf scars nearly encircling buds, 7–8 mm in diam., vascular bundle scars 3. Leaves odd-compound, opposite; estipulate; strongly aromatic, pellucid punctate along margin. Leaflets (7 or)9(or 11), mostly opposite, sometime alternate, or unequal at base; leaflet blade elliptic to ovate-oblong, symmetric, 21–32 × 13–16 cm, pilose when young or glabrous, but most becoming glabrous at maturity, base attenuate, sometimes slightly oblique, margin subentire or with minimal and fine serrulations not easily observed, apex acute or acuminate, sometime caudate, lateral veins pinnate, 6–11 pairs, mostly not prominent abaxially, curved forward to acute, again divided and disappearing before reaching margin; petiole 5.5–7.5 mm long. Inflorescences, a panicle 6.5–13.5 × 4.5–9 cm, loose or compact, nearly corymbose, terminal or opposite to young stem, with many flowers in several clusters, clusters opposite or nearly so; peduncle 4–8.5 cm long, without scales or pubescent, branching or not. Flowers: male: 5-merous, sepals 5, petals 5, stamens 5, anthers yellow, globose, ca. 1 mm long and in diam., 2-lobed, longitudinally dehiscent, disc small, around pistillode, pistillode clavate, white pubescent at apex; female: 5-merous, sepals 5, petals 5, staminode clavate; carpels 5, ovary 5-locular, ovule 1 per locule, style very short or nearly absent, stigma capitate, 5-lobed, much shorter than ovary, persistent. Fruit a drupe, black, 8–9.4 × 7.5–8.7 mm, subglobose, 5-locular, stone-like, glabrous, most with 5 grooves and angles when dry; fruiting pedicel ca. 0.4 mm long. Seed 1 per locule, brown, sometimes with black pits, ellipsoid, to 4.5 × 2.5–3 mm, slightly compressed, shiny; endosperm oily, cotyledons flattened, embryo straight; germination epigeal.

KEY TO THE SPECIES OF *PHELLODENDRON*

1. Panicle 8.5–13.5 × 6.5–9 cm, loose, peduncle 5–8.5 cm long, branches at least 1 cm long; tree, 25–35 m high (cultivated in North America, Europe, Australia, New Zealand, and northern Asia) ____________________ **1. P. amurense**
1. Panicle 6.5–9.5 × 4–6.5 cm, compact, peduncle 4–6 cm long, unbranched or nearly so; tree, 15–20(–25) m (cultivated in North America and Europe) ____________________ **2. P. chinense**

1. Phellodendron amurense Rupr., Bull. Cl. Phys.-Math. Acad. Imp. Sci. Saint-Petersbourg Ser. 2, 15:353. 1857.

Phellodendron amurense Rupr var. *angustifolum* E.L. Wolf, *P. amurense* var. *japonicum* (Maxim.) Ohwi, *P. amurense* Rupr var. *latifolium* E.L. Wolf, *P. amurense* var. *lavallei* (Dode) Sprague, *P. amurense* var. *molle* (Nakai) S.H. Li & S. Z. Liou, *P. amurense* f. *molle* (Nakai) Y.C. Zhu, *P. amurense* var. *sachalinense* F. Schmidt, *P. amurense* var. *wilsonii* (Hayata & Kaneh.) C.E. Chang.
Phellodendron insulare Nakai
Phellodendron japonicum Maxim.
Phellodendron kodamanum Makino
Phellodendron lavallei Dode
Phellodendron macrophyllum Dode
Phellodendron molle Nakai
Phellodendron nikkomontanum Makino
Phellodendron piriforme E. Wolf
Phellodendron sachalinense (F. Schmidt) Sargent, *P. sachalinense* Rupr. var. *suberosum* (H. Hara) H. Hara, *P. sachalinense* (F. Schmidt) Sarg. var. *suberosum* H. Hara
Phellodendron wilsonii Hayata & Kaneh.

Phellodendron amurense was introduced in the 1850s to the West (Rehder 1940). By 1874, it was cultivated at the then two-year-old Arnold Arboretum of Harvard University (Goodale 1877; Roca-Garcia 1970; Del Tredici 1995). Since then the tree has been reintroduced into the Arboretum many times from different countries (China, Japan, and Russia, especially 1900–1920s) until later years of the 20th century (Rehder 1940; Anonymous 1971). By 1910, the tree was cultivated both in Europe and in North America, at such

Table 1. Bark thickness of *P. chinense* cultivated in northeastern North America

Arboretum Name	Inventory No.	CR	OLB	ILB	Voucher*
Morton Arboretum	V57-55-30	230	2.8	1.5	*J.S. Ma 5101*
Morton Arboretum	V57-80-85	140	2.2	1.4	*J.S. Ma 5100*
Arnold Arboretum	6963-2A	132	0.8	0.5	*J.S. Ma 5116*
Arnold Arboretum	55-55C	203	1.2	0.6	*J.S. Ma 5117*
Dawes Arboretum	s.n.	138	0.8	0.6	*J.S. Ma 5107*
Average:		168.6	1.56	0.92	Ratio: 1.7: 1

*: CR: Circumference of trunk at DBH, OLB: outer layer of bark, ILB: inner layer of bark; all voucher specimens are deposited in BKL, all measurements are in cm.

places as Royal Botanical Garden Kew of England, Breslau, Poland, the USDA Bureau of Plant Industry, Glenn Dale, Maryland, the Arnold Arboretum, Massachusetts, and Cornell Plantations, New York. Among them, the Arnold Arboretum played a very important role for redistributing the species, especially in North America. By the 1930s, it had been collected from California, Michigan, New York (Grier and Grier 1928), Ohio, Pennsylvania, Washington D.C. and Canada, and now, it is widely planted in more than 20 states within the USA (USDA Hardiness Zone 3–7(–8); Schopmeyer 1974; Dirr 1998; Hensley et al. 1991; Jacobson 1996; also see Fig. 1). Gardens and arboreta in Russia also played a very important role in the spread into European gardens and arboreta, nurseries, and parks (Bean 1976).

Because *P. amurense* recently has been considered an invasive alien in northeastern North America (Hao et al 2004; Glaeser & Kincaid 2005; Invasive Species Initiative 2005; Invasivespecies.gov 2005), some cultivated plants have been removed, e.g., at Dawes Arboretum, all female trees had been cut down when the author visited in spring 2004). This kind of action, however, may go too far because the species has only escaped and become naturalized in only a few places in northeastern North America (http://plants.usda.gov/), around the vicinity of gardens, arboreta, or parks in urban areas, or along residential roadsides where they were planted, e.g., in New York City (Anonymous 1991; Anonymous 1995; Glaeser & Kincaid 2005). Among the specimens examined for this study, all were collected in residential areas or urban habitats even though it was reported as becoming invasive in the larger New York Metropolitan area (Greller 1977; Greller & Calhoon 1979; Mitchell 1999; 2001; Lamont & Young 2002; Glaeser 2005; Glaeser & Kincaid 2005), e.g., New York Botanical Garden (Cruz & Nee 2003; Small & Alexander 1933) and Forest Park, Queens Co., New York City (Anonymous 1961). Although, seeds of *P. amurense* possibly require a dormant period for germination (Starshova 1979; Zhu & Dong 1990; Mizui & Kikuzawa 1991; but see Read 1974), there are no reports about this from the natural areas in northeastern North America. Therefore, it cannot be treated as an invasive species if we accept recent concepts of naturalization and invasion of alien plants (Richardson et al. 2000; Pysek et al. 2004). Furthermore, there has been no damage reported to the native flora even though the potential exists for *P. amurense* to become an invasive in the future, especially in northeastern North America (Massachusetts Invasive Plants List 2005).

Original distribution.—Mixed forests, below 2500 m: China (Beijing, Hebei, Heilongjiang, Jilin, Liaoning, Nei Mongol, Shandong, Taiwan: 2,000–2,700 m), Japan, Korea, and the Russian Far East.

Cultivated distribution.—**CANADA:** British Columbia, Ontario. **USA:** California, Colorado, Connecticut, Delaware, Georgia, Illinois, Indiana, Kansas, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Tennessee, Virginia, Washington, Washington DC; also in Australia, Belgium, the Czech Republic and Slovakia, Denmark, England, Estonia, Finland, France, Germany, Hungary, Ireland, the Netherlands, New Zealand, Norway, Poland, Russia, Scotland, and Spain.

Cultivated specimens studied: **CANADA. BRITISH COLUMBIA. Vancouver:** Elizabeth Park, 14 Jun 1988, *G.B. Straley 4809* (MOR, NA). **ONTARIO. Ottawa:** Central Experimental Farm Campus of Brockport, 8 Jun 1974, *W.I. Illman cco19082* (NYS); Dominion Arbo-

Fig. 1. Map of cultivated collections of *Phellodendron amurense* in North America.

retum and Botanic Garden, #120646, 10 Jul 1939, *J.M. Gillett X-2-257* (NA), 29 Aug 1939, fruit, *G.H.M. Lawrence 778* (BH); 10 Jul 1939, *H.A. Senn 1940* (BH).

U. S. A.: **CALIFORNIA. San Francisco Co.:** Golden State Park, 20 May 1933, *E. Walther s.n.* (A); University of California Davis, 2 Aug 1972, *H. Fong s.n.* (CM). **CONNECTICUT. Fairfield Co.:** Hill Road, 9 Apr & 20 Aug 1941, flower & fruit, *E.H. Eames s.n.* (CONN); Sherman, Turner Mt., Caretakes's Lodge, 28 Jun 1989, *M. Ardwin s.n.* (CONN); **Litchfield Co.:** Salisbury Southeast side of Prospect Mt., 23 May 1985, *L.J. Mehrhoff 11350* (CONN); 10 Oct 1985, fruit, *11792* (CONN). **Tolland Co.:** Storrs, Mountain Road and Rte 44, 20 Oct 1999, fruit, *B.A. Connolly 42* (CONN); 23 May 1969, *M. Lefor & F.H. Wolfe 647* (BH, MASS). **DELAWARE. New Castle Co.:** Greenville, Cuba Botanical Park, 6 Jun 1968, *Cuba Botanical Park Herbarium 115* (A, K). **GEORGIA. Cherokee Co.:** Reinhardt College Campus, 4 Jun 1983, *F.G. Meyer & P.M. Mazzeo 19708* (A, CM, MOR, NA). **ILLINOIS. Champaign Co.:** 31 Aug 1970, *R.A. Evers 103534* (A), 18 Oct 1998, fruit; *S.R. Hill 31181* (NY); 17 May 1972, *B. Nelson, B. Little & C. Crist 602* (A). **Cook Co.:** 9 Jul 1983, fruit, *L. Nee, 27451* (F). **DuPage Co.:** Lisle, Morton Arboretum, 15 Jun 1995, *K. Altvatter & J. Hammond 7115V95* (F); 19 Jun 1995, fruit, *7134V95* (F, seed from Botanischer Garten und Botanisches Museum Berlin-Dahlem, Berlin); 11 Oct 1994, fruit, *B.K. Altvatter & P. Steinhouse 6901V94*, 358-25 (F, seed from Arnold Arboretum); 3 Aug 2001, *W. Hess & K. Allen 9688* (F, NY); 18 Jun 1997, *G. Hickman & J. Pinkard 7926V97* (NA); 9 Jul 1998, *S.K. DeMink s.n.* (F); 10 Oct 1998, fruit, thick cork bark, *R.D. Hyerczyk 1598* (MOR); 10 Oct 1998, fruit, *1601* (NA); 7 Sep 1998, *D.S. Kirt 475-32* (NA); *S.N. Kobal 95-14* (MOR); 7 Aug 1987, *F.A. Swink 7406* (MOR); 30 Sep 1992, *G. Wilhelm s.n.* (MOR); Will, Pilcher Park-Joliet Park District, 10 Oct 1998, fruit, *R.D. Hyerczyk 1601* (MOR). **INDIANA. Monroe Co.:** Bloomington, Indiana University Campus, 29 Jul 1949, fruit, *R.B. Ledin s.n.* (CONN). **MARYLAND. Baltimore Co.:** Carroll Park, 15 May 1979, *F.G. Meyer & R. Fisher 17479* (NA); 15 May 1979, *17480* (A); Charles, Bryans Farm, 27 Sep 1975, fruit, *F.G. Meyer 15282* (NA); 3 Jul 2000, fruit, *B.W. Steury 7036* (NA). **Prince George's Co.:** Glenn Dale, USDA Bureau of Plant Industry, 20 Sep 1906, *I. Tidestrom 1805* (NA). **Montgomery Co.:** Silver Spring, 11 Aug 1975, *F.G. Meyer & P.M. Mazzeo 15262* (NA). **MASSACHUSETTS. Hampshire Co.:** Amherst, University of Mass., 18 Sep 1966, fruit, *H.E. Ahles 64704* (MASS 2 sheets); 1 Jul 1969, fruit, *A.C. Gibson 965* (A); *S.R. Hill 16999* (NY); 12 Oct 1940, *R.E. Torrey s.n.* (MASS); 8 Jun 1945, *s.n.* (MASS); 29 Aug 1946, fruit, *s.n.* (GH, MASS); 6 Jun 1951, *R.E. Torrey & E. Putala s.n.* (MASS); Holyoke

Range, South Hadley, 12 Sep 1999, *K.B. Searcy 52* (MASS); Northampton, Smith College, 21 May 1969, *A.C. Gibson 362* (A), Reading, Jun 1879, *W.H. Manning s.n.* (BH). **Norfolk Co.:** Brookline, 1 Sep 1965, *Baldini s.n.* (A 2 sheets). **Suffolk Co.:** Jamaica Plain, Arnold Arboretum, 16 Jun 1960, fruit, *B.K. Boom 40329* (L, from Japan in 1905); 16 Jun 1960, *40331* (L, collected by Wilson from Japan in 1919); 16 Jun 1960, *40332* (L); 16 Jun 1960, fruit, *40338* (L), 27 Jun 1917, *H.H. Chung 5251* (PE 2 sheets); 23 Oct 1979, fruit, *K. Clausen, S. Davis, C. Warren & M. Awolcott 79168* (BM); 20 Aug 1904, fruit, *E.J. Cole s.n.* (A, MICH); 8 Jun 1980, *S. Davis, C. Warren & M. Wolcott 80-201-B* (BH, F, PE, raised from seed of *Wilson 11263*, 17 Feb 1919 from Japan); 9 Jun 1982, fruit, *S. Davis et al. 558* (A, BH, F, from Arnold Arboretum #7544-C, seed from J. G. Jack, Azuma, Japan, 15, Dec 1905); 15 Sep 1982, fruit, *S. Davis & M. Wolcott 566* (A, BM, BH, F, from Arnold Arboretum #7544-C, seed from J. G. Jack, Azuma, Japan, 15, Dec 1905); 18 Aug 1960, fruit, *T.R. Dudley s.n.* (A); 10 Aug 1984, fruit, *S. Elsik, B. Mackenzie, A. Kosmidis, & L. Stockman 1655* (A, BH, Arnold Arboretum #646-66-A); 30 May 1986, *4269* (A, BH, Arnold Arboretum #401-56-A); 30 May 1986, *4270* (A, BH); 30 May 1986, *4280* (A, BH, Arnold Arboretum #13232-B); 25 Jun 1969, fruit, *A.C. Gibson 868* (A, Arnold Arboretum #12202-1-B); 25 Jun 1969, fruit, *869* (A, Arnold Arboretum #13232-A); 25 Jun 1969, fruit, *870* (A, Arnold Arboretum 13232-B); 25 Jun 1969, fruit, *873* (A, Arnold Arboretum #7544-c, from J. Jack 1905, Japan); 5 Sep 1985, fruit, *S. Elsik, G. Good & K, Groves 3407* (A, Arnold Arboretum #362-54-A, seed from Japan in 1952); 5 Sep 1985, *3417* (A 2 sheets, Arnold Arboretum #1242-57-A); 21 Oct 1986, fruit, *S. Elsik & R. Zinman 4866* (A, Arnold Arboretum #646-66-B, from *J.G. Jack s.n.* 3 Nov 1919); 18 Jul 1913 & 17 Oct 1920, *C. Schneider 142-15* (BKL 2 sheets); 15 Nov 1908, fruit, *143-17* (BKL); 17 Oct 1915, fruit, *4961-1* (BKL); 17 Oct 1918, *s.n.* (BKL); 18 May 1926, *s.n.* (BKL); 15 Sep 1930, fruit, *s.n.* (BKL); 15 Sep 1922, *H. Teuscher s.n.* (A 8 sheets, MOR, #143-6 from Bot. Garden Petersb. in 1874); 18 Jul 1914, fruit, *L.G. Hornby s.n.* (MICH); 7 Jun 1927, *N. Judd s.n.* (A, Arnold Arboretum #1008-26); 9 Sep 1931, *Kobuski & Ronsh s. n.* (A 2 sheets, Arnold Arboretum #150-28, from 143-6, 1928); 8 Sep 1931, *s.n.* (A, Arnold Arboretum #1008-26, 2nd exp. Farrie, 1926); 4 Sep 1985, *D. Michener & S. Elisk 3403* (A, BH, Arnold Arboretum #389-68-A); 3 Jun 1936, *E.J. P. s.n.* (A, BH, Arnold Arboretum #143-9-B), Jun 1937, *s.n.* (A, MOR, Arnold Arboretum #7544, seed from J. G. Jack in Azuma, Japan, 1905); 3 Jun 1936, *s.n.* (A, BH, MOR, from #21607-A, seed of Bot. Inst., Leningrad, USSR in 1926); 17 Sep 1936, fruit, *s.n.* (A 4 sheets, MOR, from #12202-1, Grafted from #12202, Arnold Arboretum in. 1919); 17 Sep 1936, fruit, *s.n.* (A, #19480-D, seed from Bot. Gard., Muenchen, Germany in 1925); 17 Sep 1936, fruit, *s.n.* (A, #19481-C, seed from L. Spath, Berlin, Germany); *E.H. Wilson 876* (A); 11 May 1904, *C.S. Sargent s.n.* (A); 6 Jun 1973, *L. Segal & A. Thompson 71* (A, Arnold Arboretum #12202-1-A); 5 Oct 1922, *H. Teuscher s.n.* (MOR, Arnold Arboretum #10724, *E.H. Wilson 11263*, seed collected by Wilson, from Taiwan (Formosa) in 1919); 29 May 1986, *R. Zinman & J. Carey 4264* (A, BH, Arnold Arboretum #1244-57-A); Somerville, Tufts University Campus, 5 Aug 1998, fruit, *NHN/EGM/APC s.n.* (CONN); Wellesley, 2 Aug 1972, fruit, *S.A. Spongberg & H. Clement 72-51* (A, BM). **MICHIGAN. Washtenaw Co.:** Ann Arbor, University of Michigan Arboretum, 7 Oct 1931, fruit, *J.H. Ehlers 4999* (MICH). **Clinton Co.:** East Lansing, Michigan State University Campus, 8 Jun 1979, *W.T. Gillis 15109* (CONN). **MISSOURI. Boone Co.:** Columbia, Missouri University Campus, Summer 1960, fruit, *W. Campbell s.n.* (MOR). **St. Louis Co.:** St. Louis, Missouri Botanical Garden, 21 Aug 1989, fruit, *M.T. Crosby 84* (TI, #U-5780); 26 Jul 1974, fruit, *J. Slama 38* (A, BH). **NEW YORK. Bronx Co.:** Bronx, New York Botanical Garden, 1937, *L. Croizat s.n.* (NY 5 sheets); 11 Jul 1923, fruit, *A.S. Foster s.n.* (BH); 1909, fruit, *H. Hallier s.n.* (L); 26 Jul 1929, *H. Moldenke 4926* (NY); 16 Aug 1995, fruit, *C. Morenberg 115* (NY); 30 Aug 1980, fruit, *S. Mori 13639* (NY); 29 May 1994, *23700* (NY); 5 Jul 1993, fruit, *M. Nee 43585* (BH, NY); 30 Sep 2003, fruit, *52592* (NY); 3 Oct 2003, fruit, *52593* (NY); 4 Oct 2003, fruit, *52594* (NY); 5 Oct 2003, fruit, *52595* (NY); 8 Oct 2003, fruit, *52596* (NY); 10 Oct 2003, fruit, *52597* (NY); 10 Oct 2003, fruit, *52598* (NY); 11 Oct 2003, fruit, *52599* (NY); 11 Oct 2003, fruit, *52600* (NY); 13 Oct 2003, fruit, *52601* (NY); 13 Oct 2003, fruit, *52602* (NY); 23 Sep 2003, fruit, *52950* (NY); 18 Jun 1931, fruit, *P. Wilson s.n.* (NY). **Kings Co.:** Brooklyn, Brooklyn Botanic Garden, 6 Aug, 1979, fruit, *T.J. Delendick s.n.* (BKL); 25 May 1982, fruit, *s.n.* (BKL 5 sheets); 25 May 1982, *s.n.* (BKL 3 sheets); 26 May 1982, *s.n.* (BKL 2 sheets); 26 May 1982, *s.n.* (BKL 6 sheets); 26 May 1982, *s.n.* (BKL 5 sheets). **Nassau Co.:** 8 Jul 1997, *S.D. Glenn 2777* (BKL, NYS); 25 Aug 1995, *D. Kunstler s.n.* (BKL). **Ontario Co.:** Geneva, New York Agricultural Experimental Station, 19 Aug 1921, fruit, *F. Blank s.n.* (BH). **New York Co.:** Central Park, 12 Sept 1914, *E.B. Jaultiruck s.n.* (BKL 2 sheets). **Orange Co.:** Sterling Forest, 5 Jul 2000, fruit, *R.S. Mitchell 10751* (BKL); fruit, 11 Sep 2004, *G. Moore, T. Delius & J.S. Ma 6864* (CONN); Scarboro, 31 Nov 1895, fruit, *W.H. Manning s.n.* (BH). **Somerset Co.:** 25 May 2000, *S.D. Glenn 4161* (BKL). **Suffolk Co.:** Islip, along LIRR, 27 Jul 1994, *S.D. Glenn 48* (BKL). **Tompkins Co.:** Ithaca, Cornell University Plantation, 7 Oct 1946, fruit, *M.W. Allen s.n.* (BH 2 sheets); 23 Jun 1890, fruit, *L.H. Bailey s.n.* (BH); May 1985, fruit, *H. Banks s.n.* (BH); 9 Oct 1941, *S.H. Burnham s.n.* (BH 2 sheets); 24 Oct 1940, fruit, *J. Comman s.n.* (BH 2 sheets); 16 Jun 1904, *J.E. Coit s.n.* (BH) & fruit, 25 Aug 1904, *s.n.* (BH); 24 Aug 1952, fruit, *A.J. Eames s.n.* (BH); Summer 1946, fruit, *A. Schulze s.n.* (NYS). **Westchester Co.:** Yonkers, 20 Jun 1938, seedling, *H.N. Moldenke 10600* (BH, NY). **NORTH CAROLINA. Buncombe Co.:** Biltmore, 19 Jul 1894, *W.H. Manning s.n.* (BH); 27 May & 2 Aug 1898, flower and fruit, *S. P. 7086* (F, NY). **OHIO. Butler Co.:** Oxford, 27 May 1993, *M.A. Vincent 5894* (NA). **Hamilton Co.:** Cincinnati, Mt. Airy Forest Park, 10 Oct 1934, fruit, *E.G. Hutchinson s.n.* (BH). **Cuyahoga Co.:** Cleveland, Gordon Park, 5 Jun 2000, *G. Wilder & M. McCombs 13672* (MICH). **Franklin Co.:** Columbus, Ohio State University, 10 May 1967, *J.F. Cooke & R.L. Stuckey s.n.* (A, NA). **OREGON. Ravalli Co.:** Corvallis, Oregon State University, 3 Jun 1968, *J. Dennis 2931* (A). **PENNSYLVANIA. Allegheny Co.:** Pittsburgh, Highland Park, 26 Jun 1961, *M. Armbruster s.n.* (CM); 17 May 2002, *B.L. Isaac & J.A. Isaac 14339* (CM 2 sheets); 14 Oct 1973, *V. Phelps, s.n.* (CM); 27 Aug 1937, *R.J. Templeton & J.R. Steck s.n.* (CM); Pittsburgh, 17 May 2002, *A. Rhoads s.n.* (MOAR); 24 Oct 2004, *s.n.* (MOAR). **Berks Co.:** 14 Jun 1968, fruit, *W.C. Brumbach 6262* (A); 14 Jun 1968, fruit, *6271* (A); 22 May 1969, *6763* (A, NA, NY); 11 Aug 1971, fruit, *7644* (A, NY). **Bucks Co.:** 12 Aug 1998, *A.F. Rhoads & T.A. Block s.n.* (MOAR); 6 Aug 1980, fruit, *A.E. Schuyler 5481* (PH). **Delaware Co.:** Haverford College, 17 May 1942, *P.T. Haas s.n.* (PH); 28 Aug 1995, fruit, 28 Jul 1941, *s.n.* (BKL, PH); 11 Oct 1933, *E.J. P. s.n.* (A, Arnold Arboretum #972-34). **Lancaster Co.:** Elizabeth, 16 Jul 1930, *E.M. Gress s.n.* (PH). **Leigh Co.:** Allentown, 26 May 1956, *R.L. Schaeffer, Jr. 50574* (PH); 22 May 1959, *s.n.* (PH). **Mercer Co.:** 31 Aug 1967, *J.M. Fogg s.n.* (MOR); 11 Jul 1968, fruit, *s.n.* (A); 26 May 1970, *s.n.* (A); 12 May 1973, *S.A. & H. Spongberg 73-*

220 (A, BM). **Montgomery Co.:** Melrose Park, 15 Jul 1937, *C.G. Armstrong s.n.* (PH); 20 Aug 1971, fruit, *J.M. Fogg s.n.* (NY); *B. Long 39270* (PH); 29 Jun 1970, Merion, Arboretum of Barnes Foundation, 11 Jun 1980, fruit, *J.M. Fogg s.n.* (MOR); *L.K. Henry s.n.* (CM); 19 Feb 1933, Fort Washington Park, *A. Zakyzewski & T. Livshultz s.n.* (PH). **Philadelphia Co.:** Morris Arboretum, 27 Oct 1967, *J.M. Fogg, Jr. s.n.* (MOAR, #55-14); 12 Nov 1932, fruit, *without collector 969* (MOAR 3 sheets); 1 Jun 1933, *1712* (MOAR 2 sheets); 24 May 1934, *2681* (MOAR); Philadelphia, Lakeside Avenue, 26 Jul 1950, *B. Long 71831* (PH). **Northumberland Co.:** Snyder, 27 Sep 1927, *H.N. Moldenke 3551* (NY). **Westmoreland Co.:** Greensburg, 1952, *C.W. Kalbfus s.n.* (CM). **TENNESSEE. Knox Co.:** Knoxville, Agriculture Campus, University of Tennessee, 13 Jun 1972, fruit, *P.M. Mazzeo & F.G. Meyer 12858* (MOR, NA); formerly Sanford Arboretum (now property of W. E. Fleury, 3425 Lakeview Dr.), 15 Jun 1972, fruit, *P.M. Mazzeo & P.G. Meyer 12913* (MOR, NA). **Franklin Co.:** Winchester, Shadow Nursery, RRI, 6 Jun 1983, *F.G. Meyer & P.M. Mazzeo 19765* (CM, MOR, NA). **VIRGINIA. Clarke Co.:** Boyce, 25 May 1970, O. E. White Arboretum, *F.G. Meyer & P.M. Mazzeo 12430* (NA); Richmond, 11 Jun 1974, fruit, *B.F. Kiltz 540* (NA). **WASHINGTON. King Co.:** Seattle, Washington Park Arboretum, 30 May 1991, *J. Canary 94* (NA); 17 Oct 1991, *C. Bates 30* (NA). **WASHINGTON, D.C.:** Library of Congress Grounds, Aug 1931, fruit, *E.H. Walker 1737* (NA); White House, South Grounds, 22 May 1980, *F.G. Meyer & P.M. Mazzeo 17804* (MOR, NA); National Arboretum, 20 Jun 1994, fruit, *F.G. Meyer & P.M. Mazzeo 17804* (NA); Tidal Basin, 10 Jun 1977, *F.G. Meyer & H. Wester 15918* (MOR); Soldier's Home, University of America, 1938, fruit, *F. Baeehle s.n.* (NA). **WISCONSIN. Dane Co.:** Madison, 13 Aug 1986, fruit, *M. Nee 20818* (NY).

2. Phellodendron chinense C.K. Schneid., Ill. Handb. Laubholzk. 2:126, fig. 79 c–d, 1907.

Phellodendron amurense f. *longipes* Y.C. Wu
Phellodendron chinense var. *falcatum* Huang, *P. chinense* var. *glabriusculum* C.K. Schneid., *P. chinense* var. *omeiense* Huang, *P. chinense* var. yunnanense Huang
Phellodendron fargesii Dode
Phellodendron sinense Dode
Phellodendron sinii Y.C. Wu

Phellodendron chinense was introduced into North America much later, approximately 100 years after it was described in 1907, and much of its introduction to North America as well as to Europe was based on E. H. Wilson's collections from central and southwest China a century ago (Roca-Garcia 1970). This species, however, has not been as popular as *P. amurense*, but cultivated in the gardens and arboreta in Hardiness Zone V (Rehder 1940). It has never been reported as escaped or naturalized.

Original distribution.—Mixed forests, below 2000 m: China (?Anhui, ?Fujian, ?Guangdong, ?Guangxi, ?Guizhou, Hubei, Hunan, ?Jiangsu, ?Jiangxi, Shaanxi, Sichuan, Yunnan, ?Zhejiang. Since the species has been longtime cultivated or naturalized in some places (with "?" before the province) in China, their native distributions or cultivation cannot be obtained with certainty.

Cultivated distribution.—**CANADA:** Ontario. **USA:** Colorado, Massachusetts, New York, Pennsylvania; also in Belgium, England, Germany, Hungary, Ireland, Italy, and Scotland.

Cultivated specimens studied: **U.S.A. MASSACHUSETTS. Suffolk Co.:** Jamaica Plain, Arnold Arboretum, 9 Jun 1982, *K. Clausen, S. Davis, C. Warren & M. Awolcott 557* (A, BH, BM, Arnold Arboretum #6963-2-A); 23 Oct 1979, fruit, *79-168* (A, BH, Arnold Arboretum #6963, seed of *Wilson 161*); 23 Oct 1979, *S. Davis, C. Warren & M. Wolcott 79-168* (F, Arnold Arboretum #6963, from seed of *Wilson 161* in Changyang Hsien, W. Hupeh, China, Feb. 1908, tree, 50'); 9 Jun 1982, *S. Davis et al. 557* (A, Arnold Arboretum #6963-2-A, seed from Wilson, Changyang Hsien, W. Hupeh, China, Feb. 1908); 25 Jun 1969, fruit *S. Elsik, B. Mackenzie, A. Kosmidis, & L. Stockman 871* [A, Arnold Arboretum #7245); 25 Jun 1969, fruit, *874* (A, Arnold Arboretum #6963-A), 5 Sep 1985, fruit, *S. Elsik, G. Good & K, Groves 3416* (A, BH, Arnold Arboretum #6963-2-A); 16 Jun 1939, *E.J. P. s.n.* (A, Arnold Arboretum #6963-1-A); 16 Jun 1892, *R. Rehder s.n.* (A 3 sheets); 5 Nov 1917, fruit, *s.n.* (A 2 sheets, Arnold Arboretum #6963); 15 Oct 1917 & 5 Nov 1917, fruit, *s.n.* (A 2 sheets, Arnold Arboretum #7425); 6 Jun 1918, *s.n.* (A, Arnold Arboretum #7245); 17 Sep 1918, *C.K. Schneider 161* (BKL); 18 Sep 1918, fruit, *876* (BKL) & 17 Oct 1920, fruit (BKL, from Arnold Arboretum #6963). **NEW YORK. Bronx Co.:** Bronx, New York Botanical Garden, 25 Sep 1922, fruit, *L.H. Bailey s. n.* (BH). **Tompkins Co.:** Ithaca, Cornell University Plantation, 27 Sep 1995, fruit, *G.M. Elston 96-3* (BH). **PENNSYLVANIA. Mercer Co.:** Arboretum of Barnes Foundation, 31 Aug 1967, *J.M. Fogg Jr. s.n.* (BKL); 7 Sep 1970, fruit, *s.n.* (A, BH). **Philadelphia Co.:** Morris Arboretum, 15 Sep 1959, fruit, *J.M. Fogg, Jr. s.n.* (MOAR); 14 Mar 1933, fruit, without collector *1351* (MOAR 2 sheets).

ACKNOWLEDGMENTS

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BOOK REVIEWS

JEFF LOWENFELS and WAYNE LEWIS. 2006. **Teaming with Microbes: A Gardener's Guide to the Soil Food Web.** (ISBN 0-88192-775-5, hbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax). $24.95, 196 pp., 74 color photos, 1 color illustration, 17 diagrams, 6" × 9".

The new book entitled *Teaming with Microbes* by authors Lowenfels and Lewis is a fantastic resource. These authors have presented soil science and the soil food web in a completely understandable way. The interweaving of photographs, drawings and the easy reading style make this a very readable text for anyone with an interest. Gardeners especially will benefit from reading this book; they will come away with a comfortable (and applicable) understanding of the soil food web in relationship to their gardens and lawns.

The book is separated into two parts: basic science and applications. The first part of the book creates a terrific foundation for all the parts of the soil food web by using explanations of soil profiles, textures, pH, and providing readers with descriptions of various soil inhabitants from the bottom of the web up. There is a chapter dedicated to bacteria, fungi, algae, slime molds, protozoa, nematodes, arthropods, worms, gastropods, and reptiles, mammals and birds. Within each of these chapters on soil inhabitants' information, the authors provide what each are, how they act within the soil web, and how these organisms contribute to nutrient cycling. The authors focus a good bit of time and provide substantial information on both bacteria and fungi as is warranted based on the importance of these organisms in the soil food web.

The second part of the book focuses on helping the reader apply his/her newfound soil information to creating a healthy soil food web in their lawns and gardens. The authors demonstrate these applications via the use of nineteen separate rules, all of which are integrated into the remaining eleven chapters. For instance, rule number two states that "Most vegetables, annuals and grasses prefer their nitrogen in nitrate form and do best in bacterially dominated soils." Rule three relates to trees, shrubs and perennials preferring fungal dominated soil and nitrogen in a form other than nitrate. These rules are interspersed into the explanations of each application and are also presented in a succinct list form in the appendix. This application section of the book includes chapters on …how soil food webs apply to gardening, tools for restoring soil food webs, use of compost, mulch and compost teas, maintenance of trees and other perennials, and growing annuals and lawns. There is also a brief chapter with seasonal activities to promote a healthy soil food web.

Teaming With Microbes is an outstanding book for those gardeners interested in a solid understanding of how to create a healthy lawn and garden. This book would also be a beneficial read for horticulturists, soil and turf science students, agronomists, or any other interested readers. Authors Lowenfels and Lewis have done a superb job of making soil science and soil food webs understandable; they even provide resource sections for readers whom have further interests in the subjects covered. Definitely a recommended read!!—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

DAVID TAYLOR (ed.). 2006. **Pride of Place: A Contemporary Anthology of Texas Nature Writing** (ISBN 13: 978-1-57441-208-6, pbk.). University of North Texas Press, P.O. Box 311336, Denton, TX, 76203-1336, U.S.A. (**Orders:** www.unt.edu/untpress, 800-826-8911, 940-565-2142, 940-565-4590 fax). $16.95, 214 pp., b/w photos, 6" × 9".

The larger-than-usual type size in *Pride of Place* seems apt for this collection of essays about larger-than-life Texas. David Taylor, a professor and Honors Advisor at the University of North Texas, has assembled a group of some of the best Texas writers to put pen to paper in this delightful contemporary anthology. Taylor hastens to say in the introduction that what binds Texans together is pride, not geography. And pride of place is what binds together these essays. After all, "It ain't braggin' if it's true."

Beginning with Roy Bedichek's "Still Water," it includes Carol Cullar and Barbara "Barney" Nelson on the Rio Grande region of West Texas, John Graves's evocative "Kindred Spirits" on Central Texas, Joe Nick Patoski's celebration of Hill Country springs, Pete Gunter on the Piney Woods, David Taylor himself on North Texas, Gary Clark and Gerald Thurmond on the Coastal Plains, Ray Gonzles and Marian Haddad on El Paso, Stephen Harrigan and Wyman Meinzer on West Texas, and Naomi Shihab Nye on urban San Antonio.

If you're not from Texas, you'll "get it" after reading this book. If you are from Texas, reading this is like being a kid on the front porch of a summer evening, listening to the grownups spin their tales.

Texas truly is a "State of Mind," as the old song goes. This anthology reflects that, and *Pride of Place* will be a proud addition to the Texas section of this reviewer's bookshelf.—*Penny McCook, Volunteer, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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NOTES ON *LECHEA MARITIMA* VAR. *VIRGINICA* (CISTACEAE)

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ABSTRACT

We assess variation within *Lechea maritima* and provide a key to infraspecific taxa. Specimen citations document the range of *L. maritima* var. *virginica*.

RESUMEN

Se valora la variación en *Lechea maritima* y se aporta una clave de taxa infraspecíficos. Las citas de especímenes documentan el área *L. maritima* var. *virginica*.

Lechea maritima Legg. var. *virginica* Hodgdon is restricted to maritime sands, historically known from coastal Virginia including the southern Delmarva Peninsula (Hodgdon 1938). In recent years, botanists have discovered var. *virginica* in adjacent states (see specimens cited below). To better understand and evaluate the status of var. *virginica*, we examined over 80 specimens from throughout the range of *L. maritima* housed at NCSC, NCU, VPI, and WILLI. Specimens at NCU and VPI were annotated in 1984 by D. Lemke to *Lechea maritima* without varietial designation. In their analysis of the genus in the southeastern United States, Wilbur & Daoud (1961) omitted *L. maritima*, because at that time it was not known from their area of coverage. For an excellent description of the nominate variety, see Barringer (2004).

IDENTIFICATION AND KEY

We found that plants of var. *virginica* are generally more robust than those of var. *maritima*, with notably thicker stems. Hodgdon (1938) suggested that the main above-ground stems of var. *virginica* may be perennial, but this has not been verified. Measurements of stem thickness indicate that those of var. *virginica* (2.0–4.0 mm) are significantly wider than those of the nominate variety (1.0–2.5 mm), which suggests that southern plants may well be perennial. Whereas stems of var. *maritima* usually are strongly ascending and tend to have inflorescence branches along both sides, stems of var. *virginica* usually are weakly ascending to procumbent and tend to have inflorescence branches along one side.

Seed number and shape are the most consistently reliable characters that we tested; the great majority of specimens had seeds of only one type. We rarely found capsules of var. *virginica* to contain more than two seeds, whereas capsules of var. *maritima* contain three or four seeds, never two. One specimen at NCU (*Windler 3279*, Assateague Island, Worcester County, Maryland) had three seeds in most capsules, each seed more-or-less three-sided but mildly concave ventrally. This same specimen also had a few capsules with two seeds, also three-sided but strongly concave ventrally. Otherwise, this specimen resembled var. *virginica* in its robust size, stem 2.7 mm in diameter, and dull brown sepals. A second specimen at NCU (*Ahles 57756*, north of Fenwick Beach, Sussex County, Delaware) has some capsules with three seeds and some with two; otherwise the plants match var. *virginica*. Thus, near the range limits of the two varieties of *L. maritima*, one may expect to encounter specimens that show evidence of hybridization. Hodgdon included measurements of seed length in his key; we did not evaluate this character. Sepal color exhibits tendencies (tinged maroon northward, dull brown southward), but is difficult to apply consistently due to variation.

Hodgdon's key works reasonably well in separating var. *virginica* from var. *maritima*, but there is significant overlap in his vegetative characters, so we have de-emphasized them. We include a modified key here in which seed number, seed shape, and stem width are stressed.

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1 Seeds 3–4(–5), weakly 3-sided and more-or-less resembling sections of an orange, or 2-sided and convex ventrally; main stems 1.0–2.5 mm diameter, strongly ascending-erect to subprocumbent; sepals strongly tinged maroon, occasionally dull brown; southern Maine to Delaware ____ var. **maritima**

1 Seeds 2(–3), 2-sided and flattish, concave ventrally; main stems 2.0–4.0 mm diameter, procumbent to ascending; sepals dull brown, occasionally tinged maroon; southeastern Delaware to northeastern North Carolina ____ var. **virginica**

DISTRIBUTION AND RARITY

Hodgdon (1938) stated that var. *maritima* ranges from southern Maine to Delaware, but did not cite specimens of the nominate variety, so we do not know where in Delaware var. *maritima* was taken. At the time of his monograph, var. *virginica* was known only from Norfolk (now City of Chesapeake), Northampton, and Princess Ann (now City of Virginia Beach) counties in Virginia. Currently this variety is known from eight counties in Virginia, one in Maryland, one in Delaware, and one in North Carolina. Although apparently rare in the latter three states, var. *virginica* is of frequent occurrence in Virginia. It occurs within several national and state protected areas with much suitable habitat and is not under any acute range-wide threat, although seashore development poses a severe threat outside of refuges. Therefore, we rank it G5T3, using criteria developed by NatureServe. Representative specimens are cited below.

DELAWARE. Sussex Co.: sand dunes, 3.6 mi N of Delaware-Maryland line on Del. 14, N of Fenwick Beach, *Ahles 57756* with Baird (NCU). **MARYLAND. Worcester Co.:** Assateague Island, stabilized dunes with *Hudsonia*, two mi south of paved road, *Hill 15741* (NCU); sand dunes just N of Ocean City on Md. 528, *Ahles 57730* with Baird (NCU). **NORTH CAROLINA. Dare Co.:** Nags Head, on US 158 bypass, about 2 mi N of US 64, in rear dune zone, *Kindell 477* (NCSC); Jockeys Ridge State Park, sound side, maritime dry grassland, Kirkman (report to NC Natural Heritage Program). **VIRGINIA. Accomack Co.:** Assateague Island, Harvill 15113 (NCU); Chincoteague National Wildlife Refuge, Assateague Island, *Fleming 12644* (WILLI). **City of Chesapeake Co.:** near Ocean View, *Kearney, Jr. 1001* (US, cited in Hodgdon 1938). **City of Virginia Beach Co.:** sandy lot, Atlantic Blvd, *Ware 7371 with Kral* (VPI); N of Virginia Beach, *Fleming 10040* (WILLI); Back Bay National Wildlife Refuge, *Chamberlain 25-11* (VPI). **Lancaster Co.:** cited in Terwilliger et al. 1991. **Matthews Co.:** Diggs Beach, *Montfrans 165* (WILLI). **Middlesex Co.:** N 685 (WILLI). **Northampton Co.:** near Kiptopeake Beach, *Harvill 15363* (NCU). **Northumberland Co.:** cited in Terwilliger et al.1991.

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RECOGNITION OF *LECHEA PULCHELLA* VAR. *RAMOSISSIMA* (CISTACEAE)

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ABSTRACT

A new combination is made: **Lechea pulchella** Raf. var. **ramosissima** (Hodgdon) Sorrie & Weakley.

RESUMEN

Se hace la nueva combinación: **Lechea pulchella** Raf. var. **ramosissima** (Hodgdon) Sorrie & Weakley.

Hodgdon (1938) revised the genus *Lechea* and recognized three varieties within *L. leggettii* Britton & Hollick. The nominate variety (named var. *typica* Hodgdon), ranges from eastern Massachusetts to northeastern Ohio and south to northern and western Virginia. Variety *moniliformis* (E.P. Bicknell) Hodgdon occurs near the coast from southeastern Massachusetts to southern New Jersey; localized disjunct populations occur within old shorelines of the Great Lakes in Illinois, Indiana, Michigan, Ohio, and Ontario. Variety *ramosissima* Hodgdon occurs from southeastern Virginia to central Florida and west to eastern Texas. In a revision of *Lechea* in the southeastern United States, Wilbur and Daoud (1961) accepted Hodgdon's var. *ramosissima*, but without assessing its distinctiveness.

Wilbur (1966) argued that Rafinesque's older names should be used for many of the names used by Hodgdon and others. Thus, *L. leggettii* became a synonym of *L. pulchella* Raf. However, in this paper Wilbur declined to recognize varieties, stating that "...I am not convinced that these tendencies represent biological varieties or subspecies." In a study of *Lechea* in New Jersey, Barringer (2004) did not recognize varieties and did not mention the southern taxon *ramosissima*.

MATERIALS AND METHODS

We examined over 150 specimens from NCU, VPI, and WILLI. Specimens represented a broad geographic range from Massachusetts to Florida and Louisiana; however, we paid special attention to the potential zone of overlap of var. *pulchella* and var. *ramosissima* in the mid-Atlantic states. Specimens represented 13 counties in Virginia, 28 in North Carolina, and 3 in Maryland. We assessed Hodgdon's (1938) key characters of seed number, seed shape, density of capsules, panicle shape, and panicle branching. We also assessed plant height.

RESULTS

We found that these characters, if used in combination, satisfactorily separated a high percentage of specimens with mature fruit. The most useful characters were seed number, seed shape, density of capsules, and plant height. Table 1 summarizes these characters. Density of capsules refers to the arrangement of capsules on the ultimate branches: in var. *pulchella* they vary from a tight cluster (or glomerule) to a crowded row of capsules that actually or nearly touch one another; in var. *ramosissima* the capsules vary from a loosely arranged row (capsules separated by one to a few mm) to a row of capsules that may touch one another. Panicle shape and branching, as defined by Hodgdon (1938), were difficult to apply effectively, but we include them here for completeness.

We experienced little difficulty in assigning specimens to var. *pulchella* or to var. *ramosissima*. All specimens from North Carolina and southward exhibited characters of var. *ramosissima*, with no characters of var.

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TABLE 1. Morphological characters used to distinguish varieties in *Lechea pulchella*.

	var. *pulchella*	**var. *ramosissima***
seed number	3(–4)	2(–3)
seed shape	relatively narrow and 3-sided, like sections of an orange	broad and compressed, or obscurely 3-sided
density of capsules	clustered at branch tip, or in a dense row	in a sparse row, sometimes in a dense row
plant height	25–55 cm	35–80 cm
panicle shape and branching	ovoid to subcylindric; principle branches subequal, relatively short	subcylindric to subglobose; principle branches diminishing upward, relatively long

pulchella. Similarly, specimens from Maryland and northward exhibited characters only of var. *pulchella* (or of var. *moniliformis*). Virginia specimens from Caroline County (*Wieboldt 9538* VPI) and City of Suffolk, (*Fleming 11235* WILLI) had three seeds per capsule and seeds variously shaped, but had capsule density and plant height characters typical of var. *ramosissima*. Virginia specimens from Fairfax County (*Hunnewell 6506* VPI) and Prince William County (*Townsend 3532* VPI) had three seeds per capsule and seeds variously shaped, but had capsule density and plant height typical of var. *pulchella*. These specimens apparently are examples of hybridization. Examination of additional specimens in the zone of overlap in eastern Virginia—and in adjacent Maryland and North Carolina—may reveal additional evidence of natural hybridization. However, since a small percentage of collections appear to exhibit intermediate characters, we believe that recognition of var. *ramosissima* is warranted, based on the concept of varieties as incompletely separated evolutionary entities with correlated morphological and ecogeographic differences. In this regard, we stress the importance of using several key characters when identifying varieties within *Lechea pulchella*, since there is some overlap in any given character.

While many species in the eastern United States exhibit little variation from north to south (*Liriodendron tulipifera* L.), others exhibit a clinal pattern (*Limonium carolinianum* (Walter) Britton). Still other species exhibit a more-or-less distinct shift of characters in the region of the Virginia-North Carolina boundary. *Kalmia angustifolia* L. and *K. carolina* Small, considered species by some and varieties by others, is an example.

Lechea pulchella Raf. var. **ramosissima** (Hodgdon) Sorrie & Weakley, comb. nov. BASIONYM: *Lechea pulchella* Raf., New Fl. N. Amer. 1:91. 1836. *Lechea leggettii* Britton & Hollick var. *ramosissima* Hodgdon, Rhodora 40:119–123, pl. 491, fig. 3. 1938. TYPE: U.S.A. MISSISSIPPI. Jackson Co.: Ocean Springs, 29 Jul 1896, *Pollard 1109* (HOLOTYPE: GH; ISOTYPES: F, NY, US).

Lechea pulchella var. *ramosissima* ranges on the coastal plain from southeastern Virginia (Accomack, Caroline, City of Suffolk, City of Virginia Beach, Greensville, and Northampton counties; specimens at NCU, VPI, WILLI) south to central Florida (reaching Hernando and Martin counties, Atlas of Florida Vascular Plants, www.plantatlas.usf.edu) and west to western Louisiana (Beauregard Parish, specimen at NCU) and eastern Texas (Orange County, Turner et al. 2003); disjunct in central Tennessee (Coffee County, Wilbur & Daoud 1961) and northeast Georgia (Rabun County, specimen at NCU). Habitats include dry to mesic pine-oak woods, pine savannas, pine flatwoods, borders of shrub-tree pocosins, moist powerlines, dry fields, roadsides, and railroad rights-of-way. In many of these habitats, fire is a recurring disturbance.

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BOOK REVIEWS

Barrie Juniper and David J. Mabberley. 2006. **The Story of the Apple.** (ISBN: 0-88192-784-8, hbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 503-227-3070 fax, 1-800-327-5680). $29.95, 240 pp., 20 color photos, 40 illustrations, 9 maps, 7" × 9".

Have you ever wondered where apples come from? Yes, those enjoyably crisp and juicy apples that we're told are as American as, well, apple pie. The answer has been provided in the new book entitled *The Story of the Apple* by authors Barrie Juniper and David Mabberly. *The Story of the Apple* is a richly researched book loaded with references to support the author's work. This well-documented history of the apples' origins and geographical dissemination throughout history also includes many beautiful images of the people, places and equipment involved; it contains a mixture of both color and black & white images.

The book begins by providing readers with the foundation of apple knowledge; i.e. the title of chapter one is "What are apples?" Chapter two, entitled "Origin of the apple," includes information on pollinators, scientific nomenclature, cropping phases and dispersal methods (bears and horses especially). The authors trace the origin of the sweet apples of today to the Tian Shan fruit forest in the mountains of Central Asia. In chapters three and four, the authors describe how early humans and animals interacted with apple fruit, wood and seeds; and include the history of grafting of fruit and apple trees throughout history. The fifth and sixth chapters focus on the movement of apples from Asia to Europe and into North America via land and sea routes. The fifth and sixth chapters also include information on the cultural influence of the apple in place names and family names, as well as in various cultural folklore. In chapter seven, an interesting history of apple cider and other apple preservation techniques used around the world is provided. The final chapter provides readers with an overview.

The authors have been very thorough in providing referenced information in this text; the end result requires readers to pay more attention to detail. For example readers must first keep in mind the different species the authors discuss: there are crab apples (*Malus sylvestris*) and more commonly known sweet apples (*Malus pumila*). However, such details are important to the points being made and add significantly to the valuable information provided in this text. This reader found the book especially interesting regarding the topics of fruit-tree grafting, use of the word apple (and non-English lingual equivalents) and apple folklore. Along with color plates of various apple species, the book contains many other interesting images; among them are black and white woodcuts of historic cider making equipment.

Apple historians, horticulturalists and enthusiasts will delight in *The Story of the Apple*. Authors Juniper and Mabberly have provided a well-researched history of the apple including the origins of the sweet apple as well the many uses of the apple fruit and wood in various cultures worldwide. Color plates, photographs and black and white images add significantly to understanding the importance of apples all over the world and throughout history. Explore *The Story of the Apple* and read about the extraordinary journey of the apple from Asia to every corner of the Earth.—*Lee Luckeydoo, Herbarium, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

Jim Kimmel (text) and Jerry Touchstone Kimmel (photographs). 2006. **The San Marcos: A River's Story.** (ISBN 13: 978-1-58544-542-4, pbk.). Texas A&M University Press, 4354 TAMU, College Station, TX 77843-4354, U.S.A. (**Orders:** http://www.tamu.edu/upress/, 979-458-3982, 979-847-8752 fax). $29.95, 155 pp., 184 color photos, 26 b/w photos, 1 drawing, 1 chart, 4 maps, 8⅝" × 10¼".

What do mastodons, treed Gypsy bears, Texas wildrice, blind salamanders, and Ralph the Swimming Pig have in common? They are all part of the story of the San Marcos River, an iconic river in Central Texas. Jim Kimmel's affectionate and detailed text and his wife Jerry's beautiful photos bring to life the natural and cultural history of a river whose headwaters are thought to be the site of some of the oldest human settlements - 12,000 years old – on the North American continent.

The book examines the San Marcos River from several perspectives: geology, geography, history, biology, and botany. It covers the river's history from the uplift that created the Balcones Fault millions of years ago, creating the conditions for the springs to issue, to the present day efforts to protect the Edwards Aquifer, which nourishes the river, from excessive pumping. The peoples who have lived, and live today, on its banks are brought to life. Native and endangered plants and animals as well as sometimes pesky nonnative species are discussed in the text and listed in the attractive appendices. The reader is left with an understanding and appreciation of the San Marcos river's beauty and diversity.

Jim Kimmel, one of Texas' most distinguished geographers, is a professor at Texas State University in San Marcos and directs the university's Center for Nature and Heritage Tourism. His family has lived in the San Marcos area for several generations. Jerry Touchstone Kimmel is a nationally known watercolor artist and accomplished photographer.

The reviewer, a former San Marcos resident, can almost feel the tingle of the 72° water on her toes as she writes this review. Hmmm…a leisurely float from just below the dam at Spring Lake to Rio Vista Dam seems in order for this summer.—*Penny McCook, Volunteer, Botanical Research institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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SEED AND CAPSULE MORPHOLOGY IN SIX GENERA OF HEDYOTIDEAE (RUBIACEAE): *THECAGONUM, NEANOTIS, DENTELLA, KOHAUTIA, PENTODON,* AND *OLDENLANDIOPSIS*

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ABSTRACT

Morphological variation in the seeds and capsules of selected species of six genera of Hedyotideae (Rubiaceae) is described and illustrated by scanning electron microscopy. Oldenlandioid (trigonous) seeds occur in the genera *Dentella* and *Pentodon*. The numerous areolar tubercles in *Pentodon* seeds are shown in enlarged views. The seeds in two species of *Kohautia* have distinctive rounded areolar protrusions. *Oldenlandiopsis* has unique capsules and seeds, the latter oblate. The sulcate seeds of *Thecagonum*, an Asian segregate from *Oldenlandia*, have several rounded or elongate depressions bordered by strongly sinuous walls. *Oldenlandia strigulosa*, with similar seeds, is formally transferred to *Thecagonum*. The Asian genus, *Neanotis*, a segregate from *Anotis*, has houstonioid seeds with a hilar ridge in a ventral depression.

RESUMEN

Se describe e ilustra la variación morfológica en las semillas y las cápsulas de especies seleccionadas de seis géneros de Hedyotideae (Rubiaceae) mediante microscopia electrónica de barrido. Las semillas oldenlandioides (trígonas) ocurren en los géneros *Dentella* y *Pentodon*. Los tubérculos areolares numerosos en las semillas de *Pentodon* se muestran a gran aumento. Las semillas de dos especies de *Kohautia* tienen salientes areolares redondeados distintivos. *Oldenlandiopsis* tiene las cápsulas y semillas únicas, la última de ellas obladas. Las semillas sulcadas de *Thecagonum*, un segregado asiático de *Oldenlandia*, tienen varias depresiones redondeadas o alargadas confinadas por paredes fuertemente sinuosas. *Oldenlandia strigulosa*, con las semillas similares, se transfiere formalmente a *Thecagonum*. El género asiático, *Neanotis*, segregado de *Anotis*, tiene las semillas houstonioides con una costilla hilar en una depresión ventral.

INTRODUCTION

This study continues investigations of seeds and capsules in the tribe Hedyotideae by means of scanning electron microscopy (SEM), studies that began with Terrell, Lewis, Robinson, and Nowicke (1986). The present paper describes and illustrates morphological variation in seeds and capsules of *Thecagonum, Neanotis*, *Dentella*, *Kohautia*, *Pentodon,* and *Oldenlandiopsis.* Previous studies of *Oldenlandia* seeds (Terrell & Robinson 2006) provided information about the trigonous (3-angled) seeds of that genus. Two of the genera studied here, *Dentella* and *Pentodon*, have trigonous seeds, and the other four genera have seeds with varying distinctive characteristics.

MATERIALS AND METHODS

The herbarium of the U.S. National Museum (US), Smithsonian Institution, Washington, D.C., provided most of the capsules and seeds for this study. One or more samples of each species were examined under a dissecting microscope to determine sizes, shapes and other characters. Selected samples were mounted on stubs and examined with scanning electron microscopes located at the Electron Microscope Laboratories at the Smithsonian Institution or at the U.S. Department of Agriculture, Beltsville, Maryland. The information provided for each genus includes names, synonyms, general distributions, and descriptions and illustrations of seeds and capsules.

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RESULTS AND DISCUSSION

1. DENTELLA J.R. & G. Forst., Char. Gen. Pl. 13.1775. Type species: *Dentella repens* (L.) J.R. & G. Forst., Char. Gen. Pl. ed. 2, 26. t. 13.1776. *Oldenlandia repens* L., Mant. Pl. 40.1767.

Distribution.—One or two species in S.E. Asia, Sri Lanka, Malesia, Taiwan, Micronesia, Polynesia (Ridsdale 1998). Adventive in coastal western Mexico (*E.J. Lott 3116* from Jalisco and other Mexican collections in herbarium US). Also locally adventive in Baltimore, Maryland (Reed 1970).

Chromosome number.—Dentella repens: $2n = 36$ (Raghavan & Rangaswamy 1941).

Dentella repens resembles *Oldenlandia* species, but differs in having 5-merous flowers. The plants are small creeping annual or perennial herbs. Leaves small, ca. 2–10 mm long, oblanceolate to obovate. Stipules interpetiolate, to 1 mm long. Flowers solitary, axillary, isostylous. Corolla 3–4 mm long, narrowly tubular, white.. Anthers ca. 0.5 mm long. Stigmas bifid.

Capsules 2.5–4 × 2.5–3 mm, subglobose, densely hairy, crowned with calyx lobes, fully inferior, walls thin, fragile. They are reputed by Ridsdale (1998) to be indehiscent. Seeds (Table 1) numerous per capsule, 0.3–0.6 mm in diam.or slightly longer than wide, trigonous or obtusely angulate, basal face elliptical, lateral faces larger, somewhat concave, hilum punctiform, apical, areoles polygonal, walls thick, testa surface featureless (Figs. 1 A,B). The trigonous seeds are similar to those in *Oldenlandia*, thus are oldenlandioid.

Collection examined using SEM.—Clemens 3276 (US), Indo-China. Also observed were *E.J. Lott 3116* (US) and *A. C. Sanders et al. 10597* (UCR), both from Jalisco, Mexico.

2. KOHAUTIA Cham.& Schltdl., Linnaea 4:156.1829. Type species: *Kohautia senegalensis* Cham. & Schltdl., Linnaea 4:156.1829.

Distribution.—The genus has about 60 species in Africa, Madagascar, and tropical Asia, with 12 species in Tropical East Africa (Verdcourt 1976). In addition, Halford (1991) described one species in Australia. Verdcourt (1989) recorded 13 species from the Flora Zambesiaca region.

Chromosome number.—Lewis (1965) reported the chromosome number of *Kohautia* as $x = 9$. He found pollen grains to be 3 to 8-colporate and relatively small, and stated that nearly all species of *Kohautia* were easily separated by their pollen from those of *Oldenlandia* and other African taxa in the tribe Hedyotideae.

Our SEM study of *Kohautia* has been restricted to one species and, therefore, the genus was excluded from Table 1. We found an unusual seed type which we consider worth reporting because of the areolar protrusions.

Kohautia coccinea Royle, Ill. Bot. Himal.: 241, t. 53/1.1835. It occurs from Africa to India. It is an annual herb with pink to purple flowers usually in spikes or racemes, corolla 5–11 mm. long, tubes narrowly cylindrical. Seeds of *K. coccinea* examined using SEM: *Burger 3545* (US), Ethiopia.

Capsules 3–5.5 mm long, oblong-ellipsoid, loculicidally dehiscent (Verdcourt 1976). Seeds 0.6–0.7 × 0.35–0.4 mm, black, obtusely angulate, hilum apical, areoles polygonal, their walls thin to rather thick, each areole containing a conspicuous large round protrusion (Fig. 1 C,D). These protrusions may occur in other species in *Kohautia*. Halford (1992) illustrated a seed of the Australian species *Oldenlandia spathulata* Halford which shows round protrusions in the areoles, but he did not comment on them. He placed *O. spathulata* in a group of three species including *O. spermacocoides* (F. Muell.) F. Muell. and *O. crouchiana* (F. Muell.) F. Muell. Specimens of these three Australian species of *Oldenlandia* were not available to us. It is suggested that *O. spathulata* may belong in *Kohautia*.

3. OLDENLANDIOPSIS (Griseb.) Terrell & W.H. Lewis, Brittonia 42:185.1990. Type species: *Oldenlandiopsis callitrichoides* (Griseb.) Terrell & W.H. Lewis, Brittonia 42:185.1990. *Oldenlandia callitrichoides* Griseb., Mem. Amer. Acad. Arts n.s. 8:506.1863. *Hedyotis callitrichoides* (Griseb.) W.H. Lewis, Rhodora 63:222.1961.

Distribution.—One species in West Indies, Central America and Mexico (Yucatan). Adventive in Africa (Sierra Leone), northern South America (Guyana), United States in Dade County, Florida, and Hawaiian Islands: Oahu and Maui.

A synopsis of the United States species of *Oldenlandia* (Terrell 1990) treated five species. Included

TABLE 1. Seed characters in *Thecagonum, Neanotis, Dentella, Oldenlandiopsis, Pentodon.*

	Thecagonum biflorum	***Neanotis* (4 species)**	***Dentella***	***Oldenlandiopsis***	***Pentodon***
Number per capsule	numerous	2-20 or more	numerous	20-35	numerous
Length mm	0.3–0.6	0.5–1.3	0.3–0.6	0.3–0.5	0.3–0.5
Shape, type	ovoid, subglobose	cymbiform or shallow cup	conoidal	oblate	trigonous
Hilum	punctiform	low, linear ridge	punctiform	punctiform	punctiform
Hilum location	centric or acentric	in shallow depression	apical	centric	apical
Ventral surface, type	irregularly sulcate	reticulate	reticulate	reticulate	reticulate
Ventral surface	several small rounded or elongate depressions	polygonal areoles	polygonal areoles	polygonal areoles	polygonal areoles
Walls/borders	sinuous, conspicuous	straight/curved, not conspicuous	straight	sinuous/ straight	bearing many minute tubercles

among these was *Oldenlandia callitrichoides* Grisebach, which Terrell and Lewis (1990) soon described as *Oldenlandiopsis callitrichoides* (Griseb.) Terrell & W.H. Lewis.

The plants are creeping, soft and delicate, and may be superficially confused with *Oldenlandia* species, but very few *Oldenlandia* species are creeping (versus merely prostrate).

Capsules 1.0–2.7 × 0.5–2 mm, narrowly turbinate or obconic, thin-walled, fragile, retuse or truncate, 9/10 or fully inferior, somewhat compressed, glabrous, dehiscing loculicidally and later separating into four narrow segments. These capsules differ entirely from the characteristically subglobose, indurate capsules of not only *Oldenlandia* but also from a number of other examined hedyotoid genera.

Seeds (Table 1) 20–35 per capsule, 0.3–0.5 × 0.2–0.4 mm, oblate (depressed-ellipsoid, depressed-subglobose), or obtusely angulate, hilum punctiform, centric, testa reticulate, areoles polygonal, walls sinuous or straight, surface minutely papillose (Fig.1 E,F). The seeds are distinctive in being more or less oblate. Collection examined using SEM: *E. & B. Terrell 5022* (US), Dade Co., Florida.

There are two other basic differences that also distinguish *Oldenlandiopsis* (Terrrell & Lewis 1990) as a distinct genus: (1) pollen with 8-colporate apertures instead of 3(–5), (2) chromosome number $2n = 22$ ($x = 11$) instead of $x = 9$; the only other *Oldenlandia* species with $x = 11$ is *Oldenlandia microtheca* (Terrell & Robinson 2006).

4. PENTODON Hochst., Flora 27: 552.1844. TYPE SPECIES: *Pentodon pentandrus* (Schumach. & Thonn.) Vatke, Oesterr. Bot. Z. 25:231.1875. *Hedyotis pentandra* Schumach. & Thonn., Kongel. Danske Vidensk. Selsk. Naturvidensk. Math. Afh. 3:71.1827. *Oldenlandia pentandra* (Schumach. & Thonn.) DC., Prodr. 4:427.1830, non Retz.

Hedyotis halei Torr. & A. Gray, Fl. N. Amer. 2:42.1841. *Oldenlandia halei* (Torr. & A. Gray) Chapm., Fl. Southern U.S. 181.1860. *Pentodon halei* (Torr. & A. Gray) A. Gray, Syn. Fl. N. Amer. 1, 2:28.1884. The name *Pentodon halei* was created for American plants from collections prior to 1841, but plants were found to be conspecific with *P. pentandrus.*

Distribution.—Two species in Africa (see also Verdcourt 1976, 1989, Rogers 1987). Adventive in Florida and southeastern U.S. west to eastern Texas. Also adventive in Cuba, Nicaragua, and Brazil.

The chromosome number is $x = 9$ based on *Pentodon halei*, $n = 9$, $2n = 18$ (Lewis 1962); and *P. pentandrus*, $n = 9$ (Lewis 1965). Pollen is 3-aperturate and resembles most species of *Oldenlandia* (Lewis 1965).

Pentodon pentandrus var *pentandrus* is as follows: Annual or short-lived perennial fleshy herbs. Leaves lanceolate to elliptic, 3–8 × 0.3–2.5 mm. Stipules interpetiolate, fimbriate, 0.5–5 mm long. Flowers 5-merous, terminal or axillary, isostylous or heterostylous. Calyx and corolla 5-lobed, corolla funnelform. Stigmas bifid.

Capsules (Fig. 2 D) 2–4 × 2–3.5 mm, oblong, somewhat compressed, conspicuously nerved, thin-walled, fragile, loculicidally dehiscent. Seeds (Fig. 2 A-C) numerous, 0.3–0.5 mm in diam., trigonous or irregularly

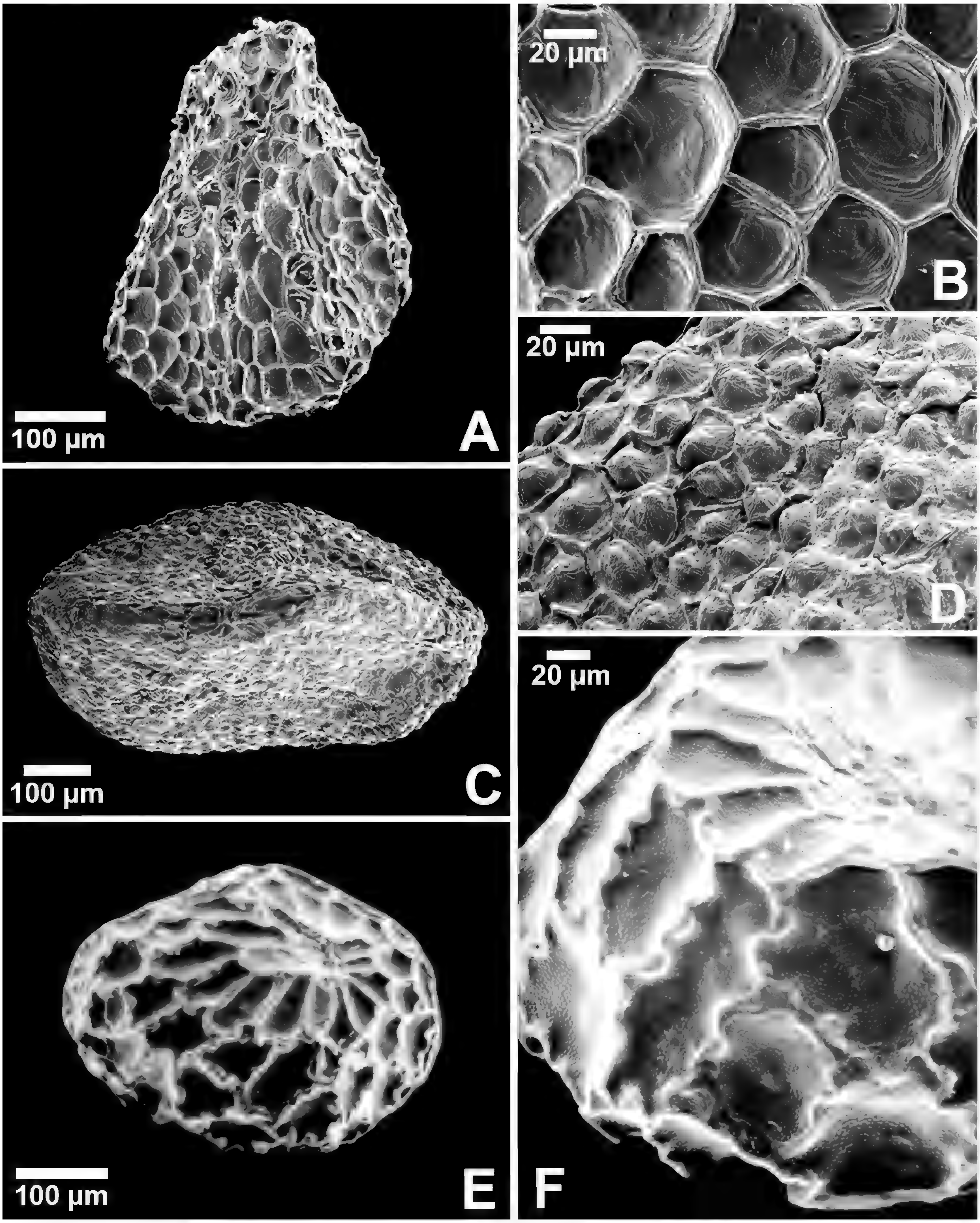

Fig. 1. Seeds examined by SEM. **A–B.** *Dentella repens, Clemens 3276* (US), Indo-China. **C–D.** *Kohautia coccinea, Burger 3545* (US), Ethiopia. **E–F.** *Oldenlandiopsis callitrichoides, E. & B. Terrell 5022* (US), Florida. **A,** end view; **B, F,** enlarged areoles; **C, E,** ventral views; **D,** areoles showing rounded protrusions.

and obtusely angulate, hilum punctiform, apical, testa reticulate, areoles elongate or polygonal, areole walls with numerous minute tubercles (Fig. 2 B,C). Seed collection examined using SEM: *Thieret 16435* (SMU), Louisiana.

Pentodon capsules are distinctive in being oblong with soft, compressed walls. The seeds (Table 1) are trigonous, thus appear oldenlandioid. The noteworthy feature of the seeds are the numerous minute tubercles attached to the areole walls, somewhat enlarged in Fig. 2. These tubercles were noted by Lewis, but have not been previously illustrated. Such tubercles have not been seen in any other taxon of the tribe.

5. THECAGONUM Babu, Bull. Bot. Surv. India 11:214.1969. Type species: *Thecagonum pteritum* (Bl.) Babu. *Gonotheca* Bl. ex DC., Prodr. 4: 429.1830 (non Raf., Med. Repos. 5:352.1808, Compositae). Babu (1969) proposed the new name, *Thecagonum*, to replace the illegitimate name, *Gonotheca* Bl. ex DC., a later homonym. Babu separated this genus from *Oldenlandia* by its having a 4-angled fruit, not terete, and seeds globose or subglobose, not angular. He recognized four species in *Thecagonum*. Specimens of the fourth species, *T. parishii* (Hook.f.) Babu, native to India and Malesia, were not available to us.

1. Thecagonum biflorum (L.) Babu, Bull. Bot. Surv. India 11:214.1969. *Oldenlandia biflora* L., Sp. Pl. 119.1753. *Hedyotis biflora* (L.) Lam., Tabl. Encycl. 1:272.1791.

Oldenlandia paniculata L., Sp. Pl. ed. 2. 1667.1763.

The synonymy here follows Fosberg & Sachet (1991) in their treatment of Micronesian species of *Hedyotis* in which they delimited *Hedyotis* broadly with *Oldenlandia* as a subgenus.

Distribution.—This well known species usually called *Oldenlandia biflora* has a wide distribution from India to China, Malesia, Micronesia, and Polynesia. Flora Vitiensis (Smith & Darwin 1988) stated "crevices of arid rocks along coasts," and listed distribution as tropical Asia to Mauritius, throughout Malesia, eastward to Fiji, Tonga, Niue, and Samoa.

Collections examined using SEM.—Fosberg 39194 (US), Guam; *Fosberg 33792* (USF), Marshall Islands; *Anderson 2126* (US), Caroline Islands.

Chromosome number.—Oldenlandia paniculata: $n = 36$ (Raghavan & Ragaswamy 1941*); O. biflora*: $n = 18$ (Lewis and Oliver 1970); $2n = 54, 72$ (Selvaraj 1987).

Perennial herbs. Stems erect to prostrate. Leaves 8–40 × 3–13 mm, lanceolate, elliptic, or ovate-lanceolate. Stipules 1–2 mm, interpetiolate, margins with teeth or setae. Inflorescence terminal and axillary. Corollas broadly tubular, tubes ca. 2 mm long, lobes ca. 1 mm long.

Capsules 2–4 × 2–4 mm, subglobose, somewhat compressed, walls thin and fragile, about 4/5 to fully inferior, dehiscing loculicidally and septicidally.

Seeds (Table 1) numerous per capsule (ca. 65 in one capsule), 0.3–0.6 × 0.3–0.6 mm, ovoid, subglobose, or obtusely angulate, hilum centric, punctiform, surface with crowded, variously-sized, shallow, rounded or elongate depressions, their walls thick and strongly sinuous (Fig. 3). These depressions are entirely unlike the conventional areoles of many species, and may be described as sulcate, a term defined by Kiger and Porter (2001), as "Having one or more elongate, relatively narrow and shallow depressions (sulci)." These distinctly different seeds support the removal of *Oldenlandia biflora* from the genus *Oldenlandia* and the recognition of *Thecagonum* as a distinct genus

2. Thecagonum strigulosum (DC.) Terrell & H. Rob., comb. nov. Basionym: *Oldenlandia strigulosa* DC., Prodr. 4:427.1830. *Hedyotis strigulosa* (DC.) Fosberg, Smithsonian Contr. Bot. 45:28.1980.

Hedyotis coreana H. Lév., Repert. Spec. Nov. Regni Veg.11:64.1912.
Oldenlandia albido-punctata Merr., Philipp. J. Sci., C, 9:297.1914.

This species was not included in *Thecagonum* by Babu (1969), however, it was recognized as closely related to *Hedyotis biflora* by Fosberg and Sachet (1991). They provided a complete description of it and in their key to species distinguished *Hedyotis strigulosa* from *H. biflora* in characters of the leaves, inflorescence, and capsules. They described capsules as being firm, thick-walled, and broadly ovoid, compared to *H. biflora* which is thin-walled and subglobose. *Hedyotis strigulosa* seems not to have been transferred to *Thecagonum*, so we do so here.

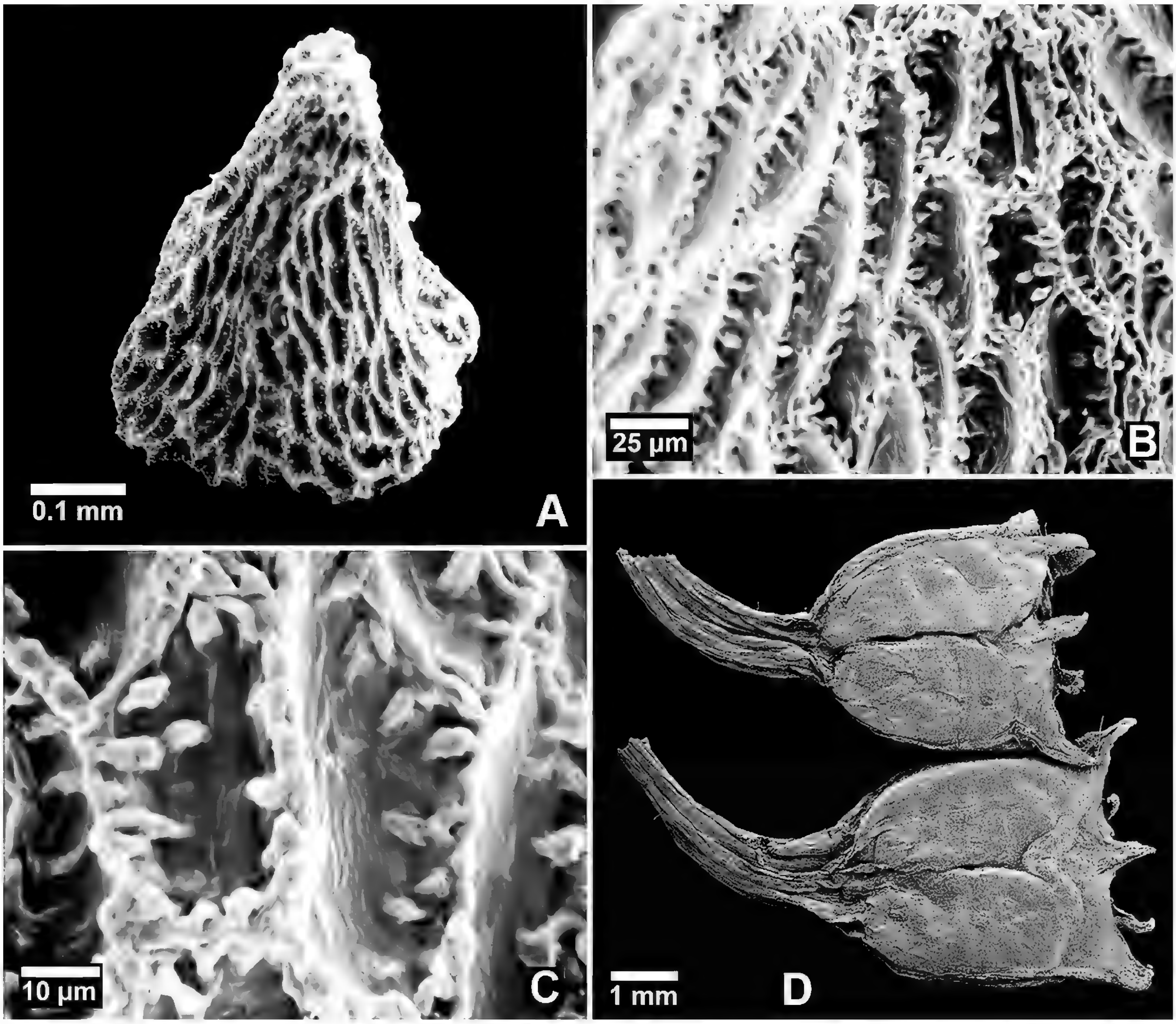

Fig. 2. Seeds and capsules of *Pentodon pentandrus* examined by SEM. A–C. *Thieret 16435* (SMU), Louisiana. D. *Lewalle 1527* (US), Burundi. A, seed, end view; B, C, enlarged areoles showing numerous tubercles; D, capsules.

Our seeds are approximately 0.4–0.6 mm long and have rounded or elongate depressions like the seeds of *T. biflora*, but differ in the seeds being mostly obtusely angulate.

Collections examined using SEM.—Moran 4618 (US) and *Necker 362* (US), both from Guam, Marianas Islands. These two collections were cited as *Hedyotis strigulosa* by Fosberg and Sachet (1991).

3. Thecagonum pteritum (Bl.) Babu, Bull. Bot. Surv. India 11:214.1969. *Hedyotis pterita* Bl., Bijdr. 972.1826. *Gonotheca blumei* DC., Prodr. 4: 429.1830, nom. illeg. *Oldenlandia pterita* (Bl.) Miq., Fl. Ind. Bat. 2:193.1857.

Succulent herb to 10 cm tall. Leaves 3–6 × 0.5 cm, elliptic or lanceolate. Flowers terminal and axillary. Capsules 4–7 × 4–6 mm, oblong or obovate, somewhat compressed, walls fragile, winged, wings apparently two per capsule, to ca. 1 mm wide (Fig. 4 C). The capsules resemble those of *Pentodon pentandrus* in general shape and texture, thus they differ from the capsules of the two preceding species of *Thecagonum*. The epithet, pterita, refers to the winged capsules.

Seeds numerous per capsule, 0.5–0.6 × 0.4–0.5 mm, broadly ellipsoid-angulate or obtusely angulate, hilum punctiform or slightly elongate, centric, surface with variously-sized rounded or elongate depressions, walls thick, sinuous, testa densely papillose (Fig. 4 A, B). The seeds are generally similar to those of *T. biflorum*.

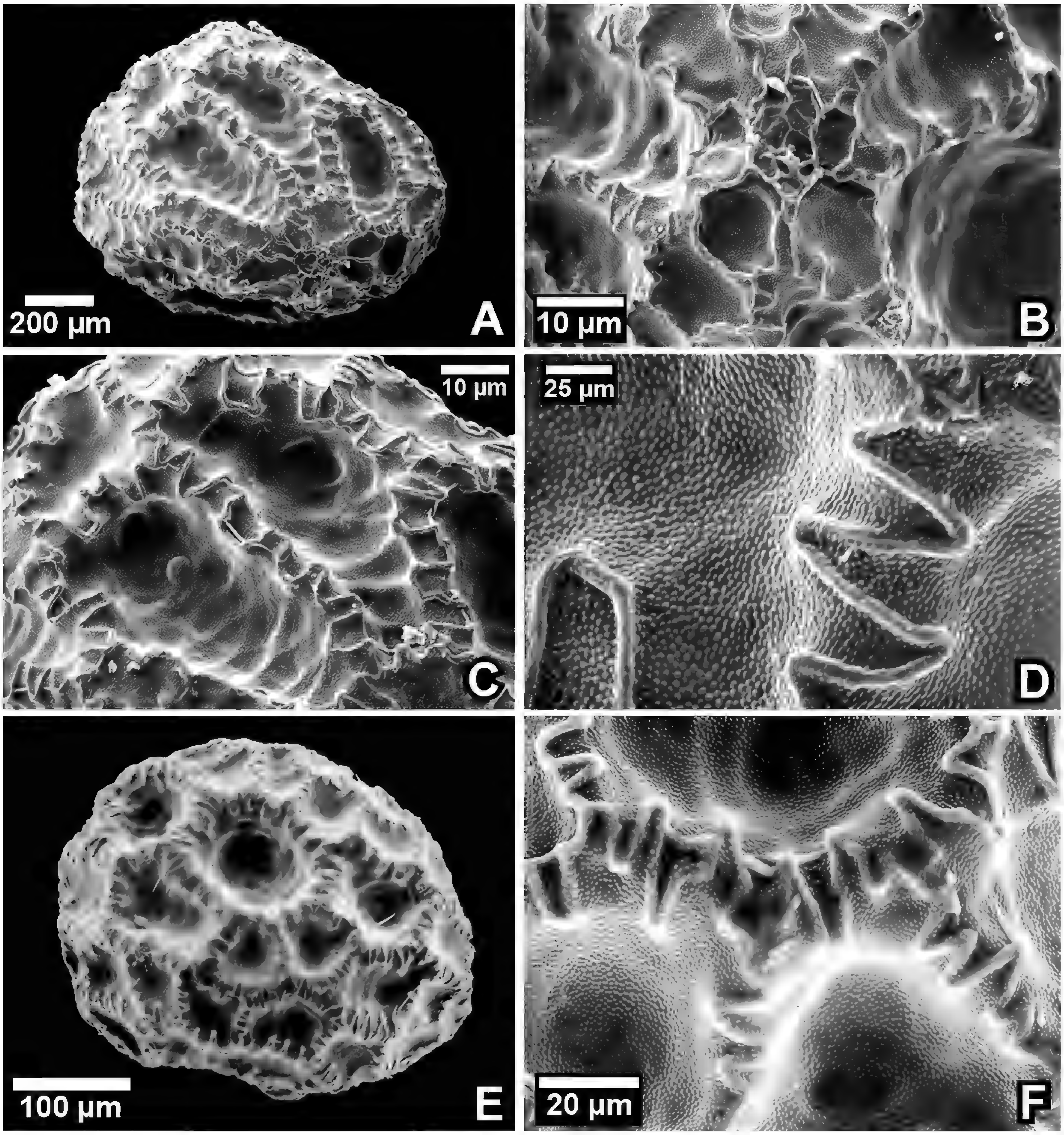

Fig. 3. Seeds of *Thecagonum biflorum* examined by SEM. A–D. *Fosberg 39194* (US), Guam. E–F. *Fosberg 33792* (USF), Marshall Islands. A, C, E, surface depressions and sinuous borders; B, hilar area of surface; D, F, enlargements of depressions, borders, and numerous minute papillae.

Distribution.—India to Malesia.

Collections examined using SEM.—*Ramos s.n.*, Apr 1909 (US), Luzon, P.I.; *Merrill 6730* (US), Negros, P.I.

Oldenlandia ovatifolia (Cav.) DC., Prodr. 4:427.1830. *Hedyotis ovatifolia* Cav., Icon. 6:52.1801.*Thecagonum ovatifolium* (Cav.) Babu, Bull. Bot. Surv. India 11:214.1969.

Oldenlandia nudicaulis Roth, Nov. Pl. Sp. 95. 1821. *Hedyotis nudicaulis* (Roth) Wight & Arn., Prodr. 416.1834.

This species was listed under *Thecagonum* by Babu (1969), however, its seeds lack the depressions typical of *T. biflora, T. strigulosa*, and *T. pterita*, and instead are reticulate with polygonal areoles like those in other

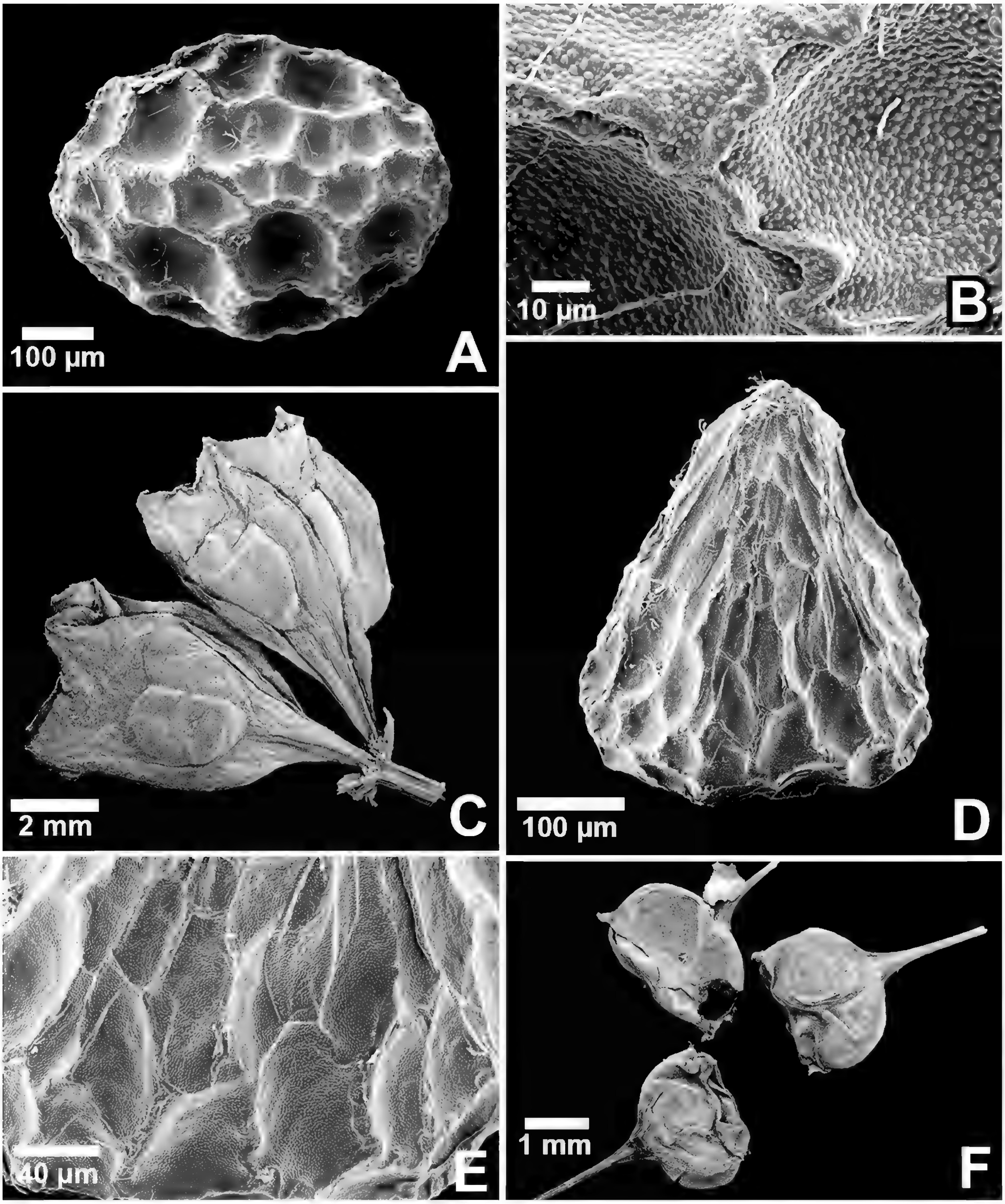

Fig. 4. Seeds and capsules examined by SEM. A–C. *Thecagonum pteritum,* A–B. *Ramos s.n.,* Apr 1909, Luzon, P.I.; C, *Merrill 6730* (US), Negros, P.I. D–F. *Oldenlandia ovatifolia,* D, E, *Toroes 4448* (US), Sumatra; *F, Belsher 558* (US), Upper Burma. A, depressions and sinuous borders; B, enlargements of border and minute papillae; C, F, capsules; D, seed, side view; E, enlargement of polygonal areoles.

genera. The capsules generally resemble those of some species of *Oldenlandia* (Fig. 4 F). The seeds are conoidal. We suggest that this species be retained in *Oldenlandia*.

Annual herb, stems 4–20 cm tall, leaves broadly ovate, appearing conspicuously large compared to the entire plant, inflorescence cymose, corolla tubes 0.5–1 mm long, lobes 1.5–2 mm long. Capsules 2–2.5 ×

2.5–3 mm, subglobose or slightly wider than long, walls fragile, thin, 7/8 to fully inferior. Seeds 30–40 per capsule, 0.4–0.5 × 0.4–0.5 mm, conoidal or irregularly conoidal, hilum apical, punctiform, areoles polygonal, usually longer than wide, walls thick, testa densely papillose (Fig.4 D,E).

Distribution.—India to Java and Malesia.

Collection examined using SEM.—Toroes 4448 (US), Sumatra; *Belsher 558* (US), Upper Burma. Two other collections were also studied: *Toroes 1804* (US), Sumatra; *Toroes 3514* (US), Sumatra.

6. **NEANOTIS** W.H. Lewis, Ann. Missouri Bot. Gard. 53:34.1966. TYPE SPECIES: *Neanotis indica* (DC.) W.H. Lewis, Ann. Missouri Bot. Gard. 53:38.1966. Putoria? indica DC., Prodr. 4:577.1830.

Distribution.—Southeast Asia and Malesia (Ridsdale 1998). There are 28 species in genus (Lewis 1966; Ridsdale 1998).

Lewis (1966) removed 28 species from *Anotis* and placed them in a new genus, *Neanotis*, but did not provide a description of the new genus. The validity of the name *Neanotis* has been questioned, however, we follow Saldanha and Nicolson (1976) and Ridsdale (1998) in accepting its validity. One of our reviewers (Kirkbride) advises that the name *Neanotis* is valid because there is an indirect reference to a description.

Lewis (1966) found that the pollen of *Neanotis* differs by six important characters from that of *Hedyotis* and *Oldenlandia*. He concluded that *Neanotis* pollen is distinct and differs from all other members of the Hedyotideae.

Chromosome numbers.—$x = 9$. *N. hirsuta* var. *glabricalycina* (Honda) W.H. Lewis, $2n = 36$, Taiwan (Lewis et al. 1967); *N. gracilis* (Hook. f.) W.H. Lewis, $2n = 18$, Nepal (Malla et al. 1978).

Species studied, with synonyms, and distributions are as follows:

1. **Neanotis calycina** (Hook.f.) W.H. Lewis, Ann. Missouri Bot. Gard. 53:37. 1966. *Anotis calycina* Hook.f., Fl. Brit. India 3:73.1880.

Distribution.—Himalayas, India, Burma (Myanmar), Vietnam, China.

Collection treated using SEM.—Stainton 1590 (BM), Nepal. Other examined collections not using SEM were *Stainton et al. 7107* (BM), Nepal; *Henry 13512* (K, US), China.

2. **Neanotis hirsuta** (L.f.) W.H. Lewis, Ann. Missouri Bot. Gard. 53:38.1966. *Oldenlandia hirsuta* L.f., Suppl. Pl. Syst. Veg. 127.1782.

Distribution.—Himalayas to China, Japan, Malaysia.

Collection examined using SEM.—Mousset 271 (US), Java.

3. **Neanotis monosperma** (Wight & Arn.) W.H. Lewis, Ann. Missouri Bot. Gard. 53:40.1966. Hedyotis monosperma Wight & Arn., Prodr. 410.1834.

Distribution.—India and Sri Lanka.

Collection examined using SEM.—Tirvangadum 514 (K, US), Sri Lanka. Collection examined but not using SEM: *Fosberg 50050* (US), Sri Lanka. Approximately 30 other US collections from Sri Lanka were noted; most of these lacked mature flowers or fruit.

4. **Neanotis tubulosa** (G. Don) Mabb., Taxon 29:606.1980. *Oldenlandia tubulosa* G. Don, Gen Hist. 3:531.1834. *Neanotis quadrilocularis* (Thwaites) W.H. Lewis, Ann. Missouri Bot. Gard. 53:40.1966. *Hedyotis quadrilocularis* Thwaites, Enum.Pl. Zeyl.144.1859. *Anotis quadrilocularis* (Thwaites) Hook.f., Fl. Brit. India 3:74.1880.

Distribution.—India, Sri Lanka.

Collection examined using SEM.—Saldanha 17811 (US), India. *Neanotis tubulosa* (formerly *N. quadrilocularis*) differs from the other three species in having a 4-loculate instead of a 2-loculate capsule and seeds with a slightly deeper depression surrounded by a thicker margin. This species has been generally accepted as congeneric with other *Neanotis* species.

Morphological data from *N. calycina* are briefly as follows: Herbaceous annual; stem 5–25 cm tall; leaves ovate-lanceolate, 0.5–3.5 × 0.2–1.5 cm, flowers in axillary or terminal cymes, corollas white, pink, or purple, infundibular-cylindrical, 2–3 mm long.

TABLE 2. Seed characters in four *Neanotis* species.

Characters	*calycina*	*monosperma*	*hirsuta*	*tubulosa*
Length mm	0.5–0.7	0.9–1.2	1.1–1.3	0.6–0.7
Thickness	thick	thick	rather thick	thick
Shape, kind	cymbiform	cymbiform	cymbiform/saucer	cymbif./shallow cup
Shape in outline	suborbicular/oblong/ell.	oblong, ell., suborbic.	suborbic./elliptic	suborbic./brdly. ell.
Compression	slight to moderate	moderate	moderate	moderate
Dorsal face	rounded/convex	strongly rounded	rounded/convex	convex
Hilar ridge	low, linear	low, linear	low, linear	low, shortly linear
Depression	medium to shallow	shallow	shallow or flattish	small cup
Margin shape	thickened/rather thin	slightly or not thickened	low/ flattish	thickened
Areoles texture	coarse	coarse	coarse	coarse
Areoles walls	indurate	indurate	indurate	indurate

The apically dehiscent capsules of *Neanotis* species are generally of a subglobose type, but differ in being either slightly longer than wide (as in *N. richardiana* (Arn.) W.H. Lewis) or wider than long (as in *N. monosperma*). They are relatively small and have comparatively few of the rather bulky seeds (ca. 2–20 per capsule).

We examined seeds of the four species by SEM (Table 2). An inclusive morphological description (Table 1) is as follows: Seeds (Fig. 5) 0.5–1.3 mm long or wide, dull black or dark brown, thick, cymbiform to shallowly cup-shaped, in outline suborbicular, oblong, or broadly elliptic, compression moderate, dorsal face strongly rounded to convex, ventral face with a low linear hilar ridge in a shallow to medium-sized depression, margin thickened or flattish, hilar ridge slightly higher to slightly lower than the bordering margin, areoles polygonal, usually appearing coarse and indurate. The seeds usually have a "chunky" appearance because the dorsal face (Fig. 5 F) is often rounded.

The seeds of *Neanotis* resemble those of *Houstonia*, particularly the *H. purpurea* group (subgenus *Chamisme*) of four species in eastern North America (Terrell 1996), but are thicker and coarser. Plants of the *Neanotis* species examined here also resemble the *H. purpurea* group in being small to medium-sized perennial (or annual) herbs with lanceolate or ovate leaves. Other data, however, do not favor a close relationship: pollen morphology is distinctly different as noted previously, and the chromosome numbers are $x = 6$ for *H. purpurea* and $x = 9$ for *Neanotis*. If the two groups originated from the same basic stock, they underwent long isolation on separate continents.

KEY TO SEEDS AND CAPSULES OF THE STUDIED GENERA

1. Seed surface not reticulate, lacking areoles, with several shallow rounded or elongate depressions ______ **Thecagonum**
1. Seed surface reticulate, areoles (cells) numerous, rounded or polygonal.
  2. Seed surface with areoles each with a large rounded protrusion ______ **Kohautia**
  2. Seed surface with areoles lacking a rounded protrusion.
    3. Seeds 3-angled (trigonous, conoidal).
      4. Seeds with areole walls bearing numerous small tubercles; capsules compressed, oblong, thin ______ **Pentodon**
      4. Seeds with areole walls lacking tubercles; capsules subglobose ______ **Dentella**
    3. Seeds compressed or ovoid, not 3-angled.
      5. Seeds oblate, lacking a hilar ridge ______ **Oldenlandiopsis**
      5. Seeds somewhat compressed, with a hilar ridge in a ventral depression ______ **Neanotis**

ACKNOWLEDGMENTS

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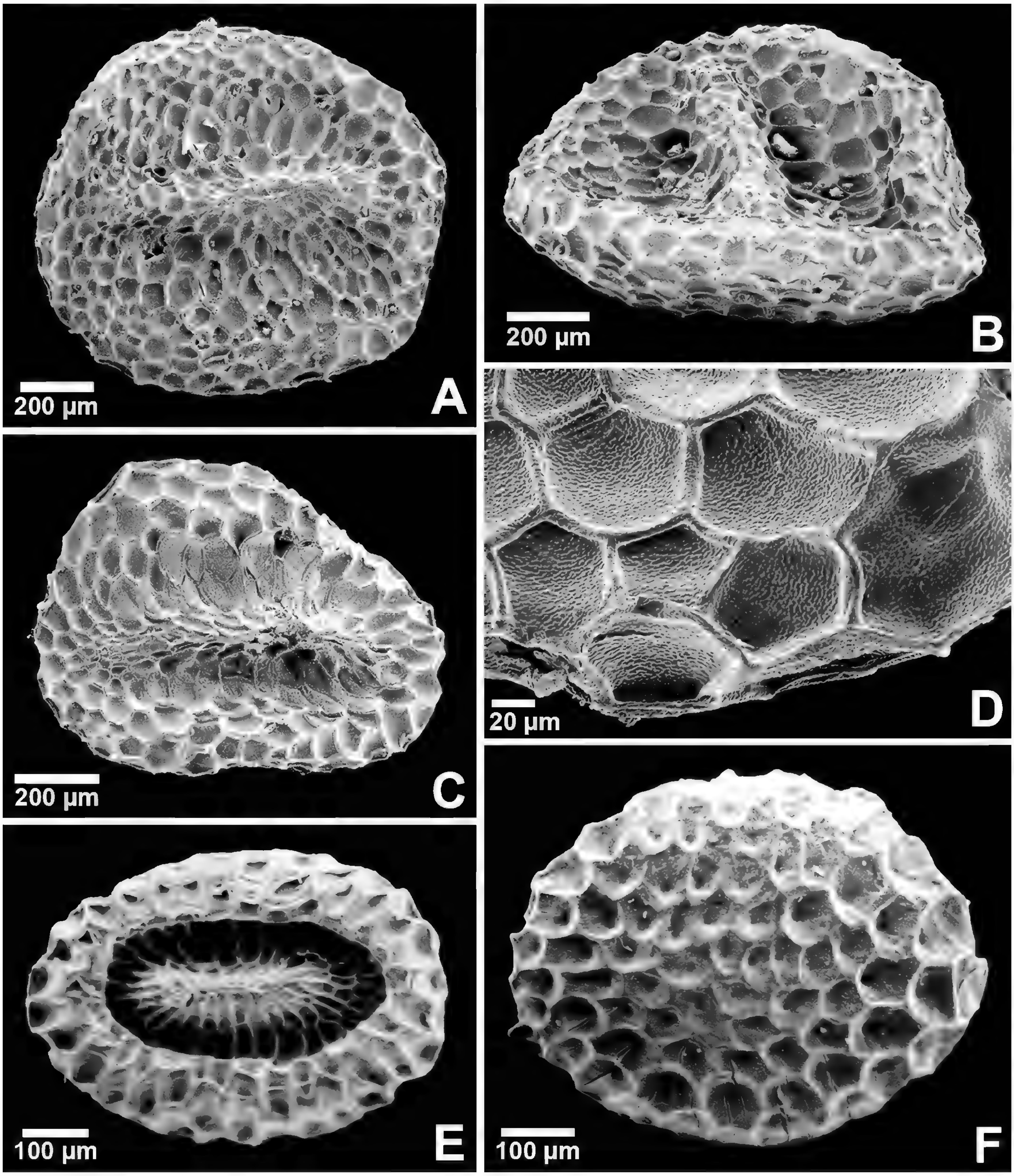

Fig. 5. Seeds of *Neanotis* species examined by SEM. A, B, *N. hirsuta, Mousset 271* (US), Java. C, D, *N. monosperma, Tirvangadum 514* (US), Sri Lanka. E, F, *N. tubulosa, Saldanha 17811* (US), India. A–C, E, ventral views; D, enlargement of areoles and minute papillae; F, dorsal view.

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NOTES ON *PHRAGMITES AUSTRALIS* (POACEAE: ARUNDINOIDEAE) IN NORTH AMERICA

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ABSTRACT

Three taxa of *Phragmites australis* have previously been reported in North America. While native *P. australis* subsp. *americanus* has been formally described, questions remain as to the subspecific status of the introduced and Gulf Coast lineages. Here we attempt to provide answers to commonly asked questions and describe a consistent nomenclature for one of these two lineages. While it has been treated previously as a variety, we recognize the Gulf Coast lineage as **Phragmites australis** subsp. **berlandieri.** This subspecies is distributed along the southernmost border of the United States and extends its distribution south through Mexico and Central America into South America. Issues regarding the taxonomic identity of the introduced lineage are also discussed.

RESUMEN

Tres taxones de *Phragmites australis* han sido citados previamente en Norteamérica. Mientras la nativa *P. australis* subsp. *americanus* ha sido descrita formalmente, aún quedan problemas como el estatus subespecífico, de las plantas introducidas y las de la Costa del Golfo. Aquí intentamos contestar a las preguntas comunes y proponer una nomenclatura consecuente para uno de estos dos linajes. Aunque ha sido tratada como una variedad, reconocemos el linaje de la Costa del Golfo como **Phragmites australis** subsp. **berlandieri**. Esta subespecie está distribuida por las fronteras sureñas de los Estados Unidos, extendiéndose hacia el sur por México y Centroamérica hasta Suramérica. Además se examina la identidad taxonómica del linaje introducido.

Phragmites australis (Cav.) Trin. ex Steud. is a widely distributed species found in marsh systems all over the world. In 2002, Saltonstall demonstrated that it is represented in North America by three different genetic lineages. Of these, one is native and endemic to North America, one is found in both North and South America, and one is introduced and invasive. The native endemic has been named *P. australis* subsp. *americanus* Saltonstall, P.M. Peterson & Soreng and is widespread across North America, extending from Canada to southern California, across the Midwest, and along the Atlantic Coast to North Carolina (Fig. 1a). The Gulf Coast lineage is found from the Atlantic coast of Florida, around the Gulf of Mexico, across the southernmost states to the Gulf of California and south through Mexico and Central America into South America (Fig. 1b). In 2004, Saltonstall, Peterson and Soreng stated that this taxon corresponded to *P. australis* var. *berlandieri* (Fourn.) C.F. Reed. It is not clear whether it is introduced or native to the Americas and possibly other subtropical regions. The invasive introduced lineage of *P. australis* is now widespread across North America and its distribution overlaps with both the other lineages (Fig. 1c). The use of different ranks for the lineages and confusion over how the Gulf Coast lineage relates to native and introduced *P. australis* has led to questions that we address in this manuscript.

Nomenclature of the invasive introduced lineage

Introduced *Phragmites australis* most likely originates from Europe (Saltonstall 2002). This creates a nomenclatural dilemma. The holotype of *P. australis* was collected near Port Jackson [Sydney Harbor], Australia in 1799. Clayton (1968) considered Australian and European specimens to be conspecific, but treated plants from the Mediterranean region as *P. australis* subsp. *altissimus* (Benth.) Clayton. In doing so, he automatically brought the name *P. australis* subsp. *australis* into existence. These two subspecies may be “rather imperfectly distinguished” (p. 116) by the shape of the upper glume (Clayton 1967). Tutin (1980) did not recognize any infraspecific taxa in his treatment of *Phragmites* for *Flora Europaea*. Phillips (1995) placed Ethiopian plants in *P. australis* subsp. *altissimus*, but did not state how they differed from subsp. *australis*. She described the

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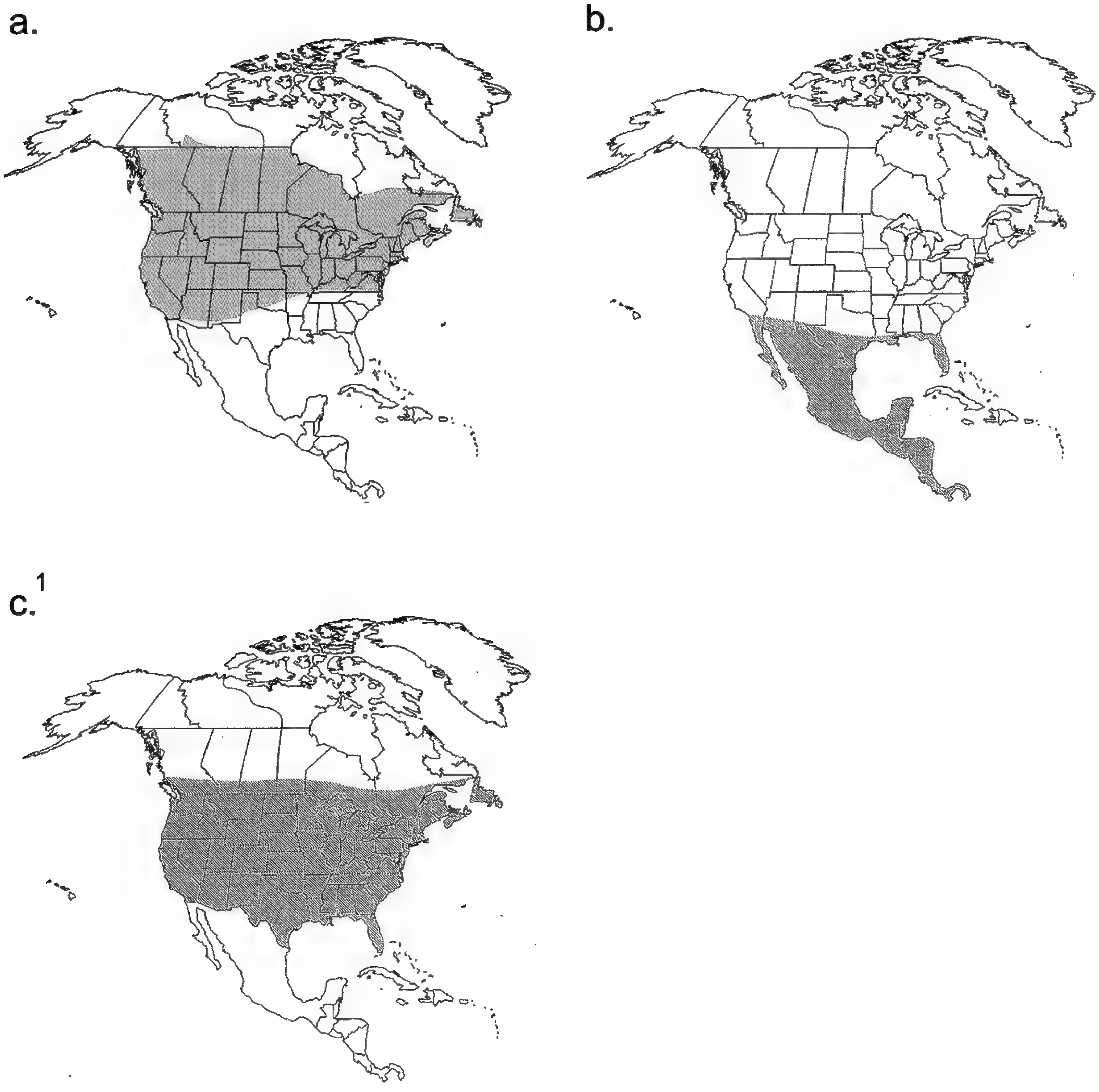

Fig. 1. Distribution of a) Native, b) Gulf Coast, and c) Introduced lineages of *Phragmites australis* in North America. Reprinted from Saltonstall et al. 2004.

plants of *P. australis* subsp. *altissimus* as having culms 3–6 m tall, leaf blades 30–60 cm long by 1–3 cm wide, and panicles 30–50 cm long. This is very similar to the description Wheeler et al. (2002) provided for plants from New South Wales, Australia: Plants to about 6 m tall, leaf blades to 50 cm long and 3.5 cm wide, panicles 15–30 cm long. Both descriptions provide additional details, but there is no evident distinction between the two.

The genetic relationship between European and Australian *P. australis* populations is poorly understood at this time. Chloroplast DNA haplotype M, which North American introduced *P. australis* possesses, is widespread across Europe and Asia. Haplotype Q, which is distinct from all haplotypes found in Europe, was found in Australia (Saltonstall 2002). Further, in a phylogeographic study of *Phragmites* using AFLPs,,

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[1] Although not documented across the Gulf Coast except for in the Mississippi River Delta (Saltonstall 2002), introduced *Phragmites* may already have invaded these regions and certainly has the potential to spread into them. The distribution of introduced *Phragmites* is not known south of the U.S. border and thus is not included in this figure.

Lambertini et al. (2006) recognized a distinct Australian/Asian clade within *P. australis*. The relationships of the European taxa to the Australian taxon are unclear and need further investigation. It is also not known to which of the named European taxa introduced *P. australis* belongs. Therefore, it is not possible at this time to identify the appropriate subspecific name for the introduced lineage in North America.

Nomenclature of the Gulf Coast lineage

In treating the Gulf Coast lineage as *Phragmites australis* var. *berlandieri*, Saltonstall et al. (2004) left unanswered the question as to its subspecific status. Although botanical names are never shown with more than one infraspecific rank, if both subspecific and varietal ranks are used, it is desirable to show how the taxa relate to each other. Morphologically, the Gulf Coast strain resembles the introduced lineage more than the native. It differs significantly from the introduced strain in only one of the four characters measured, lower glume length, and was intermediate between the other two lineages at most characters (Saltonstall et al. 2004). Examination of microsatellite DNA variation (Saltonstall 2003) revealed that Gulf Coast populations had unique alleles and allele phenotypes at most loci. They all share the same cpDNA haplotype I, which was also found in some South American samples and one sample from Guam, and has several mutations which distinguishes it from haplotype M (Saltonstall 2002). They also share similar isozyme profiles, which differ from those of introduced *P. australis* (Pellegrin and Hauber 1999). Clearly, they represent a taxon that is distinct from that of the invasive introduced lineage and from subsp. *americanus*. It is not as yet clear how widely the Gulf Coast taxon is represented outside the Americas.

Saltonstall et al. (2004) recognized the Gulf Coast lineage as a variety but, in retrospect, it seems better to name it a subspecies so as to reflect the equivalence of its genetic differentiation to that of subsp. *americanus*. The lineage has sometimes been called *Phragmites karka* Retz. (Jones 1997), the holotype of which was collected in India. It is possible, though not evident, that the Gulf Coast lineage belongs to that species. It seems best, therefore, to employ the same epithet for the subspecies as was earlier used at the varietal rank in Saltonstall et al. (2004). If this lineage is subsequently determined to belong to the same taxon as *P. karka*, then that name will have precedence at the species level, but will have no effect at the subspecies level since there are no subspecific names in *P. karka*. We propose a new subspecies combination for the Gulf Coast lineage below.

Phragmites australis subsp. **berlandieri** (E. Fourn.) Saltonstall & Hauber, comb. nov. Basionym: *Phragmites berlandieri* E. Fourn., Bull. Soc. Bot. France 24:178. 1877. *Phragmites communis* var. *berlandieri* (E. Fourn.) Fernald, Rhodora 34:211. 1932. *Phragmites maximus* var. *berlandieri* (E. Fourn.) Moldenke, Torreya 36:93. 1936. *Phragmites communis* subsp. *berlandieri* (E. Fourn.) Á. Löve & D. Löve, Bull. Torrey Bot. Club 81:33. 1954. *Phragmites australis* var. *berlandieri* (E. Fourn.) C.F. Reed, Phytologia 63:410. 1987. Type: U.S.A. Texas: entre Laredo y Bejar, Feb 1828, *J.L. Berlandier 1446* (lectotype designated by Saltonstall et al. 2004: P, [see notes by Catling 2006]; isolectotype: US-82049 fragm. ex P!, US-82049 fragm. ex Pitt. & Dur.! [Bruxelles]), US-82049 fragm. ex W!).

Clearly, questions remain concerning *Phragmites,* many of which require a global approach. The purpose of this paper is simply to provide a consistent nomenclature, to the extent that it is possible, for the lineages that occur in North America. The following key using morphological and genetic features is given to separate these three lineages (from Saltonstall et al. 2004).

KEY TO THE LINEAGES OF *PHRAGMITES AUSTRALIS* IN NORTH AMERICA

1. Ligules 1.0–1.7 mm long; lower glumes 3.0–6.5 mm long; upper glumes 5.5–11.0 mm long; lemmas 8.0–13.5 mm long; leaf sheaths caducous with age; culms exposed in the winter, smooth and shiny; rarely occurs in a monoculture; chloroplast DNA haplotypes A-H, S, Z, AA, AB, AC (see Saltonstall 2002, 2003) ______ **P. australis** subsp. **americanus** (Native lineage)
1. Ligules 0.4–0.9 mm long; lower glumes 2.5–5.0 mm long; upper glumes 4.5–7.5 mm long; lemmas 7.5–12.0 mm long; leaf sheaths not caducous with age; culms not exposed in the winter, smooth and shiny or ridged and not shiny; usually occurs as a monoculture; chloroplast DNA haplotypes I or M.
   2. Culms smooth and shiny; southern California, Arizona, New Mexico, Texas to Florida, throughout Mexico and Central America; chloroplast DNA haplotype I ______ **P. australis** subsp. **berlandieri** (Gulf Coast lineage)
   2. Culms ridged and not shiny; southern Canada from British Columbia to Quebec south throughout the Continental United States; chloroplast DNA haplotype M ______ **P. australis** (Introduced lineage)

ACKNOWLEDGMENTS

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THE TAXONOMY OF *CAREX TRISPERMA* (CYPERACEAE)

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ABSTRACT

Ora Willis Knight described *Carex trisperma* Dewey var. *billingsii* O.W. Knight in 1906, but it has not been quantitatively compared to its presumed sister taxon, *C. t.* var. *trisperma*. I tested the hypothesis implied by earlier taxonomic treatments that the two varieties are not morphologically, ecologically, geographically, and genetically distinct. To test these hypotheses, I analyzed DNA fingerprints, measured morphological characters, mapped specimen localities and recorded *in situ* canopy conditions. The two varieties are distinct based on AFLP fragment data. Based on morphological analyses, the two varieties are distinguishable by leaf width, ligule length, inflorescence length, and number of perigynia per terminal spike. *Carex t.* var. *billingsii* is a temperate plant of the northeastern United States and adjacent Canada and is confined to partially shaded/open areas in acidic bogs within deciduous forests. *Carex t.* var. *trisperma* ranges farther west, south and east than *C. t.* var. *billingsii* and grows mostly in shaded areas of bogs and swamp forests in both deciduous and boreal biomes. If *C. t.* var. *billingsii* were simply an open-grown morphotype of *C. t.* var. *trisperma*, then it would be likely that the distribution of *C. t.* var. *billingsii* would overlap that of *C. t.* var. *trisperma* and thus, be present in open bogs west of Michigan. The absence of *C. t.* var. *billingsii* in areas where *C. t.* var. *trisperma* is common suggests a genetic rather than an environmental basis for the differences in morphological characters. The geographic, ecological, morphological, and genetic data strongly suggest that *C. t.* var. *billingsii* warrants recognition at the rank of species and the new combination is effected.

Key Words: *Carex*; sedge; AFLP; morphometrics; sedge ecology; phytogeography; DNA fingerprints; sphagnum bog

RESUMEN

Ora Wills Knight describió *Carex trisperma* Dewey var. *billingsii* O.W. Knight en 1906, pero no ha sido comparado cuantitativamente con su presunto taxon hermano, *C. t.* var. *trisperma*. He probado que la hipótesis implicada en tratamientos taxonómicos previos que las dos variedades son morfológica, ecológica, geográfica, y genéticamente distintas. Para probar estas hipótesis, analicé las huellas de DNA, medí caracteres morfológicos, representé en mapas las localidades de los especimenes y tomé datos *in situ* de las condiciones del manto. Las dos variedades se distinguen en base a los datos de los fragmentos AFLP. Basándose en los análisis morfológicos, las dos variedades se pueden distinguir por la anchura de las hojas, longitud de la lígula, longitud de la inflorescencia, y número de utrículos por espiga terminal. *Carex t.* var. *billingsii* es una planta templada del Noreste de Estados Unidos y la parte adyacente de Canadá y está confinada a áreas parcialmente sombrías/abiertas en ciénagas ácidas dentro de bosques caducifolios. *Carex t.* var. *trisperma* llega hasta más al Oeste, más al Sur y al Este que *C. t.* var. *billingsii* y crece en áreas sombrías de ciénagas y pantanos forestales en biomas caducifolios y boreales. Si *C. t.* var. *billingsii* fuese simplemente un morfotipo de lugares abiertos de *C. t.* var. *trisperma*, sería probable que la distribución de *C. t.* var. *billingsii* se solapase con la de *C. t.* var. *trisperma* y estuviese presente en ciénagas abiertas del Oeste de Míchigan. La ausencia de *C. t.* var. *billingsii* en áreas donde *C. t.* var. *trisperma* es común sugiere una base genética en vez de ambiental para las diferencias en los caracteres morfológicos. Los datos geográficos, ecológicos, morfológicos, y genéticos data sugieren que *C. t.* var. *billingsii* merece el reconocimiento a nivel de especie.

During a botanical foray, in 1906, Ora Willis Knight, discovered a "peculiar little sedge" at Jewett Brook Bog in Maine. Upon further inspection, he decided that the sedge was merely a variant of typical *Carex trisperma* Dewey (Fig. 1), which was common in shaded portions of the bog. Knight named this plant *Carex trisperma* var. *billingsii* (Fig. 1) and described the foliage of *C. t.* var. *billingsii* as "setaceous or filiform," the inflorescence as having 1–2 spikelets per culm, and its habitat as "sunny." This habitat description was contrasted to that of *C. t.* var. *trisperma*, which grew "abundantly…under the trees" (Knight 1906).

The two *Carex trisperma* varieties have never been thoroughly evaluated taxonomically. Gleason and Cronquist (1991) and Toivonen (2002) briefly reported the differences between the two varieties, the most prominent of which are narrower leaves and fewer, smaller perigynia in *C. t.* var. *billingsii*. Gleason and Cronquist (1991) also reported that *C. t.* var. *billingsii* ranges from New Brunswick to Vermont and Pennsylvania. Toivonen (2002) extended that range to include Michigan and adjacent areas in Canada.

This study examines the morphology, phytogeography, ecology, and genetic relationships of the two

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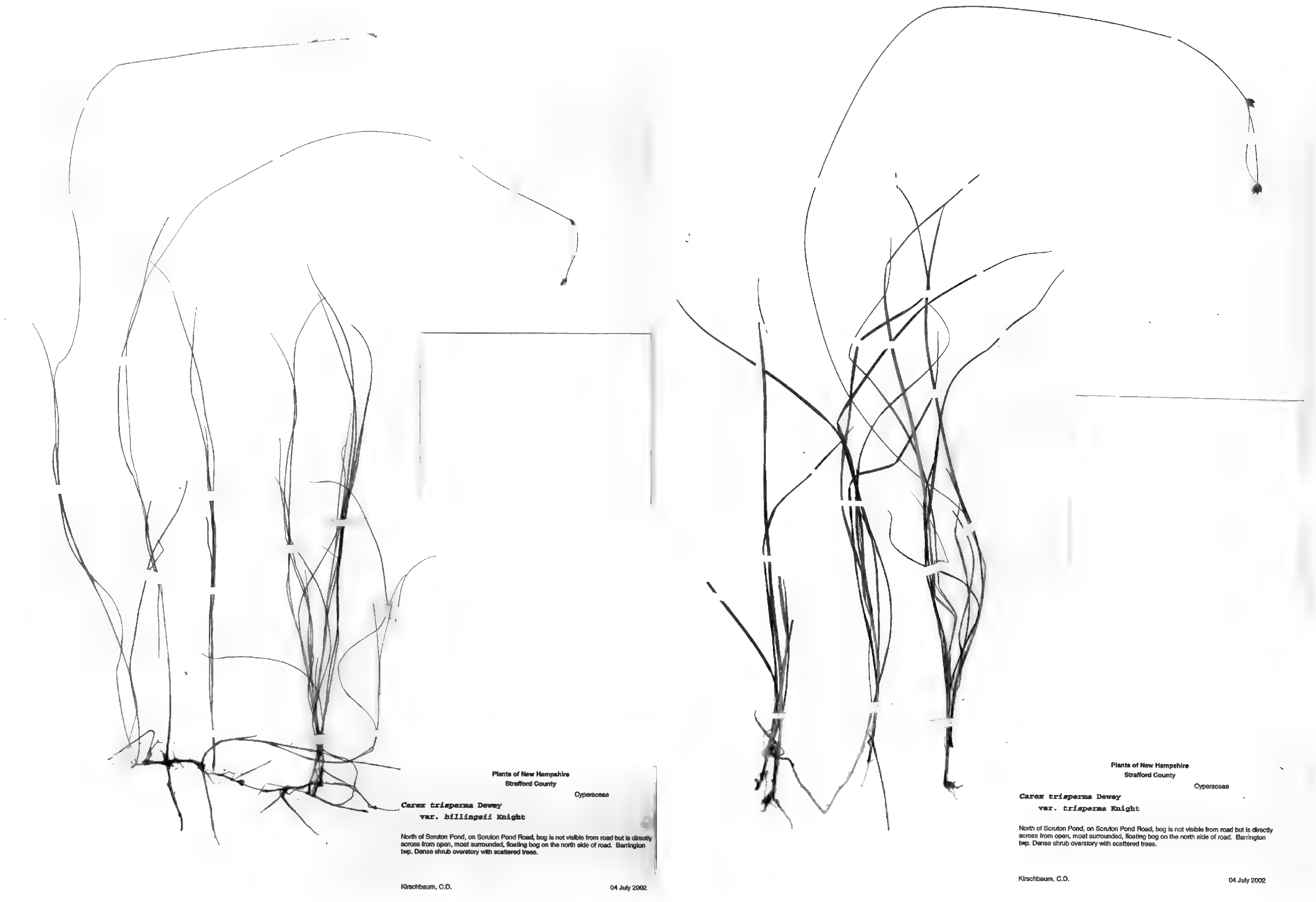

Plants of New Hampshire
Strafford County
Cyperaceae
Carex trisperma Dewey
var. billingsii Knight

North of Scruton Pond, on Scruton Pond Road, bog is not visible from road but is directly across from open, moat surrounded, floating bog on the north side of road. Barrington twp. Dense shrub overstory with scattered trees.

Kirschbaum, C.D. 04 July 2002

Plants of New Hampshire
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Kirschbaum, C.D. 04 July 2002

Fig. 1. The habit of *Carex trisperma* Dewey var. *trisperma* (right) and var. *billingsii* Knight (left), based on collections from New Hampshire, Strafford Co., near Scruton Pond, 04 Jul 2002, *Kirschbaum, s.n. Carex t.* var. *billingsii* is distinguished from *C. t.* var. *trisperma* with gross morphology by its narrower leaves and smaller, fewer flowered female spikes.

varieties in order to evaluate their taxonomic ranks as currently treated. I tested the hypothesis that the two varieties are distinct species using analyses of 19 morphological characters, AFLP genetic markers, habitat observations and the geographical distributions of the two taxa. If there are clear distinctions in morphology, ecology, and distribution, and if sympatric plants of both varieties can be distinguished by unique genetic markers, then raising *C. t.* var. *billingsii* to the species level will be supported. This study is the first quantitative analysis of *Carex trisperma* varieties and identifies potential variations to include in future phylogenetic studies of *Carex* sect. *Glareosae* G. Don.

MATERIAL AND METHODS

Field Sites and Collections Methods.—A total of 259 individual plant specimens were collected from 22 different sites throughout the range of *C. t.* var. *billingsii* from July to September 2002 and in New York and Michigan in August and September 2003 (Table 1). The two varieties were syntopic at 13 of these sites. At two sites (Dawson Ponds and Corea Heath) *C. t.* var. *billingsii* was found without *C. t.* var. *trisperma* in the immediate vicinity of the bog (William Crins, pers. comm. and Anton A. Reznicek, pers. comm.). At all sites where both varieties were abundant, at least one individual of each variety was collected. Voucher specimens (MICH) were collected for morphological analysis, and several leaves of these specimens were immediately placed in silica gel for molecular analysis.

Herbarium Specimens and Distribution Mapping.—Specimens from herbaria (MICH, DAO, MT, and GH) were used for morphological measurements (along with field collected specimens) and distribution mapping. Nineteen morphological characters were selected for detailed measurement (Table 2). Data were collected from twenty specimens of each variety selected from localities throughout the Northeastern United States. Specimen label information was used to map the distributions of the two varieties A total of 310 specimens were mapped with ArcView GIS 3.2 (Environmental System Research, Inc.). Collections of *Carex trisperma* were investigated at WIS, MO, MSC, UWSP, OS and CLM to determine if *C. t.* var. *billingsii* ranged further south than previously reported. On the edge of *C. t.* var. *billingsii's* range in Michigan, sphagnum bogs in Allegan County and Barry County in Michigan's lower peninsula were also checked for the presence of *C. t.* var. *billingsii*.

Specimens of both varieties were thinly sliced with a scalpel blade to prepare specimens for scanning electron microscopy (SEM) (Jane Gillies, pers comm.). For SEM, the specimens were mounted onto a polished stub with double-stick carbon-permeated tape. As necessary, further attachment to the stubs was made with colloidal graphite. The specimens were then coated with gold and examined with an AMRay 18201 scanning electron microscope. For the anatomical cross-sectional analysis, a freezing microtone was used to obtain sections thin enough to be photographed under a compound microscope.

Molecular analysis.—Amplified Fragment Length Polymorphisms (AFLPs) were used to investigate species boundaries and evaluate genetic similarity within and between varieties of *Carex trisperma*. Genomic DNA was extracted from 8–12 mg of silica-dried leaf material from 12 syntopic populations and two specimens (one of each variety) from different bogs in or near Algonquin Provincial Park (APP and DLB, Table 1) for a total of 26 individuals. I isolated DNA using GenElute Plant Genomic DNA Miniprep kits (Sigma-Aldrich) with the addition of 50 units of Ribonuclease (RNase A solution, Sigma-Aldrich) to eliminate RNA contamination and 10 mg of Polyvinylpyrrolidone (PVPP, Sigma-Aldrich) to precipitate secondary compounds. RNase and PVPP were added after cell lysis and prior to incubation.

AFLP protocols followed Vos et al. (1995) with modifications by Berres (2002) and Hipp (2004). I used the selective amplification primers ("EcoRI + ATG"; 5' GAC TGC GTA CCA ATT C**AT G** 3' and "MseI + CAG";5' GAT GAG TCC TGA GTA A**CA G** 3') based on previous AFLP work in *Carex* subgenus *Vignea* section Ovales by Hipp (2006). The underlined bases on each primer correspond to the known sequences of double stranded adapters ligated to the cut ends of genomic DNA subsequent to restriction digestion. The bases in bold type are selective nucleotides employed in the AFLP process to reduce the bands amplified to an interpretable number.

Table 1. Collection localities of specimens used for AFLPs, morphometrics, and ecological information (*). AFLPs were screened in one individual of each variety in 12 syntopic populations except for JBB. Allopatric specimens from Ontario sites; APP and DLB were also included in the AFLP analysis. Specimen collectors include [1]AAR = Anton A. Reznicek, WJC = William J. Crins, GH = Geoffrey Hall, JH = Justin Hohn, CDK = Chad D. Kirschbaum, CJR = Carl J. Rothfels and TR = Todd Ristau (nf = not found, **at km 8 along Hwy 60).

Site Code	Locality	State/ Province	No. of Samples variety *trisperma*	No. of Samples variety *billingsii*	Collector[1]
BPB	Bog Pond*	ME	20	20	CDK
CH	Corea Heath	ME	nf	1	AAR
2ABB	Hwy 2A Bonus Bog	ME	2	nf	CDK
JBB	Jewett Brook Bog	ME	1	1	CDK
OPB	Otter Pond Bog*	ME	20	20	CDK
PMB	Petit Manan	ME	1	1	AAR
GLB	Gorman Lake Bog	MI	1	1	CDK + JH
ILB	Independence Lake Bog	MI	1	nf	CDK + JH
MNB	Minden Bog	MI	2	10	CDK
ML	Miner Lake Bog	MI	1	nf	CDK + JH
BHB	Bray Hill Bog*	NH	20	20	CDK
HPB	Heath Bog Natural Area	NH	2	2	CDK
MPB	Mud Pond (Fox State Forest)*	NH	20	20	CDK
SPB	Scruton Pond	NH	1	1	CDK
AB	Allenburg Bog	NY	2	nf	CDK + TR
MSL	Moss Lake Bog	NY	1	1	CDK + TR
LCB	Lake Carmi Bog	VT	20	20	CDK
QBC1	Zone 18	QBC	6	nf	GH
QBC2	Zone 19	QBC	2	nf	GH
APP	Algonquin Prov. Park**	ONT	10	nf	WJC
DLB	Dawson Ponds	ONT	nf	1	WJC
CTB	Copetown Bog	ONT	4	3	CJR
		Totals	137	122	

The final PCR product was cleaned with Centri-Sep column kits (Princeton Separations), mixed with a fluorescent-red-labeled size standard (GeneScan™ -500 ROX™, Applied Biosystems) and Hi-Dye deionized formamide (Applied Biosystems). Deantured and snap-chilled samples were loaded into a 96-well sample tray for capillary electrophoresis using ABI's Prism 310 Genetic Analyzer. The operation of the 310 Genetic Analyzer followed ABI protocols (Applied BioSystems 2000, 2001) with modifications and optimizations described in Kirschbaum (2005).

Analytical Methods.—I compared morphological character measurements between varieties using a two-tailed Mann-Whitney U test. Characters that were significantly different (Table 2) were included in a Principal Component Analysis (PCA) in order to assess relationships between the two taxa based on overall variation in the quantitative characters. Prior to the PCA, correlation analysis between all characters was carried out to test for character correlation, which would have heavily weighted correlated characters (Sokal & Sneath 1963; Abbott et al. 1985). None of the variables used in this analysis was significantly correlated ($p < 0.05$, $r > 0.75$) and, thus, all 19 were used in the analysis. To provide equal weight among characters, the data were Z-score transformed before conducting the PCA. These procedures standardized all measurements so that each variable had a mean of zero and a standard deviation of one (Sokal & Sneath 1963). Principal component scores for the first three axes were graphed on a scatter plot. Discriminant Function Analysis (DFA) was used to achieve maximum discrimination among samples on the basis of the transformed variables and a priori designations of samples to a taxon (i.e., *C. t.* var. *billingsii* or *C. t.* var. *trisperma*). Both PCA and

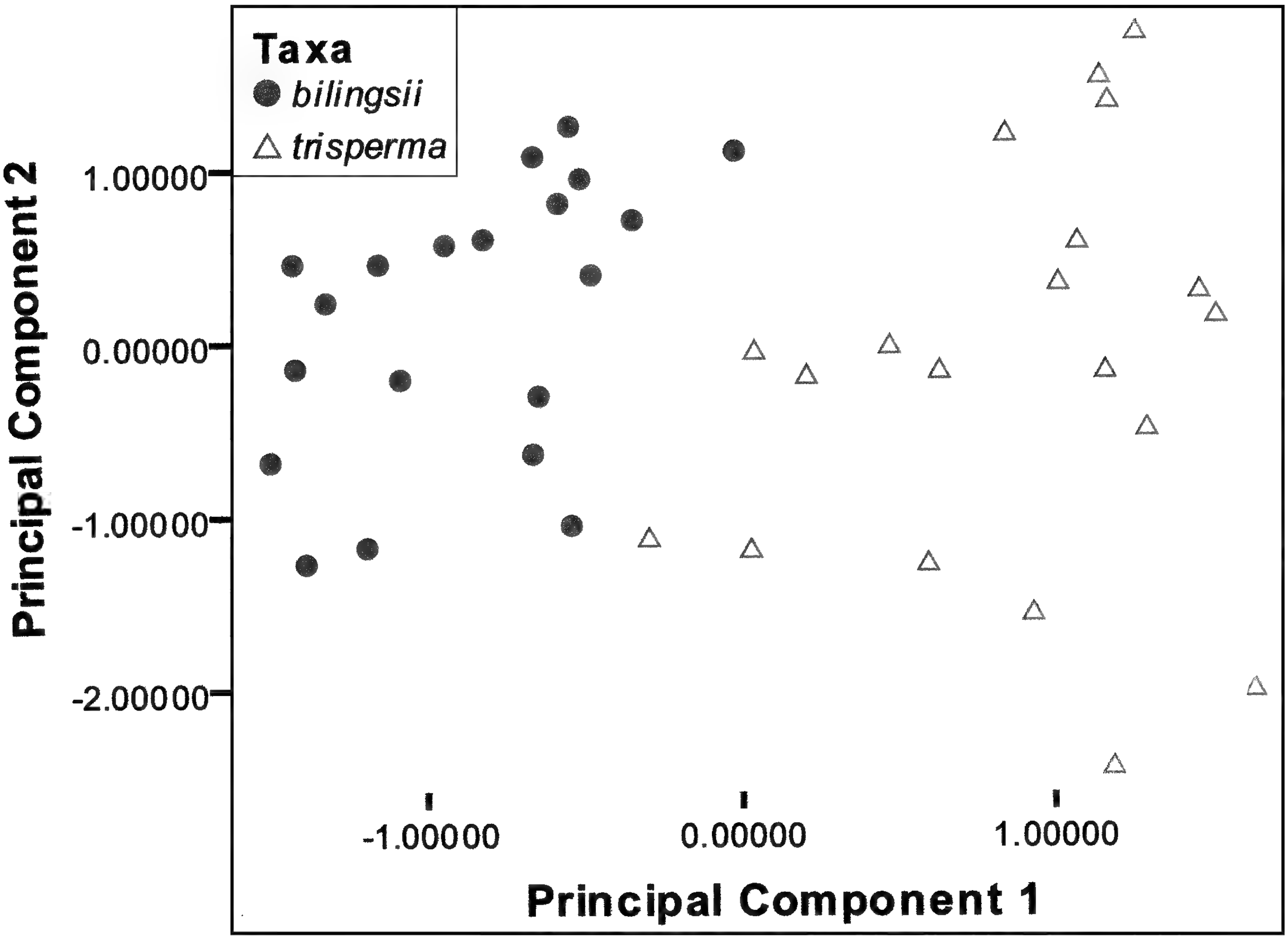

Fig. 2. A scatter plot of the scores of Principal Components 1 and 2 for morphological characters of *Carex trisperma* Dewey varieties.

DFA were used to determine the relative importance of characters that distinguish the two taxa. SPSS 11.5 (Statistical Package for the Social Sciences, Inc.) was used for all analyses of the morphological data.

The raw AFLP fragment data (i.e., fragment size, amplitude, etc.) were copied from ABI's GeneScan^{TM} software to a Microsoft Excel spreadsheet. A macro was used to create a matrix of ones and zeros that denoted the presence or absence of a peak for each specimen. This matrix was then edited with reference to a GeneScan chromatograph. Small peaks that were present in at least 11 of the 13 samples from each variety were added to a plant's profile if the peak in question had an amplitude within 100 RFUs of the original amplitude threshold (800 RFU). Fragments that were present in only 1 sample out of 26 were considered to be artifacts of PCR or electrophoresis and were eliminated from the analysis. A total of 31 fragments were eliminated from the original GeneScan data set as a result of this editing.

The data matrix with the presence or absence of AFLP fragments for each specimen was used to calculate pairwise genetic distance matrices, using Nei and Li's (1979) genetic distance index for fragments in Phylip 3.62 (Felsenstein 2004) and Jaccard's (1908) distance measure in PC-ORD 4.32 (McCune and Medford 1997). Nei and Li's pairwise genetic distances were compared graphically using SYSTAT 10.2.01 (SYSTAT Software Inc.).

To examine taxon boundaries with the genetic data, I performed ordination using Nonmetric Multidimensional Scaling (NMS) in PC-ORD. NMS was chosen because, unlike phylogenetic or some phenetic approaches (e.g., UPGMA or Neighbor Joining) to analyzing molecular data, NMS does not assume that any hierarchical patterns are present in the data, an assumption that would be invalid at the start of such a study (Lessa 1990). NMS, compared to other methods of ordination, such as Principal Component Analysis, does not assume linearity among the variables and allows for the analysis of distance measures. Since Nei and

Table 2. Summary of quantitative characters (means, ± standard error and ranges, n=20) measured and qualitative characters observed on herbarium specimens of *Carex trisperma* varieties *trisperma* and *billingsii*. Characters that were significantly different* (two-tailed Mann-Whitney U test (MWU), asymptotic significance [*as*] < 0.05) between the two varieties were analyzed using Principal Component Analysis (PCA). Scores of the principal component (PC) axes are given for the six characters used in the PCA. **Discriminant Function Correlation Coefficient = Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. **Highly weighted characters are highlighted.**

Quantitative Characters	**variety *trisperma***	**variety *billingsii***	**PC 1**	**PC 2**	**PC 3**	**DFCC****
Number of spikes per inflorescence *	2.7±0.13	2.3±0.10	0.38	0.69	0.06	-0.01
(MWU=117.5, *as*=0.01)	(2–4)	(2–3)				
Number perigynia per lateral spike *	2.9±0.2	2.2±0.15	0.57	0.17	0.65	0.03
(MWU=106, *as*<0.001)	(1–5)	(1–3)				
Number of perigynia per terminal spike*	3.7±0.29	2.1±0.15	**0.71**	0.36	0.30	0.27
(MWU=59, *as*<0.001)	(1–6)	(1–3)				
Achene length (mm) *	2.0±0.03	1.8±0.04	0.55	0.39	0.53	0.09
(MWU=94, *as*<0.001)	(1.7–2.2)	(1.3–2.0)				
Terminal Bract (Bristle) length (mm) *	51.1±2.87	41.9±3.31	0.56	0.31	0.15	0.23
(MWU=124, *as*=0.04)	(28–74)	(15–72)				
Inflorescence length (mm) *	38.8±2.65	22.6±1.16	**0.78**	0.34	0.12	**0.37**
(MWU=51, *as*<0.001)	(14–55)	(14–32)				
Ligule length (mm) *	1.1±0.08	0.5±0.05	**0.81**	0.20	0.31	**0.41**
(MWU=27, *as*<0.001)	(0.5–1.9)	(0.3–1.2)				
Leaf width (mm) *	1.2±0.06	0.4±0.03	**0.83**	0.25	0.18	**0.78**
(MWU=0.5, *as*<0.001)	(0.8–1.9)	(0.3–0.8)				
Pistillate scale width (mm) *	1.4±0.03	1.2±0.04	0.60	0.22	0.24	0.04
(MWU=99.5, *as*<0.001)	(1.1–1.7)	(0.9–1.5)				
Pistillate scale length (mm)	2.7±0.07	2.7±0.07	Not analyzed in PCA	Not analyzed in PCA	Not analyzed in PCA	0.03
(MWU=188, *as*=0.744)	(2.2–3.2)	(2.2–3.2)	″	″	″	
Staminate scale length (mm)	3.2±0.13	3.0±0.12	″	″	″	0.08
(MWU=167, *as*=0.371)	(2.4–4.6)	(2.2–4.3)	″	″	″	
Perigynia length (mm)	3.2±0.08	3.2±0.06	″	″	″	-0.07
(MWU=185.5, *as*=0.693)	(2.2–3.7)	(2.7–3.9)	″	″	″	
Perigynia width (mm)	1.4±0.03	1.4±0.04	″	″	″	0.24
(MWU=196.5, *as*=0.923)	(1.2–1.7)	(0.9–1.8)	″	″	″	
Achene width (mm)	1.3±0.03	1.2±0.04	″	″	″	0.31
(MWU=197, *as*=0.933)	(1.1–1.5)	(0.8–1.4)	″	″	″	
Qualitative Characters			″	″	″	

Li's (1979) genetic distance index is not available in PC-ORD, Jaccard's Coefficient was used as a similarity measure. Jaccard's Coefficient has been shown to perform better than other nonevolutionary-based coefficients in elucidating relationships between closely related taxa (Landry & Lapointe 1996).

At sites in New England and Michigan, I randomly selected individuals at several bogs and noted the light conditions under which the plant was growing (either completely under a tree or shrub canopy or in a partly shaded/open condition). These two categories are based on the original habitat descriptions of the two varieties given by Knight (1906) and habitat notes from herbarium specimens. Given these broad habitat descriptions, 95% of the plants visited were precisely placed in these categories. The frequencies of 169 plants growing in each condition were analyzed by variety with χ^2 analysis.

RESULTS

Morphology.—The number of spikes per inflorescence, number of perigynia per lateral spike, achene

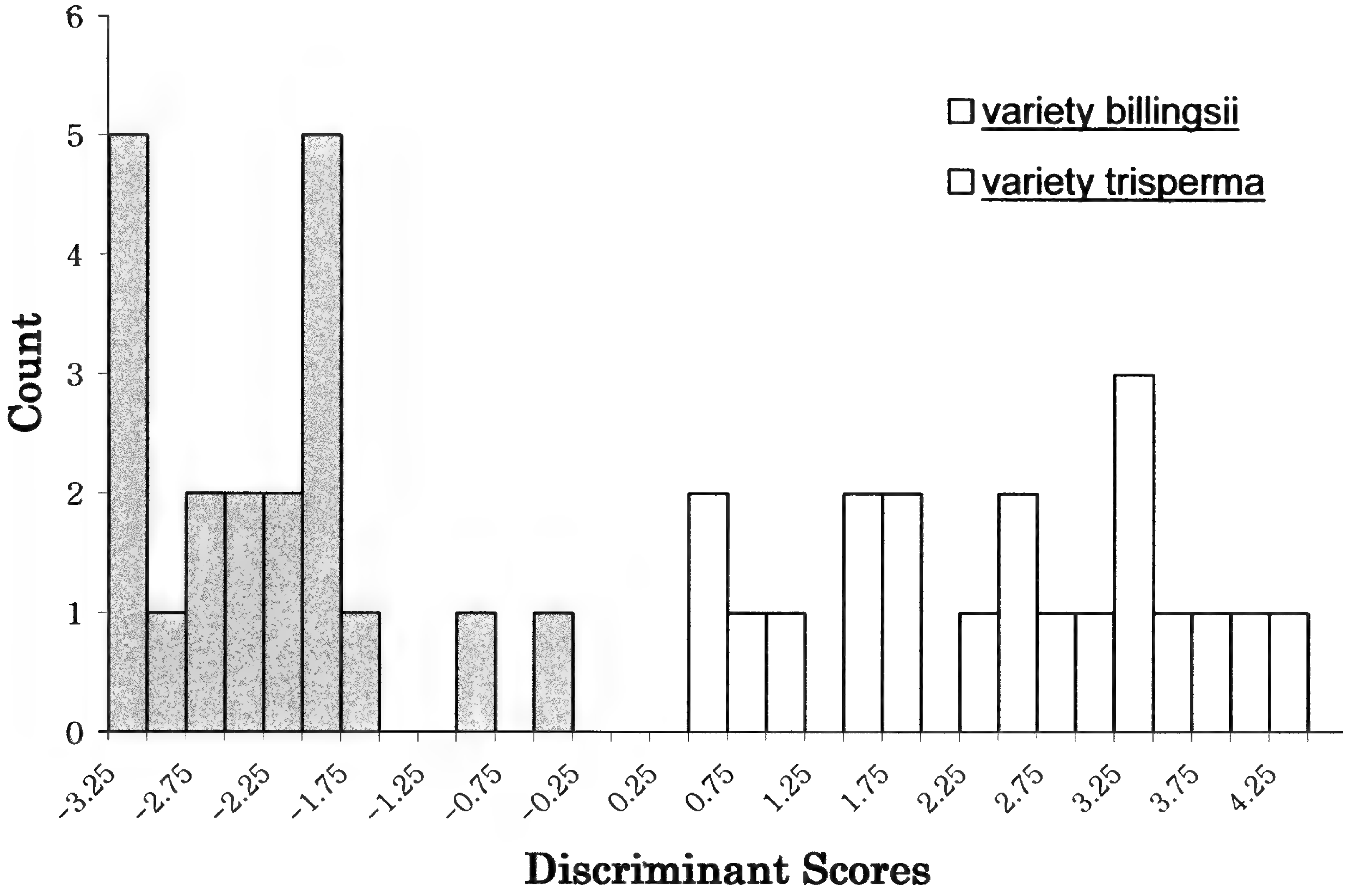

Fig. 3. A histogram of the discriminant function scores for *Carex trisperma* Dewey varieties, based on 14 measured morphological characters.

length, terminal bract (bristle) length, inflorescence length, ligule length, leaf width, and pistillate scale width differed significantly between varieties (two-tailed Mann-Whitney U test, asymp. sig. < 0.05) (Table 2). No observable differences were noted for qualitative characters, such as achene shape, sheath apex, or ligule shape and scale venation.

The overall variation of morphological characters, analyzed by PCA, is summarized by a scatter plot of the scores of Principle Components 1 and 2 (Fig. 2). These scores resolved two groups (Fig. 2). The two taxa separated on the first axis, which explained 44% of the total variance (Fig. 2). The second and third axes, however, only explained 13 and 11% of the total variance, respectively. Characters with high component (loading) scores (> 0.70) on axis one included leaf width, ligule length, inflorescence length, and number of perigynia per terminal spikelet (Table 2). As the values on axis one increases, all four of these characteristics increase and are associated with taxa described as *C. t.* var. *trisperma* (Fig. 2).

I assessed the relative importance of the morphological characters that distinguish the two taxa with Discriminant Function Analysis. A distinct separation of the two taxa is evident on a histogram of the discriminant function scores (Fig. 3). The three most highly weighted characters were the same as the highly weighted characters on Principal Component 1 in the PCA (Table 2, Fig. 6). Leaf width, ligule length, and inflorescence length will be the most useful for field recognition (Fig. 4).

The differences in leaf width originate through significant differences in leaf structure. Scanning electron microscope and leaf cross section photos demonstrate the anatomical differences that account for difference in leaf width (Fig. 5). The margins of *C. t.* var. *billingsii* leaves are involute above the sheath but fuse distally, which accounts for the triangular shape of the leaf in cross section. The leaves of *C. t.* var. *billingsii* have 1–2 large areas of aerenchyma tissue on the left and right sides of the midrib. The leaves of *C. t.* var. *trisperma* are thinly M-shaped in cross section, but appear flat apically and are deeply channeled, or keeled, on the

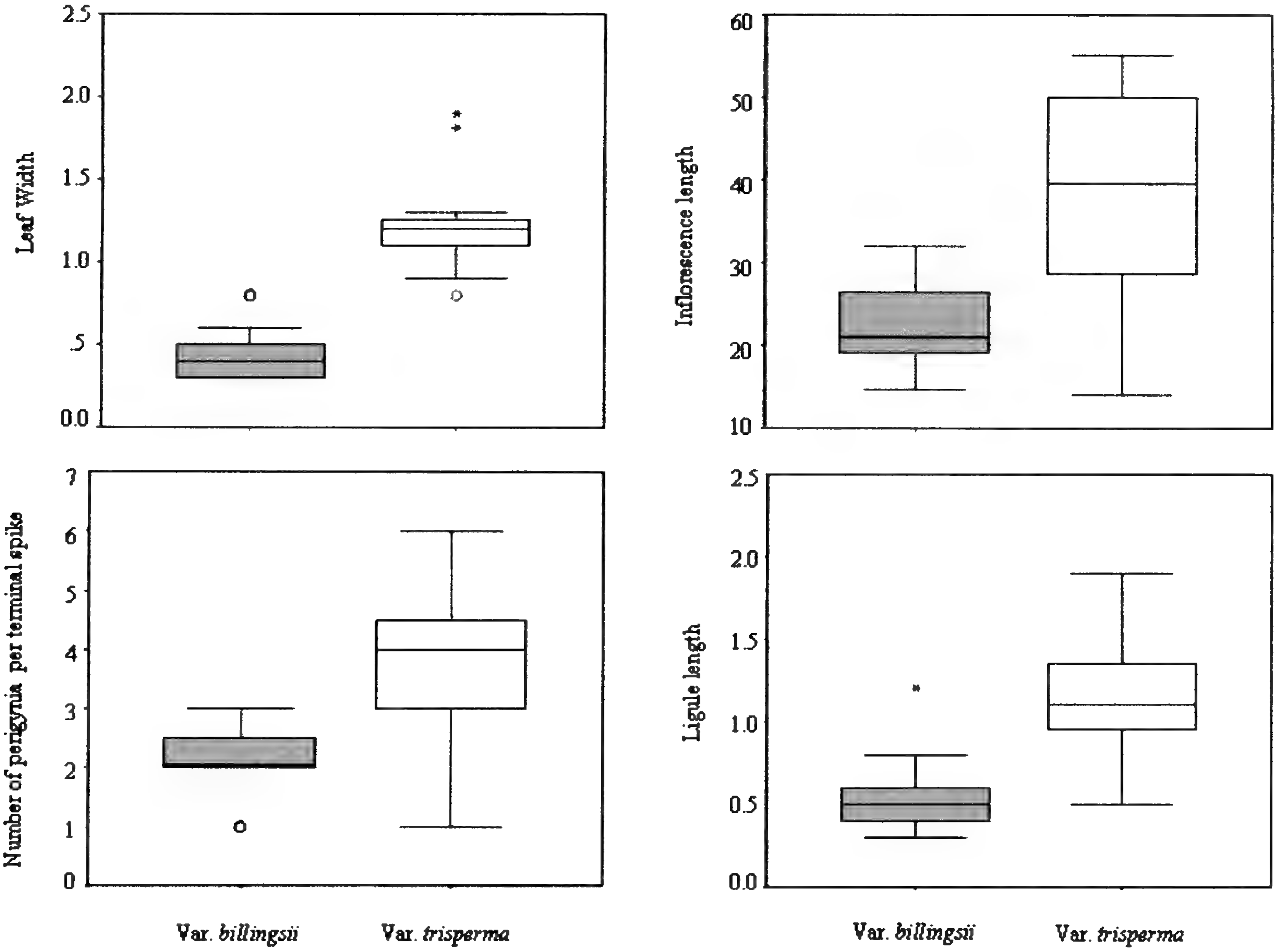

Fig. 4. Box plots of the four morphological characters that best distinguish *Carex trisperma* varieties.

abaxial surface, thus appearing V-shaped basally (near the sheath). There are 4–5 areas of aerenchyma tissue on either side of the midrib of *C. t.* var. *trisperma*.

Genetic Similarity.—A total of 102 loci were scored from GeneScan chromatographs. Ninety-two (90%) of those markers were polymorphic. DNA fragments ranged from 39 to 466 base pairs in length. The average (± standard error) fragment length was 148 ±9.4 base pairs, indicating a bias towards smaller fragments. Eighty-two markers were scored, and 80% (66) were polymorphic in *C. t.* var. *billingsii*. For *C. t.* var. *trisperma*, ninety-five markers were observed of which 86% (82) were polymorphic. With the primer pairs that were used, fragment sizes of 143, 155, and 173 base pairs were uniquely found in all specimens of *C. t.* var. *billingsii*, and fragment sizes of 154 and 178 base pairs were uniquely found in all specimens in *C. t.* var. *trisperma*.

The scatter plot of the ordination scores calculated using Jaccard's similarity index and nonmetric multidimensional scaling cleanly separated the two varieties (Fig. 6). The best solution (defined by the dimensionality with the lowest final stress from a real run) is a 3-dimensional solution with a final stress value of 13.7. All three axes explain 85% of the variance with 23%, 44%, and 18% of the va riance explained on the first, second, and third axes, respectively.

The mean intraspecific pairwise genetic distance (Nei & Li 1979) across all specimens was 0.01 (± 0.0003). Intraspecific genetic pairwise distances ranged from 0.0008 to 0.024. Genetic distances within varieties *trisperma* and *billingsii* (summarized in Fig. 7) ranged from 0.003 to 0.024 and from 0.0008 to 0.015, respectively. The mean pairwise genetic distance within var. *trisperma* was 0.011 (± 0.0004), whereas the mean pairwise genetic distance within var. *billingsii* was 0.009 (± 0.0004).

Phytogeography.—The two *Carex trisperma* varieties have overlapping ranges in the northeastern United

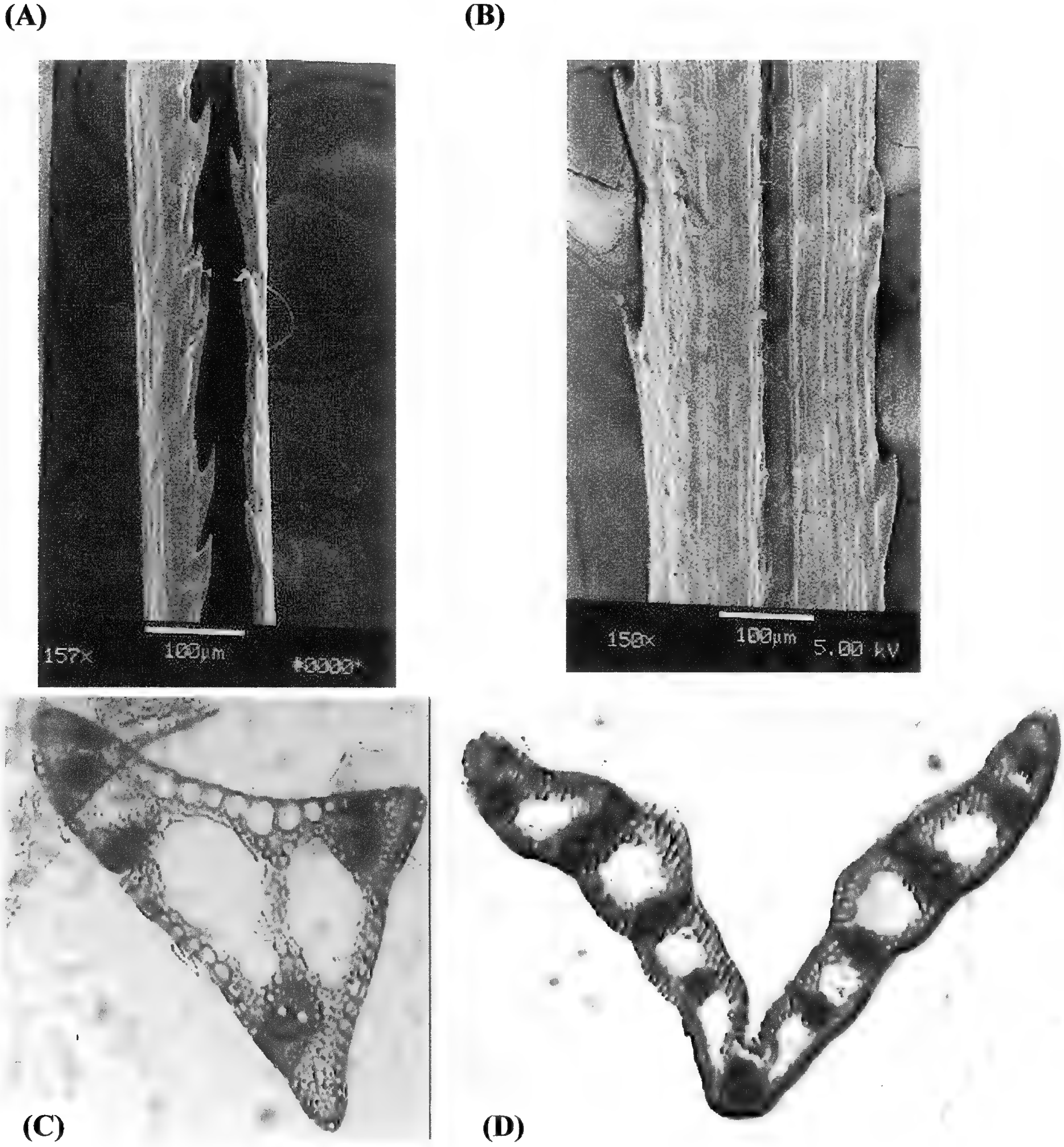

Fig. 5. Scanning electron microscope (SEM) and cross sectional photographs of leaves, which explain differences in leaf width due to internal structure. (A) SEM photograph of the basal portion of a leaf from *Carex trisperma* variety *billingsii* Knight. (B) SEM photograph of the apical portion of a leaf from *Carex trisperma* Dewey variety *trisperma*. (C) Cross sections of an apical portion of a *Carex trisperma* variety *billingsii* leaf. (D) Cross sections of a basal portion of a *Carex trisperma* variety *trisperma* leaf. (Scanning electron microscope photos were taken by Jane Gillies.)

States, southern Ontario, and Quebec (Fig. 8). Both taxa are found as far east as Newfoundland. *Carex t.* var. *billingsii* is found throughout New England, and its distribution follows the St. Lawrence seaway west through the Great Lakes. The range of *C. t.* var. *trisperma* extends farther north, south, and west. *Carex t.* var. *billingsii* ranges farther west and north than previously reported by Gleason and Cronquist (1991), but is congruent with the distribution reported by Toivonen (2002) (Fig. 8).

Carex ttrisperma var. *billingsii* may be more widespread than previously described. The farthest southwestern record of *C. t.* var. *billingsii* is from Ingham County, Michigan (Parmelee 246 MSC, 134054). A specimen of *C. t.* var. *billingsii* collected in Wexford County, Michigan (south of Traverse City), in the northern

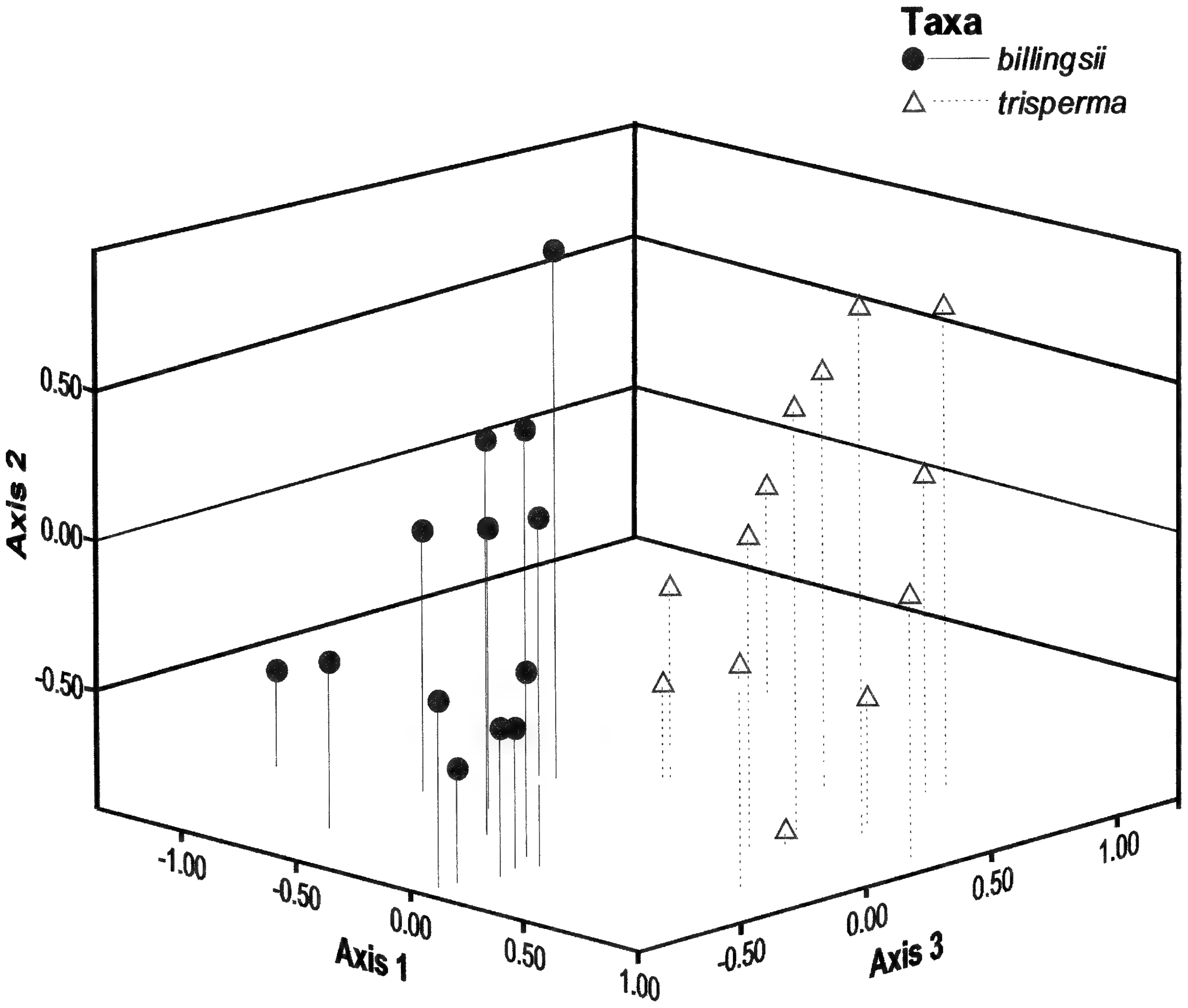

Fig. 6. A 3-dimensional scatter plot of nonmetric multidimensional scaling ordination scores for AFLP marker data derived from Carex trisperma Dewey varieties *billingsii* Knight and *trisperma*.

Lower Peninsula, recently found at MICH, expands the taxon's range farther north in Michigan. Searches in southwestern lower Michigan, however, did not disclose any further localitities. Specimens recently collected from Allegany County in New York (*Kirschbaum*, *s.n.*) and Susquehanna County in southeastern Pennsylvania (Naczi 10065.) suggest potential localities farther inland and away from coastal areas of the eastern seaboard and Great Lakes. Ombrotrophic bogs in northwestern Pennslyvania, northern Ohio, and Indiana are potential locations for new populations of *C. t.* var. *billingsii*. However, specimens reviewed at WIS, MO, UWSP, OS, and CLM yielded no further range extensions for *C. t.* var. *billingsii*.

Ecology.—*Carex t.* var. *billingsii* mostly grows in full-to-partial sunlight. Often it grows in dense clumps in ombrotrophic bogs at the base of low-growing ericaceous shrubs or along deer trails and narrow water channels. Unlike *C. t.* var. *billingsii*, *C. t.* var. *trisperma* is not restricted to acidic sphagnum bogs and, on the basis of herbarium label data, is commonly found in densely shaded swamp forests of various floristic, hydrological, and edaphic compositions. At many of the sites, I also found *C. t.* var. *trisperma* in swamps that were deeply shaded by tree canopies that were adjacent to the main bog mat. When growing in bogs *C. t.* var. *trisperma* is commonly (but not always) found in shaded portions such as dense tamarack or ericaceous shrubs stands.

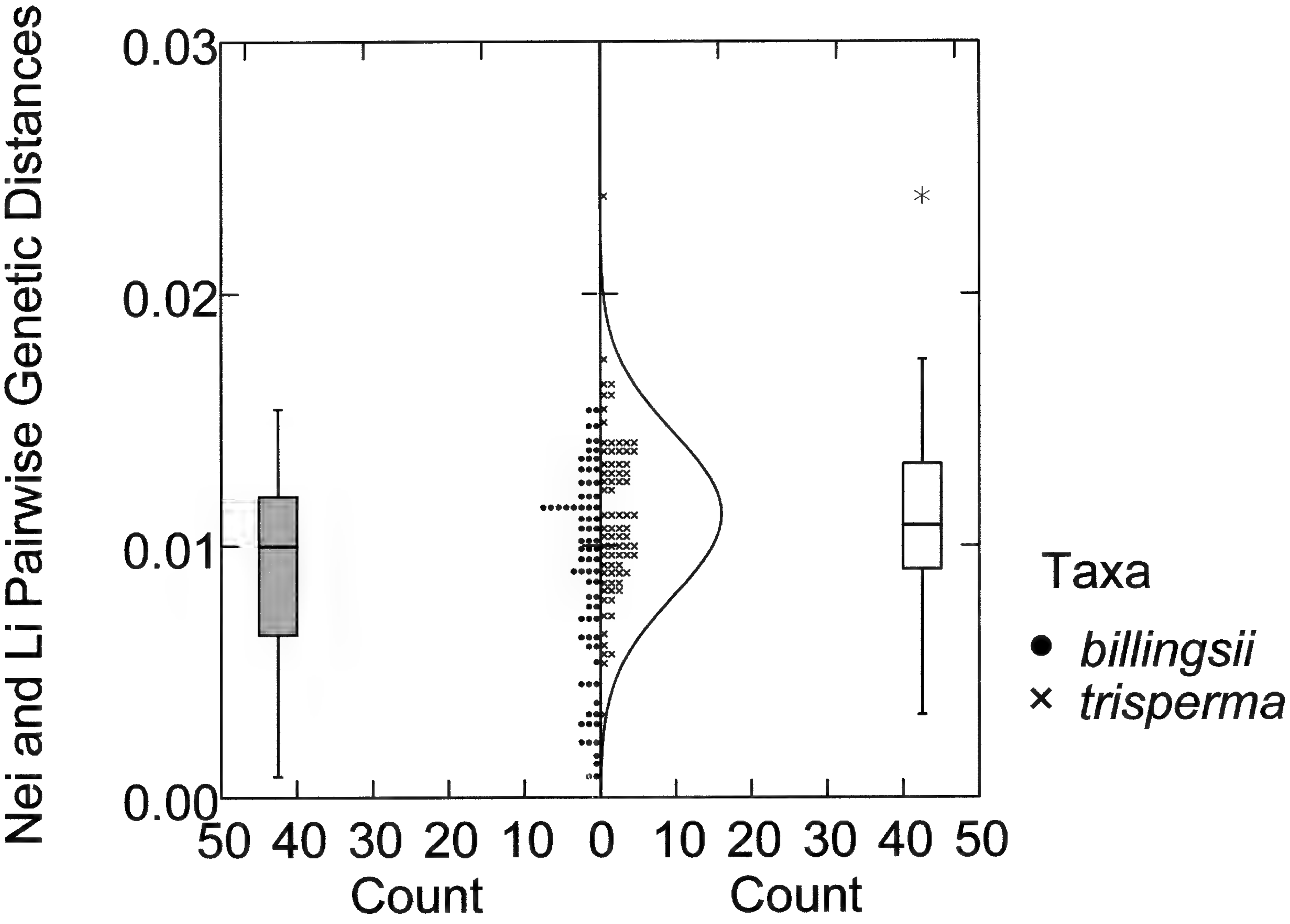

Fig. 7. A summary of Nei and Li pairwise genetic distances between specimens, which were calculated from the presence or absence of AFLP fragments.

Several individuals of *C. t.* var. *trisperma* were documented in this study and on herbarium labels as growing in full sunlight, and several *C. t.* var. *billingsii* were noted as growing in shaded areas. These individuals retain their expected morphological characteristics despite growing in a-typical habitats. Seventy-six percent of the 89 *C. t.* var. *billingsii* observations I collected were growing in open and slightly shaded (from low-growing shrubs) areas and 24% of the specimens were found under tall shrub or tree canopies. Sixty-four percent of the 80 *C. t.* var. *trisperma* observations I collected were found growing under tall shrub or tree canopies and 36% were growing in open and slightly shaded conditions. The proportion of plants growing in the predicted, "typical" light conditions for *C. t.* var. *trisperma* and *C. t.* var. *billingsii* was significantly different ($\chi^2 = 5.7$, $p < 0.02$ and $\chi^2 = 21.1$, $p < 0.001$, respectively) from expected proportions of 50% of the specimens in each condition.

DISCUSSION

Morphology.—PCA and DFA support the recognition of two distinct entities among the herbarium specimens measured in this study (Figs. 4, 5, and 6). Both multivariate analyses place high importance on leaf width, ligule length, inflorescence length, and the number of perigynia per terminal inflorescence in discerning the two varieties (Table 2, Fig. 6). The more diminutive measurements of *C. t.* var. *billingsii* agree with previous descriptions by Knight (1906), Gleason and Cronquist (1991), and Toivonen (2002). The lack of morphologically intermediate specimens and the clear morphological distinctions between the two taxa, based on analysis of several characters simultaneously (Fig. 4), do not support Knight's contention that *C. t.* var. *billingsii* is a transitional form of *C. t.* var. *trisperma*.

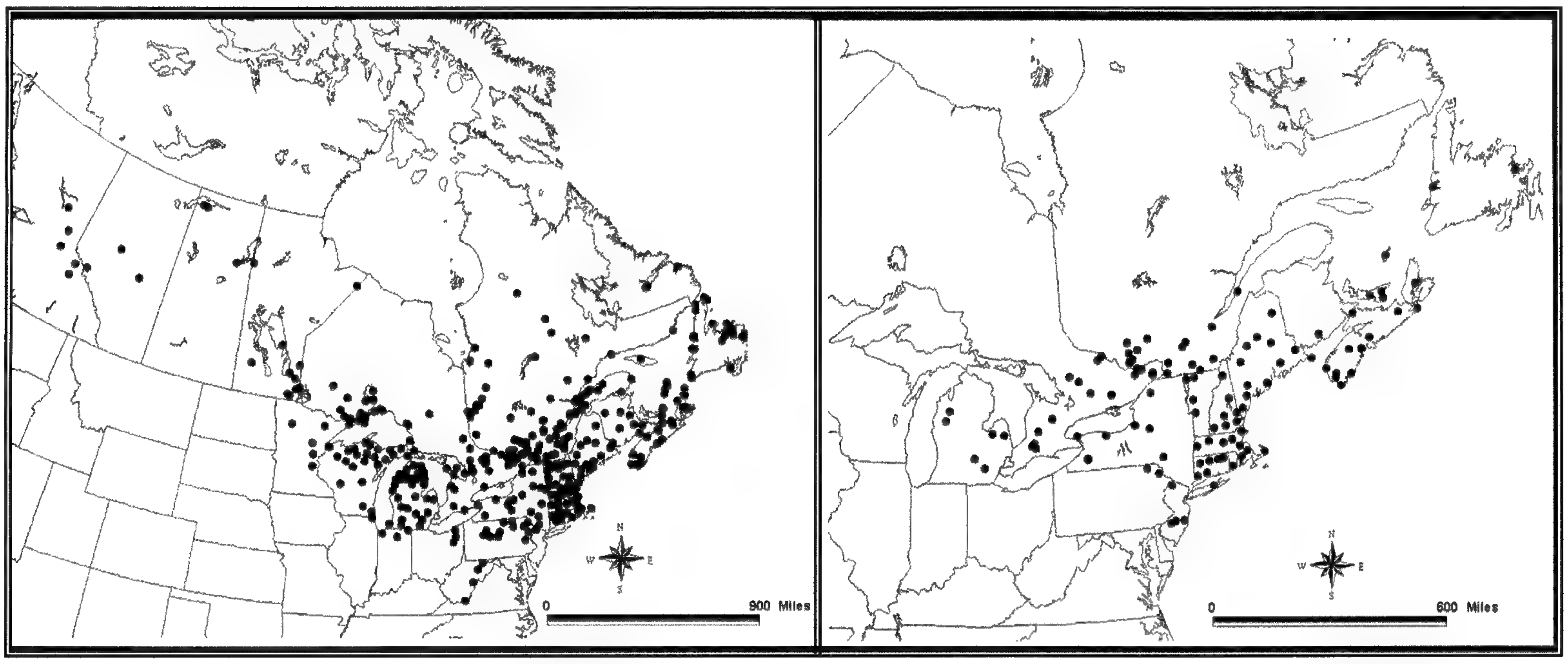

Fig. 8. The distribution of *Carex trisperma* Dewey varieties *trisperma* (left) and *billingsii* Knight (right) mapped from 310 herbarium specimens and recent collections.

Phytogeography and Ecology.—*Carex trisperma* var. *billingsii* and var. *trisperma* each have a unique geographic distribution and ecology (Figs. 2–3). *Carex t.* var. *billingsii* has been found only in the northeastern United States and adjacent Canada. Despite occurring in *Sphagnum* bogs, *C. t.* var. *billingsii* is a temperate plant and is mostly confined to sites within the deciduous forest biome (Brown & Lomolino 1998). The distribution of *C. t.* var. *trisperma*, however, spans the deciduous forest biome and reaches into the boreal or sub-arctic biome (Brown & Lomolino 1998) and extends farther west, south, and north than that of *C. t.* var. *billingsii*.

In many sites in the east, the two varieties are syntopic (Table 1); however, *C. t.* var. *billingsii* has never been collected west of Michigan. If *C. t.* var. *billingsii* were simply an open-grown morphotype of *C. t.* var. *trisperma*, then it would be likely that the distribution of *C. t.* var. *billingsii* would overlap that of *C. t.* var. *trisperma* and thus be present in open bogs west of Michigan. However, *C. t.* var. *billingsii* has not been collected in any of the well-studied bogs of southern Wisconsin or northern Minnesota, regions known for peat bogs that are found in glacial lake beds (i.e., Glacial Lake Wisconsin and Agassiz Lake). Thus, the absence of *C. t.* var. *billingsii* in areas where *C. t.* var. *trisperma* is common suggests a genetic rather than an environmental basis for the differences in morphological characters.

Comparisons of the canopy conditions in which the two varieties were found provide evidence of some ecological distinction between the two taxa. *Carex t.* var. *trisperma* is typically found in shaded conditions, and *C. t.* var. *billingsii* is typically found in open conditions. This lack of morphological plasticity in opposing light conditions was also noted on herbarium specimens. For example, a specimen of *C. t.* var. *trisperma* collected by Reznicek, 11367, Naczi and Case was "from a small colony in full sun on a hummock in the open bog." Each taxon retains its morphological characters across habitats with different light conditions.

These observations agree with Anderson et al. (1996), who quantified habitat characteristics of *C. trisperma* in Maine. Even though they did not analyze their data by variety, they found that *Carex trisperma* grew under a range of shaded-to-open conditions with a mean percent canopy cover of 53 (± 35.8 S.D.).

Genetic Analyses.—Nei and Li's (1979) genetic distances within varieties *trisperma* and *billingsii* ranged from 0.003 to 0.024 and 0.0008 to 0.015, respectively (Fig. 8). Hipp (2004), in a study of the *Carex tenera* Dewey group of section *Ovales* Kunth, provided the only reasonable benchmark for comparison within *Carex*. Genetic distances ranged from 0.03 to 0.08 among three species in the *C. tenera* group (Hipp 2004). These numbers indicate a much higher level of genetic divergence between species in the *C. tenera* group than between the *C. t.* varieties. However, the species of the *Carex tenera* group can be diagnosed easily with morphological characters (Hipp 2004), as can the varieties of *Carex trisperma* (Figs. 4–6). This suggests that in *Carex*, morphological distinctiveness does not always correlate with genetic divergence.

Nonmetric multidimensional scaling supports genetic distinction between the two varieties. Intravarietal genetic distances were significantly higher in *C. t.* var. *trisperma* than in *C. t.* var. *billingsii*. This suggests greater genetic diversity in *C. t.* var. *trisperma*, which is also consistent with its relatively more extensive distribution compared to that of *C. t.* var. *billingsii*.

While genetic differentiation alone is not sufficient for delimiting species boundaries, the molecular analyses combined with the consistent differences in morphological, geographical, and ecological data to strongly suggest that *C. t.* var. *billingsii* is distinct enough from *C. t.* var. *trisperma* to warrant raising *C. t.* var. *billingsii* to the rank of species. Indeed, phenotypic clusters based on morphological data in plants often correspond closely to independent reproductive lineages identified by crossing studies (Rieseberg et al. 2007). The fact that morphometric data and molecular genetic data both demonstrate strong differences between the varieties tested in this study supports raising these varieties to species rank.

CONCLUSION

The morphological data presented in this paper suggest that *Carex trisperma* and *Carex billingsii* comb. et stat. nov can be separated on the basis of a distinct set of morphological characters, of which leaf width, ligule length, inflorescence length, and the number of perigynia are the most diagnostic. Based on phenetic analyses of the AFLP fragment data using nonmetric multidimensional scaling, the two varieties are distinct. The combination of geographic, ecological, morphological, and genetic data strongly suggest that *Carex trisperma* var. *billingsii* is distinct enough from *C. t.* var. *trisperma* to warrant raising *C. t.* var. *billingsii* to the rank of species.

Future phylogenic analyses that evaluate evolutionary relationships within sect. *Glareosae* should include these two species along with other putative members of this group. The author hopes that the recognition of *C. billingsii* at the rank of species will bring this species to the attention of wetland scientists and conservation biologists who can further study the ecological differences between it and *Carex trisperma* and also further document the abundance of *C. billingsii* in bogs on the fringe of its distribution to determine whether protection status is warranted.

TAXONOMIC TREATMENT AND KEY TO SPECIES

Leaves 0.8–1.9 mm wide, flat or thinly M–shaped, ligules 0.5–1.9 mm long, inflorescences (14–)23–55 mm long, spikes per inflorescence (2–)3–4, terminal spikes with (1–)2–6 perigynia per spike ________________ **Carex trisperma**

Leaves 0.3–0.8 mm wide, filiform-involute, ligules 0.3–0.8(–1.2) mm long, inflorescences 14–32 mm long, spikes per inflorescence 2–3, terminal spikes with 1–3 perigynia per spike________________________________ **Carex billingsii**

NOMENCLATURE

Carex billingsii (O.W. Knight) C.D. Kirschbaum, comb. et stat. nov. Basionym: *Carex trisperma* var. *billingsii* O.W. Knight, Rhodora 8:185. 1906. *Carex trisperma* f. *billingsii* (O.W. Knight) B. Boiven, Naturaliste Canad. 94:523. 1967. Type: U.S.A. Maine: Somerset Co.: Pleasant Ridge Twp., the drier portions of upper Jewett Bog, 5 Jul 1906, *O.W. Knight, J. Murdoch Jr., E.B. Chamberlain, R.A. Ware, S. Rollins 5066* (holotype: not seen, see below; isotype: GH!).

It is not certain where Knight's holotype for *C. t.* var. *billingsii* was deposited. I have contacted curators at MAINE, VT and GH but they were not able to locate the type specimen. A duplicate of the type (cited above) is located at GH and another specimen, *Knight 2021*, collected at the same locality and on the same date as the specimen that Knight cited as the type specimen is also at GH.

One untypified name referable to the *Carex trisperma* alliance exists, *Carex quaternaria* Sprengel (1826), based on material from New Jersey. The type of *Carex quaternaria* appears to have been destroyed at Berlin. However, the description states "Spiculis 4 floris" (spikes four-flowered) (Sprengel 1826) (presumably the basis for the specific epithet *quarternaria*). *Carex billingsii* is smaller and averages fewer flowered spikes than *C. trisperma*, and no specimen has been observed with four perigynia in a spike. *Carex quaternaria* is certainly the same entity as *Carex trisperma*, which can have up to six perigynia per spike. A neotype for *Carex quaternaria* from New Jersey and having some spikes with 4 perigynia is selected below.

Species Description.—*Carex billingsii*. Plants glabrous, loosely cespitose; rhizomes with slightly fibrous or non-fibrous sheaths, basal sheaths dark to light brown. Fertile culms erect at anthesis, elongating and arching toward the ground after fruiting, 20–36 cm with 2–3 spikes per inflorescence. Leaves of the fertile culm (1)3 or 4 located on the lower 1/3 of the culm. Leaf blades filiform-involute above the sheath, leaf margins fusing distally, 7–13 × 0.3–0.8 mm. Leaves triangular in cross section, with 1–2 large areas of aerenchyma tissue on the left and right sides of the midrib. Ligule 0.3–0.8(–1.2) mm long, obovate or with rounded apex. Sheaths hyaline, apex concave. Inflorescence 14–32 mm long, proximal bract 15–63(–72) mm, often exceeding inflorescences. Base of proximal bract sometimes elongated and expanded 1.7–3.2(–4.1) × 0.8–1 mm. Terminal spikes 3.3–4.7 × 1.9–3.2 mm with 1–3 perigynia per spike, lateral spikes 3.5–4.5 × 1.5–2.5(–3.1) mm with 1–3 perigynia per spike. Spike with 2 staminate flowers and ascending to slightly diverging perigynia. Proximal-most and penultimate spikes 2.2–6 mm apart, penultimate and distal-most spike (when present) 6–23 mm apart. Perigynia 2.7–3.9 × 0.9–1.6(–1.8) mm widest just below the middle. Beak of the perigynia 0.4–0.7 mm, truncate to bi-dentulate with teeth 0.1 mm long. Abaxial nerves of the perigynia 14–19(–25), adaxial nerves 9–12. Pistillate scales 2.2–3.2 × 0.9–1.5 mm with green midrib between whitish-green margins, apex acute (mucronate), 1/2–2/3 as long as the perigynia. Stigmas 0.03–0.1 mm wide. Staminate scales 2.2–4.3 × 0.9–1.4 mm with similar coloring as pistillate scales. Anthers 0.9–1.5 mm long. Achenes 1.3–2.0 × 0.8–1.4 mm, ovate, broadly elliptical or obspatulate. Base of the achene rounded, truncate, cuneate or attenuate, apex rounded or truncate. Fruiting mid-June–September. Found in sunny and in shaded areas of ombrotrophic, tamarack, spruce and cedar bogs, often on tops and sides of sphagnum hummocks, along trails and small creeks, wet, sandy swales in NJ pine barrens, *Chamaecyparis* Spach swamps bordering salt marshes in MA and interdunal string bogs in Quebec. Often associated with ericaceous shrubs such as *Kalmia angustifolia* L., *Chamaedaphne* Moench, *Ledum* L. and *Vaccinium* L.

Specimens examined: **CANADA. NEWFOUNDLAND:** Trepassey, Avalon Peninsula, 053°24'00"W, 46°43'00"N, 16 Aug 1924, *Fernald, Long, Dunbar 26376* (GH). **ONTARIO:** 6 Jul 1915, *Frere Rolland-Germain s.n.* (DAO); 12 Jul 1923, *Malte s.n.* (MICH); Middlesex, Sifton (Byron) Bog, UTM Grid 734575, Map 40 I/14, 081°25'00"W, 43°00'00"N, 4 Jul 1991, *Reznicek, McLeod 8810* (MICH). **PRINCE EDWARD ISLAND:** Kings, Murray River, N of the river on Route 24, 062°32'00"W, 46°02'00"N, 22 Jul 1953, *Erskine, Smith 2103* (DAO). **QUEBEC:** Berthier, Lanoraie, 073°13'00"W, 45°58'00"N, 6 Jul 1932, F. Marie-Victorin, *F. Rolland-Germain 49208* (MT); Kamouraska, Peat bog 1 mi NE of Riviere Ouelle, 069°49'00"W, 47°32'00"N, 6 Aug 1947, *Calder 1282* (DAO); Labelle, NE du Grand lac Nominingue, pres de la riviere Rouge, Bellerive, 27 Jul 1939, *F. Lucien, F. Eloi 577* (MT); North Bay, 3 mi N of Tomiko River bridge along Hwy 11, N of North Bay, 23 Sep 1959, *Calder, Kukkonen 24287* (DAO); Gatineau, Masham Twp., Conc. V, (Outaouais), 13 km WNW of Wakefield, 31 F/9 156575 (UTM grid), Ottawa District, 076°05'W, 45°40'N, 29 Jun 1988, *Reddoch 398* (DAO); Les Sillons, W side of Hwy 199, S of Pont du Detroit, N end of Ile du Hvre aux Maisons, 14 Aug 1998, *Oldham 21198* (MICH).

UNITED STATES. CONNECTICUT. Hartford Co.: Burlington, 11 Jun 1921, *Weatherby D2120* (GH). **Hartford Co.:** Black Spruce bog S of Rte 168 near Congamond Lake, 22 Jun 1982, *Mehrhoff 6343* (MICH). **Litchfield Co.:** Kent, 4 Jul 1930, *Torrey s.n.* (MICH). **Tolland Co.:** bog near railroad tracks and Rte I-84, 4 Jul 1990, *Mehrhoff 13514* (MICH). **MAINE. Aroostook Co.:** T8N, R5W, 25 Jul 1941, *Pease, Bean 29029* (GH); Fort Fairfield, the Aroostook River Basin, 5 Jul 1940, *Chamberlain 1715* (GH); E side of Hwy 2A (Alt 2) ca. 2.7 mi S of Forkston-TAR2WELS township line. 0577721E 5082451N UTM Zone 19T (Units: km, Datum: NAD 83), 6 Jul 2002, *Kirschbaum s.n.* (n/a). **Hancock Co.:** Corea Heath, SW side of Hwy 195 ca 1 mi NW of Corea, 068°00'W, 44°23'N, 16 Jul 1992, *Reznicek 9149* (MICH); head of Torrey Pond, Deer Isle, 7 Jul 1915, *Hill 2179*, (GH). **Somerset Co.:** Jewett Brook Bog, NE of Jewett Pond, 150 ft NW of Jewett Brook and past the turn to Jewett Pond campsites, 4.7 mi NW of Cross rd. along Rowe Pond Rd., Pleasant Ridge Twp. 0420195E 4998596N UTM Zone 19T (Units: km, Datum: NAD 83), 7 Jul 2002, *Kirschbaum s.n.* (n/a). **Washington Co.:** 8 Jul 1993, *Reznicek 9620*, (MICH). **MASSACHUSETTS. Barnstable Co.:** Harwich, 3 Aug 1913, *Weatherby s.n.* (GH). **Berkshire Co.:** Lost Pond, Becket, 16 Jul 1909, *Hoffmann s.n.* (GH). **Middlesex Co.:** Littleton, No date, *Manning(?) s.n.* (GH). **Middlesex Co.:** Tewksbury, no date, *Gray(?) s.n.* (GH). **MICHIGAN. Washtenaw Co.:** Gorman Lake Bog on the S end of Gorman Lake off Lindley Rd. in Waterloo State Recreation Area, ca. 8 mi NW of Dexter., 21 Sep 2002, *Kirschbaum s.n.* (n/a). **NEW HAMPSHIRE. Cumberland Co.:** Bog Pond, 0.75 km off Haskell Hill Rd. by way of power line right-of-way on private property. Northern Harrison twp., 0370429E 4886298N UTM Zone 19T (Units: km, Datum: NAD 83), 7 Jul 2002, *Kirschbaum s.n.* (n/a). **Hillsborough Co.:** off hiking trail on the W side of Mud Pond in Fox State Forest. Hillsborough twp., 0264272E 4780594N UTM Zone 19T (Units: km, Datum: NAD 83), 4 Jul 2002, *Kirschbaum s.n.* (n/a). **Strafford Co.:** between Mt. Hussey and Mt. Chesley, Farmington, 20 Jul 1967, *Hodgon 15735* (GH); N of Scruton Pond, on Scruton Pond Rd., Barrington twp., 4 Jul 2002, *Kirschbaum s.n.* (n/a). **NEW JERSEY. Burlington Co.:** Chatsworth, 1 Jul 1932, *Hermann 3380*, (MICH). **Ocean Co.:** Forked River, No date, *Churchill s.n.* (GH); Pole Bridge Brook, 2 mi WSW, Whitings, 17 Jul 1914, *Long 10321* (GH). **NEW YORK. Allegany Co.:** Moss

Lake Bog on Moss Lake off Sand Hill Rd. ca. 2.5–0.0 mi SW of Houghton, Caneadea twp. 0731623E 469767N UTM Zone 19T (Units: km, Datum: NAD 83), 11 Jul 2002, *Kirschbaum s.n.* (n/a). **PENNSYVANIA. Susquehaanna Co.:** 2 mi N of Burnwood, W side of Ball Lake, 24 Aug 2003, *Robert F.C. Naczi 10065* (DOV). **VERMONT. Franklin Co.:** 055°45'00"W, 51°33'00"N, 25 Jul 1912, *Woodward s.n.* (GH). **Grand Isle Co.:** S. Alburg, 16 Jul 1939, *Knowlton s.n.* (GH).

Carex trisperma Dewey, Amer. J. Sci. Arts 9:63. 1825. Basionym: *Neskiza trisperma* (Dewey) Raf., Good Book. Amenit. Nat. Philad. 27. 1840. Type: U.S.A. Massachusetts: Berkshire Co.: Williamstown, without collection date, *C. Dewey* (lectotype designated here: GH 63033).

U.S.A. Massachusetts. [probably Bershire Co.]: Williamstown-Deerfield, grows in the form of bogs in sphagnous place among hills, [no collection date], *C. Dewey* (GH 27464).

Carex quaternaria Spreng., Systema Vegetabilium 3:809. 1826. Type: U.S.A. New Jersey. Sussex Co.: Culvers Gap, swamp, 30 May 1919, *Ludlow Griscom, No. 14336* (neotype designated here: GH-s.n.)

Species Description. *Carex trisperma*. Plants glabrous, loosely cespitose; rhizomes with slightly fibrous or non-fibrous sheaths, basal sheaths dark to light brown. Fertile culms erect at anthesis, elongating and arching toward the ground after fruiting, 15–65 cm with (2–)3–4 spikes per inflorescence. Leaves of the fertile culm (2)3 or 4(5) located on the lower 1/3 of the culm. Leaf blades, appearing flat apically and deeply channeled, or keeled on the abaxial surface, (9–)13–18(–24) × 0.8–1.9 mm. Leaves thinly M-shaped in cross section with 4–5 areas of aerenchyma tissue on each side of the midrib. Ligule 0.5–1.9 mm long, obovate or with rounded apex. Sheaths hyaline with sheath apex concave. Inflorescence (14–)23–55 mm long, proximal bract 28–74 mm, often exceeding inflorescences. Base of proximal bract sometimes elongated and expanded 1.5–3.7 × 0.6–14 mm. Terminal spikes 4.4–6.5 × 2.5–4.4 mm with (1–)2 perigynia per spike, lateral spikes 3.6–5.0 × 2.4–4.7 mm, with (1–)2–6 perigynia per spike. Spike with 2 staminate flowers and ascending to slightly diverging perigynia. Proximal-most and penultimate spikes 4.3–12 mm apart, penultimate and distal-most spike (when 3 spikes are present) (14)21–33(46) mm apart. Perigynia 2.2–3.7 × 1.2–1.7 mm widest just below the middle. Beak of the perigynia 0.4–0.7 mm, truncate to bi-dentulate with teeth 0.1–0.2 mm long. Abaxial nerves of the perigynia 13–21, adaxial nerves 7–14. Pistillate scales 2.2–3.2 × 1.1–1.7 mm with green midrib between whitish-green margins, apex acute to mucronate, 1/3–2/3 as long as the perigynia. Stigmas 0.05–0.1 mm wide. Staminate scales 2.4–4.6 × 0.5–1.2 mm with similar coloring as pistillate scales. Anthers 1–1.5 mm long. Achenes 1.7–2.2 × 1.1–1.5 mm, ovate, broadly (narrowly) elliptical or obspatulate. Base of the achene cuneate or attenuate, apex rounded or truncate. Fruiting early June–August. Found in deep to partial shade and occasionally in sunny areas of ombrotrophic sphagnum bogs and cedar and spruce swamp forests and wet-mesic deciduous woods. Associated with *Picea rubens* Sarg., *Abies balsamea* (L.) P. Mill., *Taxus canadensis* Marsh., *Acer rubrum* L. and *Pinus strobus* L. in bogs and swamps of New England, *Chamaecyparis* Spach swamps in MA, *Thuja occidentalis* L., *Picea mariana* (P. Mill.) B.S.P., *Acer rubrum* L. and *Larix* P. Mill. swamp forests from New York and Ontario westward and open Sphagnum-Ericaceae bogs across its range, especially northward.

Specimens examined: **CANADA. ALBERTA:** Swan Hills Twp., 65–R 9–W5M, 115°45'00"W, 54°45'00"N, 7 Aug 1960, *Pegg 880* (DAO). **BRITISH COLUMBIA:** Barkerville, 12.5 mi by road NNE of Barkerville on road to Bowron Lake, 121°23'00"W, 54°14'00"N, 9 Aug 1954, *Calder, Savile, Ferguson 14328* (DAO). **NEW FOUNDLAND:** Virginia Water, near St. John's, No date, Robinson, *Schrenk 100* (GH); near Isthmus Cove, Pistolet Bay, 5 Aug 1925, Wiegand, *Gilbert, Hotchkiss 27612* (GH); Forteau, Belle Isle, 14 Aug 1925, *Long 27614* (GH); Goose Bay, 060°21'W, 53°19'N, 10–12 Aug 1949, *Schofield 749* (DAO). **MANITOBA:** Lac Du Bonntet, 7 Jul 1949, *Breitung 7474* (DAO); Lac du Bois, along trail to South Lake, 095°40'W50°16'N, 18 Aug 1982, *Keleher 954* (DAO); near Keyhole Lake, inland from NW shor of Tod Lake., 101°45'50"W56°34'06"N, 20294, 24 Jul 1955, *Ritchie 1268* (DAO); NW side of Tulibi Lake, 19 Jun 1955, *Ritchie 822* (DAO); Taiga Biological Station, Wallace Lake., 095°20'W51°02'N, 5 Jul 1979, *Keleher 737* (DAO). **NOVA SCOTIA:** Antigonish, vicinity of Seascape Cottages, W of Bayfield, 062°00'00"W, 45°37'00"N, 20 Jun 1992, *Oldham 13841* (MICH). **ONTARIO. Nipissing District:** 0.25 mi S of Jack Lake on old logging road, 078°33'00"W, 45°35'00"N, 12 Jun 1958, *Kazdan 617* (DAO); Mowe L. Rd just S. of Plummes L. on recently built road shoulder, 090°43'W, 48°20'N, 27 Jun 1981, *Garton 20180* (MICH). **Norfolk Regional Municipality:** Turkey Point Provincial Park, Wilderness Zone, Delhi Tp. Mun., UTM 545265 (401/9) (sq17NT52), 080°19'00"W, 42°42'00"N, 27 May 1987, *Oldham, Sutherland, Kirk 7206* (MICH); Bruce, Schmidt L, 29 Jul 1987, *Johnson s.n.* (MICH). **SASKATCHEWAN:** S shore of Lake Athabasca, E of William River. Vicinity of "Little Gull" Lake., 109°00'W59°01'N, 22826, 29 Jun 1962, *Angus 295-62* (DAO)**;** ca. 5 km SSE of Archibald Lake, ca. 13 km NNW of Davy Lake, 108°30'W58°58'N, 29078, 8 Jul 1979, *Harms, 27411* (DAO); Wollaston Lake Rd, mile 10, Hwy 105, ca. 130 mi N of La Ronge., 103°37'W56°20'N, 22 Jul 1973, Ternier *s.n.* (DAO). **QUEBEC:** 075°55'51"W, 45°38'18"N, 12 Jul 1922, *Malte 384/22* (MICH); Rupert House, E coast of James Bay, 18 Jul 1929, *Potter 91* (GH); Red Bay, N shore of the Gulf of St. Lawrence, 26 Jul 1929, *Abbe 1062* (GH); Grand Lake, Blue Grass Brook, near Camp 11, 5 Aug 1951, *Rolueau 2206* (MICH); Abiti-East, Harricanaw River Maizerets Twp. 0.75 mi E of river, 078°03'W, 49°11'N, 24 Jul 1958, *Bentley 58163* (DAO).

UNITED STATES. CONNECTICUT. Windham Co.**:** Windham, 17 Jun 1914, *Weatherby 3472* (GH). **ILLINOIS. Lake Co,:** 3 Aug 1906, Gleason, *Shobe s.n.* (MICH). **MASSACHUSETTS. Plymouth Co.:** Norwell, 6 Jun 1932, *Knowlton s.n.* (GH). **Worcester Co.:** 17 Jun 1938, *Weatherby, Weatherby s.n.* (MICH). **MAINE**. **Grand Lake.:** Blue Grass Brook, near Camp 11, 5 Aug 1951, *Rolueau 2206* (MICH). **Hancock Co.:** Central Tract, Brooklin, 2 Aug 1914, *Hill 1769* (GH). **Lincoln Co.:** Cathedrdal Woods, Monhegan Island, 29 Jun 1919, *Jenney, Churchill, Hill 3170* (GH). **Piscataquis Co.:** Squaw Moosehead Station, 9 Jul 1917, *Sanford 60605* (GH). **Ostesgo Co.:** N side Old State R d . (F38) ca. 13.5 Km E of Otsego Lake , SE 1/4 sect. 10, T29N R2W. Lat. & Long. 44° 54' 55" N, 84° 31' 46" W, 15 Jul 2002, *A.A. Reznicek 11367* (MICH). **Piscataquis Co.:** Greenville Junction, 8 Jul 1917, *Sanford 6032* (GH). **Somerset Co.:** Jewett Brook Bog, NE of Jewett Pond. 150 feet NW of Jewett Brook and past the turn to Jewett Pond campsites, 4.7 mi NW of Cross Rd. along Rowe Pond Rd., Pleasant Ridge Twp. 0420195E 4998596N UTM Zone 19T (Units: km, Datum: NAD 83), 7 Jul 2002, *Kirschbaum s.n.* (n/a); Pleasant Ridge, Upper Jewett Bog, 5 Jul 1906, *Murdoch 2022* (GH). **Washington Co.:** salt marsh along Sandy R, behind Sandy R Beach, 3.5 mi ENE Jonesport, E side of Hwy 187, 067°32'W, 44°34'N, 7 Jul 1993, *Reznicek 9615* (MICH). **MICHIGAN. Baraga Co.:** along US Highway 41 near W end of Lake Michigamme, 22 Jun 1950, *Richards 3184* (MICH). **Berrien Co.:** Buchanan Bog, 30 May 1930, *Herbert s.n.* (MICH). **Iron Co.:** *Larix* Bog, near Deer Lake, 10 m NE of Crystal Falls, 088°20'W, 46°24'N, 8 Aug 1934, *Grassl 8057* (MICH). **Lake Co.:** Ca. 2.5 mi N of Bristol, 18 Jul 1973, *Voss 14227* (MICH). **Schoolcraft Co.:** T42N, R16W, Sect. 11 NW1/4NE1/4, SW1/4SE1/4, 2 Sep 1971, *Henson 269* (MICH). **Washtenaw Co.:** Gorman Lake Bog on the S end of Gorman Lake off Lindley Rd. in Waterloo State Recreation Area, ca. 8 mi NW of Dexter, 21 Sep 2002, *Kirschbaum s.n.* (n/a). **MINNESOTA. Aitkin Co.:** 0.7 mi S of McGrath, 25 Jun 1940, *Moore, Moore 13263* (MT). **Cook Co.:** S of Grand Portage along Highway 61, 15 Aug 1987, *Castaner 9986* (MICH). **NEW HAMPSHIRE. Coos Co.:** Magalloway River, 3 Aug 1914, *Pease 16207* (GH); Bray Hill Bog, NE of Whitefield of county road 116 (Jefferson Rd.) on the NW side of Bray Hill Rd., Whitefield twp., 0297240E 4920187N UTM Zone 19T (Units: km, Datum: NAD 83), 7 Jul 2002, *Kirschbaum s.n.* (n/a). **Cumberland Co.:** Bog Pond, 0.75 km off Haskell Hill Rd. by way of power line right-of-way on private property, northern Harrison twp., 0370429E 4886298N UTM Zone 19T (Units: km, Datum: NAD 83), 7 Jul 2002, *Kirschbaum s.n.* (n/a). **Hillsborough Co.:** off hiking trail on the W side of Mud Pond in Fox State Forest. Hillsborough twp., 0264272E 4780594N UTM Zone 19T (Units: km, Datum: NAD 83), 4 Jul 2002, *Kirschbaum s.n.* (n/a). **Strafford Co.:** N of Scruton Pond, on Scruton Pond Rd., Barrington twp., 4 Jul 2002, *Kirschbaum s.n.* (n/a). **NEW YORK. Allegany Co.:** Moss Lake Bog on Moss Lake off Sand Hill Rd. ca. 2.5–3.0 mi SW of Houghton, Caneadea twp. 0731623E 469767N UTM Zone 19T (Units: km, Datum: NAD 83), 11 Jul 2002, *Kirschbaum s.n.* (n/a). **Hamilton Co.:** border of The Plains, South Branch of the Moose River, 10 Aug 1950, *Smith, Weaver 7577* (DAO). **Oneida Co.:** *Knieskern s.n.* (MICH). County unknown, Adirondack Mountains, 20 Jun 1936, *Killip 31814* (MICH). **OHIO. Stark Co.:** thickets in center of Brewster Bog, 0.2 mi SE, jct. of M Eaton St and Wellbrook Ave, Navarre Quad, 10 Jul 1984, *Cusick, Denny, Munch 23633* (MICH). **PENNSYVANIA. Elk Co.:** ca. 11 km S of town, 078°15'W, 41°15'N, 18 Jun 1997, *Grund 1918* (MICH). **Tioga Co.:** 4.5 mi NW of Morris, 077°20'51"W, 41°37'07"N, 29 May 1975, *Rothrock 309* (MICH). **VERMONT. Franklin Co.:** Berkshire, 15 Jun 1912, *Underwood 2122* (GH). **WISCONSIN. Jackson Co.:** Bear Bluff Twp, in the old bed of Glacial Lake, T21N, R01E, Sect. 29, 19 Jun 1958, *Hartley 3969* (DAO). **Iron Co.:** between Hwy 51 and Rice L, near CNW RR, 2 mi NW of Mercer, T43N, R03E, Sect. 26 NW1/4, 3 Jul 1976, *Cochrane, Cochrane 7547* (MICH). **WEST VIRGINIA. Giles Co.:** Big Good Bed at head waters of Little Stony Creek, Salt Pond Mt., 9 Jun 1946, *Wood 5972* (GH). **Pocahontas Co.:** 0.2 mi S of park office, Droop Mountain Battlefield State Park, NW, US Rte 219, N of Droop, 1 Jun 1990, *Cusick 28918* (MICH); ultimate headwaters of First Fork of Shavers Fork Creek, ca. 2 air mi 110 degrees from Shavers Fork crossing at Randolph County line, ca. 4.2 air mi NE of Cass Scenic RR State Park off For Serv Rd 235, Back Allegheny Mtn, Monongahela National Forest, 27 Jul 1994, *Nelson 15881* (MICH). **Tucker Co.:** beyond Little Blackwater, near camp 70 near 3200f, Canaan Valley, 1 Aug 2007, *Allard 10106* (GH).

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BOOK REVIEWS

EDWARD C. SMITH. 2006. **Incredible Vegetables from Self Watering Containers.** (ISBN 978-1-58017-556-2, pbk.). Storey Publishing, 210 Mass MoCA Way, North Adams, MA 02147, U.S.A. (**Orders:** www.storey.com, sales@storey.com, 1-800-865-3429). $19.95, 254 pp., color photos, maps, index, 8½" × 10⅞".

The book, *Incredible Vegetables from Self Watering Containers*, is divided into three main sections that describe a new way to grow vegetables (with containers), the materials needed to get started and how to manage a container garden, and a detailed list of the typical varieties of edible plants that will grow in containers (this section comprises the largest portion of the book).

Many people believe that containers or pots are solely used for flowers. The first section informs the reader that this is not the case. Growing plants in pots has been around for generations. However, growing vegetables in pots is a relatively new process. The author mentions that there are a few key problems that one might encounter when planting a garden in pots: an increase in watering, less productive plants compared to those found in the ground, or an inability to garden organically. The basic solution to these problems is to choose the correct container and proper soil mixture for your plant. For example, a gardener today has the ability to create a self watering container, also known as a continuous-flow watering system. These require less time spent watering, keep the plant from wilting or drying in between watering sessions, and allow nutrients to be kept in closer proximity to the plant's root system. The water in a continuous-flow watering system is drawn up through the soil by the plant's root system and remains with the plant longer. This process reduces the amount of nutrients that would normally be lost through leaching. The soil mixture is also very important in growing a productive plant. The author gives examples of the correct combination of peat moss, vermiculite or perlite, limestone, and compost that should be used in containers. Smith's information will help the reader see how simple it is for one to create a container garden.

In the second section, the author explains how a gardener could combine available resources and tools to create a profitable vegetable container garden. Some important advice is "to start small" and do your research on the proper location and pot size for a particular plant. This will make sure your gardening is successful. The author gives the reader great examples on how to mix and match several plants in one pot, and lists the proper techniques for caring for each variety of plant. These techniques include when to water, proper location (determined by the plant's tolerance of shade or sun), management of pests, proper time to harvest or collect vegetables, and the proper instructions on stowing containers through the winter. All of these helpful tips will help the reader become a better gardener.

The final section introduces the reader to a variety of edible vegetables, flowers, and herbs that grow well in pots. This section is well labeled and it is easy for the reader to locate the exact plant they are looking for. The types of plants range from your basic garden varieties such as tomatoes and cucumbers to edible flowers such as sunflowers and violas. Detailed care instructions are given for each particular plant. These instructions include proper pot use, favorable weather conditions for each plant, particular bugs or pests that might appear or infest the plant, and the right time to harvest your vegetables. This section will prove to be very helpful for a novice gardener.

This book would be an important tool for any gardener, ranging from an amateur to a professional. The author's use of detailed instructions and descriptions can help motivate any reader to create their own container garden. The book was written in such a way that those new to science and gardening would understand the importance of finding the perfect container and creating the proper soil mixture. The reader will take away a deeper knowledge on how important soil type is to the longevity of their plants, and how one needs to find a good location for each specific plant. I would recommend this book to any gardener that is limited on the proper space for a garden or tempted to try their own container garden.—*Keri McNew, MS Biology, Project Manager, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

ALLAN M. ARMITAGE. 2006. **Armitage's Native Plants for North American Gardens.** (ISBN 0-88192-760-0, hbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax). $49.95, 451 pp., 443 color photographs, 7½" × 10½".

Native plants often require less water and maintenance than non-native plants. Although not intended for members of the "right wing of the Native Party" according the author, this handsome book is an excellent information source for North American gardeners who want to introduce native plants into their gardens and landscaping. Plants are included based on their availability to mainstream gardeners. Over 630 species and cultivars are included, arranged alphabetically by plant genera. At the back of the book are useful lists of native plants that fill particular garden needs, including drought-tolerant plants, water-loving plants, plants that attract butterflies or hummingbirds, deer- and rabbit-resistant plants, and plants for different growing conditions from full sun to heavy shade. The author provides entertaining commentary about his personal experiences with these plants along with detailed information including Latin names, plant families, common names, habitat, cultivars, hardiness zones, maintenance, and recommended propagation. Fascinating information on the etymology of the plants' Latin and common names are also included. In addition, this book is packed with over 400 color photographs. The useful sources and resources section includes lists of nurseries that carry native plants, local and regional native plant societies, internet sites, and useful books for the native plant gardener. I found this book to be packed full of useful information, while remaining enjoyable and easy-to-read.—*Marissa N. Oppel, Collections and Research Assistant, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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THOMAS WALTER TYPIFICATION PROJECT, II: THE KNOWN WALTER TYPES

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ABSTRACT

Thomas Walter, a South Carolina plantation owner and skilled amateur botanist, in the 1780s wrote a flora that was the first treatment of American plants employing the binomial nomenclature and sexual classification system of Linnaeus. Walter's *Flora Caroliniana* contained many species new to science and whose names are of modern use. So that these names shall be used in a consistent way, provision has been made for each name to be represented by a single specimen, its type. But Walter designated no types; later authors, following internationally agreed-upon rules, have chosen specimens to serve as lectotypes or neotypes. A compilation is provided here of all known replacement types of Thomas Walter names.

RESUMEN

Thomas Walter, un propietario de una plantación en Carolina del Sur y botánico amateur, en los años 1780s escribió una flora que constituyó el primer tratamiento de las plantas americanas usando la nomenclatura binomial y el sistema de clasificación sexual de Linnaeus. La *Flora Caroliniana* de Walter contenía muchas especies nuevas para la ciencia y cuyos nombres son de uso moderno. Para que estos nombres estén en uso de un modo consistente, se han hecho las provisiones necesarias para que cada nombre esté representado por un solo espécimen, su tipo. Pero Walter no designó tipos; autores posteriores, siguiendo normas internacionalmente aceptadas, han escogido especimenes para que sirvan como lectotipos o neotipos. Se aporta una compilación de todos los tipos reemplazados conocidos de los nombres de Thomas Walter.

The Thomas Walter Typification Project is an ongoing effort to determine appropriate type specimens for the many names of new plant species described by Thomas Walter in his *Flora Caroliniana* (1788). Walter himself left no herbarium, but he had access to the collections made by John Fraser in the Carolinas and Georgia. Fraser's specimens, now in the Natural History Museum, London, often bear Walter's identifications or comments, and are at times chosen as replacement types by later authors. Or, when no specimen is present in the Fraser collection, specimens gathered by other persons have been chosen by later authors to serve as replacement types for Walter's names.

The Fraser collection, because of its association with the author of the *Flora*, is commonly known as the "Walter Herbarium." It is in the form of a large folio containing 690 usually very small, often fragmentary specimens collected by John Fraser during an eighteen-month trip to the American southeast, from the fall of 1786 through the early spring of 1788. During that time Fraser met and was befriended by Walter who examined and partially annotated at least part of Fraser's collection. Fraser also carried Walter's manuscript to England and saw it to publication.

The Fraser collection of the Natural History Museum—perhaps better known as the "Fraser/Walter herbarium" to distinguish it from the presence in Paris of another part of the specimens collected by Fraser—has been described in detail as an initial step in the analysis of the Walter names (Ward, 2006). Somewhat more than half of the specimens have labels that carry Walter's handwriting, either an identification or partial identification, or a comment. Approximately half of the specimens bear similar identifications and/or comments by Fraser, while a significant number show the handwriting of both.

Though many authors have referred to the Fraser/Walter herbarium as having been collected by Walter, or as having been the basis for his new names, there is no credible contemporary evidence that Walter used the collection in this way. Even where his handwriting is present, it is far more probable that he formed most of his descriptions from plants available *in vivo* and that he saw the specimens only after his manuscript was complete or essentially so. This conclusion has been documented and justified elsewhere (Ward, 2007). Such specimens, though contemporary in time, are of course irrelevant to typification of Walter's names.

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One small category of names given by Walter, however, cannot be separated from linkage with the Fraser collections. Though Walter (1788) stated his observations had come from a 50-mile radius of his plantation on the Santee River in what is now Berkeley County, South Carolina, it has long been recognized that at least some of his species are unknown on the Carolina coastal plain (Harper 1911; Ewan 1969). It appears certain, as Fraser has claimed (1789), that a number of species not known in Walter's area could have come to him only as a result of Fraser's far wider travels (Ward 1962a, 2007). When a specimen of such a species is found in the Fraser/Walter herbarium it is reasonable to conclude, though gathered by Fraser, either the individual specimen or other, supplementary material of the same collection was actually used by Walter in his writing. Supplemental materials may indeed have been available, for Walter's descriptions commonly contain details not shown in the Fraser specimens.

The International Code of Botanical Nomenclature (Greuter et al., 2000) dictates rules that govern determination of types. If, as here believed, no surviving specimens can be stated to be the only materials used by Walter, no holotype of a Walter name is possible. If a species described by Walter and known only outside his area is represented by a specimen collected by Fraser, the Fraser/Walter specimen may reasonably be designated as its lectotype. If, however, either no specimen has survived, or the species is known in Walter's area and may well have been described by him without use of the herbarium, a neotype may be selected.

At times authors have assigned type designation that are at variance with the origin of the materials as described here. In such cases the Code (Art. 9.8) permits the type designation to be corrected to the appropriate status. Such corrections have been made here where appropriate. The convention is faithfully followed, that lectotypes are "designated" and neotypes are "selected."

The Code (Art. 7.10) requires that a designation of lectotype or selection of neotype is without standing unless published. However the Code, especially in former years, has not provided guidance for a standard mode or place of publication. With this latitude, authors have used diverse outlets in publishing their type citations. Commonly, of course, typifications appear as a component of monographic treatments or revisions. But typifications have also been encountered in free-standing floristic notes, in proposals for conservation of a non-legitimate name, in captions of illustrations, and even in a pre-meeting abstract of a paper to be presented. All, if effectively published and if the type element is clearly indicated as such by the typifying author (Art. 7.11), are valid, and are accepted here.

Names are also found to be cited as having been typified when the circumstances of their publication do not justify type status. Notably, some members of a series of identifications by Hitchcock (1905), of grasses in the Fraser/Walter herbarium, are simply references to certain specimens and fall short of the author having treated them as types. Several type selections in theses and dissertations, though clearly stated, also fail because of the non-published format of their presentation. Such nonvalid typifications are excluded here.

The present tabulation of 67 published Walter types includes 13 that are lectotypes (8 of them corrected to that status) and 52 neotypes (34 of them corrected). Two names listed as neotypes are scheduled for publication elsewhere (Ward, in press). The designations are of specimens in the Fraser/Walter herbarium (43 names), as well as in other herbaria (22 names). The name used by Walter (*Flora Caroliniana* 1788) is given, with appropriate page number. The modern name for each is also listed, in most cases employing nomenclature used in the current flora of the Carolinas (Radford et al. 1968). Frequently used synonyms may also be given. [An index of all relevant Walter names and modern equivalents will be provided later in the present series.]

The names are presented in alphabetical order following Walter's usage. A discussion and/or justification accompanies each name. Typifying authors, with their determination of lectotypes or selection of neotypes, are cited. Further comments may include a simple statement of range and frequency in the Carolinas (indicative of the probability that Walter knew the plant *in vivo*); reference to any appropriate specimens in the Fraser/Walter herbarium (with designators as in Ward, 2006); and notation of whatever handwriting may be on the label.

TYPIFICATIONS

WALTER'S NAME: *Aesculus parviflora* Walter (p. 128)
MODERN NAME: **Aesculus parviflora** Walt.
Rare in SC (one county). Spm. 62a-A was labeled "*Juglans Alba nova*" by Fraser. Rembert (1984) has designated this specimen, *Fraser/Walter 62a-A, [1787]* (BM), made by Fraser in South Carolina along the Savannah River across from Augusta, Georgia, as LECTOTYPE of *Aesculus parviflora* Walt.

WALTER'S NAME: *Andromeda ferruginea* Walter (p. 138)
MODERN NAME: **Lyonia ferruginea** (Walt.) Nutt.
Nearly absent from SC (2 counties); frequent in adjacent northeastern GA, Judd (1981: 411) designated a specimen, *Fraser s.n., [1787]* (P), from South Carolina or Georgia, as LECTOTYPE of *Andromeda ferruginea* Walt., basionym of *Lyonia ferruginea* (Walt.) Nutt. This specimen was among the materials Fraser sold to Charles Louis L'Heritier in Paris (Fraser 1789). Although no indication is given that Walter saw or used that particular Fraser specimen, the absence of the species from the area in which Walter directly obtained his materials suggests that the specimen may have been part of a collection obtained by Fraser in his wider travels and utilized by Walter in forming his description. A fragment (spm. 6-C) in the Fraser/Walter herbarium was labeled as "*Andromeda ferruginea*" by Fraser, but has been identified as *Lyonia fruticosa* (Judd 1981: 419–420).

WALTER'S NAME: *Angelica lobata* Walter (p. 115)
MODERN NAME: **Ligusticum canadense** (L.) Britt.
Nearly absent from the SC coastal plain, but common inland; likely a Fraser discovery. Spm. 7-C, a crumpled vegetative scrap, was labeled "*Angelica*" by Fraser. It was identified as *Ligusticum canadense* by Fernald and Schubert (1948: 217), and called "the type." Though Walter's name will doubtless remain in synonymy of *Ligusticum canadense*, *Fraser/Walter 7-C [1787]* (BM) is corrected here to LECTOTYPE of *Angelica lobata* Walt. (= *Ligusticum canadense* (L.) Britt.).

WALTER'S NAME: *Anonymos bracteat*[*a*] Walter (p. 181); nom. illegit.
MODERN NAME: **Zornia bracteata** Walt. ex Gmel.
Frequent in eastern SC. No specimen has been identified. Walter's name is illegitimate, but his description still serves as the foundation for Gmelin's name (Ward 1962b). Mohlenbrock (1961: 30) selected *Duncan 11557, [29 July 1950]* (US), from McDuffie County, Georgia, as NEOTYPE for *Zornia bracteata* Walt. ex Gmel., with duplicate (GA) as ISONEOTYPE.

WALTER'S NAME: *Anonymos graminifol*[*ia*] Walter (p. 197); nom. illegit.
MODERN NAME: **Vernonia angustifolia** Michx.
Frequent throughout. Walter's name was omitted by Gmelin (1792). The name is illegitimate (Ward 1962b), and the epithet cannot be transferred. The epithet was used by Willdenow (1803), but applied to a species of *Liatris*. Willdenow's name was formed independently and is not a transfer; though he referred to Walter, he gave a new diagnosis. A specimen (spm. 32-A) labeled "*Chrysocoma affinis* F 309" was identified as *Liatris graminifolia* Willd. by Gaiser (1950: 414), but rejected as type of *Anonymos graminifolia*. [Gaiser was correct in this rejection, though her reason was doubt as to its authenticity; Walter's *Anonymos graminifolia*, as determined by his identification of other Fraser specimens, was *Vernonia angustifolia*.] Gaiser, apparently in belief that the plant Walter had described was a *Liatris*, erroneously selected *White s.n., 25 Oct 1948* (GH), a plant of *Liatris graminifolia* Willd., from Wilmington, New Hanover County, North Carolina, as Walter's "type." Though Gaiser's incorrect typification of an illegitimate name is without application, in the interest of completeness it is here listed and corrected to NEOTYPE for *Anonymos graminifolia* Walt.

WALTER'S NAME: *Anonymos procumbens* Walter (p. 86); nom. illegit.
MODERN NAME: **Houstonia procumbens** (Walt. ex Gmel.) Standley [= *Hedyotis procumbens* (Walt. ex Gmel.) Fosberg; *Poiretia procumbens* Gmel.]
Frequent to common throughout. There is no specimen. Lewis (1966) has selected *Palmer s.n., 2-10 June*

1902 (US), from Charleston County, South Carolina, as NEOTYPE for *Poiretia procumbens* Gmelin, basionym of *Houstonia procumbens* (Walt. ex Gmel.) Standley.

WALTER'S NAME: *Anonymos rotundifolia* Walter (p. 181)
MODERN NAME: **Crotalaria rotundifolia** Walt. ex Gmel. [= *Crotalaria angulata* Mill.]
Common in eastern SC. Spm. 67-D has been termed "type" by authors (Fernald & Schubert 1948; Ward 1962b; Windler 1974). The label ("*Lupinus affinis*") is in Walter's hand. Since this species would surely have been familiar to Walter near his home, and the label indicates he did not recognize it to be his "*Anonymos rotundifolia*," there is no reason to believe this specimen was used by him. Its designation as type cannot be dismissed, but *Fraser/Walter 67-D, [1787]* (BM), the foundation for *Crotalaria rotundifolia* Gmelin, is corrected here to NEOTYPE. Fernald and Schubert's argument (1948: 202–203), equating Walter's plant with *Crotalaria maritima* Chapm., is incorrect; Chapman's type came from Cape Sable ("Palm Cape"), southernmost peninsular Florida, and differs in leaf form and pubescence.

WALTER'S NAME: *Anonymos sessifol[ia]* Walter (p. 108); nom. illegit.
MODERN NAME: **Mitreola sessilifolia** (Walt. ex Gmel.) D. Don [= *Cynoctonum sessilifolium* Walt. ex Gmel.]
Common in eastern SC. Spm. 117-B is a slender stem of poor diagnostic character, marked with Fraser's number 685. It was labeled "*Genus nov. Pentand digyn*" by Walter, not recognized by him as his *Anonymos* "*sessifolia*." Walter would have had living materials available; spm. 117-B could scarcely have been used by him in forming his description. Walter's name is illegitimate, but his description still serves as the foundation for Gmelin's name (Ward 1962b). Leeuwenberg (1974: 21) has designated no. 685 as "holotype" of *Mitreola sessilifolia*. In view of Walter's failure to recognize the plant as his own, *Fraser/Walter 117-B, [1787]* (BM) is here corrected to NEOTYPE for *Cynoctonum sessilifolium* Gmel., basionym of *Mitreola sessilifolia* (Walt. ex Gmel.) D. Don. Because the specimen scarcely shows useful diagnostic features, an epitype would be welcome.

WALTER'S NAME: *Anonymos setac[ea]* Walter (p. 170)
MODERN NAME: **Agalinis setacea** (Walt. ex Gmel.) Raf.
Frequent throughout. Pennell (1920: 282) stated the "type" had been identified in the British Museum by A. B. Rendle. This presumably is spm. 51-A. Walter's name is illegitimate, but his description still serves as the foundation for Gmelin's name (Ward 1962b). The specimen bears Walter's hand: "*Gerardia...terminalis.*" Though very unlikely to have been used by Walter in preparing his description, its somewhat indirect designation as type by Pennell restricts further choice; his designation of *Fraser/Walter 51-A, [1787]* (BM) is here corrected to NEOTYPE for *Gerardia setacea* Gmel., basionym of *Agalinis setacea* (Walt. ex Gmel.) Raf.

WALTER'S NAME: *Anthoxanthum giganteum* Walter (p. 65)
MODERN NAME: **Erianthus giganteus** (Walt.) Beauv.
Common throughout the SC coastal plain. Spm. 113-B bears the label "*Anthoxanthum*" in Fraser's distinctive hand. Hitchcock (1905: 33) stated the specimen, since it "agrees with the description and is the only species of the genus" that Walter described, "may be taken as the type." Gandhi and Dutton (1993), without reference to a specific specimen, noted BM to contain the Walter "type." The abundance of this species within Walter's territory and the probability that he knew it in the living state (he noted the height to be 8 feet) make it unlikely this Fraser specimen was given any weight by him. However, having been emphasized by Hitchcock and noted by Gandhi and Dutton, Walter's specimen can continue to serve by correction of Hitchcock's use of *Fraser/Walter 113-B, [1787]* (BM) to that of NEOTYPE for *Anthoxanthum giganteum* Walt., the basionym of *Erianthus giganteus* (Walt.) Beauv.

WALTER'S NAME: *Arundo gigantea* Walter (p. 81)
MODERN NAME: **Arundinaria gigantea** (Walt.) Muhl.
Common throughout. Hitchcock (1905: 53) identified a specimen (spm. 113-A) as this species, but did not designate it as a type. McClure (1973: 26) took that step, but called the specimen the "Holotype." He noted the accompanying label to read "*Arundo gigantea*" but failed to recognize the hand as that of Fraser. Since

the species is common immediately adjacent to Walter's homesite, and there is no indication Walter saw or used Fraser's specimen, *Fraser/Walter 113-A, [1787]* (BM) is here corrected to NEOTYPE for *Arundo gigantea* Walt., basionym of *Arundinaria gigantea* (Walt.) Muhl. Since 113-A consists solely of a stem apex bearing two leaves and is marginally diagnostic, an epitype would be welcome.

WALTER'S NAME: *Arundo tecta* Walter (p. 81)
MODERN NAME: **Arundinaria gigantea** (Walt.) Muhl.
Only one *Arundinaria* is common in the Carolinas. Walter, under *A. tecta*, described the first-year stems as "*culmis tectis*" ("stems sheathed") by young leaf-bases, and named the second-year stems *A. gigantea* (branches fully developed, making the plant seem larger). There is no specimen labeled as *Arundo tecta*. Though (as interpreted here) *A. tecta* is a synoym of *A. gigantea*, McClure (1973: 28) has selected *McClure 22000, [1952?]* (US), from Anne Arundel County, Maryland, as NEOTYPE for *Arundo tecta* Walt., basionym of *Arundinaria tecta* (Walt.) Muhl.

WALTER'S NAME: *Athanasia graminifolia* Walter (p. 200)
MODERN NAME: **Marshallia graminifolia** (Walt.) Small
Infrequent in eastern SC. Spm. 16-F was identified as *Marshallia graminifolia* by Channell (1957: 112) and referred to as the "type" of *Athanasia graminifolia*. The label ("*Athanasia*") appears to be in Walter's hand. But since materials were available near Walter's home, it is unlikely he used this specimen in preparing his description. *Fraser/Walter 16-F, [1787]* (BM) is therefore here corrected to NEOTYPE for *Athanasia graminifolia* Walt., basionym of *Marshallia graminifolia* (Walt.) Small.

WALTER'S NAME: *Athanasia obovata* Walter (p. 201)
MODERN NAME: **Marshallia obovata** (Walt.) Beadle & Boynton
Two specimens (16-C, 16-D) were identified as *Marshallia obovata* var. *obovata* by Channell (1957: 83, 88–89) and referred to as the "type" of *Athanasia obovata*. He further concluded, with the aid of W. T. Stearn, that they represented the "leafy-stemmed" taxon, which thus becomes var. *obovata*. That variety occurs only on the piedmont, west of Walter's area; the specimen therefore was probably collected by Fraser. [Var. *scaposa* Channell occurs only on the coastal plain.] Walter's description may well have been based on plants of var. *scaposa* accessible to him in or near Berkeley County. But Channell's assignment of the typical name to a specimen of the western variant fixes the name in that usage. Channell did not select which of the two specimens was to be the type and which the isotype. Both are labeled "*Athanasia*" in Walter's hand. Since Walter probably based his description on var. *scaposa* and may not have seen these materials of var. *obovata* until after completion of his text, *Fraser/Walter 16-C, [1787]* (BM) (marked "*A. obovata*," probably by Gray) is here corrected to NEOTYPE for *Athanasia obovata* Walt., basionym of *Marshallia obovata* (Walt.) Beadle & Boynton. *Fraser/Walter 16-D* (BM) (unmarked) then becomes an ISONEOTYPE.

WALTER'S NAME: *Athanasia trinervia* Walter (p. 201)
MODERN NAME: **Marshallia trinervia** (Walt.) Trel. ex Branner & Coville
Unknown in modern SC, very rare in NC (one county) and GA (two counties). There is no specimen. Yet once found near Walter's home; a specimen from Berkeley County, South Carolina, *Cranmore Wallace s.n., 1841* (CHARL), has been selected by Channell (1957: 68, 72–73), as NEOTYPE for *Athanasia trinervia* Walt., basionym of *Marshallia trinervia* (Walt.) Trel. ex Branner & Coville.

WALTER'S NAME: *Carduus carolinianus* Walter (p. 195)
MODERN NAME: **Cirsium carolinianum** (Walt.) Fern. & Schub.
Cirsium carolinianum is so rare in the Southeast (4 counties in NC, 1 in SC, 3 in GA) that Walter's plant may not be the species that presently bears his name. But Fernald and Schubert (1948: 229, plate 1115) have identified spm. 25-C (a near-naked scape with single head, labeled "*Carduus*" by Walter) as *C. carolinianum*, and cited it as "Walter's TYPE." Thus, whatever the possibility Walter was writing of another species more common near his home, his name is now locked into its present usage. Since a discovery by Fraser in his

wider travels would appear the only way Walter may have seen this plant, *Fraser/Walter 25-C, [1787]* (BM) is here corrected to LECTOTYPE of *Carduus carolinianus* Walt., basionym of *Cirsium carolinianum* (Walt.) Fern. & Schub. Because of the poor quality of the specimen, an epitype would be welcome.

WALTER'S NAME: *Cenchrus carolinianus* Walter (p. 79)
MODERN NAME: **Cenchrus incertus** M.A. Curtis
Common in eastern SC. There is no specimen. Hitchcock (1905: 48), perhaps not realizing there is more than one species of *Cenchrus* in the Carolinas, suggested that Walter's description referred to *C. tribuloides* L.; Walter's "*spinosis laevibus*" forecloses that possibility. Reveal (1990) selected a NEOTYPE for *Cenchrus carolinianus* Walt. of material from Beaufort County, South Carolina, *Boufford, Bartholomew & Spongberg 23096, 12 Sept 1982* (BM), currently known as *C. incertus* M.A. Curtis (1837), thereby temporarily displacing that name. But, following revision of the I.C.B.N. in 1994, Walter's name was formally rejected (Brummitt 1995), thus restoring *C. incertus*. Though Walter's diagnosis contains elements poorly compatible with *C. incertus* (Wilbur 1991), that common species would surely have been present in the fields of his Santee River plantation.

WALTER'S NAME: *Chrysocoma gigantea* Walter (p. 196)
MODERN NAME: **Vernonia gigantea** (Walt.) Trel. ex Branner & Coville
If this species, rare in SC (two counties). No specimen. Walter's plant is more likely to have been *Vernonia glauca* (L.) Willd. or *V. noveboracensis* (L.) Michx. But *Vernonia gigantea* is often quite tall, and corresponds to one feature of Walter's plant: "*caule 8 ad 10-pedali*." Urbatsch (1972: 236), lacking any Walter type, preserved conventional usage by selecting a collection (cited below) of *V. gigantea* (as customarily defined) as the neotype of that name. He, however, did not select a specimen (required by Art. 9.6) of the 7 cited duplicates; that omission is remedied by selection here of *Bozeman & Radford 11593, 3 Nov 1967* (FLAS), from Jasper County, South Carolina, as NEOTYPE for *Chrysocoma gigantea* Walt., basionym of *Vernonia gigantea* (Walt.) Trel. & Branner. The duplicates (COLO, IND, NY, OKLA, TENN, WVA) become ISONEOTYPES.

WALTER'S NAME: *Collinsonia praecox* Walter (p. 65)
MODERN NAME: **Collinsonia canadensis** L.
Unknown on SC coastal plain, frequent westward; likely a Fraser discovery. No specimen has been identified. Spm. 96-H is this genus, but lacks flowers, and Peirson et al. (2006: 403, 406) stated it "cannot be determined with certainty." They then selected *Newberry 1912, 6 Sept 1982* (NCU), from Chester County, South Carolina, as NEOTYPE for *Collinsonia praecox* Walt.

WALTER'S NAME: *Commelina caroliniana* Walter (p. 68)
MODERN NAME: **Commelina caroliniana** Walt. [= *Commelina hasskarlii* C.B. Clarke]
This name has generally been disregarded or has been thought unassignable. Faden (1989) has observed that collections from the southeastern coastal plain assumed to be of *Commelina diffusa* Burm. are actually of two entities: that species; and a second one Faden equated with *C. hasskarlii* C. B. Clarke, an Asiatic species previously unrecognized in the United States. Faden then identified (by photo) a specimen in the Fraser/Walter herbarium (35-C) as this second species and concluded its prior name was *C. caroliniana* Walt. He noted the label to read "*Commelina*," but did not recognize the hand to be that of John Fraser. Then, overlooking the tenuous connection of Walter to these specimens, Faden designated what is here termed *Fraser/Walter 35-C, [1787]* (BM) as the "lectotype" of *C. caroliniana*. Since there is no indication that Walter saw or used the specimen, it is here corrected to NEOTYPE for *Commelina caroliniana* Walt.

WALTER'S NAME: *Convallaria biflora* Walter (p. 122)
MODERN NAME: **Polygonatum biflorum** (Walt.) Ell.
Infrequent on the SC coastal plain (but incl. Berkeley Co.), common westward. Spm. 35-B was labeled "*Convallaria*" by Walter, and is of fair quality. It has been annotated as "TYPE," perhaps by J. E. Dandy at direction of Ownbey (1944: 394) who cited this specimen as "type." Since the plant may well have been known by Walter and there is no evidence the specimen was seen by him prior to preparing his diagnosis,

Fraser/Walter 35-B, [1787] (BM) is here corrected to NEOTYPE for *Convallaria biflora* Walt., basionym of *Polygonatum biflorum* (Walt.) Ell.

WALTER'S NAME: *Coreopsis gladiata* Walter (p. 215)
MODERN NAME: **Coreopsis gladiata** Walt.
Rare in SC, but known in Berkeley Co. No specimen has been identified. Smith (1976: 195–196) has selected *Godfrey 8238, 15 Sept 1939* (F), from Georgetown County, South Carolina, as NEOTYPE for *Coreopsis gladiata* Walt., with duplicate (TENN) as ISONEOTYPE.

WALTER'S NAME: *Coreopsis major* Walter (p. 214)
MODERN NAME: **Coreopsis major** Walt.
Frequent in SC, though rare on the coastal plain. Spm. 37-B appears to be this; its label has no writing, which may explain why it was not noted by Smith (1976). There is no evidence Walter saw or used the specimen. Smith (1976: 170) has selected *Tracy 4360, 10 June 1898* (NY), from Ocean Springs, Jackson County, Mississippi, as NEOTYPE for *Coreopsis major* Walt., with duplicate (F) as ISONEOTYPE.

WALTER'S NAME: *Corypha Palmetto* Walter (p. 119)
MODERN NAME: **Sabal palmetto** (Walt.) Lodd. ex Schult. & Schult.
Infrequent along SC coast. There is no specimen. Zona (1990: 646) selected ("designated") *Curtiss 2677, July [1894?]* (NY), from Jacksonville, Duval County, Florida, as NEOTYPE for *Corypha palmetto* Walt., basionym of *Sabal palmetto* (Walt.) Lodd. ex Schult. & Schult., with duplicates (BH, F, GA, GH, MICH, MO, US) as ISONEOTYPES.

WALTER'S NAME: *Corypha pumila* Walter (p. 119)
MODERN NAME: **Sabal minor** (Jacq.) Pers.
Common in coastal SC. No specimen. Though a type is scarcely needed, Zona (1990: 643) selected *Hexamer & Maier s.n., May 1855* (GH), from St. Andrews, Charleston County, South Carolina, as NEOTYPE for *Corypha pumila* Walt. (= *Sabal minor* (Jacq.) Pers.), with duplicate (CM) as ISONEOTYPE.

WALTER'S NAME: *Cucubalus polypetalus* Walter (p. 141)
MODERN NAME: **Silene polypetala** (Walt.) Fern. & Schub.
Walter's name was brought forward by Fernald and Schubert (1948: 198) as *Silene polypetala* (Walt.) Fern. & Schub., on the evidence of spm. 38-E (a single crumpled flower). The specimen was surely collected by Fraser along the Flint River, west-central Georgia, its closest location. It bears, in Walter's hand, the words "*Cucubalus polypetalus*," and a 3-digit number assigned by Fraser. But Walter's description of *Cucubalus polypetalus* does not fit the plant. Walter's words, "*Cal. inflatus*" ("calyx inflated"), "*petala fauce nuda*" ("petals smooth at throat"), and "*floribus polypetalis*" ("flowers with many petals"), suggest one of the several *Silene* species with expanded ("inflated") calyces and non-auricled (=crowned), deeply bi-lobed petals. Walter may have had an early contact with *Silene cucubalus* Wibel (1799), an introduced species now well established in the mountains of NC. *Lychnis alba* Mill., another introduced species with an inflated calyx, is less likely since its petals are auricled, unlike *Cucubalus*.

Fernald and Schubert noted the single flower (plate 1105) as "Walter's type" of *Cucubalus polypetalus*. That action, other than by conservation, is irrevocable; the error in understanding which of Walter's names applied to the fragmentary specimen does not invalidate their action. However, since Walter's description indicates he had access to more complete materials that were perhaps part of the same collection, *Fraser/Walter 38-E, [1787]* (BM) is here corrected to LECTOTYPE of *Cucubalus polypetalus* Walt., basionym of *Silene polypetala* (Walt.) Fern. & Schub.

WALTER'S NAME: *Echites difformis* Walter (p. 98)
MODERN NAME: **Trachelospermum difforme** (Walt.) Gray
Common throughout. Krings (2003) identified "Walter 215" (spm. 41-C) as this species, and cited it as "holotype" of *Echites difformis*. The label bears "*Echites*" by Walter and "*Difformis*" by Fraser. Since the plant

is common in his immediate area, Walter would have had no need for this specimen and there is no indication he used it in forming his diagnosis. Thus *Fraser/Walter 41-C, [1787]* (BM) is here corrected to NEOTYPE for *Echites difformis* Walt., basionym of *Trachelospermum difforme* (Walt.) Gray.

WALTER'S NAME: *Eupatorium pilosum* Walter (p. 199)
MODERN NAME: **Eupatorium pilosum** Walt.
Common in eastern SC. Spm. 45-A was labeled "*Eupatorium*" by Walter; the label also bears a 3-digit number assigned by Fraser. The specimen was identified as *Eupatorium pilosum* by Fernald and Schubert (1948: 225–226, plate 1114), then referred to as "Walter's TYPE." The probability is high that Walter had ready access to living materials growing near his home and did not see this specimen until shown it by Fraser. Fernald and Schubert's typification must be given recognition, but *Fraser/Walter 45-A, [1787]* (BM) is here corrected to NEOTYPE for *Eupatorium pilosum* Walt.

WALTER'S NAME: *Gentiana Catesbaei* Walter (p. 109)
MODERN NAME: **Gentiana catesbaei** Walt.
Infrequent in eastern SC. Spm. 50-A was labeled as "*Gentiana*" and spm. 50-B as "*Gentiana saponaria*," both in Walter's hand. Fernald (1939: 555–556) referred to 50-A in discussion of *G. catesbaei*, but his text left open the possibility he considered it *G. saponaria*. Later, Fernald (1947, plate 1078) identified spms. 50-A and 50-B as the "type" of *Gentiana catesbaei*. [He (1947: 176) erroneously identified the label of 50-A as having been written by "James Britten (apparently)."] Rembert (1980) again identified spm. 50-A as *G. catesbaei*, though he did not designated it as type. Of the two, spm. 50-A is of better quality; it is reasonably complete, with leaves and flowers. Though Fernald included both specimens within his "type" of *Gentiana catesbaei* Walt., his designation of *Fraser/Walter 50-A, [1787]* (BM) is here corrected to LECTOTYPE. *Fraser/Walter 50-B* (BM) then becomes an ISOLECTOTYPE.

WALTER'S NAME: *Gratiola acuminata* Walter (p. 61)
MODERN NAME: **Mecardonia acuminata** (Walt.) Small [= *Bacopa acuminata* (Walt.) Robinson]
Frequent throughout. "[Walter's] description [is] evidently of plant here considered" (Pennell 1920: 236). Spm. 53-B was numbered "668" by Fraser and labeled "*Gratiola*" by Walter. It was cited (as "Walter 668") by Pennell (1935: 66) as "Type." Since Walter would surely have been familiar with the plant near his home, *Fraser/Walter 53-B, [1787]* (BM) is here corrected to NEOTYPE for *Gratiola acuminata* Walt., basionym of *Mecardonia acuminata* (Walt.) Small.

WALTER'S NAME: *Gratiola ramosa* Walter (p. 61)
MODERN NAME: **Gratiola ramosa** Walt.
Common on SC coastal plain. "Descriptive of this plant" (Pennell 1920: 240). Pennell (1935: 79) cited an unspecified specimen as "Type," noting "it shows well the characters of the species now considered, the calyx lacking subtending bractlets." He does not mention an accompanying number. Since spm. 53-D is the only specimen on the page without such a number, and since 53-D well matches modern specimens, it is accepted as Pennell's type. It was labeled "*Gratiola*" by Fraser. Since Walter would not have had use for the specimen in forming his description, *Fraser/Walter 53-D, [1787]* (BM) is here corrected to NEOTYPE for *Gratiola ramosa* Walt.

WALTER'S NAME: *Hedysarum grandiflorum* Walter (p. 185)
MODERN NAME: **Desmodium cuspidatum** (Muhl. ex Willd.) Loud.
Infrequent throughout SC. Not *Hedysarum grandiflorum* Pallas (1773). Fernald and Schubert (1948: 203) identified spm. 55-C as *Hedysarum grandiflorum* and referred to it as "Walter's TYPE." The specimen was labeled "*Hedysarum Flore magnus*" by Walter, who seemed not to recall the name he had already given it. Walter's name is a later homonym and thus illegitimate. But, having been typified by Fernald and Schubert, their designation of *Fraser/Walter 55-C [1787]* (BM) is here corrected to NEOTYPE of *Hedysarum grandiflorum* Walt.

Walter's name: *Helenium aestivale* Walter (p. 210)
Modern name: **Gaillardia aestivalis** (Walt.) H. Rock
Absent from SC coastal plain, frequent on piedmont; possibly a Fraser discovery. Rock (1956) has designated spm. 56-C as lectotype of *Helenium aestivale* (= *Gaillardia aestivalis*). The specimen is labeled "*Helenium*" in Walter's hand. Rock's designation of *Fraser/Walter 56-C, [1787]* (BM) as lectotype is appropriate. A second specimen (spm. 56-B), labeled "*Helenium*" by Fraser, was designated by Rock as "syntype." With the tenuous assumption that it is part of the same collection, *Fraser/Walter 56-B [1787]* (BM) is here corrected to isolectotype of *Helenium aestivale* Walt.

Walter's name: *Helenium serotinum* Walter (p. 210)
Modern name: **Gaillardia pulchella** Foug. [= *Gaillardia serotina* (Walt.) H. Rock]
Infrequent on SC coastal plain. Rock (1956) identified a specimen (spm. 56-D) as a *Gaillardia*, and designated it as the lectotype of *Helenium serotinum* (and made the combination *Gaillardia serotina*). The typification was not critical since Fougeroux' name (1787) is prior to Walter's. But Walter's hand on the label ("*Helenium*") makes plausible Rock's designation of *Fraser/Walter 56-D, [1787]* (BM) as lectotype of *Helenium serotinum* Walt.

Walter's name: *Helenium vernale* Walter (p. 210)
Modern name: **Helenium vernale** Walt.
Infrequent in eastern SC (incl. Berkeley Co.). Rock (1956) has designated spm. 56-A as lectotype of *Helenium vernale*. The specimen bears the hand of Fraser, who identified it only as "*Helenium*." Since the species is known from Berkeley County, it is likely that Walter prepared his description independently of this specimen. However, the specimen having been given type status, Rock's designation is retained, but *Fraser/Walter 56-A, [1787]* (BM) is here corrected to neotype for *Helenium vernale* Walt.

Walter's name: *Hydrangea radiata* Walter (p. 251)
Modern name: **Hydrangea arborescens** L. ssp. **radiata** (Walt.) McClintock
Not known on the SC coastal plain, but frequent inland, thus probably a Fraser discovery. The word "*Hydrangea*" in Walter's hand on spm. 59-B indicates he saw the specimen. Fraser added the epithet "*Radiata*," written after he had access to Walter's manuscript or book. The specimen is of good quality. It was annotated as the "Type of *Hydrangea radiata*" by E. McClintock in 1954; the designation was published as "Type collection: *Walter s.n.* (BM)" for *H. arborescens* ssp. *radiata* (McClintock 1957: 172). McClintock's designation is retained, but *Fraser/Walter 59-B [1787]* (BM) is here corrected to lectotype of *Hydrangea radiata* Walt.

Walter's name: *Kalmia hirsuta* Walter (p. 138)
Modern name: **Kalmia hirsuta** Walt.
Rare in SC (5 counties, all just south of Walter's Berkeley Co.). Probably a discovery of Fraser's; a "new villose Kalmia" was noted among other Fraser plants (letter from Walter to Forsyth–Rembert 1980: 17). Spm. 62b-C, a nearly bare twig, was labeled "*Kalmia Hirsuta Nova*" by Fraser. Southall and Hardin (1974) referred to a specimen on page 62 as the "type." Since this fragment may have been part of better materials brought by Fraser to Walter and used by him in preparation of his diagnosis, *Fraser/Walter 62b-C, [1787]* (BM) is here corrected to lectotype of *Kalmia hirsuta* Walt. The specimen, however, is unidentifiable without the label and serves no useful purpose as a type. An epitype would be welcome.

Walter's name: *Lobelia glandulosa* Walter (p. 218)
Modern name: **Lobelia glandulosa** Walt.
Frequent on SC coastal plain. There can be no confidence that Walter had *Lobelia glandulosa*, rather than *L. elongata* Small which is perhaps more common. But McVaugh (1936: 288) considered a "few fragments" (GH), taken in 1839 from the Walter herbarium, to be the "type" of *L. glandulosa*. [These materials have now been returned to the Walter herbarium (correspondence attached to folio: C. A. Weatherby, 28 Jan 1936; M.L. Fernald, 20 Jan 1936) and public apology made (Fernald 1937).] Since the specimen (65-G) bears only the hand of Fraser, and there is no indication that Walter made use of the collection, *Fraser/Walter 65-G, [1787]* (BM) is here corrected to neotype for *Lobelia glandulosa* Walt.

Walter's name: *Ludwigia apetala* Walter (p. 89)
Modern name: **Ludwigia palustris** (L.) Ell.
Common throughout. Spm. 66-A was labeled "*Ludwigia ?*" by Walter. It was identified (from microfiche) by Peng et al. (2005: 336) as *Ludwigia palustris*, and was cited as the "holotype" of *L. apetala* Walt. Since the species would have been well-known to Walter and there is no indication that he made use of this specimen, Peng et al.'s citation of *Fraser/Walter 66-A, [1787]* (BM) is here corrected to neotype for *Ludwigia apetala* Walt. (= *Ludwigia palustris* (L.) Ell.).

Walter's name: *Ludwigia decurrens* Walter (p. 89)
Modern name: **Ludwigia decurrens** Walt.
Common throughout. Spm. 66-C was labeled "*Ludwigia decurrens*" by Walter. An unspecified specimen ("Herb. Walter," identified from photo) was cited as "type" of *Ludwigia decurrens* Walt. by Ramamoorthy and Zardini (1987: 88). Since the species was available to Walter near his home and the specimen would not have been needed to form his description, *Fraser/Walter 66-C, [1787]* (BM) is here corrected to neotype for *Ludwigia decurrens* Walt.

Walter's name: *Ludwigia pilosa* Walter (p. 89)
Modern name: **Ludwigia pilosa** Walt.
Common on SC coastal plain. Spm. 66-D was labeled "*Ludwigia pilosa*" by Walter, and appears to be that species; the specimen also bears "658" in Fraser's hand. A specimen bearing number 658 was cited by Peng (1989: 282) as "holotype" of *Ludwigia pilosa*. Since the species was available to Walter elsewhere and there is no evidence that spm. 66-D was used by him in preparation of his text, *Fraser/Walter 66-D, [1787]* (BM) is here corrected to neotype of *Ludwigia pilosa* Walt. Peng et al. (2005: 345) later cited the "lower left-hand specimen" on page 66 (again, 66-D) as the "holotype" of *Ludwigia arcuata* Walt., clearly in gross error!

Walter's name: *Ludwigia linearis* Walter (p. 89)
Modern name: **Ludwigia linearis** Walt.
Common in eastern SC. Spm. 66-E is this; it was labeled "*Ludwigia*" by Walter. A specimen (not specifically designated; "Walter Herbarium, p. 66," identified from photo) was cited by Peng (1989: 244) as "holotype" of *L. linearis*. Since Walter would not have needed this specimen and there is no evidence he saw it prior to preparing his description, *Fraser/Walter 66-E, [1787]* (BM) is here corrected to neotype for *Ludwigia linearis* Walt.

Walter's name: *Nymphaea pentapetala* Walter (p. 155)
Modern name: Perhaps **Nelumbo lutea** (Willd.) Pers.
If this species, rare in SC (4 counties). Spm. 75-F, a single petal, was labeled by Walter as "The Great Nymphaea." Ward (1977) noted that, though poorly described ("*corolla...pentapetala alba*"), Walter's plant was clearly a *Nelumbo*; he argued that it may have been either *Nelumbo lutea* or *N. nucifera* and must remain of uncertain application. Wiersema and Reveal (1991) "with great trepidation" interpreted *N. pentapetala* to be *Nelumbo lutea*, a later name (1788 vs. 1799); they then selected *Hunt & Martin 2056,* 5 June 1943 (CLEM), from Charleston County, South Carolina, as Walter's neotype, and simultaneously proposed rejection of his name. With unanimous support from the Committee for Spermatophyta, *Nymphaea pentapetala* Walter was then nomenclaturally rejected (Brummitt 1995), preserving *Nelumbo lutea*.

Walter's name: *Nymphaea reniformis* Walter (p. 155)
Modern name: Perhaps **Nymphaea odorata** Ait.
There is no specimen in the herbarium. Walter's name has been consistently disregarded. Ward (1977) believed Walter's description to have been based on mixed material with elements of both *Nymphaea* and *Nelumbo*. Wiersema and Reveal (1991) selected *Godfrey & Tryon 471,* 12 Jul 1939 (DUKE), a specimen of *Nymphaea odorata* Ait. var. *gigantea* Tricker, from Berkeley County, South Carolina, as neotype, and simultaneously proposed rejection of Walter's name. Because of its unreconcilable ambiguity, *Nymphaea reniformis* Walter was then nomenclaturally rejected (Brummitt 1995). Familiar epithets of *Nymphaea* and *Nelumbo*

thus remain unchallenged. Being listed last in the genus suggests this to be a late addition from Fraser, a frequent practice of Walter's.

Walter's name: *Nymphaea sagittifolia* Walter (p. 155)
Modern name: **Nuphar luteum** (L.) Sibth. & Sm. ssp. **sagittifolium** (Walt.) Beal
Occasional on the lower SC coastal plain. There is no specimen in the herbarium. Walter's description was identified by Ward (1977). Beal (1956: 335) selected *McCarthy s.n., July 1885* (NY), from eastern North Carolina, as neotype for *Nymphaea sagittifolia* Walt.

Walter's name: *Oenanthe filiformis* Walter (p. 113)
Modern name: **Oxypolis filiformis** (Walt.) Britt.
Frequent on the SC coastal plain. No specimen has been identified. Tucker et al. (1983: 300) have selected *Porcher s.n., 17 Sept 1981* (BM), from Berkeley County, South Carolina, as neotype for *Oenanthe filiformis* Walt., basionym of *Oxypolis filiformis* (Walt.) Britt., with duplicates (CITA, DOV) as isoneotypes.

Walter's name: *Ophrys barbata* Walter (p. 221)
Modern name: Perhaps **Calopogon barbatus** (Walt.) Ames, more likely **Calopogon pulchellus** (Salisb.) R. Br.
Calopogon pulchellus is frequent in eastern SC. Walter—and Fraser—would surely have known it, also perhaps the much rarer *C. pallidus* Chapm. and *C. barbatus*. Walter's description does not permit judgment as to which of these species he meant by his *Ophrys barbata*—the lip is bearded in all. Spm. 77-E is clearly a *Calopogon*. Its original label bears only the single word "*Ophrys*" in Fraser's hand; it was later annotated as "*Ophrys barbata / Calopogon parviflorus*" by A. A. Eaton. Goldman (1998) stated the specimen to be "Walter's type" of *C. barbatus*, but he then identified it as *C. multiflorus* Lindl. [He was surely in error. *Calopogon multiflorus* is nearly absent from the Carolinas and Georgia (a single station in NC, with unverified reports from SC and GA), and morphology of the specimen is either of *C. barbatus* (viz. Eaton id.) or is inconclusive.] Goldman then selected *Orzell & Bridges 16163,* 21 Mar 1991 (TEX), from Baker County, Florida, as neotype for *Ophrys barbata* Walt. Goldman next proposed conservation of *Ophrys barbata* with this new type; his proposal was promptly accepted by the Committee for Spermatophyta.

Goldman may not have recognized the only writing on the original label was by Fraser, not Walter, nor that there is no indication the specimen was seen or used by Walter; these details were not brought before the Committee. Goldman's action, however, is of value in that by selecting a neotype that continues the historic interpretation, the name *Calopogon barbatus* retains its classic meaning.

Walter's name: *Origanum flexuosum* Walter (p. 165)
Modern name: **Pycnanthemum flexuosum** (Walt.) BSP.
Common in eastern SC. Spm. 79-C was labeled "*Origanum*" by Walter. It was identified (from photo) by Fernald and Schubert (1948: 220–222, plate 1112) as *Pycnanthemum flexuosum* and designated as "Walter's TYPE." Since the plant is common near his home it is unlikely that Walter used this specimen in preparing his description. Even so, having been cited as "type" by Fernald and Schubert, *Fraser/Walter 79-C, [1787]* (BM) has attained formal status. It is here corrected to neotype for *Origanum flexuosum* Walt., basionym of *Pycnanthemum flexuosum* (Walt.) BSP.

Walter's name: *Panicum hirtellum* Walter (p. 72)
Modern name: **Echinochloa walteri** (Pursh) Heller
Not *Panicum hirtellum* L. [= *Oplismenus hirtellus* (L.) Beauv.], a tropical species. Hitchcock (1905: 35) found three specimens in the Walter herbarium that had been labeled "*Panicum hirtellum*." The first of these (115-A) Hitchcock called "the long-awned form of *P. crus-galli* L." [= *Echinochloa crusgalli* (L.) Beauv.], and the second (115-B) "a densely flowered long-awned form [that is the] *P. hispidulum* of Muhlenberg, who cites *P. hirtellum* Walt." Spms. 115-A and 115-B are both labeled in Walter's hand. [The third, 115-C, is *Panicum virgatum* L.] Hitchcock favored placing Walter's name in synonymy under *P. crus-galli* (now *Echinochloa crusgalli*). Pursh (1814), however, had correctly interpreted Walter's plant as new, and named it *Panicum walteri* [= *Echinochloa walteri* (Pursh) Heller.] *Panicum hirtellum* Walter thus remains the basis for the modern *E. walteri*.

Echinochloa crusgalli is abundant throughout the Carolinas, but is "believed to be adventive from Europe or Asia" (Gould et al. 1972), while the similar *E. walteri* is common in coastal areas of the Carolinas where it is native. Hitchcock (1920: 138) referred to a specimen (115-B) as what "may be taken as the type." Though Walter saw this specimen (as demonstrated by his hand on the label), there is no certain evidence he used it in preparation of his text. Hitchcock's action must be acknowledged, but the status of *Fraser/Walter 115-B, [1787]* (BM) is here corrected to NEOTYPE for *Panicum hirtellum* Walt. (= *Panicum walteri* Pursh; *Echinochloa walteri* (Pursh) Heller).

WALTER'S NAME: *Phalaris caroliniana* Walter (p. 74)
MODERN NAME: **Phalaris caroliniana** Walt.
Frequent on SC coastal plain. No specimen was found in the herbarium by Hitchcock (1905: 40), nor Anderson (1961). Anderson found the description perplexing but concluded there was "no other species of the Carolina grass flora that would fit the description" better than *P. caroliniana*. He then selected *Duncan 9468, [4 May 1949]* (US), from McCormick County, South Carolina, as NEOTYPE for *Phalaris caroliniana* Walt., with duplicate (GA) as ISONEOTYPE.

WALTER'S NAME: *Phyllanthus caroliniensis* Walter (p. 228)
MODERN NAME: **Phyllanthus caroliniensis** Walt.
Frequent throughout. Spm. 83-E was labeled "*Phyllanthus affinis*" by Walter. Webster (1970: 60) cited a specimen on page "83" as "holotype" of *P. caroliniensis* ssp. *caroliniensis*. Since Walter neither recognized this specimen as his new species, nor would have been in need of it for his diagnosis, *Fraser/Walter 83-E, [1787]* (BM) is here corrected to NEOTYPE for *Phyllanthus caroliniensis* Walt.

WALTER'S NAME: *Pinguicula caerulea* Walter (p. 63)
MODERN NAME: **Pinguicula caerulea** Walt.
Frequent on SC coastal plain. Spm. 104-D was identified as *Pinguicula caerulea* by Fernald and Schubert (1948: 224), then referred to as its "TYPE." The label is misplaced; it reads "*Utricularia gibba*" in Walter's hand. [Fernald and Schubert erroneously described it (plate 1113) as "mislabeled by Fraser."] The label that should have been with spm. 104-D is to be found with spm. 83-F (a plant of *Oxalis violacea*). Since the label of "*Pinguicula caerulea*" that should have accompanied spm. 104-D truly was in Fraser's hand, there is no indication that Walter saw or used the specimen. Thus *Fraser/Walter 104-D, [1787]* (BM) is here corrected to NEOTYPE for *Pinguicula caerulea* Walt.

WALTER'S NAME: *Pinguicula lutea* Walter (p. 63)
MODERN NAME: **Pinguicula lutea** Walt.
Infrequent on SC coastal plain, but known in Berkeley County. Spm. 83-G was identified as *Pinguicula lutea* by Fernald and Schubert (1948: 224), then referred to as its "TYPE" (plate 1113). Since the label ("*Pinguicula lutea*") is in Fraser's hand and there is no indication that Walter saw or used the material, *Fraser/Walter 83-G, [1787]* (BM) is here corrected to NEOTYPE for *Pinguicula lutea* Walt.

WALTER'S NAME: *Potamogeton pinnatum* Walter (p. 90)
MODERN NAME: **Myriophyllum pinnatum** (Walt.) BSP.
Infrequent on SC coastal plain. Aiken (1981) reported John Lewis "examined the Walter specimen [86-B] for me." This specimen was labeled "*Potamogeton monoicum*" in Walter's cramped hand. Aiken did not convey the specimen was already annotated "*Potamogeton pinnatum* Walt., Fl. Carol. p. 90, M.L. F[ernald]." Though Aiken called this specimen the "holotype," it is much more likely that Walter prepared his description from fresh material found near his home. Appropriately, *Fraser/Walter 86-B, [1787]* (BM) is here corrected to NEOTYPE for *Potamogeton pinnatum* Walt., basionym of *Myriophyllum pinnatum* (Walt.) BSP.

WALTER'S NAME: *Prasium purpureum* Walter (p. 166)
MODERN NAME: **Physostegia purpurea** (Walt.) Blake
Common on SC coastal plain. Spm. 87-A was labeled "*Prasium*" by Fraser. It was identified as (a synonym of)

Physostegia purpurea by Blake (1915: 134), and designated as lectotype by Cantino (1981, 1982). In absence of evidence the specimen was seen or used by Walter, *Fraser/Walter 87-A, [1787]* (BM) is here corrected to NEOTYPE for *Prasium purpureum* Walt., basionym of *Physostegia purpurea* (Walt.) Blake.

WALTER'S NAME: *Quercus sinuata* Walter (p. 235)
MODERN NAME: **Quercus sinuata** Walt.
Rare, perhaps found only along the Santee River. Believed to be a hybrid of *Quercus falcata* and *Q. phellos*. There is no specimen in the herbarium. A NEOTYPE has been selected for *Quercus sinuata* Walt. (Ward, in press).

WALTER'S NAME: *Rhexia Alifanus* Walter (p. 130)
MODERN NAME: **Rhexia alifanus** Walt.
Common in eastern SC. No specimen. James (1956: 218) selected *James 675, 17 June 1955* (GH), from Pineville, Berkeley County, South Carolina, as NEOTYPE for *Rhexia alifanus* Walt. Noted by Kral and Bostick (1969).

WALTER'S NAME: *Rhexia lutea* Walter (p. 130)
MODERN NAME: **Rhexia lutea** Walt.
Frequent in eastern SC. No specimen. James (1956: 216) selected *James 678, 17 June 1955* (GH), from St. Stephen, Berkeley County, South Carolina, as NEOTYPE for *Rhexis lutea* Walt. Noted by Kral and Bostick (1969).

WALTER'S NAME: *Salix alpina* Walter (p. 243)
MODERN NAME: **Salix humilis** Marsh.
Nearly absent from SC, frequent in mountains and piedmont of NC. Spm. 93-C was labeled by Fraser as "*Salix Minor* of Fraser" and was identified by Blake (1915: 136) as *Salix alpina* Walter; Blake noted it "may be considered the type." *Salix alpina* is a later synonym (Marshall 1785 vs. Walter 1788), and designation of its type is not needed for stability of the current name. But Blake's reference to the specimen requires acknowledgment of his choice. Though the specimen bears only Fraser's hand, absence of the species from Walter's immediate area indicates it may have been part of materials brought to him by Fraser, which justifies correction of *Fraser/Walter 93-C, [1787]* (BM) to LECTOTYPE of *Salix alpina* Walt.

WALTER'S NAME: *Sarracenia rubra* Walter (p. 152)
MODERN NAME: **Sarracenia rubra** Walt.
Infrequent throughout SC. A photo of spm. 95-B is given by Rembert (1980: 24). The specimen was designated as "type" by McDaniel (1971). However, since it was collected and labeled (as "*Sarracenia Rubra*") by Fraser, and there is no evidence it was seen or used by Walter, *Fraser/Walter 95-B, [1787]* (BM) is here corrected to NEOTYPE for *Sarracenia rubra* Walt.

WALTER'S NAME: *Sarracenia minor* Walter (p. 153)
MODERN NAME: **Sarracenia minor** Walt.
Common in eastern SC. A photo of spm. 95-C is given by Rembert (1980: 24). The specimen was designated as "type" by McDaniel (1971). However Walter labeled the specimen "*Sarracenia lutea*," either a *lapsus calami* for *S. flava*, or he failed to recognize it as the plant he had described as *S. minor*. Thus *Fraser/Walter 95-C, [1787]* (BM) is here corrected to NEOTYPE for *Sarracenia minor* Walt.

WALTER'S NAME: *Silene Catesbaei* Walter (p. 141)
MODERN NAME: **Silene catesbaei** Walt. [= *Silene polypetala* (Walt.) Fern. & Schub.]
Very rare (2 counties in FL, 4 counties in GA, unknown in SC and NC). No specimen in the herbarium bears this name. Walter's description of *Silene catesbaei* is a near-exact match for the plant colloquially known as Fringed Catchfly. A NEOTYPE has been selected for *Silene catesbaei* Walt. (Ward, in press).

WALTER'S NAME: *Sophora villosa* Walter (p. 134)
MODERN NAME: **Baptisia cinerea** (Raf.) Fern. & Schub.
Infrequent in eastern SC. Spm. 100-E, labeled by Walter as "*Sophora*" and by Fraser as "*Villosa*" and bearing

Fraser's number "360", was identified by Fernald and Schubert (1948: 200–201) as "the Walter type" of *Sophora villosa* (= *Thermopsis villosa* (Walt.) Fern. & Schub.). They also depicted the specimen (plate 1106) with the label, "TYPE of *Sophora villosa* Walt." The specimen is indeed of a *Thermopsis*, but Walter's description is of a *Baptisia*, surely *B. cinerea*. *Thermopsis villosa* is known only in the Carolina mountains, where available only to Fraser (undoubtedly the source of spm. 100-E). Walter described five legumes as *Sophora*, believed by him to be congeneric. Four of his *Sophora* are clearly identifiable species of *Baptisia* that are frequent-to-common in eastern SC. "*Sophora villosa*", third in his tabulation, corresponds to *Baptisia cinerea* (Raf.) Fern & Schub. It is most unlikely that Walter would have inserted the morphologically different, unfamiliar *Thermopsis* between the four similar *Baptisia* species, and then omitted treatment of a fifth species also found in eastern SC.

But typification cannot be reversed (short of conservation), and the plant fragment, an inflorescence branch bearing two flowers, is by the action of Fernald and Schubert (1948) the type of *Sophora villosa* Walt., the basionym of *Thermopsis villosa* (Walt.) Fern. & Schub. Since there is little probability that Walter saw or used the specimen, Fernald and Schubert's unfortunate citation of *Fraser/Walter 100-E, [1787]* (BM) can only here be corrected to NEOTYPE for *Sophora villosa* Walt.

WALTER'S NAME: *Stellaria uniflora* Walter (p. 141)
MODERN NAME: **Arenaria uniflora** (Walt.) Muhl.
Rare, on granite outcrops of the lower piedmont. Surely a discovery of Fraser. Spm. 100-K was labeled "*No Name*" by Fraser. The specimen was identified (from photo) by Fernald and Schubert (1948: 195–197) as *Arenaria uniflora*, then equated with Walter's *Stellaria uniflora*, and designated its "TYPE" (plate 1103). Since it is most likely Walter based his description on materials brought to him by Fraser, *Fraser/Walter 100-K, [1787]* (BM) is here corrected to LECTOTYPE of *Stellaria uniflora* Walt., basionym of *Arenaria uniflora* (Walt.) Muhl.

WALTER'S NAME: *Utricularia inflata* Walter (p. 64)
MODERN NAME: **Utricularia inflata** Walt.
Frequent in eastern SC. Spm. 104-E was labeled "*Utricularia minor*" by Walter (but is not *U. minor* L., of Europe). Though (from photo) its identity is unclear, the specimen was designated by Taylor (1989: 662) as the "lectotype" of *Utricularia inflata* Walt. But since it would surely have been familiar to Walter and described by him from fresh material, *Fraser/Walter 104-E, [1787]* (BM) is here corrected to NEOTYPE for *Utricularia inflata* Walt.

WALTER'S NAME: *Viscum album ?* (p. 241)
MODERN NAME: **Phoradendron serotinum** (Raf.) M.C. Johnst. [= *Phoradendron "leucarpum"* (Raf.) Reveal & M.C. Johnst.]
Frequent throughout. Not *Viscum album* L., a European species. *Fraser/Walter 110-F, [1787]* (BM) is a scarcely identifiable scrap, labeled simply "*Viscum*" in Walter's hand. The specimen was designated ("selected") by Reveal and Johnston (1989) as LECTOTYPE for "*V. ? album*" of Walter. Then, having attached a specimen to Walter's description (and name?), they used the specimen as the basis for *Viscum leucarpum* Rafinesque (a misspelling of "*leucocarpum*"!), itself the basis for *Phoradendron leucarpum* (Raf.) Reveal & Johnston. Their lectotypification cannot be discarded. But since Walter had merely made a tentative error of identification and was not publishing a new name, a simpler action would have been to recognize the irrelevance of Walter's name, and select a better-quality neotype for *Viscum leu[co]carpum* Raf.

WALTER'S NAME: *Xyris caroliniana* Walter (p. 69)
MODERN NAME: **Xyris caroliniana** Walt. [= *Xyris flexuosa* Muhl. ex Ell.]
No specimen. In search for the type of Walter's *Xyris caroliniana*, Kral (1966: 236) located a John Fraser specimen (at P) that corresponded to *X. flexuosa*. That inconspicuous dry-soil species surely is not what Walter knew in the rice fields of his Santee River plantation, nor could it later (DBW obs., July 1990) be found anywhere in the vicinity of Walter's homesite. Its linear, twisted leaves conform poorly with Walter's "*fol. gladiatis*." But, however inappropriate, the Fraser specimen having been designated by Kral as the type of *X.*

caroliniana, Walter's name is best left assigned to the species otherwise known as *X. flexuosa*. Since Fraser's collections were made quite independently of Walter, *Fraser s.n., [1787]* (P), from another location and by a different collector, is here appropriately corrected to NEOTYPE for *Xyris caroliniana* Walt.

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Lectotypes and neotypes are too often published in unexpected places. There can be no assurance that none have been overlooked in the present compilation. But for their help in pursuit of the elusive goal of completeness, I am grateful to Bruce F. Hansen (USF), Peter C. Hoch (MO), Guy L. Nesom (BRIT), Kent D. Perkins (FLAS), James S. Pringle (HAM), David H. Rembert (USCH), and Robert L. Wilbur (DUKE). I have received encouragement and inspiration from Charles E. Jarvis (BM), with his long-ongoing project to record types of all Linnaean names. I also thank Alexander Krings (NCSC) and Robert L. Wilbur (DUKE) for their careful and most helpful review of the manuscript.

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BOOK NOTICES

HELEN PICKERING. 2006. **Wildflowers of Mombacho, Nicaragua: Flores Silvestres del Mombacho.** (ISBN 1-889878-14-6, pbk.). *Sida, Botanical Miscellany* 28. Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A. (**Orders:** www.britpress.org, http://www.brit.org/Sida/Sida28.htm, 817-332-4441 ext. 32). $15.00, 217 pp., 500 + color photographs, 6½" × 8½".

Volcán Mombacho and its associated National Park are in southwestern Nicaragua, about 30 miles south of Managua, near the town of Granada. The guide covers the whole of Volcán Mombacho (now dormant but with fumarolic fields and hot springs over a large area) including both the evergreen, humid forest between 800 meters and the crest at 1345 meters and the dry, deciduous forest below 800 meters. If the scope of the book were limited to this small area, it might be of limited interest, because relatively few will be able to visit the park. But the majority of plants covered occur in similar habitats throughout Central America and about one-third are widely distributed in the tropics. For the tropically challenged (including me) this is a wonderful volume—use it as a review of families and genera (even species, since many of them are widespread) or as an introduction to Central American plant diversity.

200 species in 174 genera, 63 families, are included (below). The species are first divided by color, then alphabetically by genus and species. For each species, there are two or three excellent photos, often including fruits and habit. "Descriptions and information on habitat and flowering periods are taken from the Flora of Nicaragua, published by the Missouri Botanical Garden in 2001."

Acanthaceae (6 genera, 6 species), Agavaceae (1, 1), Amaranthaceae (6, 6), Apocynaceae (3, 3), Araceae (5, 6), Asclepiadaceae (2, 2), Asteraceae (24, 34), Begoniaceae (1, 1), Bignoniaceae (1, 1), Boraginaceae (3, 3), Brassicaceae (2, 2), Bromeliaceae (4, 7), Campanulaceae (2, 2), Cannaceae (1, 1), Caprifoliaceae (1, 1), Clethraceae (1, 1), Clusiaceae (1, 1), Commelinaceae (5, 5), Convolvulaceae (1, 2), Costaceae (1, 1), Cucurbitaceae (2, 2), Cyperaceae (2, 3), Ericaceae (2, 2), Euphorbiaceae (5, 5), Fabaceae (s.l.) (7, 7), Flacourtiaceae (1, 1), Gesneriaceae (3, 3), Haemodoraceae (1, 1), Heliconiaceae (1, 2), Lamiaceae (1, 2), Loganiaceae (1, 1), Malpighiaceae (1, 1), Malvaceae (3, 4), Marantaceae (2, 2), Margraviaceae (1, 1), Melastomataceae (7, 7), Meliaceae (1, 1), Menispermaceae (1,1), Moraceae (1, 1), Myrinaceae (1,1), Myrtaceae (2, 2), Nyctaginaceae (1, 2), Orchidaceae (13, 16), Oxalidaceae (1, 1), Palmae (1, 1), Papaveraceae (2, 2), Passifloraceae (1, 1), Phytolaccaceae (2, 2), Piperaceae (1, 1), Poaceae (1, 1), Polygalaceae (1, 1), Rubiaceae (10, 10), Scrophulariaceae (2, 2), Solanaceae (5, 8), Sterculiaceae (1, 1), Tiliaceae (1, 1), Turneraceae (1, 1), Ulmaceae (1, 1), Urticaceae (2, 2), Verbenaceae (6, 6), Vitaceae (1, 1), Zingiberaceae (2, 2), Zygophyllaceae (1,1).—*Guy L. Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

LYNN COULTER. 2006. **Gardening with Heirloom Seeds: Tried-and-True Flowers, Fruits, and Vegetables for a New Generation**. (ISBN 0-8078-5680-0, pbk.). University of North Carolina Press, P.O. Box 2288, Chapel Hill, NC 27515-2288, U.S.A. (**Orders:** www.uncpress.unc.edu, 919-966-3561, 919-966-3829 fax). $22.50, 316 pp., color photographs, 8" × 9".

Gardening with Heirloom Seeds: Tried-and-True Flowers, Fruits, and Vegetables for a New Generation is a journey into the world of heirloom gardening. Heirloom plants are cultivated species that are at least 50 years old. Many are easier to grow and more disease-resistant than modern cultivars. The often taste better, as well. In this "sampler for heirloom seeds" Lynn Coulter describes 50 heirloom seed varieties in loving detail. Most can be grown in anywhere in the United States, but some are better suited to the warmer climate of the South, where the author makes her home. The plants are organized by gardening season: spring through winter. This paperback edition is generously illustrated with gorgeous color photographs of garden plants and color images from vintage out-of-print seed catalogs. A favorite of mine is the photograph of "Moon and Stars" watermelons, which have blue rinds spotted with yellow "stars" just like the night sky. Personal stories about the joy and meaning in heirloom seed gardening, seed saving, and seed swapping are interesting. In addition, useful gardening advice and spaces for notes are also included, along with resources for heirloom seeds and gardens. Apart from the joy that gardeners derive from growing unusual heirloom varieties, heirloom seeds have another value. They broaden the genetic diversity of the plants in our modern food supply, which is important in avoiding disasters like the Irish potato famine.—*Marissa N. Oppel, MS, Collections and Research Assistant, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

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THOMAS WALTER TYPIFICATION PROJECT, III: LECTOTYPES AND NEOTYPES FOR 20 WALTER NAMES, AS RECOGNIZED IN THE FRASER/WALTER HERBARIUM

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ABSTRACT

Thomas Walter's *Flora Caroliniana* (1788) contained numerous species new to science and whose names are of modern use. Many of the species he described were independently collected by John Fraser, whose specimens were seen by Walter before being taken to England. To ensure that Walter's names shall be used in a consistent way, appropriate specimens from the Fraser collection are here chosen as types, to represent 20 of the names published by Walter.

RESUMEN

La *Flora Caroliniana* (1788), de Thomas Walter, contiene numerosas especies que son nuevas para la ciencia, con nombres de uso moderno. Muchas de las especies descritas por Walter fueron colectadas independientemente por John Fraser, cuyos especímenes fueron vistos por Walter antes de ser llevados a Inglaterra. Para asegurar que los nombres de Walter serán usados en una manera consistente, se escogen, como tipos, los especímenes apropiados de la colección de Fraser, para representar 20 de los nombres publicados por Walter.

The Thomas Walter Typification Project is intended to bring understanding and nomenclatural precision to the many plant names published by Thomas Walter in his *Flora Caroliniana* (1788). The present task is to choose from the Fraser/Walter herbarium those specimens that are believed to be part of the material used by Walter, or are of such quality and confident identification that though not likely used by Walter may be selected to represent his new species.

In the 1780s Thomas Walter, an English resident of South Carolina, operated a rice plantation on the cleared bottomlands of the Santee River, in what is now Berkeley County. A classical education and an inquisitive mind led Walter to observe the native plants around him, and then to attempt their identification through use of his few books by Carl Linnaeus. Though the descriptions were brief and in Latin, Walter was able to match many of the local plants with Linnaeus' names. Other plants, however, did not match, and Walter wrote his own descriptions, also in Latin, of the species he thought to be new. In 1786, John Fraser, a venturous Scot in search of plants useful for English horticulture, met Walter and shared his interest in the native species. In 1788 Fraser returned to England, taking with him his numerous collections and the manuscript of Walter's new flora.

Once in London, Fraser promptly published Walter's *Flora Caroliniana*. This small volume contained 1056 species, many identified by Walter with names from Linnaeus, the rest given names of his own (unimaginatively, perhaps, assigning 58 of them "*caroliniana*"). Of the species treated in his book, 414 (or 39%) were given new names.

The importance and number of the species now carrying names given them by Thomas Walter is seldom appreciated. In the decades before Walter, Linnaeus had seen collections made by his student Pehr Kalm, by John Clayton, the city official of Gloucester, Virginia, and by Patrick Browne and others in the West Indies. From these sources he had learned of many plants of eastern North America and had published their descriptions and names. But from the Carolinas to southern Florida, very little botanical information had reached Europe. Walter was thus in position to find and name numerous species not previously known to science.

Walter kept no herbarium. Though later writers have stated that he had done so, and that it has since been lost or was perhaps given to Fraser, in none of Walter's surviving correspondence, nor in his book, nor in the writings of Fraser, is there evidence that Walter prepared or used a herbarium (Ward 2007a).

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But Fraser certainly did! Though he was in the Southeast for only 18 months, with collection possible during only a single growing season, he gathered specimens widely and with enthusiasm. His field practices were recorded with disdain by Michaux (Sargent 1889; Ward 1977, in transl.), and the often-fragmentary specimens now surviving in his herbarium well illustrate his haste and inexperience. Walter had opportunity to review much of Fraser's collection—over half (368, or 53.5%)) of the specimens kept by Fraser bear labels with Walter's handwriting (Ward 2007a)—and to name many as best he could. A portion of these specimens, selected by Fraser after his return to England, were retained by him. Others were sold to Charles Louis L'Heritier (Fraser 1789; Stafleu 1963) and are now in the DeCandolle Herbarium, Geneva; still others are in the Herbarium Lamarck, Paris.

The subset of 690 specimens retained by Fraser were mounted by him and/or his sons in a folio volume now held by the Natural History Museum, London. They form what is often called the "Walter Herbarium," or more appropriately, the Fraser/Walter herbarium, and are frequently consulted for suggestion as to what Walter may have meant by certain of his new names. A previous number of this series (Ward 2006) has addressed the characteristics and contents of this folio herbarium. Many of the species described and given new names by Walter are not represented in the Fraser folio. And even for those that are, there is no assurance that Walter used them in preparation of his *Flora* (Ward 2007a).

A great majority of the species described by Walter occur on the Carolina coastal plain and would very possibly have been known to him during the years he was preparing his *Flora*. For such species there is no reason to believe he had need of or made use of dried specimens, either from a herbarium of his own or that of Fraser. Walter, in his Latin introduction, reported that "for a long time he [Walter] has cultivated in his own garden the very many plants which he describes" (Walter 1788; Rembert 1980, in transl.). Thus, even though there may also be a specimen in the Fraser collection, for coastal plain species it is best to accept that Walter's descriptions were prepared largely or wholly from fresh materials. Such species, if not addressed previously by other authors, are now in need of a substitute type, a neotype.

The International Code of Botanical Nomenclature (McNeill et al. 2006) provides that when a name is unrepresented by a type specimen, or the original type specimen has been lost, a replacement specimen may be selected from another source. Such specimens are termed neotypes, and carry the same status as the missing type.

But it has long been recognized (Harper 1911; Ewan 1969) that a number of species treated by Walter do not grow within the limited area (perhaps 50 mile radius, centered on his Santee plantation) specified by Walter (1788). The means by which Walter encountered these plants is believed to have been Fraser, who is known to have traveled into the Appalachians of the western Carolinas and as far south as the Altamaha River, Georgia (Ward 2006). Fraser himself (1789) claimed to have provided Walter with some 200 new species, although survey of the *Flora* shows only 103 species (9.7%) known to grow only outside Walter's immediate area.

Though relatively few, these species now not known within Walter's area yet included within his *Flora* pose a special problem. Often Walter's description contains observations well beyond what is shown by the specimens alone—color and other details of the flowers (when the specimen itself is fruiting or sterile), height of the plant, etc. It is thus possible Walter based his descriptions on more generous materials—perhaps also provided by Fraser, perhaps from another source. Yet, with the generous assumption that the extra-territorial specimens in the Fraser collection are related to Walter's basis, they may be treated as part of the original material, or lectotypes.

The present number of this series includes only those lectotypes and neotypes that can adequately be based on specimens of the Fraser/Walter herbarium. Another number of this series (Ward 2007b) lists all known lectotypes and neotypes chosen by previous authors. A future number (or series of numbers) will encompass the many neotypes that must be selected from new materials.

It is understood that a risk accompanies selection of neotypes, in that there can never be certainty what was intended by the original author and that distortion of the original meaning will result if the new type differs significantly from the one once in the author's hand. Yet absence of a type carries its own potential for misrepresentation through the lack of a fixed basis against which new collections may be tested. Though previous authors have at times selected dubious or seriously defective specimens from the Fraser/Walter herbarium as neotypes, their actions cannot now be abrogated. But it is believed the neotypes selected here would not have been rejected by Thomas Walter as representative of his new species.

The 20 Walter types published here include 7 specimens that are designated as lectotypes and 13 specimens that are selected as neotypes. All are based upon specimens in the Fraser/Walter herbarium, London. (Specimens are designated as described in Ward 2006.) The lectotypes are obligatory choices, once the thesis is accepted that materials of extra-territorial species must have been seen by Walter. The neotypes are chosen of specimens that display adequate diagnostic characteristics and are believed to represent their species as currently understood. These typifications are here presented in the format used previously (Ward 2007b), in alphabetical sequence, using the names given them by Thomas Walter.

TYPIFICATIONS

WALTER'S NAME: *Actaea dioica* Walter (p. 152)
MODERN NAME: **Aruncus dioicus** (Walt.) Fern.
Nearly absent from SC, common in western NC; probably a Fraser discovery. Spm. 1-G is this, but bears only "*Actea*" in Fraser's hand. The specimen is of decent quality and may be part of the materials used by Walter in forming his description. Thus *Fraser/Walter 1-G [1787]* (BM) is here designated LECTOTYPE of *Actaea dioica* Walt., basionym of *Aruncus dioicus* (Walt.) Fern.

WALTER'S NAME: *Andromeda Catesbaei* Walter (p. 137)
MODERN NAME: **Leucothoe axillaris** (Lam.) D. Don
Common in eastern SC. Spm. 6-H was labeled "*Andromeda Catesbaei*" by Walter. It was annotated "Holotypus for the name *A. catesbaei* Walt." by N. C. Melvin in 1976, but the designation has not been published. Even though the name will remain in synonymy under *Leucothoe axillaris* (= *Andromeda axillaris* Lamarck, 1783), *Fraser/Walter 6-H [1787]* (BM) is of respectable quality and justifies selection here as NEOTYPE for *Andromeda catesbaei* Walt.

WALTER'S NAME: *Anonymos paniculat[a]* Walter (p. 198); nom. illegit.
MODERN NAME: **Carphephorus paniculatus** (Walt. ex Gmel.) Hebert [= *Trilisa paniculata* (Walt. ex Gmel.) Cass.]
Common in eastern SC. Although *Anonymos paniculata* is illegitimate, Gmelin (1792: 1204) based his name on Walter's description (Ward 1962). Spm. 32-D appears to be this. The handwriting is muddled, but includes "*paniculata*" in Walter's hand. Walter would not have needed this specimen. But its quality is fair (though its basal leaves are lacking), and *Fraser/Walter 32-D [1787]* (BM) is here selected as NEOTYPE for *Chrysocoma paniculata* Gmel., basionym for *Carphephorus paniculatus* (Walt. ex Gmel.) Hebert.

WALTER'S NAME: *Anonymos tinctori[a]* Walter (p. 68), nom. illegit.
MODERN NAME: **Lachnanthes caroliniana** (Lam.) Dandy [= *Lachnanthes tinctoria* (Walt. ex Gmel.) Ell.]
Common on the SC coastal plain. This plant was long known as *Lachnanthes tinctoria* (Walt.) Ell. After the decision by the 1950 International Botanical Congress that combinations made under "*Anonymos*" were illegitimate, Ward (1962) proposed Gmelin (1791: 113) as the first validating author. Wilbur (1962) found that Lamarck had done so five months earlier, but made the unneeded combination, *L. caroliniana* (Lam.) Wilbur. *Fraser/Walter 117-C [1787]* (BM), labeled "*nova genera*" in Fraser's hand and named to genus by A. Gray, is here selected as NEOTYPE for *Heritiera tinctorium* Gmel., basionym of *Lachnanthes tinctoria* (Walt. ex Gmel.) Ell.

WALTER'S NAME: *Arethusa racemosa* Walter (p. 222)
MODERN NAME: **Ponthieva racemosa** (Walt.) Mohr
Occasional in coastal SC. The label of spm. 8-D ("*Arethusa racemosa*") is in Walter's hand. But since the species would have been available to Walter near his home and the accompanying 3-digit number ("??9") indicates the specimen to be a Fraser collection, it may not have been seen by Walter until after completion of his manuscript. Blake (1915) correctly called it "an excellent specimen." *Fraser/Walter 8-D [1787]* (BM) is thus here selected as NEOTYPE for *Arethusa racemosa* Walt., basionym of *Ponthieva racemosa* (Walt.) Mohr.

Walter's name: *Asclepias polystachia* Walter (p. 107)
Modern name: **Asclepias exaltata** L.
Westernmost NC and SC, unknown on the SC coastal plain. Spm. 10-H was labeled "*Asclepias Novum*" by Fraser. The specimen was identified (from photo) by Fernald & Schubert (1948: 218–220) as this species, but was not called its type. The specimen is mediocre, with three leaves and a largely destroyed inflorescence. But since Walter must have relied on Fraser for material of this common but exclusively montane species, *Fraser/Walter 10-H [1787]* (BM) is here designated lectotype of *Asclepias polystachia* Walt.

Walter's name: *Carpinus caroliniana* Walter (p. 236)
Modern name: **Carpinus caroliniana** Walt.
Common throughout. Spm. 26-A bears "*Carpinus*" in Walter's hand. No type is known to have been designated elsewhere. Since this tree is found on what was Walter's Santee River property, there would have been no need for him to have relied on this specimen. Even so, the specimen is of adequate quality, and *Fraser/Walter 26-A [1787]* (BM) is here selected as neotype for *Carpinus caroliniana* Walt.

Walter's name: *Cinna glomerata* Walter (p. 59)
Modern name: **Andropogon glomeratus** (Walt.) BSP.
Common throughout the SC coastal plain. Hitchcock (1905: 32) identified a specimen (spm. 113-E) as *Andropogon macrourus* Michx., presently treated as a synonym of *Andropogon glomeratus*. He associated the specimen with Walter's name on the basis of its label, "*Cinna glomerata*," but did not refer to it as a type. Though he did not comment on the handwriting, it is that of Walter. Since *Andropogon glomeratus* is common, this specimen may have been obtained by Fraser anywhere in his travels and need not have been used by Walter in preparing his description. It is however of reasonably good quality. Having been addressed by Hitchcock, *Fraser/Walter 113-E [1787]* (BM) is here selected as neotype for *Cinna glomerata* Walt., basionym of *Andropogon glomeratus* (Walt.) BSP.

Walter's name: *Cinna lateralis* Walter (p. 59)
Modern name: **Andropogon virginicus** L.
Common throughout. Hitchcock (1905: 33) interpreted a specimen (spm. 113-C), bearing the label "*Cinna*" in Fraser's hand, as "probably the basis" of *Cinna lateralis* Walt., and identified it as "one of the forms of *Andropogon virginicus* L." Though the name will surely remain in synonymy, *Fraser/Walter 113-C [1787]* (BM) is here selected as neotype for *Cinna lateralis* Walt.

Walter's name: *Cypripedium reginae* Walter (p. 222)
Modern name: **Cypripedium reginae** Walt.
Very rare: in the Carolinas, known only in NC (2 counties). Spm. 39-B is labeled "*Cypripedium Reginae*" in Fraser's hand. It has been marked as "type" (by O. Ames?), but the designation has not been published. Since Walter could have seen this species only through the agency of Fraser, this specimen (or another of the same gathering) was probably used by him. Thus *Fraser/Walter 39-B [1787]* (BM) is here designated lectotype of *Cypripedium reginae* Walt.

Walter's name: *Eupatorium compositifolium* Walter (p. 199)
Modern name: **Eupatorium compositifolium** Walt.
Common in eastern SC. Spm. 46-B, an excellent specimen, was identified (from photo) as *Eupatorium compositifolium* ["*compositum*," writ in haste] by Fernald & Schubert (1948: 227). Its label, "*Eupatorium*," is in Walter's hand, but there is no evidence it was used by him in preparation of his text. Its quality justifies selection here of *Fraser/Walter 46-B [1787]* (BM) as neotype for *Eupatorium compositifolium* Walt.

Walter's name: *Iva imbricata* Walter (p. 232)
Modern name: **Iva imbricata** Walt.
Frequent along SC coast. Spm. 61b-B appears to be this. It was labeled "*Iva ? nova*" by Walter. It has been annotated as "Lectotype" (presumably of *Iva imbricata*) by Lillian T. Gillis (date unknown); this designation is believed not to have been published. The specimen is of good quality, and merits recognition as a type.

But, in light of Walter's failure to recognize his own species, it can scarcely be ranked as lectotype. Thus *Fraser/Walter 61b-B [1787]* (BM) is here selected as NEOTYPE for *Iva imbricata* Walt.

WALTER'S NAME: *Limodorum praecox* Walter (p. 221)
MODERN NAME: **Spiranthes praecox** (Walt.) Watson
Infrequent on SC coastal plain. Spm. 65-D appears to be this. It was labeled "*Limodorum*" by Fraser, and has been annotated as "*praecox*" (by O. Ames?). There is no indication it was seen or used by Walter. But *Fraser/Walter 65-D [1787]* (BM) is of good quality and is here selected as NEOTYPE for *Limodorum praecox* Walt., basionym of *Spiranthes praecox* (Walt.) Watson.

WALTER'S NAME: *Lysimachia lanceolata* Walter (p. 92)
MODERN NAME: **Lysimachia lanceolata** Walt. [= *Steironema lanceolatum* (Walt.) Raf.]
Not known in eastern SC, frequent westward, notably along Savannah River where Fraser traveled; surely his discovery. Spm. 68-E is this; it was labeled "*Lysimachia nov*" by Walter. It is a decent specimen of an entire plant. The probability is high that Walter relied on Fraser's material. Thus *Walter 68-E [1787]* (BM) is here designated LECTOTYPE of *Lysimachia lanceolata* Walt.

WALTER'S NAME: *Magnolia Fraseri* Walter (p. 159)
MODERN NAME: **Magnolia fraseri** Walt.
Found only in mountains of western NC and SC; a John Fraser discovery. Spm. 70-A was labeled by Fraser as "*Magnolia Fraseri.*" The specimen has been annotated as "type specimen" (presumably by J.E. Dandy 1929), though this choice appears not to have been published. The fold-out plate in *Flora Caroliniana* cannot be the type, in that it was prepared in England and not seen by Walter until after publication. Since Walter only had access to material of this species through the efforts of Fraser, it is appropriate that *Fraser/Walter 70-A [1787]* (BM) is here designated LECTOTYPE of *Magnolia fraseri* Walt.

WALTER'S NAME: *Prenanthes autumnalis* Walter (p. 193)
MODERN NAME: **Prenanthes autumnalis** Walt.
Frequent in eastern SC. Spm. 87-C (no label) was annotated as *Prenanthes autumnalis* by S.F. Blake. The epithet when published in the *Flora* was not italicized, as is usual for Walter's names. Although there is no indication this specimen was seen or used by Walter, it is of good quality, and *Fraser/Walter 87-C [1787]* (BM) is here selected as NEOTYPE for *Prenanthes autumnalis* Walt.

WALTER'S NAME: *Rhamnus carolinianus* Walter (p. 101)
MODERN NAME: **Rhamnus caroliniana** Walt.
Absent from SC coastal plain, frequent inland; probably a Fraser discovery. Spm. 91-F was labeled "*Rhamnus novus*" by Walter, with "*Carolinianus*" added by Fraser. The specimen is of poor quality, but is readily identifiable. Since Walter could scarcely have seen this species without the agency of Fraser, *Fraser/Walter 91-F [1787]* (BM) is here designated LECTOTYPE of *Rhamnus caroliniana* Walt.

WALTER'S NAME: *Sium suave* Walter (p. 115)
MODERN NAME: **Sium suave** Walt.
Occasional along SC coast. Spm. 42-F has been identified as *Sium suave* by Blake (1915: 131) from direct exam, and by Fernald & Schubert (1948: 217) from photo. Neither, however, called it the type. The label ("*Eryngium*") is by Fraser and there is no evidence the specimen was seen or used by Walter. Still, it is of fair quality and, having been confirmed by the above authors, *Fraser/Walter 42-F [1787]* (BM) is here selected as NEOTYPE for *Sium suave* Walt.

WALTER'S NAME: *Statice caroliniana* Walter (p. 118)
MODERN NAME: **Limonium carolinianum** (Walt.) Britt.
Occasional along the SC coast. Spm. 101-D, a quite good specimen, is this species. Although the generic name ("*Statice*") is in Walter's hand, the specific name ("*Caroliniana*") was assigned by Fraser. It is unlikely that this specimen was used by Walter in writing his *Flora*. Even so, *Fraser/Walter 101-D [1787]* (BM) is

judged adequate to be selected here as NEOTYPE for *Statice caroliniana* Walt., basionym of *Limonium carolinianum* (Walt.) Britt.

WALTER'S NAME: *Vincetoxicum acanthocarpos* Walter (p. 104)
MODERN NAME: **Matelea carolinensis** (Jacq.) Woodson
Rare on SC coastal plain, common inland; perhaps a Fraser discovery. The epithet was not italicized in the *Flora*, though the name is by Walter. Walter noted two varieties: one, "*corollis purpureis*", is surely *M. carolinensis*; the other, "*corollis nigricantibus*" ("blackish"), is unassignable. Spm. 109-B was labeled "*Vincetoxicum*" by Walter, and has been annotated (by S.F. Blake?) as "*V. acanthocarpos* Walt." It was suggested by Drapalik (1970: 59) from photo, to be a "probable lectotype" of Walter's species. Jacquin's epithet is earlier (1787), and typification of Walter's name is not imperative. However, in support of Drapalik's tentative suggestion, *Fraser/Walter 109-B [1787]* (BM) is here designated LECTOTYPE of *Vincetoxicum acanthocarpos* Walt. (= *Matelea carolinensis* (Jacq.) Woodson).

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CHROMOSOME NUMBER OF *LAUBERTIA CONTORTA* (APOCYNACEAE: APOCYNOIDEAE) AND ITS PHYLOGENETIC IMPORTANCE

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ABSTRACT

The mitotic chromosome count for *Laubertia contorta* ($2n = 18$) is the first reported chromosome count for the genus. A discussion of the relationship of *Laubertia* to other genera and the use of chromosome numbers in constructing non-molecular phylogenies in the Apocynaceae is presented. A distribution map and color photo of the species is also provided.

Key Words: *Laubertia*, Apocynaceae, chromosome, *Forsteronia*, *Prestonia*, Mexico

RESUMEN

Se realiza el recuento de cromosomas en mitosis de *Laubertia contorta* ($2n = 18$) que es el primero el género. Se presenta una discusión de la relación de *Laubertia* con otros géneros y el uso de los números cromosomáticos en la construcción de filogenias no-moleculares en Apocynaceae. Se aporta también un mapa de distribución y fotografía en color de la especie.

A cursory review of chromosome numbers in the Apocynaceae (Van der Laan & Arends 1985; Goldblatt & Johnson 2003) indicates that 73 of the 179 genera in the Apocynaceae have been counted. Few chromosome counts in the Apocynaceae are meiotic because plants characteristically produce only between 3-8 flowers per inflorescence. In addition, because the anthers produce little pollen, it is difficult to fix the anthers at the proper meiotic phase for counting. Therefore most counts in the Apocynaceae are mitotic counts made from the region of cell division in root tips using the "squash" technique (Witkus 1951; Raffauf 1964). The majority of taxa counted are those commonly cultivated and therefore with readily accessible root tips. Van der Laan and Arends (1985) discussed in detail the systematic utility of chromosome numbers in the Apocynaceae. Based on their observations, Van der Laan and Arends (ibid) suggested that chromosome numbers have the potential for resolving some important relationships in the Apocynaceae. In addition, they pointed out that only eight of the 55 genera in the Americas have had chromosome counts reported, and they strongly suggested that more counts be pursued.

Laubertia A. DC. comprises three species of Neotropical lianas native from Central Mexico to northern South America (Morales 2002). One species, *Laubertia contorta* (Mart. & Gal.) Woodson, is endemic to Mexico, where it ranges from Sinaloa to Chiapas (Fig. 1) and is readily distinguished from the other species of the genus by its twisted corolla tube and deep maroon corollas lobes (Fig. 2a). The relationship of *Laubertia* is disputed (Williams 1999), with some authors relating it to *Echites* P. Browne and others to *Prestonia* R. Br. (Morales 2002). A morphological cladistic analysis (Fig. 3, Williams 2004) places *Laubertia* basal to a clade of four species of *Prestonia* (here referred to as the "*Prestonia*" clade). Although *Laubertia* was nested with *Prestonia*, the bootstrap support for this relationship was below 50%. Chromosome numbers were not used for one of the character states in this analysis. Since the time of this analysis chromosome counts in the Apocynaceae have accumulated, including the one presented here. This paper provides the first chromosome count for *Laubertia* and examines the utility of chromosome numbers in morphological cladistic analyses.

MATERIALS AND METHODS

Voucher and fruiting specimens (Fig. 2b) were collected during January 2003 in Mexico (Fig. 1) by the first author. Voucher specimens were mounted and deposited at SHST and GH. MEXICO. CHIAPAS: 25 ft inside

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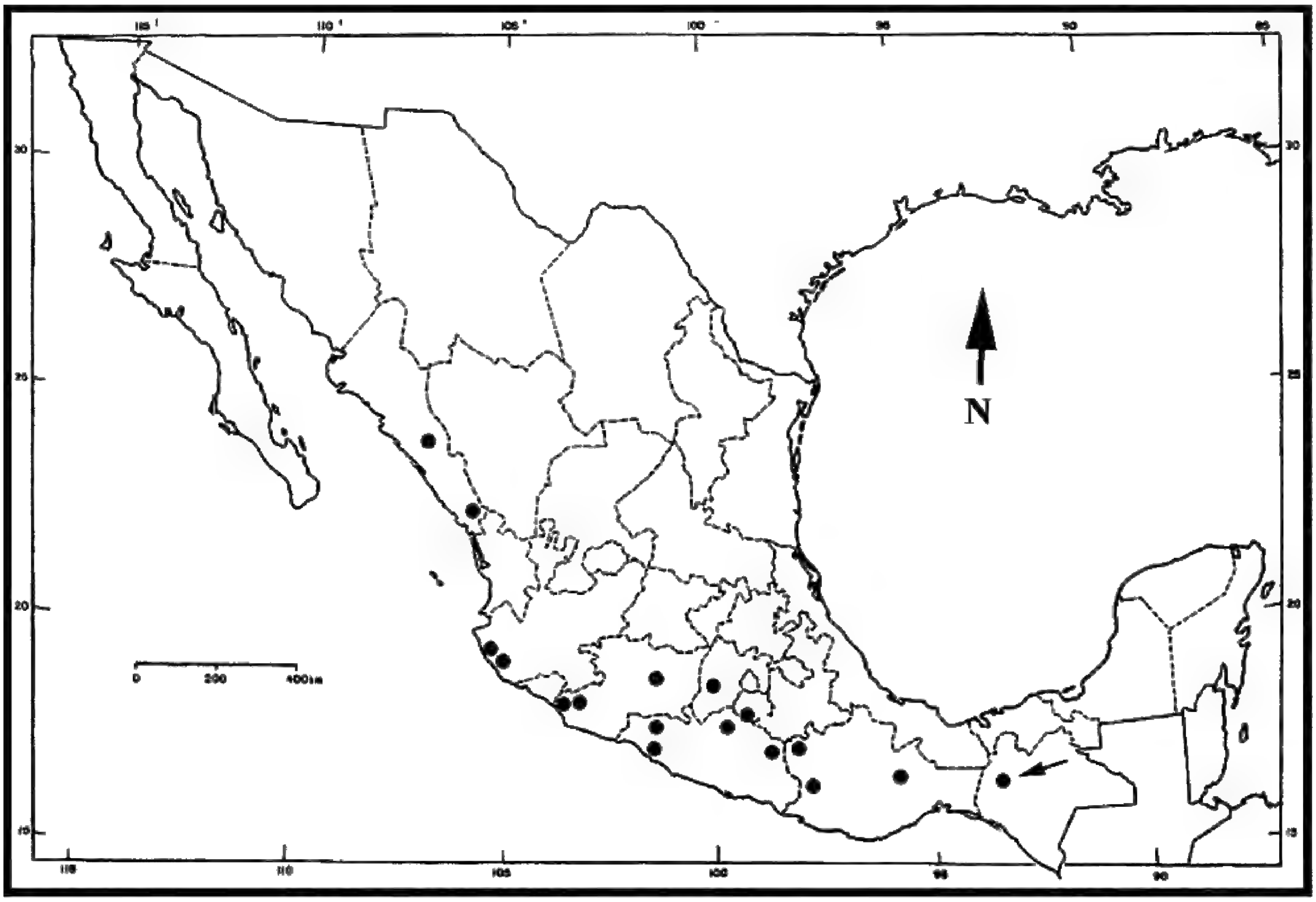

Fig. 1. Distribution of *Laubertia contora* (from Williams 1999). The arrow points to the site where follicles were collected.

the park from the entrance to "El Choreoderro" waterfall park ca. 10 mi N of Tuxtla Gutiérrez, 2 Jan 2003, *Williams 2003-1* (SHST, GH).

The collected seeds (Fig. 2c) were planted in small starter pots with commercial potting soil in July 2003 and were maintained in the greenhouse at the Department of Biological Sciences at Sam Houston State University. Twenty-four seeds were planted with no additional measures performed, such as soaking or scarification. Fifty percent of the seeds germinated (Fig. 2d) over a three month period. Once the plants developed several leaves (Fig. 2e) and an extensive root system, actively growing root tips (Fig. 2f) were collected, fixed, and analyzed using standard procedures (Van der Laan & Arends 1985).

Finally, using the same taxa, character matrix, and methodology in Williams (2004), we re-analyzed the data adding an additional character: chromosome number. Chromosome numbers for 29 of the 45 taxa included in Williams (ibid) were identified from the present study and a literature search (Van der Laan & Arends 1985; Goldblatt & Johnson 2003). The genera identified with chromosome counts were then scored based on their respective base number: 0: $x = 11$ (*Adenium* Roem. & Schult., *Apocynum* L., *Nerium* L.); 1: $x = 10$ (*Cerbera* L., *Strophanthus* DC., *Thevetia* L.); 2: $x = 9$ (*Forsteronia* G. Mey, *Laubertia*, *Parsonsia* R. Br., *Prestonia*); 3: $x = 6$ (*Echites*, *Odontadenia* Benth., *Pentalinon* Voigt); 4: $x = 8$ (*Mandevilla* Lindl.).

RESULTS

A mitotic chromosome number of $2n = 18$ or a base number of $x = 9$ was observed for *Laubertia contorta*. Van der Laan and Arends (1985) reported chromosome length in the Apocynaceae between 0.5–4 µm, with the average chromosome length between 1–2 µm. The length of the chromosomes in *L. contorta* varies between 0.5–1.5 µm, consistent with other chromosomes in the Apocynaceae.

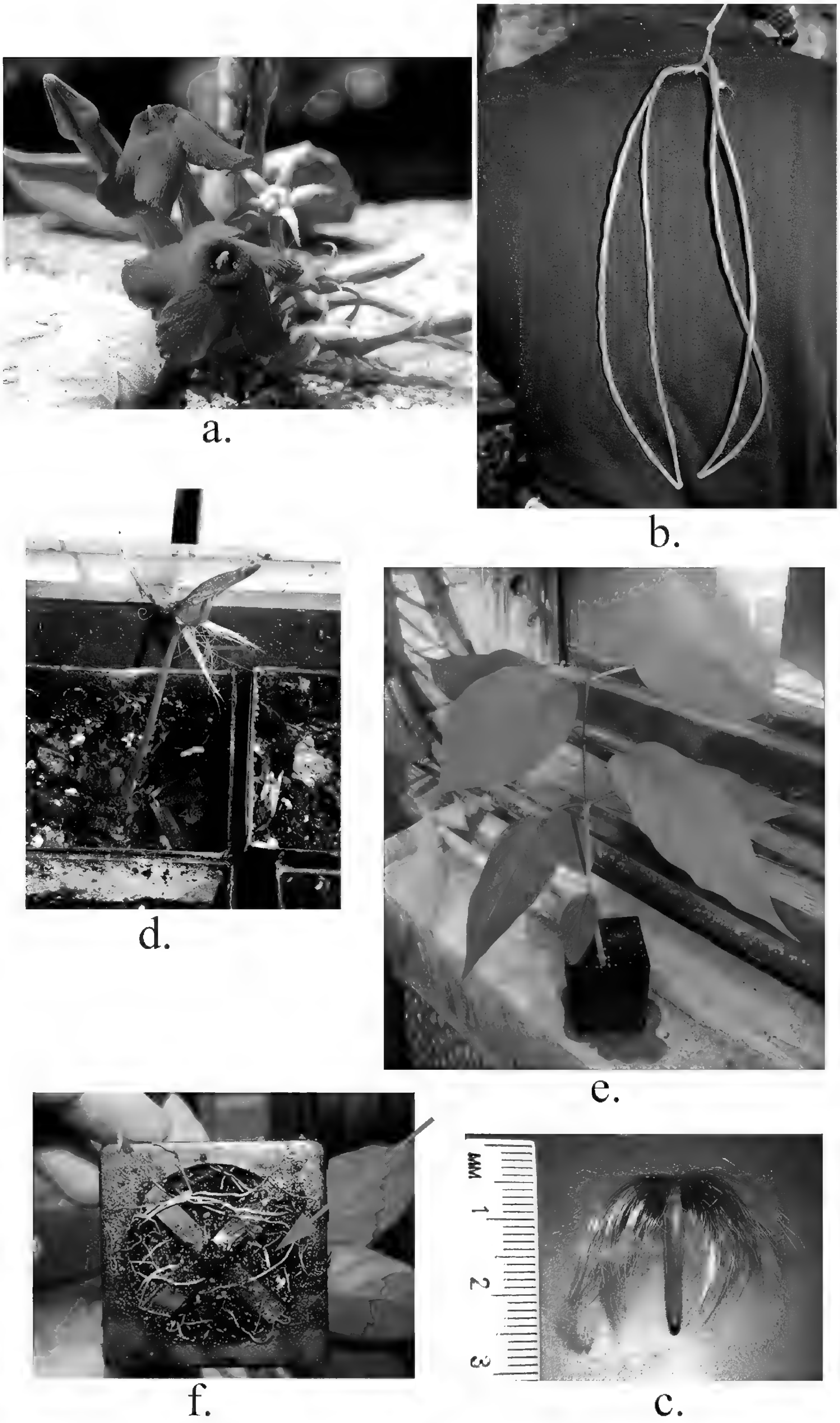

Fig. 2. Photographs of various stages and parts of *Laubertia contorta* **a.** Corolla; **b.** follicles; **c.** Seed with coma; **d.** emerging seedling; **e.** juvenile plant with leaves; **f.** root tips.

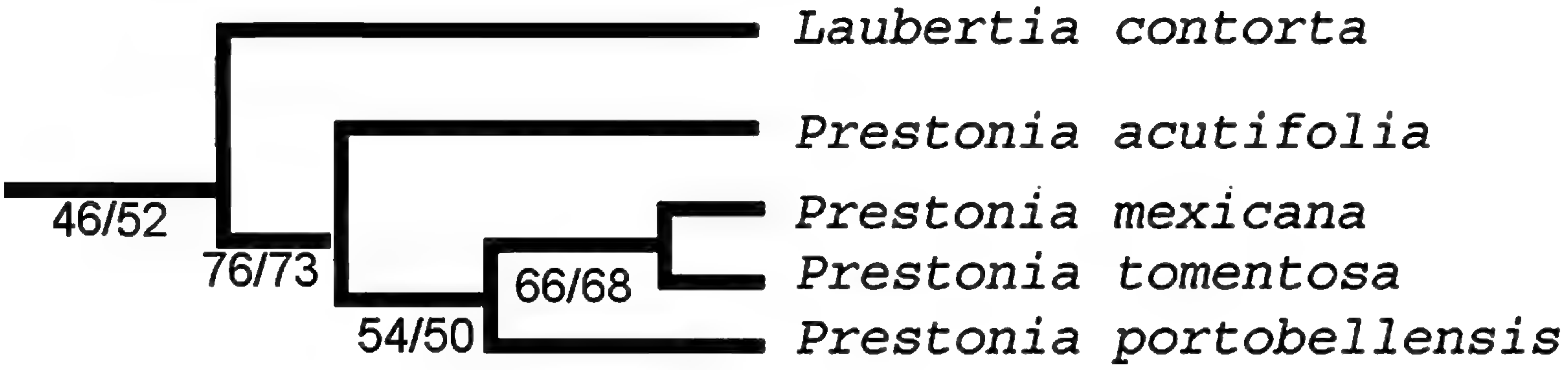

Fig. 3. Dendogram of *"Prestonia"* clade (from Williams 2004). Numbers below branches indicate bootstrap values. The first number indicates values determined in this study and the second number is from the analysis presented in Williams 2004. Only the value for the *"Laubertia/Prestonia"* branch determined in this analysis is included as the previous value was below 50%.

The heuristic search in Williams (2004) yielded a total of 48 equally parsimonious trees of 159 steps. The new search with chromosome counts added yielded a total of 98 equally parsimonious trees of 164 steps. The bootstrap value for the *Prestonia* clade (Fig. 3) was below 50% (46%) when chromosomes were not included (Williams 2004) and over 50% (52%) when chromosomes were included.

DISCUSSION

Van der Laan and Arends (1985) reported $x = 11$ as the base chromosome number for the Apocynaceae based on its prevalence in the family and on the observation that many of the plesiomorphic taxa possess a base number of $x = 11$. A review of the chromosomes numbers in the Apocynaceae presented by Van der Laan and Arends (ibid) indicates that a base chromosome number of $x = 9$ is found in eight genera represented in four of the 21 tribes recognized in the Apocynaceae (Endress & Bruyns 2000): Mesechites (*Forsteronia*), Echiteae (*Laubertia*, *Parsonsia*, *Prestonia*), Malourtieae (*Pachypodium* Lindl.), and Plumerieae (*Allamanda* L, *Plumeria* L.). The Plumerieae is in the subfamily Rauvolfioideae (anthers free from pistil head and aestivation of corolla bud sinistrorse) and differs from the other three tribes which are in the Apocynoideae (anthers fused to the pistil head and aestivation of corolla bud dextrorse). Based on subfamilial and tribal circumscription (Endress & Bruyns 2000) along with phylogenetic evidence (Williams 2004) it is suggested here that the evolution of $x = 9$ evolved independently in potentially four different clades within the Apocynaceae.

A cursory review of chromosome counts of the Apocynaceae (Van der Laan & Arends 1985; Goldblatt & Johnson 2003) shows that at present the only chromosome counts for Apocynoideae genera suggested and potentially related to *Laubertia* are for *Echites* ($x = 6$), *Forsteronia* ($x = 9$), *Parsonsia* ($x = 9$), *Pentalinon* ($x = 6$), and *Prestonia* ($x = 9$). The increased bootstrap value for the *Laubertia/Prestonia* (Fig. 3) clade calculated with the additional character state (chromosome numbers) provides further support for the close relationship between the two genera. And although the re-sampling of the data matrix, only increased the bootstrap value of the *Laubertia/Prestonia* by 6%, this increased the value of the clade to over 50%, which is often utilized as the lower threshold value for the beginning of support in phylogenies constructed from large scale datasets (Sanderson & Wojciechowski 2000) like this one. In addition, the results indicate that chromosome numbers are useful in constructing phylogenies in the Apocynaceae. Based on the phylogenetic significance of chromosome counts as potential tribal synapomorphies, it is suggested that further attempts be made to secure chromosome counts for other neotropical genera of the Apocynoidae, specifically *Allotoonia* Morales & J.K. Williams, *Angadenia* Miers, *Fernaldia* Woodson, *Rhabdadenia* Muell-Arg., *Mesechites* Muell-Arg., *Thenardia* H.B.K., *Thoreauea* J.K. Williams and additional species of *Echites* and *Prestonia*.

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BOOK REVIEWS

ETHAN B. RUSSO and FRANJO GROTENHERMEN (eds.). 2006. **Handbook of Cannabis Therapeutics from Bench to Bedside.** (ISBN 0-7890-3097-7, pbk.). Haworth Press, Inc., 10 Alice Street, Binghamton, New York, NY 13904-1580, U.S.A. (**Orders:** www.haworthpress.com, orders@haworthpress.com, 1-800-429-6784, 607-722-5857). $39.95, 471 pp., 6" × 8½".

Despite regulatory problems, there has been a lot of research on *Cannabis sativa* and the phytochemical compounds derived from it. Humans produce endocannabinoids that act on cannabinoid receptors 1 and 2 (CB_1 and CB_2). CB_1 receptors are found mainly in the brain, spinal chord, and peripheral nervous system and are associated with the psychoactive properties of *Cannabis sativa*. They are also associated with motor control, memory processing, and pain control, making them targets for drug discovery efforts. CB_2 receptors are found in the immune system and are associated with cytokine release. They are not associated with the psychoactive effects of cannabinoids. This makes the CB_2 receptors the preferred targets for drug discovery efforts, particularly for analgesic, anti-inflammatory, and antineoplastic drugs. The cannabinoid class of phytochemicals includes those with psychoactive effects like Δ^9-tetrahydrocannabinol, as well as non-psychoactive compounds like cannabinol. These two phytochemicals and many others derived from *Cannabis sativa* are under investigation by researchers, including the pharmaceutical giant Phizer, as new drugs to treat conditions including chronic pain, nausea, and other side effects from cancer chemotherapy and radiotherapy, as well as glaucoma, obesity, Parkinson's disease, and schizophrenia.

The *Handbook of Cannabis Therapeutics: From Bench to Bedside* is an informative guide to the world of cannabis research. It begins with historical ethnobotanical studies of ancient Arab and Greek texts. Three chapters are devoted to the pharmacokinetics and pharmacodynamics of the cannabinoids, including synergistic effects. This is followed by two chapters on the endocannabinoids and their receptors. A total of seven chapters are devoted to the medicinal uses of *Cannabis sativa*, including the treatment of nausea from cancer chemotherapy, loss of appetite in AIDS patients, multiple sclerosis, and crack cocaine addiction. The last section of the book is titled "Side Effects." It includes an interesting chapter by a registered nurse on *Cannabis sativa* and harm reduction, including the effect that legalization would have on the duties of health care professionals. The last chapter focuses on the positive and negative consequences of legal *Cannabis sativa* in a clinical setting.

Many of the chapters in this book were originally culled from the *Journal of Cannabis Therapeutics*, which is no longer in existence and hard to obtain. In addition, the book's editors and contributors are experts in the field of cannabis research. Therefore, this book is a useful source of hard-to-find scientifically validated information on *Cannabis sativa* as a medicine, making it a wonderful antidote to the massive amounts of misinformation and rumors about this culturally significant plant.—*Marissa N. Oppel, MS, Collections and Research Assistant, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

THOMAS J. ELPEL. 2006. **Botany in a Day: The Patterns Method of Plant Identification, 5th edition**. (ISBN 1-892784-15-7, pbk.). Hops Press, LLC, 12 Quartz Street, Pony, MT 59747-0697, U.S.A. (**Orders:** www.hopspress.com, www.wildflowers-and-weeds.com, www.mountain-press.com). $25.00, 221 pp., b/w illustrations, 8½" × 11".

Botany in a Day: The Patterns Method of Plant Identification is an excellent learning tool. It is focused on plants that grow in the northern parts of North America, however it is still useful for those of who live in the southern United States. The first part is a textbook on plant identification. It is intended to be completed in one day, although it took me longer than that. Unlike a field guide, which is a list of individual species, this guidebook is focused on recognizing visual patterns of plant groups. The book is illustrated with copious black-and-white line drawings that are incredibly helpful visual aids. The second part is focused on the edible and medicinal uses of wild plants, including an introduction to phytochemistry. This book is an excellent introduction to plant identification in the field. It has helped me to learn how to identify plants that grow here in North Central Texas.—*Marissa N. Oppel, MS, Collections and Research Assistant, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

VASCULAR PLANT TYPE SPECIMENS IN THE UNIVERSITY OF BRITISH COLUMBIA HERBARIUM (UBC)

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ABSTRACT

We provide a brief a history of the University of British Columbia herbarium and its vascular plant collection, and a catalogue of vascular plant type specimens in UBC.

RESUMEN

Se aporta una breve historia del herbario de la Universidad de la Columbia Británica y su colección de plantas vasculares, y un catalogo de tipos de plantas vasculares en UBC.

INTRODUCTION

General Collection History

The University of British Columbia Herbarium (UBC; Holmgren & Holmgren 1990) is the largest herbarium in western Canada, with approximately 600,000 accessioned specimens, including 242,000 bryophytes, 222,000 vascular plants, 67,000 algae, 35,000 lichens, and 15,000 fungi. John Davidson initiated the collection in 1912, when he became the Provincial Botanist of British Columbia. The original herbarium (not affiliated with UBC at the time) was located in the botanical offices in downtown Vancouver, and subsequently moved to a number of downtown locations before being moved to a temporary UBC location at Fairview in 1916, when John Davidson became "the demonstrator in charge of UBC herbarium and botanical garden." The collections were moved to the university campus around 1925, and were housed in various buildings closest to their curators, with the vascular plant collection located in what is now the Geology building (D. Brownstein, pers. comm.). In 1973, all five collections were moved to their present location in the Biological Sciences building. The collection will soon move again to the Beatty Biodiversity Museum, along with all the other non-anthropological UBC natural history collections.

History of the Vascular Plant Collection

Although details of the early growth of the vascular plant collection are unknown, it is well documented that many early British Columbia collectors donated their entire collections to John Davidson. Substantial early additions to the herbarium collection were donated by: Albert J. Hill (UBC database collecting years: 1875–1912; 2,500 specimens from various families, mostly from British Columbia); Eli Wilson (1903–1913; >1,000 specimens from various families, all from BC); W. Taylor (1912–1937; 900 specimens from various families, all BC); and A.E. Baggs (1910–1929; 1,000 specimens from BC and England) (The University of

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British Columbia Calendar 1922-1923; UBC database). Much of the early collection was destroyed during the 1930s by insect damage (W. Schofield, D. Brownstein, pers. comm., September 2006).

The size of the vascular plant collection increased substantially over the following decades, as a result of the efforts of many collectors and exchanges with other institutions. The collection included ~8,000 accessioned sheets in 1915, ~37,000 by 1952, 177,000 in the 1980s, and 212,000 in 1990. At present, the collection includes more than 222,000 accessioned specimens. Many of the largest donated collections of vascular plants have been from former directors of the UBC herbarium [J.W. Eastham (UBC database collecting years: 1948–1965; ~10,000 specimens from various families, all from B.C., with an emphasis on Poaceae and Cyperaceae); T.M.C. Taylor (1966–1971; ~7,000 specimens from various families, collected in Canada, Europe, and Japan, with an emphasis on pteridophytes); K.I. Beamish (1972–1974; ~6,500 specimens from various families, from Canada (B.C. and Yukon), Australia, and Tasmania, with an emphasis on Saxifragaceae and *Dodecatheon*); G.B. Straley (1990–1996; ~6,000 specimens, mainly from B.C. and U.S.A, with an emphasis on cultivated species)]. Additional large collections have been provided by U.B.C. faculty members [V.J. Krajina (1949–1975; ~10,000 specimens, mainly from B.C. and Hawaii, with an emphasis on pteridophytes), W.B. Schofield (1964–present; 1,500 specimens, mainly from western Canada (B. C. and Yukon) and Alaska], herbarium staff [J. Pinder-Moss (1968–1976; ~1,000 specimens from various families, all B. C.)], local botanists [e.g., J.A. Calder (1954–1964; 2,200 specimens, mainly from B.C.)], past graduate students [J. Pojar (1969-1975; ~800 specimens, mainly from B.C.)], and herbarium demonstrators, such as John Davidson (1916–1948; ~2,500 specimens from B.C. and Scotland). Current active collectors for the UBC herbarium are: H. Kennedy (1969–present; 1,000 specimens, mainly from South America, with an emphasis on Marantaceae); T. Goward (1979–present; 1,500 specimens, mainly from B.C.); A. Ceska (1978–present; 1,200 specimens, mainly from B.C., with an emphasis on Cyperaceae, Juncaceae, and aquatic species "whose flowers measure < 1 cm in diameter" (Adolf Ceska, pers. comm., December 2006); and F. Lomer (1988–present; ~2,000 specimens, mainly from B.C., from various families).

Of the 222,000 vascular plant specimens in UBC, ~45% are from British Columbia, and 22% are from the rest of Canada, with the Northwest Territories and Yukon Territory especially well represented. Specimens from the United States make up about 16% of the collection, with 9% from the five Pacific Coast states (Alaska, California, Hawaii, Oregon, and Washington) and 7% from the remainder of the United States. Hawaiian plants are especially well represented. About 17% of the collection originates from the rest of the world, with the largest numbers from Great Britain, Finland, China, Australia, Denmark, Japan, South Africa, Taiwan, Russia, Greenland, and Sweden.

UBC Type Collection

Until recently, most vascular plant type specimens in UBC were integrated with the general collection. We have searched the collection in an attempt to find all type specimens, though it is possible that additional type specimens (not clearly labeled as such) remain in the general collection. The composition of the vascular plant type collection largely reflects the geographic location of the herbarium and taxonomic groups of interest to researchers that are or have been associated with the UBC herbarium [e.g., studies of the neotropical genus *Calathea* (Marantaceae) by Dr. Helen Kennedy]. We have located 89 type specimens (excluding paratypes and topotypes), including seven holotypes, one isoneotype, and 81 isotypes. The geographic regions represented by the type specimens include 11 countries, eight states in the U.S.A (mostly western), three Canadian provinces, and one Canadian territory.

In this paper, we present comprehensive data for all known type specimens in UBC, including family, taxonomic name, authority, place and date of original publication, type status, country, collection locality information, habitat, collector(s), collection number, and UBC herbarium accession number. Specimens are listed alphabetically under their respective families. We have carefully examined all of the original protologues and specimens to confirm the status of type specimens. In many instances, protologue data differ from specimen label data. To provide maximum information, we therefore present all relevant protologue and specimen label data; in most cases, morphological data included on labels or in protologues are not included here. To maintain consistency throughout the manuscript, we have altered the formatting of some of the original data. Additional isotypes for several collections presented here are deposited in the United States National Herbarium (US); we include this information with the protologue data, identified with an asterisk (*) if US was not listed as a specimen repository in the original protologue. In an appendix, we provide an index to collectors and collector numbers, based on data from the UBC specimens. Authority abbreviations and publication citations follow Lawrence et al. (1968), Brummitt and Powell (1991), and Bridson and Smith (1991). This is the first published account of the UBC vascular plant type specimens, and it makes information on these historical collections available to the global botanical community to facilitate taxonomic work. All type specimens have been scanned, and high resolution images are available on the UBC herbarium webpage (http://www.botany.ubc.ca/herbarium).

CATALOGUE OF THE VASCULAR PLANT TYPE SPECIMENS IN THE UBC HERBARIUM

APIACEAE

Lomatium stebbinsii Schlessman & Constance, Madrono 26:41. 1979. **T-Protologue:** U.S.A. California. Tuolumne Co.: 4 mi (6.4 km) E of Long Barn on NE side of Bald Mountain, S2 T3N R17E, gravelly open volcanic slope and ridge crest with *Allium, Calyptridium, Arabis, Crepis, Penstemon,* and *Ceanothus*; *Pinus ponderosa* association; peduncles spreading, nearly prostrate, fruits shining, heavily grazed by rabbits, 4100 ft (1242 m), 26 May 1978, *Constance 3895* (holotype: WTU; isotypes: NY, UC, WS, US*). **T-Specimen:** CALIFORNIA. Tuolumne Co.: Sierra Nevada, 4 mi E of Long Barn on NE side of Bald Mountain (Sect. 2, Twns. 3N, R 17E), ca. 5600 ft elev., gravelly open volcanic slope and ridge crest with *Allium, Calyptridium, Arabis, Crepis, Penstemon* and *Ceanothus*, *Pinus ponderosa-Calocedrus* association, 26 May 1978, *L. Constance 3895* (isotype: UBC-V170207).

ASTERACEAE

Blennosperma bakeri Heiser, Madrono 9:103. 1947. **T-Protologue:** California. Sonoma Co.: W outskirts of Sonoma in "hog wallow" ca. 0.25 mi S of Napa Street in field on E side of street, 2 Apr 1946, *M.S. Baker 11307* (Herbarium of the University of California no. 72576; isotypes are to be distributed widely; US*). **T-Specimen:** California. Sonoma Co.: W outskirts of Sonoma in "hog wallow" ca. 0.25 mi S of Napa Street in field on E side of street, 2 Apr 1946, *M.S. Baker 11307* (isotype: UBC-V95320).

Helianthus nuttallii Torr. & A. Gray subsp. **canadensis** R.W. Long. Brittonia 18:77. 1966. **T-Protologue:** Manitoba: District de Souris, Mont Tortue, 1 mi de Mountain Side Fosse, *Boivin and Alex 10245* (holotype: DAO). **T-Specimen:** Manitoba: District de Souris, Mont Tortue, 1 mi au norde de Mountain Side Fossé, 25 Aug 1952, *Bernard Boivin and J.F. Alex 10245* (isotype: UBC-V155305).

Microseris laciniata (Hook.) Sch. Bip. subsp. **detlingii** K.L. Chambers, Sida 21:200. 2004. **T-Protologue:** U.S.A. Oregon. Jackson Co.: Siskiyou Pass, S side on the old highway where it joins Hwy. 5, 2.1 mi N of Hilt exit, grassy openings in *Quercus breweri*/*Amelancheir pallida* brushland, in heavy clay soil on slope above road, 22 Jun 1967, *K. L. Chambers 2868* (holotype: OSC; isotypes: BRIT-SMU, CAS, MO, NY, RSA, UC, US, WS, WTU). **T-Specimen:** U.S.A. Oregon. Jackson Co.: Siskiyou Pass, slope to E of the old highway, where it joins the new freeway (Hwy. 5), 2.1 mi N of the Hilts exit, R2E, T41S, Sec. 8, 3750 ft, 22 Jun 1967, *K. L. Chambers 2868* (isotype: UBC-V220903).

Solidago ×bernardii B. Boivin, Phytologia 23:21. 1972. **T-Protologue:** Kleefeld, 1.5 mi au sud-est, prairie, 16 Aug 1958, *Boivin, Bernard & Perron 12942* (holotype: DAO). **T-Specimen:** Manitoba: District de Provencher, Kleefeld, 1.5 mi au sud-est, prairie, ligules jaunes, devenant blanches, 16 Aug 1958, *B. Boivin, J.-P. Bernard, and J.M. Perron 12942* (isotype UBC-V155279).

BRASSICACEAE

Cardamine oligosperma Nutt. var. **lucens** G.S. Torr., Rhodora 17:157. 1915. **T-Protologue:** Klickitat Co.: damp places, common at Bingen, *Suksdorf 7452* (holotype: GH). **T-Specimen:** Washington. Klickitat Co.: Bingen, near my house, 10, 12 Apr 1912, *Wilhelm N. Suksdorf 7452* (isotype: UBC-V150824).

CARYOPHYLLACEAE

Silene andersonii Clokey, Bull. S. Calif. Acad. Sci. 38:2. 1939. **T-Protologue:** Nevada. Clark Co.: Charleston Mountains, on a steep, N slope in Lovell Canyon, associated with *Cercocarpus lepidofolius* Nutt. and *Artemesia tridentata* Nutt., 2,600 m, 9 Aug 1937, *Clokey 7514* (holotype: Clokey Herbarium; isotypes: CAS, US*). **T-Specimen:** Nevada. Clark Co.: Levell [*sic*] Canyon, steep, N, gravelly slope with *Artemesia tridentata* Nutt and *Cercocarpus ledifolius* Nutt., 2600 m, 9 Aug 1937, *I.W. Clokey 7514* (isotype: UBC-V111762).

CHENOPODIACEAE

Corispermum hookeri Mosyakin, Novon 5:349. 1995. **T-Protologue:** CANADA. Saskatchewan: District de Moose Jaw, palier sablonneux au pied du Coteau du Missouri, 5–6 mi à l'est de Mortlach, dune éventrée, 11 Sep 1960, *B. Boivin & G.F. Ledingham 14079* (holotype: DAO; isotypes: NY, TRT, UBC). **T-Specimen:** CANADA. Saskatchewan: District de Moose Jaw, palier sablonneux au pied du Coteau du Missouri, 5–6 mi à l'est de Mortlach, dune éventrée, 11 Sep 1960, *B. Boivin and G.F. Ledingham 14079* (isotype: UBC-V155271).

Corispermum hookeri Mosyakin var. **pseudodeclinatum** Mosyakin, Novon 5:350. 1995. **T-Protologue:** CANADA. British Columbia: beside Burnaby Lake, sand dune, 3 Oct 1965, *I. Bayly 83* (holotype: UBC). **T-Specimen:** CANADA. British Columbia: beside Burnaby Lake, sand dune, 3 Oct 1965, *I. Bayly 83* (holotype: UBC-V190492).

CYPERACEAE

Carex raymondii Calder, Rhodora 54:246. 1952. **T-Protologue:** Manitoba: Gillam, moist soil along margins of wood-road, *Schofield 1270* (holotype: DAO). **T-Specimen:** CANADA. Manitoba: Churchill District, Gillam, 27 Jul 1950, *W.B. Schofield 1270* (isotype: UBC-V40731).

Fimbristylis spathacea Roth var. **depauperata** T. Koyama, J. Jap. Bot. 30:1. 1955. **T-Protologue:** Honshu, côté d'Ichinomiya dans la prov. de Kadzusa, *T. Koyama 11120* (holotype: TSM). **T-Specimen:** JAPAN: Honshu, Kadzusa, Ichinomiya coast, scattered in stable dune sands sheltered by *Pinus thunbergii*, 11 Sep 1954, *T. Koyama 11120* (isotype: UBC-V102843).

DRYOPTERIDACEAE

Woodsia phillipsii Windham, Contr. Univ. Michigan Herb. 19:50. 1993. **T-Protologue:** U.S.A. Arizona. Cochise Co.: Rucker Canyon, Chiricahua Mts, canyon sides in pine woods, 6500 ft, 7 Oct 1945, *Phillips 2854* (holotype: GH; isotypes: ARIZ, ASC, UBC, US). **T-Specimen:** Arizona. Cochise Co.: Rucker Canyon, Chiricahua Mts, 6500 ft, 7 Oct 1945, *Walter S. Phillips 2854* (isotype: UBC-V5012).

EQUISETACEAE

Equisetum variegatum Schleich. var. **nelsonii** A.A. Eaton, Fern Bull. 12:41. 1904. **T-Protologue:** Illinois: E Chicago, along a canal, *N.L.T. Nelson s.n.* (holotype: not specified; isotype: US*). **T-Specimen:** Illinois: east Chicago, Jun 1901, *N.L.T. Nelson 85* (isotype: UBC-V3681).

FABACEAE

Oxytropis campestris DC. var. **wanapum** Joyal, Great Basin Naturalist 50:373. 1990. **T-Protologue:** U.S.A. Washington. Grant Co.: Saddle Mountain, above Lower Crab Creek and E of Beverly, T15N, R24E, S2, N1/2, elev. ca. 550 m, NNE aspect at crest of ridge, in sandy (volcanic ash) soils above steep basalt talus, 25 May 1987 (flower and early fruit), *Joyal 1264* (holotype: US; isotypes: BRY, CAN, CAS, ISC, K, MO, MONTU, NY, OSC, S, UBC, WS, WTU). **T-Specimen:** Washington. Grant Co.: Saddle Mountain, above Lower Crab Creek, sandy ridge above steep N-facing basalt talus, T15N, R24E, Sec 2 N½, ca. 600 m, common on sandy (volcanic ash) soils, 25 May 1987, *Elaine Joyal 1264* (isotype: UBC-V201206).

Oxytropis sordida (Willd.) Persoon subsp. **murrayi** Jurtsev, Arctic Fl. U.S.S.R 9:179. 1986. **T-Protologue:** Yukon: St. Elias Mts., Observation Mt. and vicinity, at terminus of Kaskawulsh Glacier, *D. F. and B. M. Murray 522*, 1966 (holotype: LE; isotypes: ALA, BRY). **T-Specimen:** CANADA. Yukon Terr.: St. Elias Mts., Observation Mt. and vic., at terminus, Kaskawulsh Glacier, ridge crest, 5500–7000 ft,. 60° 40' N, 138° 44' W., 10 Jul 1966, *David F. and Barbara M. Murray 522* (isotype: UBC-V173554).

GESNERIACEAE

Cyrtandra campaniformis St. John, Bernice P. Bishop Mus. Bull. 229:54. 1966. **T-Protologue:** Oahu, Laie Trail, Kahawainui Gulch, in moist *Metrosideros* forest, 1,250 ft, 25 Mar 1956, *H. St. John 25960* (holotype: BISH). **T-Specimen:** U.S.A. Hawaiian Islands, Laie Trail, Kahawainui Gulch, 381 m, in moist *Metrosideros* forest, 25 Mar 1956, *St. John 25960* (isotype: UBC-V38956).

Cyrtandra kailuaensis St. John, Bernice P. Bishop Mus. Bull. 229:172. 1966. **T-Protologue:** Oahu, Kailua, Fourth South Fork of the South Fork of Kahanaiki Stream, open scrub of guava, *Perrotettia*, kukui, *Rubus*, 800 ft, 18 Sep 1955, *G. Pearsall 2* (holotype: BISH). **T-Specimen:** U.S.A. Hawaiian Islands: Kailua, Fourth South Fork of Kahanaiki Stream, 244 m, 18 Sep 1950, *Pearsall 2* (isotype: UBC-V45207).

Note.—The collection date on the UBC specimen is incorrectly listed as 18 Sep 1950.

Cyrtandra pearsallii St. John, Bernice P. Bishop Mus. Bull. 229:269. 1966. **T-Protologue:** Oahu, Kailua, fourth south fork of the South Fork of Kahaniki Stream, 800 ft, open scrub of guava, *Clermontia*, *Rubus*, at base of large rock, 18 Sep 1955, *G. Pearsall 4* (holotype: BISH; isotype: US*). **T-Specimen:** U.S.A. Hawaiian Islands: Fourth South Fork of the South Fork of Kahanaiki Stream, Kailua, open scrub of guava, *Clermontia*, *Rubus*, at base of large rock, 244 m, 18 Sep 1950, *Pearsall 4* (isotype: UBC-V45209).

Note.—The collection date on the UBC specimen is incorrectly listed as 18 Sept 1950.

JUNCACEAE

Juncus laccatus Zika, Preslia 74:261. 2002. **T-Protologue:** U.S.A. Washington. Clallam Co.: low W ground, S side of Route 101 near Dry Creek and Dry Creek Road, 6 air km SSE of Angeles Point, Olympic Peninsula, 140 m, 48°06'N, 123°31'W, 27 Sep 2001, *P.F. Zika 16611* (holotype: WTU; isotypes: CAN, GH, MICH, MO, NY, OSC, PRA, UBC, UC, US). **T-Specimen:** Washington. Clallam Co.: S side of Route 101 near Dry Creek and Dry Creek road, 6 air km SSE of Angeles Point, Olympic Peninsula, low wet ground, full sun, with *Juncus hesperius*, *J. ensifolius*, *Lotus corniculatus*, *Alnus rubra*, 140 m, T30N R8W S22, 48°6' N, 123°31' W, 27 Sep 2001, *P.F. Zika 16611* (isotype: UBC-V219821).

LAURACEAE

Licaria applanata van der Werff, Novon 4:65. 1994. **T-Protologue:** ECUADOR: Pichincha, Reserva Río Guajalito, near Chiriboga, along old road Quito-Sto. Domingo, 1,850 m, *van der Werff et al. 12194* (holotype: MO; isotypes: AAU, GB, HBG, K, NY, P, QCNE, QRS, US). **T-Specimen:** ECUADOR: Pichincha, Reserva Río Guajalito, near Chiriboga, along old road Quito-St. Domingo, montane forest, Lauraceae collected in pature, 1850 m, 5 Jul 1991, *H. van der Werff, B. Gray, G. Tipas, and J. Campaña 12194* (isotype: UBC-V211491).

Ocotea rugosa van der Werff, Novon 4:70. 1994. **T-Protologue:** ECUADOR: Bolívar, in small patches of disturbed cloud forest along first 15 km of road Chillanes-El Tambo, elev. 2,100 m, *van der Werff et al. 12429* (male fl) (holotype: MO; isotypes: AAU, GB, NY, QCNE, QRS, US). **T-Specimen:** ECUADOR: Bolivar, small patches in disturbed cloud forest, rather dry, along first 15 km of road Chillanes-El Tambo, 2400 m, 18 Jul 1991, *H. van der Werff, B. Gray, and G. Tipas 12429* (isotype: UBC-V211489).

LILIACEAE

Erythronium quinaultense G.A. Allen, Syst. Bot. 26:269. 2001. **T-Protologue:** U.S.A. Washington. Grays Harbor Co.: Higley Peak, W side of summit, openings in coniferous forest, T23°N R10°W sect. 1, elev. 800 m, 24 May 1996, *Allen 9603* (holotype: UVIC; isotypes: WTU, OSC). **T-Specimen:** Washington: Grays Harbor Co.: Olympic National Forest, W side of Higley Peak along FS road #2190, S of short trail to summit, rocky ledges and openings in coniferous forest and adjacent road cutbacks on W facing slope, 2620 ft, T23N R10W sect. 1, 24 May 1996, *G.A. Allen 9603* (isotype: UBC-V218119).

MALVACEAE

Hibiscus newhousei Roe, Pacific Sci. 15:22. 1961. **T-Protologue:** Kauai, Moloaa Forest Reserve, ca. 500 ft altitude, 10 Nov 1958, *I.E. Lane 44* (holotype: not specified). **T-Specimen:** HAWAII: Kauai Island, Moloaa Forest Reserve, medium forest, "headwall," 150 m, 22.2N 159.6W, 10 Nov 1958, *I.E. Lane 44* (isotype: UBC-V183389a).

MARANTACEAE

Calathea amazonica H. Kenn., Selbyana 15:63. 1994. **T-Protologue:** PERU. Dept. Amazonas: Rio Cenepa vicinity of Huampami, ca. 5 km E of Chávez Valdivia, en bosque secundario, 200-250 m, ca. 04°30'S, 78°30'W, 1978, *E. Ancuash 1142* (holotype: MO; isotype: UBC). **T-Specimen:** PERU. Dept. Amazonas: Río Cenepa, vicinity of Huampami, ca. 5 km E of Chávez Valdivia, ca. 78°30' W, 4° 30'W, 200-250 m; gruesa hierba 30 cm, hojas pubescentes, flores blancas, en bosque secundario, no tiene usa; 1978, *Ernesto Ancuash 1142* (isotype: UBC-V208550).

Calathea anderssonii H. Kenn., Canad. J. Bot 63:1145. 1985. **T-Protologue:** ECUADOR: Napo, 15 km W of Tena along the Tena-Pamo road (road to Salcedo), along stream bank, 550 m, 19 Jul 1982, *Kennedy, Besse and Baker 4383* (holotype: NY; isotypes: AAU, BH, GB, QCA, SEL, UBC). **T-Specimen:** ECUADOR. Prov. Napo: 15 km W of Tena along the Tena-Pano road (road to Salcedo), along stream bank, 550 m, 19 Jul 1982, *Helen Kennedy, Libby Besse, and Ray Baker 4383* (isotype: UBC-V218518, 1 of 4; UBC-V183369, 2 of 4, UBC-V218519, 3 of 4; UBC-V218520, 4 of 4).

Calathea annae H. Kenn. & Marcelo, Phytologia 82:96. 1997. **T-Protologue:** Cultivated at Sítio Roberto Burle Marx, Barra de Guaratiba, Edo. Rio de Janeiro, Brazil, accession number MAR-1, from Brazil, Edo, unknown, 11 Jan 1991, *H. Kennedy and M. de F. Gomes de Souza 4696* (holotype: RB; isotypes: K, RB, Sítio RBM, UBC). **T-Specimen:** BRASIL: cultivado no Sítio Roberto Burle Marx, Barra de Guaratiba, Edo. Rio de Janeiro, 11 Jan 1991, *Helen Kennedy and M. de Fátima Gomes de Souza 4696* (isotype: UBC-V207963, 1 of 2; UBC-V207964, 2 of 2).

Note.—The UBC specimen is labeled *Calathea annae* H. Kenn. and Braga, but the taxon was described as *Calathea annae* H. Kenn & Marcelo.

Calathea anulque H. Kenn., Fl. Ecuador 32:38. 1988. **T-Protologue:** ECUADOR: Carchi, environs of Maldonado, 1450-1650 m, 2 Jun 1978, *Madison, Plowman, Kennedy and Besse 4949* (holotype: SEL; isotypes: AAU, F, QCA, UBC). **T-Specimen:** ECUADOR. Prov. Carchi: environs of Maldonado, wet montane forest, elev. 1450–1650 m, 2 Jun 1978, *M.T. Madison, T.C. Plowman, H. Kennedy, and L. Besse 4949* (isotype: UBC-V190301, 1 of 3; UBC-V190299, 2 of 3; UBC-V190300, 3 of 3).

Calathea attenuata H. Kenn., Nord. J. Bot. 6:146. 1986. **T-Protologue:** COLOMBIA: Amazonas, Leticia, 8 km out of Leticia along the road past airport, near Finca Vega, rain forest, 7 Feb 1972, *Kennedy and Andrews 1343* (holotype: MO; isotypes: AAU (sterile), COL, GB, NY, UBC). **T-Specimen:** COLOMBIA: Amazonas, Leticia, ca. 5 km out of Leticia on the road past the airport, disturbed rain forest, 7 Feb 1972, *Helen Kennedy and Robin Andrews 1343* (isotype: UBC-V184199).

Calathea caquetensis S. Suárez & Galeano, Caldasia 9:12. 2000. **T-Protologue:** COLOMBIA: Amazonas, río Yarí, margen oriental, cerca a su desembocadura en el río Caquetá, 0° 34' S, 72° 20' W, ca. 200 m, 13 Jun 1991, *G. Galeano et al. 2829* (holotype: COAH; isotypes: COL, UBC). **T-Specimen:** COLOMBIA. Departmento de Amazonas: Río Yari, margen izquierdo bajando, cerca a su desembocadura en el Río Caquetá, 13 Jun 1991, *G. Galeano, X. Martínez, and S. Suárez 2829* (isotype: UBC-V215100).

Calathea clivorum H. Kenn., Canad. J. Bot. 63:1147. 1985. **T-Protologue:** ECUADOR: Napo, 20 km W of Tena along the Tena-Pano road from Tena (road to Salcedo), 550 m, 19 Jul 1982, Kennedy, *Besse and Baker 4368* (holotype: K; isotypes: AAU, GB, M, MO, QCA, SEL, U, UBC, US). **T-Specimen:** ECUADOR. Prov. Napo: 20 km W of Tena along the Tena-Pano road from Tena (road to Salcedo), growing on a nearly vertical cliff face, 550 m, 19 Jul 1982, *Helen Kennedy, Libby Besse and Ray Baker 4368* (isotype: UBC-V183370).

Calathea compacta S. Suárez & Galeano, Caldasia 22:12. 2000. **T-Protologue:** COLOMBIA: Amazonas, río Caquetá, margen sur, Puerto Asaí, frente a Dos Islas, 0°55' S, 71°38' W, ca. 200 m, 4 Jun 1991, *G. Galeano et al. 2711* (holotype: COAH; isotype: COL, UBC). **T-Specimen:** COLOMBIA. Departmento de Amazonas: Río Caquetá, margen sur, Puerto Asai frent a Dos Isla, en cercania de la casa de Alfonso Rodríguez, *G. Galeano, X. Martínez, and S. Suárez 2711* (isotype: UBC-V215101).

Calathea contrafenestra H. Kenn., Canad. J. Bot. 62:18. 1984. **T-Protologue:** Cultivated at Marie Selby Botanical Garden, Sarasota, Florida, from rhizomes collected in Limnocócha, Ecuador (*M.T. Madison, T.C. Plowman, and L. Besse 5400*), 18 Jun 1982, *H. Luger* [*sic*] *800* (holotype: SEL; isotypes: BH, US). **T-Specimen:** Cultivated, Marie Selby Botanical Garden, Sarasota, Florida, from rhizomes collected in Ecuador, Limoncocha, Napo, Ecuador (*Madison, Plowman, and Besse 5400*), 18 Jun 1982, *Luther 800* (isotype: UBC-V184263, 1 of 2; UBC-V184262, 2 of 2).

Calathea curaraya H. Kenn., Fl. Ecuador 32:128. 1988. **T-Protologue:** ECUADOR: Napo, road (under construction) Coca-Cononaco, c. 30 km S of Río Tiputini, 200 m, 23 Jan 1982, *Harling, Bohlin, Lindström & Roth 19833* (holotype: GB; isotype: UBC). **T-Specimen:** ECUADOR: Coca, Coca-Cononaco Road (in construction), ca. 30 km S of Río Tiputini, 200 m, 23 Jan 1982, *G. Harling, J.-E. Bohlin, Marie Lindström, and Suzanne Roth 19833* (isotype: UBC-V202966).

Calathea ecuadoriana H. Kenn., Canad. J. Bot. 62:15. 1984. **T-Protologue:** U.S.A. Hawaii: Honolulu, cultivated at Lyon Arboretum, 1 Jun 1982, *H. Kennedy 4224* (holotype: US; isotypes: BH, CAN, HLA, K, M). **T-Specimen:** U.S.A. Hawaii: Honolulu, Lyon Arboretum, 1 Jun 1982, *Helen Kennedy 4224* (isotype: UBC-V220043).

Calathea fatimae H. Kenn., Phytologia 82:94. 1997. **T-Protologue:** BRAZIL: Cultivated at Sítio Roberto Burle Marx, Barra de Guaratiba, Munic. Rio de Janeiro, Edo. Rio de Janeiro, Brazil, accession number MAR-101, from rhizomes collected by *Fátima Gomes de Souza* from Morro do Coco, ca. 40 km N of the city of Campos, Munic do Campos, Edo. De Janeiro, Brazil, flowered in cultivation 11 Jan 1991, *H. Kennedy and M. de F. Gomes de Souza 4700* (holotype: RB; isotypes: K, Sítio RBM, UBC). **T-Specimen:** Cultivado no Sítio Roberto Burle Marx, Barra de Guaratiba, Edo. Rio do Janeiro, Brasil, rhizomes collected by M. F. Gomez de Souza from Morro do Coco, Munic do Campos, Edo. Rio de Janeiro, Brasil, 19 Jan 1991, *Helen Kennedy and M. de Fatima Gomes de Souza 4700* (isotype: UBC-V207965, 1 of 2; UBC-V218521, 2 of 2).

Calathea fucata H. Kenn., Fl. Ecuador 32:133. 1988. **T-Protologue:** ECUADOR: Napo, Río San Miguel opposite San Miguel, 4 Feb 1971, *Kennedy 808* (holotype: SEL; isotypes: DUKE, QCA, UBC). **T-Specimen:** ECUADOR. Napo Prov.: Río San Miguel, across river from San Miguel, Putumayo, Colombia, 4 Feb 1971, *Helen Kennedy 808* (isotype: UBC-V194073).

Calathea gandersii H. Kenn., Fl. Ecuador 32:110. 1988. **T-Protologue:** ECUADOR: Napo, road from Tena to Pano, trail through primary forest from road's end to the sawmill, 760 m, *Davis 422* (holotype: UBC). **T-Specimen:** ECUADOR. Provincio Napo: road from Tena to Pano, trail through primary forest from roads end to the sawmill, 759 m, 14 Dec 1976, *E. W. Davis 422* (holotype: UBC-V193731).

Calathea gloriana H. Kenn., Selbyana 18:35. 1997. **T-Protologue:** COSTA RICA. Prov. Heredia: Estación Biológica La Selva, Lindero Sur por las cabeceras de la Quebrada Surá, bosque secundario viejo, ca. 100 m, 19 Jul 1990, *H. Kennedy and B. Hammel 4545* (holotype: CR; isotypes: BM, MO, U, UBC, US). **T-Specimen:** COSTA RICA. Prov. Heredia: Cantón de Sarapiquí, estación Biológica La Selva, Lindero Sur por las cabeceras de La Quebrada Surá, bosque secondario, viejo, 100 m, 10°25' 30" N, 84°01'30" W, 19 Jul 1990, *Helen Kennedy and Barry Hammel 4545* (isotype: UBC-V211858).

Calathea grazielae H. Kenn. & Marcelo, Phytologia 82:101. 1997. **T-Protologue:** BRAZIL: cultivated at Sítio Roberto Burle Marx, Barra de Guaratiba, Munic. Rio de Janeiro, Edo. Rio de Janeir, Brazil, from rhizomes collected in Brazil, Edo. unknown, flowered in cultivation 19 Jan 1991, *H. Kennedy and M. de. F. Gomes de Souza 4699* (holotype: RB; isotypes: K, MO, Sítio RBM, UBC). T- Specimen: BRAZIL: cultivado no Sítio Roberto Burle Marx, Barra de Guaratiba, Edo. Rio de Janeiro, 19 Jan 1991, *Helen Kennedy and M. de Fátima Gomes de Souza 4699* (isotype: UBC-V208250, 1 of 2; UBC-V218522, 2 of 2).

Note.—The UBC specimen is labeled *Calathea grazielae* H. Kenn. and J. M. Braga (the latter authority written by hand after the label was printed). The taxon was described as *Calathea grazielae* H. Kenn. & Marcelo.

Calathea hylaeanthoides H. Kenn., Canad. J. Bot. 75:1356. 1997. **T-Protologue:** COSTA RICA. Puntarenas Prov.: Cantón de Osa, Osa Peninsula, Reserva Forestal Golfo Dulce, in Rancho Quemado Valley along Quebrada Quebradón and the Río Riyito, 200 m, 8°40' N, 83°34' W, 11 Sep 1990, H. *Kennedy, B. Hammel, and J. Solomon 4664* (holotype: CR; Isotypes: BM, COL, DUKE, F, G, GB, INB, K, MA, MICH, MO, P, U, UBC, US). **T-Specimen:** COSTA RICA. Puntarenas Prov.: Cantón de Osa, Osa Peninsula, Reserva Forestal Gulfo Dulce, in Rancho Quemado Valley along Quebrada Quebradón and the Río Riyito, 200 m, 8°40'N, 83°34'W, 11 Sep 1990, *Helen Kennedy, Barry Hammel, and James Solomon 4664* (isotype: UBC-V211818, 1 of 2; UBC-V211817, 2 of 2).

Calathea incompta H. Kenn., Canad. J. Bot. 75:1361. 1997. **T-Protologue:** COSTA RICA. Puntarenas Prov.: Cantón de Osa, Osa Peninsula, 2.5 mi SW of Rincón, by Río Agua Buena, above the airfield, tropical wet forest, 15-30 m, 8°32' N, 83°29' W, 4 Sep 1971, *H. Kennedy 1139* (holotype: UBC; isotypes: CR, K, MO, US). **T-Specimen:** COSTA RICA. Puntarenas Prov.: Cantón de Osa, Osa Peninsula, 2.5 mi SW of Rincón, by Río Agua Buena, above the airfield, 15-30 m, 8°32' N, 83°29' W, tropical wet forest, 4 Sep 1971, *Helen Kennedy 1139* (holotype: UBC-V204768, 1 of 3; V218523, 2 of 3; V218524, 3 of 3).

Calathea lagoagriana H. Kenn., Nord. J. Bot. 6:148. 1986. **T-Protologue:** ECUADOR. Napo Prov.: 33 km S of Rio Aguarico on the road from Lago Agrio to Coca, wet tropical forest, 2 Jul 1982, *Kennedy, Besse, and Baker 4288* (holotype: NY; isotypes: GB, K, MO, SEL, UBC, WIS). **T-Specimen:** ECUADOR. Napo Prov.: 33 km S of Río Aguarico on the road from Lago Agrio to Coca, wet tropical forest, ca. 350 m, 2 Jul 1982, *Helen Kennedy, Libby Besse, and Ray Baker 4288* (isotype: UBC-V189968).

Calathea lanicaulis H. Kenn., Canad. J. Bot. 63:1143. 1985. **T-Protologue:** ECUADOR: Napo, 5.6 km along the Tena-Pano road from Tena, disturbed tropical rain forest, ca. 500 m, 17 Jul 1982, *Kennedy, Besse and Baker 4373* (holotype: NY; isotypes: AAU, BH, GB, K, MO, QCA, SEL, U, UBC). **T-Specimen:** ECUADOR. Prov. Napo: 5.6 km along the Tena-Pano road from Tena, disturbed tropical rain forest, ca. 500 m, 17 Jul 1982, *Helen Kennedy, Libby Besse, and Ray Baker 4373* (isotype: UBC-V218525, 1 of 4; UBC-V183368, 2 of 4; UBC-V218526, 3 of 4; UBC-V218527, 4 of 4).

Calathea latrinotecta H. Kenn., Fl. Ecuador 32:42. 1988. **T-Protologue:** ECUADOR: Carchi, Penas Blancas, 20 km below Maldonado on Río San Juan, 900-1000 m, *Madison, Plowman, Kennedy, and Besse et al. 4646* (holotype: SEL; isotypes: AAU, F, QCA, UBC). **T-Specimen:** ECUADOR. Prov. Carchi: Pénas Blancas, 20 km below Maldonado on the Río San Juan, wet montane forest, elev. 900-1000 m, 27 May 1978, *M.T. Madison, T.C. Plowman, H. Kennedy, and L. Besse 4646* (isotype: UBC-V218579, 1 of 4; UBC-V190304, 2 of 4; UBC-V218578, 3 of 4; UBC-V218580, 4 of 4).

Calathea liesneri H. Kenn., Novon 3:49. 1993. **T-Protologue:** VENEZUALA: Territorio Federal Amazonas, Depto. Atabapo, in saddle between Cerro Duida and Cerro Marahuaca near base of Cerro Duida, medium height forest, 1,000 m, 03°34'N 65°32'W, 25 Oct 1988, *Liesner 25333* (holotype: MO; isotypes: K, UBC, VEN). **T-Specimen:** VENEZUALA: Amazonas, Atabapo, in saddle between Duida and Marahuaca near base of Duida, 1000 m, 03°34'N 65°32'W, 25 Oct 1988, *Ronald Liesner 25333* (isotype: UBC-V218528).

Calathea maasiorum H. Kenn., Brittonia 47:156. 1995. **T-Protologue:** FRENCH GUIANA: Saül, vicinity of Eaux Claires, Sentier

Botanique, from entrance to 450 m from entrance, non-flooded moist forest, ca. 250-350 m, 03°37'N 53°12'W, 10 Feb 1993, *Mori, Maas, & Mass et al. 22909* (holotype: NY; isotypes: CAY, NY, U, UBC). **T-Specimen:** FRENCH GUIANA: Saül, vicinity of Eaux Claires, Sentier Botanique, from entrance to 450 m from entrance, ca. 250-350 m, 3°37'N, 53°12'W non-flooded moist forest, 10 Feb 1993, *S. Mori, C. Gracie, T. Croat, H. Maas, P. Maas, T. Pennington, and D. Reed 22909* (isotype: UBC-V208553).

Calathea neblinensis H. Kenn., Phytologia 69:373. 1990. **T-Protologue:** VENEZUELA: Amazonas, Dept. Río Negro, near Cerro de La Neblina Base Camp which is on Río Mawarinuma, in forest near stream, 140 m, 0° 50' N, 66° 10' W, 5 Feb 1984, *R. L. Liesner 15662* (holotype: MO; isotypes: F, NY). **T-Specimen:** VENEZUELA: Territorio Federal Amazonas, Dept. Río Negro, near Cerro de La Neblina Base Camp which is on Río Mawarinuma, elev. 140 m, 0°50' N, 66°10' W, 5 Feb 1984, *Ronald Liesner 15662* (isotype: UBC-V217000).

Calathea pallidicosta H. Kenn., Nord. J. Bot. 6:143. 1986. **T-Protologue:** ECUADOR. Pastaza Prov.: 3 km S from junction with Puyo-Macas road towards Canelos (31 km total from Puyo Cemetery), disturbed tropical rain forest, 870 m, 21 Jul 1982, *Kennedy, Besse and Baker 4404* (holotype: NY; isotypes: GB, SEL, UBC). **T-Specimen:** ECUADOR. Prov. Puyo: 3 km S from junction with Puyo-Macas road towards Canelos (31 km total from Puyo Cemetery), disturbed tropical rain forest, 21 Jul 1982, *Helen Kennedy, Libby Besse and Ray Baker 4404* (isotype: UBC-V189965, 1of 3; V218529, 2 of 3; V218530, 3 of 3).

Calathea paucifolia H. Kenn., Fl. Ecuador 32:86. 1988. **T-Protologue:** ECUADOR: Pastaza, Río Pacayacu, tributary to Río Bobonaza, SE of Canelos, 10 March 1971, *Lugo 1605* (holotype: GB). **T-Specimen:** ECUADOR: Pastaza, Río Pacayacu, in the vicinity of Canelos, 10 Mar 1971, *Holguer Lugo S. 1605* (isotype: UBC-V202967 [2 separate sheets]).

Calathea plurispicata H. Kenn., Fl. Ecuador 32:33. 1988. **T-Protologue:** ECUADOR: Napo, road in construction Coca-Curaray, 20-30 km S of Coca, c. 250 m, *Harling and Andersson 11940* (holotype: GB; isotype: UBC). **T-Specimen:** ECUADOR: Napo, road Coca (Puerto Francisco de Orellana) to Curaray, 20-30 km S of Coca, primary rain forest, alt. ca. 350 m, 13 Nov 1974, *G. Harling and L. Andersson 11940* (isotype: UBC-V190302, 1 of 2; UBC-V218531, 2 of 2).

Calathea poeppigiana Loesner ex Kennedy, Fl. Ecuad. 32:77. 1988. **T-Protologue:** ECUADOR: Pastaza, tributary to Río Curarary, c. 21 km E of Curaray (Jesus Pitishka), temporary shallow pools in virgin rain forest, c. 200 m, 22 March 1980, *Harling and Andersson 17592* (holotype: GB; isotype: UBC). **T-Specimen:** ECUADOR: Pastaza, Río Namoyacu ca. 21 km E of Curaray (Jesús Pitishka), virgin rain forest, ca. 200 m, *G. Harling and L. Anderson 17592* (isotype: UBC-V203042).

Calathea retroflexa H. Kenn., Canad. J. Bot. 75:1357. 1997. **T-Protologue:** COSTA RICA. San José Province: Cantón de Pérez Zaledón, San Isidro del General, above La Ese, 3.3 km N of kilometer marker no. 126 on CR route no. 2, ca. 1380 m, 9°26'40" N, 83°43'00" W, 15 Aug 1990, *H. Kennedy 4555* (holotype: CR; isotypes: BM, F, GB, INB, K, MO, U, UBC). **T-Specimen:** COSTA RICA. San José Province: Cantón de Pérez Zaledón, San Isidro de General, above La Ese, 3.3 km N of km marker #126 on CR route #2, ca. 1380 m, 9°26'40" N, 83°43'00 W, 15 Aug 1990, *Helen Kennedy 4555* (isotype: UBC-V211816).

Calathea robinae H. Kenn., Ann. Missouri Bot. Gard. 60:419. 1973. **T-Protologue:** COSTA RICA. Limón Province: old forest ca. 2 mi from La Lola on the road to Siquirres near stream bed, 26 Feb 1971, *H. Kennedy, H. Andrews & H. L. Dressler 1379* (holotype: F; isotypes: BM, COL, CR, DAV, DUKE, GH, K, MO, NY, U, US). **T-Specimen:** COSTA RICA: Limón, old forest ca. 2 mi from La Lola on the road to Siquirres, near stream bed, *Helen Kennedy, Robin Andrews, and Robert Dressler 1379* (isotype: UBC-V204804).

Calathea steyermarkii H. Kenn. & Nagata, Brittonia 41:164. 1989. **T-Protologue:** U.S.A. HAWAII: Honolulu, cultivated at Lyon Arboretum, accession # L 76.1230 (from rhizomes collected by H. Kennedy in Parque Nacional Henri Pittier, Edo. Maracay, Venezuala), 5 Apr 1984, *K. Nagata 2886* (holotype: MO; isotypes: HLA, MAY, UBC). **T-Specimen:** Hawaii, Honolulu, cultivated at Lyon Arboretum, accession # L-76.1230 (from rhizomes collected by H. Kennedy in Parque Nacional Henri Pittier, Edo. Maracay, Venezuala), 5 Apr 1984, *Kenneth M. Nagata 2886* (isotype: UBC-V203398).

Calathea striata H. Kenn., Fl. Ecuador 32:60. 1988. **T-Protologue:** COLOMBIA: Amazonas, Leticia, 8 km out of Leticia on the road past the airport, forest on N side of road, Finca Misiones, rain forest, 11 Feb 1971, *Kennedy 813* (holotype: GB; isotypes: AAU, COL, DUKE, F, U, UBC). **T-Specimen:** COLOMBIA: Amazonas, Leticia, 8 km out of Leticia on the road past the airport, forest on N side of the road, Finca Misiones, rainforest, 11 Feb 1971, *Helen Kennedy 813* (isotype: UBC-V204750).

Calathea tinalandia H. Kenn., Canad. J. Bot. 63:1141. 1985. **T-Protologue:** ECUADOR: Pinchincha, Tinalandia Hotel grounds, km 112 on the road Quito to Santo Domingo de los Colorados, tropical moist forest, ca. 700 m, 28 Jul 1982, *Kennedy 4400* (holotype: NY; isotypes: AAU, GB, K, MO, QCA, SEL, U, UBC). **T-Specimen:** ECUADOR. Prov. Pichincha: Tinalandia Hotel grounds, km 112 on the road Quito to Santo Domingo de los Colorados, tropical moist forest, 28 Jul 1982, *Kennedy 4400* (isotype: UBC-V183373).

Calathea utilis H. Kenn., Nord. J. Bot. 6:457. 1986. **T-Protologue:** ECUADOR. Prov. Napo: Sardinas, 6 km from Baeza on road to Lago Agrio, montane wet forest, 1900 m, 16 Jul 1982, *Kennedy, Besse, and Baker 4363* (holotype: MO; isotypes: AAU, GB, K, NY, QCA, S, SEL, UBC). **T-Specimen:** ECUADOR. Prov. Napo: 6 km from Baeza on the road to Lago Agria, Sardinas, montane W forest, 1900 m, 16 Jul 1982, *Helen Kennedy, Libby Besse, and Ray Baker 4363* (isotype: UBC-V203560, 1 of 3; UBC-V218581, 2 of 3; UBC-V218582, 3 of 3).

Monophyllanthe araracuarenses S. Suárez, Galeano & H. Kenn., Novon 11:356. 2001. **T-Protologue:** COLOMBIA: Amazonas, río Caquetá, margen sur, Pena Roja, 0°39'S, 72°05'W, ca. 200 m, 9 Jun 1991, *G. Galeano, X. Martínez & S. Suárez 2767* (holotype: COAH; isotypes: COL, MO, UBC). **T-Specimen:** COLOMBIA. Departamento de Amazona: Pena Roja trocha al monte, en la margen sur del rio Caquetá, 9 Jun 1991, *G. Galeano, X. Martínez, and S. Suárez 2767* (isotype: UBC-V218577).

MELANTHIACEAE

Trillium ovatum Pursh forma **hibbersonii** T.M.C. Taylor & Szczaw., Syesis 7:250. 1974. **T-Protologue:** British Columbia: W coast of Vancouver Island, near Boat Basin, Hesquiat Harbour, 49°20'N, 136°30'W, alt. 2000 ft, 1938, *J. Hibbersonii s.n.* (holotype: UBC). **T-Specimen:** CANADA. British Columbia: near Boat Basin, Hesquiat Harbour, W coast of Vancouver Island, 1938, *J. Hibberson s.n.* (holotype: UBC-V73131).

POACEAE

Achnatherum wallowaensis J.R. Maze & K.A. Robson, Madrono 43:401. 1996. **T-Protologue:** U.S.A. Oregon. Wallowa Co.: Wallowa-Whitman National Forest, ca. 34 km N of Enterprise, near Boner Gulch along Forest Service Road 46, 45° 43' 41.16" N, 117° 08' 10.32" W (SW ¼ of SE ¼, section 24, T 3 N, R 45 E), 1481 m, 26 Jun 1993, *J. and E. Maze, K.A. Robson & T. Henn 1007* (holotype: US; isotypes: COLO, DAV, ID, NMC, OCS, UBC, UC, UTC, WTU]. **T-Specimen:** U.S.A. Oregon. Wallowa Co.: Wallowa-Whitman National Forest, near Boner Gulch along Forest Service Road 46, ca. 34 km N of Enterprise, SW ¼ of SE ¼, section 24, T 3 N, R 45 E, plants growing in shallow rocky soil at 1279 m with *Bromus tectorum*, *B. japonicus*, *Blepharipappus scaber*, *Epilobium* sp., *Poa sandbergi*, *Danthonia intermedia*, *Agropyron spicatum*, *Lomatium macrocarpum*, *Sedum stenopetalam*, *Allium tolmei*, *Eriophyllum lanatum*, *Grindellia* sp., *Achillea millefolium*, 26 Jun 1993, *J. and E. Maze, K.A. Robson, and T. Henn 1007* (isotype: UBC-V209875).

Bromus ayacuchensis Saarela & P.M. Peterson, Sida 22:919. 2006. **T-Protologue:** PERU. Departamento Ayacucho: Provincia Lucanas, 12 km E of Puquio on road towards Cuzco, (14°41'19.2 S Lat, 74°04'28.3 W Long), 3730 m, among large boulders with Berberis (Berberidaceae), above meadow with small creek, 11 Mar 2002, *P.M. Peterson 16452 & N.F. Refulio-Rodriquez* (holotype: US; isotypes: K, MO, UBC, USM). **T-Specimen:** PERU. Departamento Ayacucho: Provincia Lucanas, 12 km E of Puquio on road towards Cuzco, (14°41'19.2 S Lat, 74°04'28.3 W Long), 3730 m, among large boulders with *Berberis* (Berberidaceae), above meadow with small creek, 11 Mar 2002, *P.M. Peterson 16452 & N.F. Refulio-Rodriquez* (isotype: UBC-V222906).

Elymus ambiguus Vasey & Scribn. var. **salmonis** C.L. Hitchc., Vasc. Pl. Pacific NorthW. 1:558. 1969. **T-Protologue:** Idaho: Custer Co.: shale cliff 9 mi S of Challis, along E side of Salmon R., 31 May 1962, *Hitchcock & Muhlich 22305* (holotype: UW). **T-Specimen:** Idaho. Custer Co.: shale cliffs 9 mi S of Challis, along E side of Salmon River, 31 May 1962, *C.L. Hitchcock and C.V. Muhlick 22305* (isotype: UBC-V95381).

Oryzopsis swallenii C.L. Hitchc. & Spellenb., Brittonia 20:164. 1968. **T-Protologue:** Idaho. Clark Co.: open sagebrush slope just N of Birch Creek, 2 mi NW of Blue Dome, along Highway 28, near the Lemhi Co. line, ca. 5600 ft, 7 Jul 1965, *C.L. Hitchcock 23868* (holotype: WTU; isotype: US). **T-Specimen:** Idaho. Clark Co.: open sagebrush slope N of Birch Creek, 3 mi NW of Blue Dome, elev. ca. 5600 ft, on decomposed limestone, semi-barren gentle slope with dwarfed sagebrush and very dwarfed *Oryzopsis hymenoides*; plants tufted, the herbarium specimens representing ca. 1/10-1/2 of the whole plant, 7 Jul 1965, *C.L. Hitchcock 23868* (isotype: UBC-V116845).

Paspalum eitenii Swallen, Phytologia 14:385. 1967. **T-Protologue:** BRAZIL: Maranhão, Município de Lorêto, "Ilha de Balsas" region, between Rios Balsas and Parnaíba, collected in ravine of dry brook in extensive "caatinga" forest, 6 Apr 1962, *George Eiten and Liene T. Eiten 4091* (holotype: US). **T-Specimen:** BRAZIL: Maranhão, Municipío de Lorêto, "Ilha de Balsas" region, between the Rios Balsas and Parnaíba, ca. 30 km S of Loreto, ca. 0.5 km N of main house of Faz. São Raimundo on trail to Fazenda Santa Rita, ca. 7°19'S, 45°7-8'W, in ravine of now dry brook in extensive "caatinga" forest, soil light brown fine sand with clay, 200-300 m, 6 Apr 1962, *George Eiten and Liene T. Eiten 4091* (isotype: UBC-V117490).

POLYGONACEAE

Dedeckera eurekensis Reveal & J.T. Howell, Brittonia 28:246. 1976. **T-Protologue:** UNITED STATES. California. Inyo Co.: Last Chance Range, in a rocky canyon ca. 3 airline mi (4.8 km) SE of Eureka Valley sand dunes and 3.5 airline mi (5.6 km) NW of Marble VABM 7559, in T10S, R40E, on steep limestone, N-facing, rocky slopes in the canyon, associated with *Atriplex*, *Eriogonum* and *Prunus* at ca. 4000 ft (1200 m) elev., 29 Jul 1975, *J. L. Reveal, M. C. DeDecker & P. W. DeDecker 3909* (holotype: US; isotypes: 35 to be distributed). **T-Specimen:** California. Inyo Co.: Last Chance Range, along the jeep corridor between Saline Valley and Eureka Valley, ca. 3 airline mi SE of Eureka Valley sand dunes and 3.5 airline mi NW of Marble VABM 7559, in T.10S., R.40E., on steep limestone, N-facing rocky slopes associated with *Atriplex*, *Buddleja*, *Prunus* and *Eriogonum*, at ca. 4000 ft elev., 29 Jul 1975, *James L. Reveal, Mary C. DeDecker, and Paul. W. DeDecker 3909* (isotype: UBC-V173364).

Eriogonum natum Reveal, Great Basin Naturalist 35:363. 1975. **T-Protologue:** Utah. Millard Co.: along U.S. Highway 50-6, 46.2 mi E of the Nevada state line and ca. 43 mi W of Delta, on low white alkaline clay outcrops 50-300 meters N of the highway, ca. 0.2 mi E of the dirt road junction to the Antelope Spring-Black Hill Well roads, NNW of Sevier Lake, 13 Aug 1975, *Reveal & Reveal 3924* (holotype: US; isotypes: ARIZ, ASU, BRY, CAS, COLO, GH, ISC, K, MARY, MO, NY, OKL, OSC, PH, RM, RSA, SMU, TEX, UC, UTC, WTU). **T-Specimen:** Utah. Millard Co.: along U.S. Highway 50-6, 46.2 mi E of the Nevada State line and ca. 43 mi W of Delta, ca. 0.2 mi E of the dirt road junction of Antelope Spring and Black Hill Well with the highway NNW of Sevier Lake, 13 Aug 1975, *James L. Reveal and Mark L. Reveal 3924* (isotype: UBC-V173366).

Eriogonum umbellatum Torr. var. **furcosum** Reveal, Great Basin Naturalist 45:278. 1985. **T-Protologue:** California. El Dorado Co.: along California Highway 89, 2.2 mi S of U.S. Highway 50, on sandy granitic soil, associated with *Arctostaphylos*, *Artemisia*, and juniper-pinyon, 23 Aug 1975, *Reveal 3971* (holotype: US; isotypes: ARIZ, BRY, CAS, DUKE, F, GH, K, MARY, MEXU, MICH, MO, NY, OKL, RENO, RM, RSA, TEX, UC, UTC and elsewhere). **T-Specimen:** California. El Dorado Co.: along California Highway 89, 2.2 mi S of U.S. Highway 50, on sandy granitic soils just E of the highway, associated with *Artemisia*, pinyon-juniper, and *Arctostaphylos*, 23 Aug 1975, *James L. Reveal 3971* (isotype: UBC-V173374).

POLYPODIACEAE

Pellaea gastonyi Windham, Contr. Univ. Michigan Herb. 19:36. 1993. **T-Protologue:** CANADA: British Columbia: Kinbasket Mountain by Kinbasket River, NW of Golden, 17 Aug 1953, *Calder and Savile 11976* (holotype: US; isotypes: DAO, UBC, WTU). **T-Specimen:** CANADA. British Columbia: Kinbasket Mountain by Kinbasket River, NW of Golden, very common in rock crevices, rocky gullies and slopes at base of mountain, 17 Aug 1953, *J.A. Calder and D.B.O. Savile 11976* (isotype: UBC-V75464).

Polypodium montense F.A. Lang, Madrono 20:57. 1969. **T-Protologue:** British Columbia: Cheakamus River, *Lang 211* (holotype: UBC). **T-Specimen:** British Columbia: Basalt Columns at McGuire, Cheakamus River, in crevices in basalt, 50°N, 123°W, 2*n* = 74, 6 Nov 1964, *F.A. Lang 211-B* (holotype: UBC-V137746; isotypes: UBC-V137749, UBC-V137745).

Polystichum kwakiutlii D.H. Wagner, Amer. Fern J. 80:50. 1990. **T-Protologue:** CANADA. British Columbia: coast, Alice Arm, 10-9-(19)34, *A.D. York s.n.* (holotype: UBC). **T-Specimen:** CANADA. British Columbia: coast, Alice Arm, 10-9-1934, *A.D. York s.n.* (holotype: UBC-V4859).

PORTULACACEAE

Claytonia perfoliata Donn ex Willd. var. **angustifolia** Greene, Fl. Francisc. 2:179. 1891. **T-Protologue:** U.S.A. California: Santa Clara Co.: foothills near Stanford University, 1 Apr 1902, *C.F. Baker 487* (Neotype: NDG [designated by Miller and Chambers, Syst. Bot. Mongr. 78:120. 2006]; Isoneotypes: CAN; CAS; DS; F; GH; LL; MICH; MO; NY; POM; UBC; UC; WIS). **T-Specimen:** California. Santa Clara Co.: foothills near Stanford University, 1 Apr 1902, *C.F. Baker 487* (Isoneotype: UBC-V34942).

PTERIDACEAE

Adiantum pedatum L. var. **rangiferinum** E .S. Burgess, Proc. & Trans. Roy. Soc. Canada 4, Sect. 4:11. 1886. **T-Protologue:** …on thickly shaded rocks overhanging the waters of Gold Stream, at the base of Mount Finlayson, twelve mi from Victoria, B.C., *J.R. Anderson s.n.* (holotype: not specified). **T-Specimen:** Goldstream [*sic*], rocky streams, *J.R. Anderson s.n.* (isotype: UBC-V4181).

RANUNCULACEAE

Delphinium caprorum Ewan, Bull. Torrey Bot. Cl. 69:145. 1942. **T-Protologue:** Washington: Cascade Mts., from Goat Rocks, 7000 ft, *J.W. Thompson 15206* (holotype: COLO; isotypes: to be distributed; US*). **T-Specimen:** Washington. Lewis Co.: Cascade Mountains, alpine rock slides on Goat Rocks, 7000 ft, *J. William Thompson 15206* (isotype: UBC-V46005).

Aconitum variegatum L. subsp. **variegatum** var. **carniolicum** Starm., Fritschiana 10:1. 1997. **T-Protologue:** Slowenien, Krain, ENE Laibach (Ljubljana), etwa 3 km NW Sagor (Zagorje), im Tal vom Kotredesch-Bach (Kotredeščica) E der Ruine Gallenberg (Gamberk), 460 m, GF 9855/2 Gebüsch, 31 Aug 1996, *A. Podobnik s.n.* (holotype: LJU; isotypes: CL, GJO, GZU, IBF, JACA, KL, KRA, LE, LI, LG, LJM, M, MEL, NY, OSC, PE, Herb. Podobnik, Herb. Starmühler, TBI, TNS, TK, W, WU, Z). **T-Specimen:** Slowenien, Krain, ENE Laibach (Ljubljana), etwa 3 km NW Sagor (Zagorje), im Tal vom Kotredesch-Bach (Kotredešcica) E der Ruine Gallenberg (Gamberk), 460 m, 31 Aug 1996, *A. Podobnik s.n.* (isotype: UBC-V222228).

ROSACEAE

Crataegus atrovirens J.B. Phipps & O'Kennon, Sida 20:141. 2002. **T-Protologue:** CANADA. British Columbia: Northern Okanagan, Spallumcheen Municipality, Otter Lake Cross Road, 22 Aug 2000, *J.B. Phipps 8171 & S.R. Phipps* (holotype: UWO; isotypes: BRIT, CAN, MO, TRT, UBC, US). **T-Specimen:** CANADA. British Columbia: N Okanagan, Spallumcheen Municipality, Otter Lake Cross Rd., E side, ca. quarter mi S of Hales Rd., roadside hedge under natural trees, 1300 ft, 50°22.5'N 119°13'W, 22 August 2000, *J.B. Phipps and S.R. Phipps 8171* (isotype: UBC-V217344).

Crataegus castlegarensis J.B. Phipps & O'Kennon, Sida 20:121. 2002. **T-Protologue:** UNITED STATES. Idaho. Lemhi Co.: US 93, E side, 14.5 rd. mi N of Salmon, roadside ditch next to irrigated field, alt. ca. 3950 ft, bush, 5 m tall, foliage dull, dark, coriaceous, fruit strongly clustered, red-burgundy, with short pedicels, 20 Aug 1996, *J.B. Phipps & O'Kennon 7396* (holotype: UWO; isotypes: BRIT, CAN, MO, MONTU, TRT, UBC, V, WS). **T-Specimen:** Idaho. Lemhi Co.: US 93, 14.5 rd mi N of Salmon, E side, roadside ditch next to irrigated field, ca. 3950 ft, 45°22'N 113°57½'W, 20 Aug 1996, *J.B. Phipps and R.J. O'Kennon 7396* (isotype: UBC-V217347).

Crataegus enderbyensis J.B. Phipps & O'Kennon, Sida 20:136. 2002. **T-Protologue:** CANADA. British Columbia: just E of Enderby after bridge over Shuswap R., S side of road, rough grass near water; alt. ca 1250 ft, large bush 5 m tall, burgundy-red fruit, 25 Sept 1993, *J.B. Phipps & R.J. O'Kennon 6808* (holotype: UWO; isotypes: BRIT, CAN, DAO, UBC). **T-Specimen:** CANADA. British Columbia: just E of Enderby after bridge over Shuswap River, rough grass near water, S side of road, ca. 1250 ft, 50°33'N 119°08'W, 25 Sep 1993, *J.B. Phipps and R.J. O'Kennon 6808* (isotype: UBC-V217345).

Crataegus okanaganensis J.B. Phipps & O'Kennon, Sida 18:178. 1998. **T-Protologue:** CANADA. British Columbia: rough grass with hawthorns on Hwy. 97 near entrance to Kelowna airport, alt. 1800 ft, equals JBP 6907, bush, 4 m tall, 17 Aug 1994, *Phipps, J.B., & O'Kennon, R.J. 6974* (holotype: UWO; isotypes: CAN, TRT, UBC, US). **T-Specimen:** CANADA. British Columbia: rough grass with hawthorns on Hwy. 97 near entrance to Kelowna airport, 1800 ft, 119°24'W 49°53'N, equals JBP 6907, bush 4 m tall, 17 Aug 1994, *J.B. Phipps 6974 & R.J. O'Kennon* (isotype: UBC-V213139).

Crataegus okanaganensis J.B. Phipps & O'Kennon var. **wellsii** J.B. Phipps & O'Kennon, Sida 20:132. 2002. **T-Protologue:** U.S.A. Washington. Okanogan Co.: Palmer Lake, N side; large bush, 5 m tall, (equals *J.B.P. & R.J.O'K. 6875*), 4 May 1994, *J.B. Phipps 6905* (holotype: UWO; isotypes: BRIT, CAN, DAO, UBC, US, WS). **T-Specimen:** Washington. Okanogan Co.: Palmer Lake, N side, open hawthorn thicket at upper level of pebble beach at picnic/campsite, just E of Chopata Lodge, 1150 ft, 119°37'W 48°54'N, 4 May 1994, *J.B. Phipps 6905* (isotype: UBC-V217342).

Crataegus orbicularis J.B. Phipps & O'Kennon, Sida 20:138. 2002. **T-Protologue:** CANADA. British Columbia: Northern Okanagan, Spallumcheen Municipality, Back Enderby Rd., ca. 4 mi SE of Enderby, ca. 200 m N of creek crossing, alt. ca. 1450 ft, dense hedges E side of road, bush 4 m tall, 21 Aug 1994, *J.B. Phipps & R.J. O'Kennon 7039* (holotype: UWO; isotypes: BRIT, CAN, MO, TRT, UBC). **T-Specimen:** CANADA. British Columbia: 'Back Enderby' Rd, ca. 4 mi SW of Enderby, ca. 200 m N of creek crossing, ca. 1450 ft, 119°07'W 50°31'N, 21 Aug 1994, *J.B. Phipps and R.J. O'Kennon 7039* (isotype: UBC-V217343).

Crataegus shuswapensis J.B. Phipps & O'Kennon, Sida 20:128. 2002. **T-Protologue:** CANADA. British Columbia: Northern Okanagan, Enderby, ca. 200 m E of bridge over Shuswap River on Mabel Lake Rd., bush, 3.5 m tall, fruit deep purple (=*JBP 6910*), 20 Aug 1994, *J.B. Phipps & R.J. O'Kennon 7009* (holotype: UWO; isotypes: BRIT, CAN, DAO, TRT, UBC). **T-Specimen:** CANADA. British Columbia: ca. 200 m E of bridge over Shuswap River on road Enderby to Mabel lake, N side of road, edge of swampy woods, 1250 ft, 119°08' W, 50°33'N, 20 Aug 1994, *J.B. Phipps and R.J. O'Kennon 7009* (isotype: UBC-V217346).

SAXIFRAGACEAE

× Heuchera easthamii Calder & Savile, Brittonia 11:54. 1959. **T-Protologue:** British Columbia: 14 mi N of Hazelton, edge of thicket by Kispiox River, 19 Aug 1954, *Calder, Savile & Ferguson 14748* (holotype: DAO). **T-Specimen:** CANADA. British Columbia: at bridge crossing Kispiox River 8 mi by road N of Kispiox village, N of Hazelton, 19 Aug 1954, *J.A. Calder, D.B.O. Savile, and J. M. Ferguson 14748* (Isotype: UBC-V72935).

Saxifraga codyana Zhmylev, Byull. Moskovsk. Obshch. Isp. Prir. Otd. Biol. 97:95. 1991. **T-Protologue:** Yukon Territory: British Mts., tributary of Fith [*sic*] R., 69°07'N, 140°15'W, N271667, Jul 1980, *W. J. Cody 27166* (holotype: DAO; isotype: MW). **T-Specimen:** CANADA. Yukon Territory, British Mountains, tributary of Firth River, 69°07'N, 140°15'W, 7 Jul 1980, *W. J. Cody 27166* (isotype: UBC-V212762).

Saxifraga taylori Calder & Savile, Brittonia 11:248. 1959. **T-Protologue:** British Columbia: Queen Charlotte Islands, Mt. de la Touche near head of Fairfax Inlet, Tasu Sound, *Calder & Taylor 23511* (holotype: DAO). **T-Specimen:** CANADA. British Columbia: Queen Charlotte Islands, below Mt. de la Touche near head of Fairfax Inlet, Tasu Sound, W coast of Moresby Island, very common on boulders on coarse talus slope and rock slides from 1400'-2000', rare on cliffs, 16-17 Aug 1957, *J.A. Calder and R. L. Taylor 23511* (isotype: UBC-V124231).

SCROPHULARIACEAE

Castilleja praeterita Heckard & Bacig., Madrono 4:209. 1970. **T-Protologue:** California. Tulare Co.: N edge of Horse Meadow on Salmon Creek, ca. 7 air mi E SE of Fairview, southern Sierra Nevada, elev. 7400 ft, 10 Aug 1966, *Bacigalupi and Heckard 9190* (holotype: JEPS; isotypes: to be distributed). **T-Specimen:** California. Tulare Co.: edge of Horse Meadow, ca. 10 air mi NE of Kernville, 7400 ft, 10 Aug 1966, *Rimo Bacigalupi and L.R. Heckard 9190* (isotype: UBC-V206957).

THYMELACEAE

Daphne × mantensiana J. Manten ex T.M.C.Taylor & Vrugtman, Baileya 12:39. 1964. **T-Protologue:** British Columbia: Vancouver, garden of Mr. H. Eddie, 7 Aug 1963, *F. Vrugtman 1644* (holotype: UBC). **T-Specimen:** CANADA. British Columbia: ex hort garden of Mr. H. Eddie, Vancouver, B. C., 49° 16 N, 126° 15 W, 7 Aug 1963, *F. Vrugtman 1644* (holotype: UBC-V115036).

VISCACEAE

Phoradendron insignis Steyerm., Bol. Soc. Venez. Ci. Nat. 26:415. 1966. **T-Protologue:** VENEZUELA: Estado Bolívar, vicinity of road campamento 150 at km 150 in valley of savanna of Río Uarama below Uarama-tepui, NE of Luepa, 1200 m, 9 Mar 1962, *Julian A. Steyermark and Leandro Aristeguieta 59* (holotype: VEN). **T-Specimen:** vicinity of road campamento 150 at km 150 in valley of savanna of Río Uarama below Uarama-tepui, NE of Luepa, 1200 m, 9 Mar 1962, *Julian A. Steyermark and Leandro Aristeguieta 59* (isotype: UBC-V132586).

ADDITIONAL NOTES

Several UBC specimens are incorrectly labeled as isotypes:

A specimen [*Heller 2818a* (UBC-V181080)] of *Cibotium st.-johnii* Krajina var. *typicum* Krajina (Stud. Bot. Cechosl. 1:94. 1938) is labeled (as *C. st.-johnii*) as an isotype. This collection is listed in the protologue of *C. st.-johnii* as a paratype; the type specimen of *C. st.-johnii* is *Krajina 26*. No collections of *Krajina 26* are present in UBC.

A specimen [*St. John 20114* (UBC-V47651)] of *Cyrtandra calpidicarpa* (Rock) St. John & Storey (Occ. Pap. Bernice Pauahi Bishop Mus. 20:81. 1950) is labeled as an isotype. This name was a combination based on (the basionym) *Cyrtandra longifolia* Hbd. var. *calpidicarpa* Rock (Amer. J. Bot. 4:618. 1917), thus the UBC specimen (collected in 1940) is not an isotype because the basionym is based on a 1909 collection according to its protologue.

A collection (*Runyon 2655*) of *Cyperus aristatus* Rottb. var. *runyoni* O'Neill (Rhodora 44:56. 1942) in UBC is labeled isotype. According to the protologue, the type series for this taxon is based on *Runyon 1933*. Since the collection numbers differ, the UBC specimen is clearly not an isotype.

A specimen [*J.W. Eastham s.n.* (UBC-V26885)] of *Spiranthes romanzoffiana* Cham., collected on 18 Aug 1938 at Lucile Lake, Garibaldi, British Columbia, includes has a handwritten note: "Type collected at Unalaska presumably on Kotzebue 1st Voyage. Also found at Bantry Bay, Co. Cork, Ireland." Based on this information, this specimen has been confused in the UBC herbarium as a type specimen, but it clearly is not, as the species was described over a century earlier [Linnaea 3:32(-33). 1828].

A specimen (*B. Boivin 6789*, Loon Lake, district of North Battleford, Saskatchewan, 4 Aug 1949) with the name *Geum aleppicum* Jacq. var. *cuneatum* is labeled isotype; however, this variety was never published and is therefore a *nomen nudum*. According to online databases, duplicates of this collection (each also labeled as isotypes) are deposited in UC/JEPS and NY. There is also a duplicate labeled isotype in MO, as well as additional collections with this name (Joseph Rohrer, pers. comm.). Boivin (Phytologia 15:354. 1967), in a brief discussion of the taxonomic history and morphological variability of *Geum aleppicum* in the Canadian prairie provinces, noted "A substitute name was prepared in 1949 and used extensively on herbarium sheets but was never actually published because the reputed distinguishing characters proved to be elusive." Boivin unfortunately did not include the invalid name in his discourse, but it seems likely that he was referring to this collection of *Geum aleppicum* var. *cuneatum*, collected in the same year (by him) in which the substitute name was prepared.

APPENDIX 1

INDEX BY COLLECTORS AND NUMBER

Allen 9603
Ancuash 1142
Anderson s.n.
Bacigalupi & Heckard 9190
Baker 487
Baker 11307
Bayly 83
Boivin & Alex 10245
Boivin & Ledingham 14079
Boivin, Bernard, & Perron 12942
Calder & Savile 11976
Calder & Taylor 23511
Calder, Savile, & Ferguson 14748
Chambers 2868
Clokey 7514
Cody 27166
Constance 3895
Davis 422
Eiten & Eiten 4091
Galeano, Martínez, & Suárez 2711
Galeano, Martínez, & Suárez 2767
Galeano, Martínez, & Suárez 2829
Harling & Andersson 11940
Harling & Anderson 17592
Harling, Bohlin, Lindström, & Roth 19833
Hibberson s.n.
Hitchcock 23868
Hitchcock & Muhlich 22305
Joyal 1264
Kennedy 808
Kennedy 813
Kennedy 1139
Kennedy 4224
Kennedy 4400
Kennedy 4555
Kennedy & Andrews 1343
Kennedy & de Fátima Gomes de Souza 4696
Kennedy & de Fátima Gomes de Souza 4699
Kennedy & de Fátima Gomes de Souza 4700
Kennedy & Hammel 4545
Kennedy, Andrews, & Dressler 1379
Kennedy, Besse, & Baker 4288
Kennedy, Besse, & Baker 4363
Kennedy, Besse, & Baker 4368
Kennedy, Besse, & Baker 4373
Kennedy, Besse, & Baker 4383
Kennedy, Besse, & Baker 4404
Kennedy, Hammel, & Solomon 4664
Koyama 11120
Lane 44
Lang 211
Liesner 15662
Liesner 25333
Lugo 1605
Luther 800
Madison, Plowman, Kennedy, & Besse 4646
Madison, Plowman, Kennedy, & Besse 4949
Maze, Maze, Robson, & Henn 1007
Mori, Gracie, Croat, Maas, Maas, Pennington, & Reed 22909
Murray & Murray 522
Nagata 2886
Nelson 85
Pearsall 2
Pearsall 4
Peterson & Refulio-Rodriquez 16452
Phillips 2854
Phipps 6905
Phipps & O'Kennon 6808
Phipps & O'Kennon 6974
Phipps & O'Kennon 7009
Phipps & O'Kennon 7039
Phipps & O'Kennon 7396
Phipps & Phipps 8171
Podobnik s.n.
Reveal 3971
Reveal & Reveal 3924
Reveal, DeDecker, & DeDecker 3909
Schofield 1270
St. John 25960
Steyermark & Aristeguieta 59
Suksdorf 7452
Thompson 15206
van der Werff, Gray, & Tipas 12429
van der Werff, Gray, Tipas, & Campaña 12194
Vrugtman 1644
York s.n.
Zika 16611

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ARAUCARIAN SOURCE OF FOSSILIFEROUS BURMESE AMBER: SPECTROSCOPIC AND ANATOMICAL EVIDENCE

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ABSTRACT

Recent fossil discoveries show that Burmese amber is one of the most significant amber sites from the Early Cretaceous. We have used both nuclear magnetic resonance (NMR) and anatomical analyses to determine the plant source of amber taken from the Noije Bum 2001 Summit Site in the Hukawng Valley, Myanmar. All spectra were identified as belonging to Group A, which on the basis of a previous analysis of New Zealand amber and copal, is related to members of the Araucariaceae, especially *Agathis*. Bi- to multiseriate, angular, alternate, contiguous 5-6-sided intertracheal pitting on the fossil wood is typical of araucarioid pitting and only occurs in wood of extinct or extant members of the Araucariaceae. The amber from this mine site is considered to be derived from araucarioid (especialy *Agathis*) trees in the Araucariaceae.

Key Words: Burma, fossilized resin, tracheid pits, Nuclear magnetic resonance spectroscopy

RÉSUMÉ

De récentes découvertes chez les fossiles montrent que l'ambre birman est l'une des plus importantes sources de Crétacé ancien. Nous avons utilisé à la fois la résonnance magnétique nucléaire (NMR) et les analyses anatomiques pour déterminer la source botanique de l'ambre trouvé à Noije Bum 2001 Summit Site dans la vallée de Hukawng, Myanmar. Tous les spectres ont été identifiés comme appartenant au groupe A, qui sur la base d'analyses antérieures sur l'ambre et le copal de Nouvelle-Zélande est lié à des membres des Araucariacées, spécialement *Agathis*. Des trous trachéaux à 5-6 côtés, bi- à multisériés, angulaires, alternés, contigus, sur le bois fossile sont typiques des alvéoles des Araucarias ou d'araucarioides et se rencontrent dans le bois des membres des Araucariaceae. L'ambre de ce site minier est donc considéré comme venant *d'Agathis*, un genre actuel d'Araucariaceae."

INTRODUCTION

Burmese amber was traded with China as early as AD 100, but it was not until 1896 that fossils were reported in these deposits. In 1999, a new amber site was discovered in the Hukawng Valley in Myanmar (Poinar et al. 2005), and palynomorphs from this site were assigned to the Upper Albian of the Early Cretaceous (97–110 million years ago) (Cruickshank & Ko 2003). The same deposits have yielded the oldest bee (Poinar & Dancroft 2006), the oldest angiosperm flowers in amber (Poinar & Chambers 2005; Poinar 2004) and the first fossil evidence of vector borne diseases (Poinar & Poinar 2004), making it one of the most significant Cretaceous amber deposits in the world. Due to the scientific importance of this amber, we have used both spectroscopic and anatomical analyses to determine the plant source.

Clues to the determination of source trees of amber deposits can be provided by plant macrofossils or microfossils found in the amber or in sedimentary beds containing the amber and by spectroscopic analysis of the amber. A combination of these methods can then be used to describe source trees, as was done with *Agathis levantensis*, the araucarian tree responsible for the production of Middle East amber (Poinar & Milki 2001). Up to the present, the only spectroscopic evidence for the tree source of Burmese amber has been the nuclear magnetic resonance (NMR) analysis of three samples of Burmese amber (Lambert & Poinar 2002). The results of these analyses were conflicting with one sample unassignable (Lambert & Frye 1982), one related to the family Dipterocarpaceae (Lambert et al. 1999a) and the third related to the Araucariaceae (Lambert & Wu, unpublished research, 2002). Therefore, further analysis was undertaken with additional Burmese amber samples collected from this new site that was first mined in 2001. Tracheid fibers in one of the amber samples from this new site are characterized and used to provide anatomical evidence of the plant source.

MATERIALS AND METHODS

The amber samples analyzed in this study were collected from lignitic seams in sandstone-limestone deposits in the Hukawng Valley in Myanmar. The mine site was located on the slope of the Noije Bum hill about a mile (1.5 km) SSW of the old Khanjamaw mine site and southwest of Maingkwan (26°20'N, 96°36'E). Apparently this site had never been mined previously (Chhibber 1934) (Doug Cruickshank, pers. comm., December 20, 2006), and we refer to it as the "Noije Bum 2001 Summit Site."

Wood Fiber Analysis

A square piece of amber measuring approximately 23 mm on all sides and 6 mm thick contained numerous strips of wood fibers. This piece of amber was cut with a diamond saw along the flat side, leaving two narrow pieces of amber, each approximately 3 mm in thickness. The surfaces of these were polished and the wood fibers examined with a Nikon Optiphot optical microscope (with magnifications up to 800×). The amber pieces containing the wood fibers are deposited in the Poinar amber collection (accession# B-P-16) maintained at Oregon State University.

Spectroscopic Studies

Solid-state nuclear magnetic resonance spectroscopy with cross polarization and magic angle spinning (CP/MAS) was used to characterize the amber samples (Lambert et al. 1996). Both normal decoupling and interrupted decoupling modes were used to examine the solid-state ^{13}C NMR spectra.

Solid state ^{13}C NMR data were recorded on a 400 MHz Varian NMR System. The Direct Drive console had a clean rf architecture, a powerful digital receiver, and utilized advanced phase, amplitude modulation. The system had a 5 mm T3 PENCIL probe. The magic angle spinning rate was set to 5000 Hz. The cross polarization pulse sequence called tancpx was used for normal proton decoupling. For interrupted decoupling, the pulse sequence tancpxidref was used, in which a 50 μs delay was applied in the ^{1}H channel directly before the 180° pulse in the ^{13}C channel. A typical parameter set was as follows: spectrum frequency 100.544 MHz, spectral width 50 kHz, pulse width 3.4 μs for the 90° pulse for both ^{1}H and ^{13}C, delay time 5 μs, contact time 2 ms, acquisition time 20.5 ms, and scan number 256. Spectra were referenced to an external adamantane peak at δ 38.3 and were converted to tetramethylsilane at δ 0.0. Data were collected and processed with software VnmrJ 2.1B.

This procedure was performed on 5 separate samples (Nos.276, 375, 376, 422, 441) from the Noije Bum 2001 Summit Site. Four of the samples were clear (Nos. 276, 375, 422, 441) and one was opaque (376).

RESULTS

Wood Fiber Analysis

The tracheid surfaces contained 2–3 rows (2–3 seriate) of alternately arranged contiguous, angular, 5–6 sided tracheid pits (Fig. 1). Most of the bordered tracheid pits were hexagonal with diameters ranging from 11 to14 μm. None of these biseriate and triseriate pits possessed thickenings, such as crassulae or bars of Sanio between them. The polygonal pit cavities, which did not extend beyond the pit borders, varied from round to 5–6 sided (Fig. 1C). Resin globules occurred within some of the tracheids (Fig. 1C).

Spectroscopic Analysis

In all samples, the spectra with normal decoupling have the largest peak at δ 38 and a second, smaller peak at δ 18–20, with a broad grouping in the unsaturated region. With interrupted decoupling, the largest peak again was at δ 38, with nothing in the unsaturated region. All spectra were identified as belonging to Group

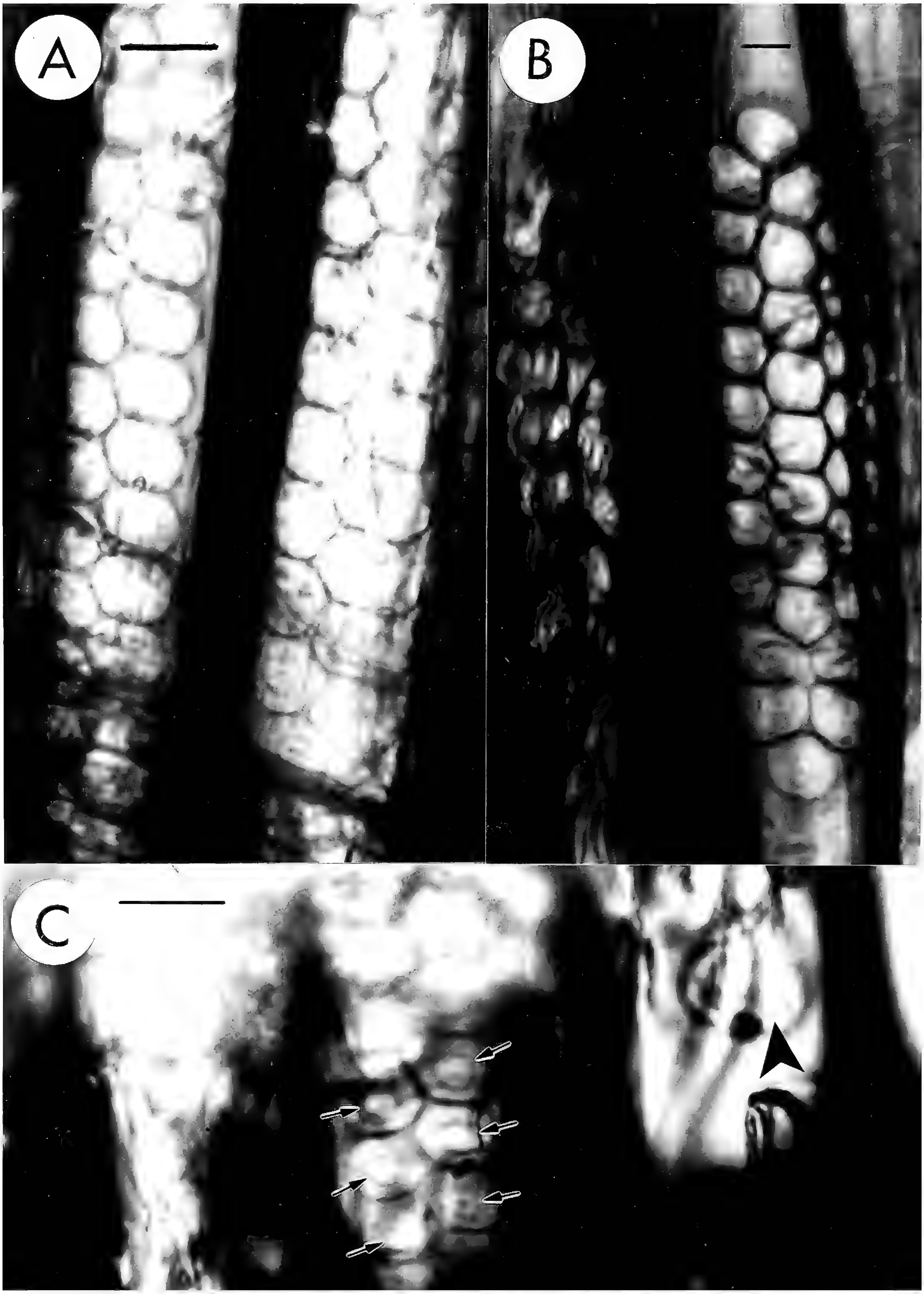

Fig. 1. **A.** Bi- and tri-seriate tracheid pits on a wood fragment in Burmese amber collected from the Noije Bum 2001 Summit Site. Scale bar = 14 µm. **B.** Contiguous, alternate, 5–6 sided pits commonly referred to as araucarioid pitting on a wood fragment in Burmese amber. Scale bar = 8µm. **C.** Pit cavities (arrows) on a tracheid fiber. Note excreted resin globule (arrowhead). Scale bar = 15µm.

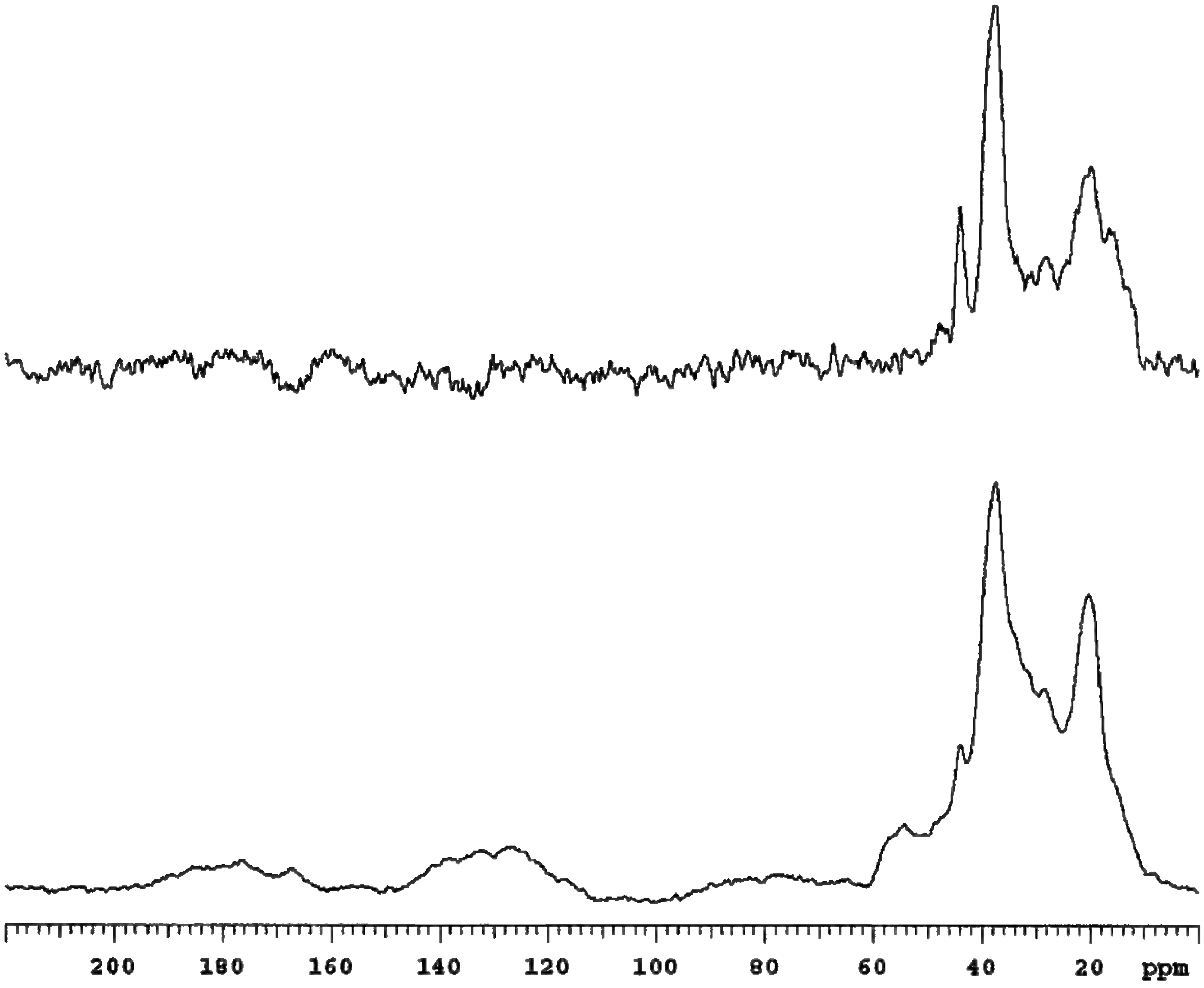

Fig. 2. ^{13}C NMR spectra of Burmese amber sample 376 collected from the Noije Bum 2001 Summit Site with normal decoupling (lower) and interrupted decoupling (upper)(x axis indicates the unit δ in ppm).

A (Fig. 2), which on the basis of a New Zealand series reported earlier (Lambert et al. 1993), is related to members of the Araucariaceae, especially *Agathis*, a genus commonly known as kauri pines now restricted to the Southern Hemisphere.

DISCUSSION

The arrangement of intertracheary pits and their cavities can be used to characterize familes and genera of conifers (Core et al. 1979; Patel 1968). Bi- to multiseriate, angular, alternate, contiguous, 5–6 sided longitudinal tracheid pits as seen on the radial walls of the tracheids, as found here, are commonly referred to as araucarioid pitting and only occur in wood of members of the Araucariaceae (Patel 1968; Tidwell 1998). Diameters of tracheid pits in members of the Araucariaceae vary from 12 to 16 µm (Core et al. 1979; Tidwall 1998) which is within range of the pits in the Burmese amber wood samples (11–14 µm). The presence of resin globules or plugs, as found in the fossilized wood, is characteristic of araucaroid tracheids (Patel 1968).

There are currently three extant genera in the family Araucariaceae: *Agathis*, *Aruacaria* and *Wollemia*. While the wood structure of *Agathis* and *Araucaria* is similar, (Langenheim 1995), recent resin of these two genera often can be distinguished by NMR analyses (Lambert & Poinar 2002), primarily because most *Araucaria* species produce gum resins (Lambert et al. 2005). In addition, resin deposits from *Araucaria* trees are small and do not polymerize and fossilize, as does *Agathis* (Langenheim 1995). While the NMR spectra of *Wollemia* and *Agathis* are similar (Lambert et al. 1999b), there is no evidence that *Wollemia* produces large deposits of resin that polymerize and form amber deposits.

Under normal decoupling conditions in NMR analyses, signals are obtained from all carbons present in the sample. With interrupted decoupling, signals are selected for quaternary carbons and carbons that are moving rapidly in the solid while other signals are edited out. These two spectral modes served as fingerprints to analyze and identify the Noije Bum 2001 Summit site amber samples as belonging to the worldwide Group A, which is most similar to members of the genus *Agathis* in the family Araucariaceae. Determination of this taxonomic grouping was based on comparisons with previously obtained NMR spectra of *Agathis* resin, copal and amber from New Zealand (Lambert et al. 1993). It has been found, however, that the ^{13}C fingerprint of modern resins (as opposed to gum resins) from the family Araucariaceae are indistinguishable from that of modern resins from the family Cupressaceae (Lambert et al. 2005). The presence of araucarioid wood fibers in the amber from the Noije Bum 2001 Summit site is collaborative evidence that the NMR spectra reported here are from a member of the Araucariaceae.

A spectroscopic comparison of fossil resins of the Cupressaceae with those of the Araucariaceae has not been made since it is difficult to obtain samples of fossilized resin associated with present day members of the Cupressaceae. There apparently are no localities that contain semi-fossilized or fossilized resin deposits of species of the Cupressaceae in soil surrounding the trees, swamps containing the stumps of former forests or in coal deposits, as occurs in New Zealand with *Agathis* (Poinar 1991; Lambert et al. 1993).

While some fragments of amber have been attributed to members of the Curpessaceae, (which now includes genera of the former family Taxodiaceae), there is no evidence that extant Cupressaceae produce copious amounts of resin under normal growth conditions. Members of this family only have a limited capacity to produce trunk resins (Langenheim 1995), the source of the majority of fossiliferous amber and then only when they experience severe traumatic stress. This is in contrast to species of *Agathis*, that produce not only copious amounts of trunk resins, but also were the source of fossilized resins (copal and amber) extending over thousands and millions of years and under a wide range of stratigraphic conditions (Halkett & Sale 1986; Poinar 1991; Lambert & Poinar 2002). While wood of the extinct conifer family Cheirolepidiaceae may also contain tracheids with araucaroid radial pitting, the absence of resin ducts and canals is a feature typical of these wood types (Axsmith & Jacobs 2005; Taylor & Taylor 1993), thus they could not have been the source of Burmese amber.

Determining araucarioid (very likely *Agathis*) trees as the source of Burmese amber is congruent with large amounts of pollen of the araucarian, *Araucaricites australis*, recovered in a palynological analysis of the sedimentary formation that contained the amber at the Noije Bum 2001 Summit Site (Davies 2001).

Commonly known as kauri or kauri pines, species of *Agathis* can become quite large and long-lived (from 500 to 1000 years) and have been compared with the Giant Sequoias of North America (Halkett & Sale 1986). By bulk alone, they would have formed a significant part of the Burmese amber forest. The climate of Burma was tropical- subtropical during the Early Cretaceous (Boucot et al. 2007), which is the preferred climate for extant *Agathis* species, all of which are now confined to the Southern Hemisphere (Poinar & Milki 2001).

Previous spectroscopic analyses of Burmese amber have been conducted with material from other sites. The first sample of Burmese amber tested (#7) was provided by Curt Beck and came from the Musée National d'Histoire Naturelle, Paris, (No. 101.604). The label stated it was collected from Mangotaimaw Hill, Myanmar. Its spectrum was broad and could not be assigned to any present group (Lambert & Frye 1982). In 1992, an analysis was performed on a piece of amber presented to the senior author by a commercial trading company located in Taiwan. This sample, (#154), which was dark brown, nearly opaque and lacked fossils, was represented as coming from the Hukong Valley in Burma. It produced a spectrum typical of the worldwide Group B, which is related to the extant angiosperm family Dipterocarpaceae (Lambert et al. 1999a; Lambert & Poinar 2002). In 2002, a sample of Burmese amber (#276) collected from the Noije Bum 2001 Summit Site, where samples were also taken by Cruickshank & Ko (2003) for their dating studies, showed a definite placement in the worldwide Group A, similar to the samples presented here. This result was simply cited in publications as Lambert & Wu, unpublished research (2002).

The present study shows that the amber from the Noije Bum 2001 Summit Site is produced from an araucarioid, quite probably a member of the genus *Agathis*. If sample #154 did originate from Burma, it indicates that at least two separate plant families (Araucariaceae and Dipterocarpaceae) were sources of amber in Myanmar, quite possibly at two distinct geological periods.

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BOOK REVIEWS

Peter Hedden and Stephen G. Thomas (eds.). 2006. **Annual Plant Reviews, Volume 24: Plant Hormone Signaling.** (ISBN 1-4051-3887-4, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** www.blackwellprofessional.com, orders@ames.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $199.99, 348 pp., illustrations, 6¼" × 9½".

The 24th volume of Blackwell Publishing's Annual Plant Review series focuses on plant hormones, signaling molecules that do not always conform to the classic definition of a hormone. For example, ethylene, a hormone exploited by our ancestors to hasten fruit ripening in the form of wound ethylene, is actually a gas. It was once used to light street lamps and was one of the first anesthetics. The gas's anesthetic effect was first discovered when a group of Chicago scientists investigating why flowers in a greenhouse would not bloom discovered that the culprit was the ethylene used to light the greenhouse. They decided to investigate the gas's effect on animals, and the world's first anesthetic was discovered. Salicylic acid is another important plant hormone with medical applications. It is used today as a topical acne and wart treatment and is the basis of the salicylate class of drugs, which include aspirin. In plants, salicylic acid is involved in protection against pathogens, thermogenesis, flowering, leaf abscission, and stomatal closure. Technological advancement has led to many recent advances in the understanding and identification of plant hormones and their receptors, actions, and interactions with the environment and each other. This volume is dedicated to recent advances in the relatively new field of plant hormone research, including eight chapters that focus on the biosynthesis and metabolism of the "classic" plant hormones: ethylene, salicylic acid, cytokinin, the gliberellins, abscisic acid, the brassinosteroids, the oxylipins, and auxin. Auxin is the first plant hormone to be discovered. It was identified as a plant growth promoter in 1926, although its effects were first observed in the 1800's. Chapter 2 covers auxin metabolism and "how plants perceive and respond to auxin." It includes a discussion of auxin receptors. The first chapter focuses on abscisic acid, which is a key hormone in regulating the drought response in plants, including mediation of "seed maturation processes such as desiccation tolerance and dormancy." Chapter 4 is focused on cytokinin, including its biosynthesis and metabolism. Its roles include the regulation of shoot and root growth, leaf senescence, stress response, and pathogen resistance. Cytokinin is believed to effect two types of signaling local (paracrine or autocrine) and long-distance, or endocrine-like signaling. Chapter 9 focuses on plant hormone distribution and transport. The last two chapters discuss plant hormones' role in reproduction, including effects in fruit, flower, and seed development. The role of plant hormones is still being elucidated, along with how their signaling occurs within plants. It is believed that future research will reveal the importance of protein degradation in this process.—*Marissa N. Oppel, Collections and Research Assistant, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

William C. Plaxton and Michael T. McManus (eds.). 2006. **Annual Plant Reviews, Volume 22: Control of Primary Metabolism in Plants.** (ISBN 1-4051-3096-2, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** www.blackwellprofessional.com, orders@ames.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $219.99, 386 pp., 6¼" × 9½".

Primary metabolism in plants is defined by the editors of this volume "…as the primary auxotrophic pathways in plants…and those in common with the primary pathways in mammalian cells." This edition of the *Annual Plant Reviews* series covers the control of primary metabolism in plants. Metabolic control, as opposed to metabolic regulation, is the adjustment of a metabolic pathway output "…in response to an external signal." The editors write in the preface that the ability to control the rates of metabolic processes is so essential to the survival of living cells that it must be as old as life itself. This book includes reviews covering the genomics, proteomics, and metabolomics of the control of primary metabolism, as well as the control of specific metabolic pathways and enzymes. There have been many advances in these fields over the last few years, and many discoveries related to plant metabolic control have been made. Aimed at scientists in the fields of plant biochemistry, physiology, molecular biology, and cell biology, the reviews gathered in this volume are excellent sources of information about the basics, as well as recent advances in our understanding of the control of primary metabolism in plants.—*Marissa Oppel, Collections and Research Assistant, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

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STATUS OF *SCHOENOPLECTUS HALLII* (HALL'S BULRUSH) (CYPERACEAE) IN THE UNITED STATES

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ABSTRACT

New information is provided on the distribution, ecology and life history, threats, research needs and conservation status for Hall's bulrush (*Schoenoplectus hallii*). Additional information is presented on taxonomy, the status of Hall's bulrush in each state where it has been recorded, management recommendations, and the adequacy of any regulatory mechanisms in place to protect or manage the species' habitat. A history is provided for previous evaluations of Hall's bulrush by the U.S. Fish and Wildlife Service, and the species' potential as a candidate for official listing under the Endangered Species Act of 1973.

RESUMEN

Se aporta nueva información sobre la distribución, ecología y historia vital, amenazas, necesidades de investigación y estado de conservación de la espadaña (*Schoenoplectus hallii*). Se presenta información adicional sobre su taxonomía, el estatus de la espadaña en todos los estados donde se ha citado, recomendaciones sobre su manejo, y lo apropiado de cualquier mecanismo de regulación para proteger o manejar el hábitat de la especie. Se aporta una historia de las evaluaciones previas de la espadaña por el U.S. Fish and Wildlife Service, y el potencial de la especies como candidata para estar colocada en la lista oficial de la Ley de Especies Amenazadas de 1973.

INTRODUCTION

McKenzie (1998) provided an initial range-wide conservation status assessment of Hall's bulrush (*Schoenoplectus hallii*) (A. Gray) S.G. Smith, which included information on distribution, ecology and life history, threats, research needs, and conservation status. Beatty et al. (2004) included a summary of some new information on *S. hallii* in a conservation assessment for the species in Region 2 of the U.S. Forest Service (USFS), but the main focus of their report was Kansas and Nebraska. Since McKenzie's (1998) analysis, new information on the species' distribution, germination requirements, and threats to its continued existence has been reported. The purpose of this paper is to summarize information received from published and unpublished reports that have been completed since the 1998 assessment (McKenzie 1998). Due to the potential confusion of *S. hallii* with the closely related *S. erectus* (Poir.) Palla ex J. Raynal and *S. saximontanus* (Fernald) J. Raynal, reports of *S. hallii* throughout the United States were re-evaluated by Ernie Schuyler of the Philadelphia Academy of Natural Sciences or S.G. Smith (Schuyler 1969; S.G. Smith, pers. comm.).

Taxonomy

Taxonomic nomenclature for plants used in this report follows Yatskievych (1999) or Yatskievych & Turner (1990) except for *Lesquerella fendleri* which follows Great Plains Flora Association (1986), *S. erectus* which follows Smith (2002b), *Nymphoides peltata* which follows Gleason and Cronquist (1991), and *Clarkia springvillensis, Lolium multiflorum,* and *Gilia achilleifolia* which follow Hickman (1993).

Schoenoplectus hallii belongs to *Schoenoplectus* section *Supini* (Cherm.) J. Raynal, in the Cyperaceae. Until recently the genus *Schoenoplectus* (Rchb.) Palla was generally included in the genus *Scirpus* L. sensu lato (e.g., Gleason & Cronquist 1991; Tucker 1987; Schuyler 1969). *Schoenoplectus* sect. *Supini* has been confused with *S.* sect. *Actaeogeton*, but it can be distinguished from that group by the frequent occurrence

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of amphicarpy (the production of solitary pistillate flowers enclosed in sheaths of basal leaves in addition to bisexual flowers in spikelets at the culm tips), which occurs in all North American species in the section, the lack of perianth (except rarely in basal flowers), and, in North American species, the presence of a cauline leaf (Smith 2002b; Smith & Hayasaka 2001, 2002). Recent investigations have led to division of *Scirpus* sensu lato into various segregate genera (e.g., Wilson 1981; Weber & Wittmann 1992; Strong 1994; Smith 1995, 2002b; Smith & Yatskievych 1996; Yatskievych 1999; Smith 2002b; Flora of North America Editorial Committee 2002). *Schoenoplectus hallii* is currently recognized by most taxonomists as the correct name for the species (Smith 1995). Raynal (1976) placed *Schoenoplectus hallii* in synonymy with *S. erectus*, but Smith (1995) provided convincing evidence why Raynal's treatment was invalid. Today most taxonomists agree that *S. hallii* is a valid, distinct species.

Schoenoplectus hallii is most similar to *S. erectus*, which is known from FL, GA, SC, TX, Mexico, South America, Asia, Africa and Australia, and *S. saximontanus*, which is known from British Columbia, CA, CO, KS, MO, NE, OH, OK, SD, TX, UT, and Mexico (Smith 2002b).

Description

A small to medium-sized, tufted annual, with short rhizomes hidden among the aerial stem bases; culms 4–45 cm long, to 1 mm wide, stiff to flaccid, cylindric, leaves 3–4 basal and one cauline, blades 1–2, 0.1–20 cm long, to 1 mm wide; lowest involucral bract sometimes resembling a continuation of the culm, 3–15 cm long, about one-half as long as the culm; inflorescence consisting of 1–7 sessile spikelets in a head-like cluster, or rarely with 1 or 2 short branches; spikelets ovoid to lanceoloid, 5–20 mm long, 2.0–3.5 mm wide; spikelet scales 2.5 to ca. 4.0 mm long, tan or pale orange-brown to straw-colored as they age, ovate, midrib region often green, midrib projecting as a short cusp (mucro) past the body of the scale; solitary pistillate flowers sometimes present at the base of the culm, enclosed by an encircling leaf sheath (most frequent late in the flowering season); perianth bristles absent; stigmas 2 or 3 in basal flowers; achenes ovoid to obovoid or nearly circular, base abruptly contracted to a short neck, apex with an abrupt beak 0.1 mm long; concave (rarely nearly flat) on one side and convex on the other, transversely rugose (corrugated) with about 15–18 conspicuous cross-wrinkles on each side, 1.3–2.0 mm long, brown when young, dark brown to black at maturity; basal achenes significantly larger (Smith et al. 2006), unequally 3-angled; $2n = 22$.

Schoenoplectus hallii is very similar to the other two species of *Schoenoplectus* sect. *Supini* that occur in North America: *S. erectus* and *S. saximontanus* (Smith 2002b). In contrast to the achenes of *S. hallii* as described above, the achenes of *S. erectus* are strongly convex on one side and slightly convex on the other side and have 10–15 ridges on the most convex side. Both *S. hallii* and *S. erectus* can be distinguished from *S. saximontanus* by their two-branched styles (three-branched in *S. saximontanus*) and by their two-sided achenes (3-sided in *S. saximontanus*). *Schoenoplectus erectus* differs from *S. hallii* and *S. saximontanus* in the color of its spikelet scales, which are bright orange on their bases and toward their tips.

Some specimens from a mixed population of *S. hallii* and *S. saximontanus* in Oklahoma have a high percentage of aborted achenes or achenes that are morphologically intermediate between the two species and may be hybrids (Magrath 2002; Smith et al. 2004). Some specimens from southwestern Georgia may be *S. erectus* × *S. hallii* hybrids (Smith 2002b).

Reported range

There is controversy in the literature concerning the historical range (pre-1981) of *S. hallii*. Previous reports from Alabama (U.S. Fish & Wildlife Service 1993), Colorado (Harrington 1954; Small 1972; U.S. Fish & Wildlife Service 1993), Florida (Beetle 1947; Koyama 1962; Radford et al. 1964; Mohlenbrock 1976; Great Plains Flora Association 1986; Robertson et al. 1994), South Carolina (Radford et al. 1964; U.S. Fish & Wildlife Service 1993), South Dakota (Great Plains Flora Association 1977), and Texas (Correll & Johnston 1970; Small 1972; Mohlenbrock 1976; Great Plains Flora Association 1986; U.S. Fish & Wildlife Service 1993; Beatty et al. 2004; O'Kennon & McLemore 2004) are either based on misdeterminations of *S. saximontanus* along the western edge of the species range, or misidentifications of *S. erectus* from the southern United States (Rolfsmeier 1995; McKenzie 1998; Smith 2002b). Further, many county records from states where *S. hallii* has been documented, as reported by the Great Plains Flora Association (1977), were based on misdeterminations of *S. saximontanus* (Rolfsmeier 1995; McKenzie 1998; Smith 2002b). A report for Oregon (Koyama 1962) was due to the misreading of the label on a specimen from near the village of Oregon, Dane County, WI. A record for Decatur County, GA, based on a voucher specimen at the State of Georgia Herbarium (T. Patrick, Georgia DNR, pers. comm.), had been previously re-determined by Schuyler (1969) to be *S. erismanae* [= *S. erectus* (Schyuler, Philadelphia Academy of Natural Sciences, pers. comm.)], and four collections from Baker and Decatur counties, GA and originally identified as *S. hallii* were redetermined by S.G. Smith to be *S. erectus* (S.G. Smith, pers. comm.).

Based on verification of specimens by Schuyler or S.G. Smith, the documented pre-1981 range for *S. hallii* is GA, IL, IA, KS, MA, MI, MO, NE, and WI (Table 1) (McKenzie 1998; Smith 2002b; Beatty et al. 2004). *Schoenoplectus hallii* has been extirpated from Massachusetts where it was last collected in 1908, and the lack of documentation since 1946 suggests that the species may have been extirpated from Georgia (McKenzie 1998; O'Kennon & McLemore 2004; NatureServe 2006). Schuyler or S.G. Smith has confirmed the identification of specimens of *S. hallii* collected from 10 states within the last 25 years (Table 1) (Smith 2002b; O'Kennon & McLemore 2004). Texas has recently been included in the range of *S. hallii* based on the discovery of the species in the state in 2003 (O'Kennon & McLemore 2004).

Apparent changes in distribution and status of *S. hallii* in the United States

For the following reasons, it is extremely difficult to assess any apparent changes in the distribution and status of *S. hallii*: 1) population numbers of this species vary widely from year to year depending on the availability of suitable wetland habitat, 2) populations may fail to emerge at some sites for many years, but re-emerge when conditions are favorable for germination, and 3) the species is frequently confused with *S. saximontanus* and *S. erectus*.

Due to the persistence of the achenes in the seed bank, the Nature Conservancy considers any site where *S. hallii* has been recorded within the last 25 years to be extant (Ostlie 1990; Ostlie & Gottlieb 1992). To determine if there has been any apparent change in the distribution and status of this species, we followed the Nature Conservancy's criterion and first analyzed all documented county and single locality records of *S. hallii* older than 25 years (Table 1, Table 2; Fig. 1). We compared that information with documented records of the species within the last 25 years (Table 1, Table 3; Fig. 2) and within the last five years (Table 1, Table 4; Fig. 3). We found that determining the exact number of records was problematic due to: 1) the frequent misidentification of specimens, 2) the lack of specific locality data given for some collections, 3) over-counting of populations that resulted when sites that were within 1 km of one another were recorded as separate sites, and 4) the failure to monitor some known sites, especially during years when drought conditions persist or when there was a lack of flooded conditions needed for germination and growth. Despite these limitations, we obtained sufficient information for comparing records within the last five and 25 years and what was known and confirmed historically.

Prior to 1981, *S. hallii* was documented at approximately 30 sites distributed across 15 counties in nine states (Table 1, Table 2). Within the last 25 years, *S. hallii* has been confirmed from approximately 84 sites scattered across 26 counties in 10 states (Table 1, Table 2). The increased number of sites documented between 1981 and 2006 largely reflects recent surveys that were conducted in IL, MO, NE and OK during years when conditions were optimal for the species (Table 1, Table 2). Over 79% of records confirmed within the last 25 years have been from IL, MO, and NE (Table 1). Within the last five years, *S. hallii* has been collected at 25 sites from 11 counties in only six states: eight sites in Missouri, six sites in Nebraska, but only one site each in IL, IN, KY, MI, OK, and TX, and none in GA, IA, KS, or MA (Table 1, Table 4). The paucity of records within the last five years may be due to drought conditions that reduced available habitat or reflect a failure to monitor sites. In Wisconsin, abnormally high rainfall flooded the only known site and prevented a survey in 2006 (S.G. Smith pers.comm.). Despite the fewer documented sites within the last five years, new populations have been recently confirmed for Indiana (M. Homoya, braska (Steinauer 2001a,b), Oklahoma (Magrath 2002; Smith 2002b) and Texas (O'Kennon &

Table 1. Approximate number of sites where *Schoenoplectus hallii* was documented historically (i.e., prior to 1981), or where the species has been confirmed within the last 25 years, and within the last 5 years.

State	Historical	Number of sites Last 25 years	Last 5 years
GA	1	0	0
IA	1	0	0
IN	0	6	3
IL	~13	~29	1
KS	7	3	0
KY	0	1	1
MA	2	0	0
MI	1	5	1
MO	2	10	10
NE	2	27	6
OK	0	1*	1*
TX	0	1	1
WI	1	1	1
Total	~30	84	25

*Includes 14 ponds

Table 2. Counties with historical records of *Schoenoplectus hallii* prior to 1981.

State	County
GA	Dougherty
IL	Cass, Mason, Menard
IA	Muscatine
KS	Harvey, Reno
MA	Essex, Middlesex
MI	Muskegon
MO	Howell, St. Louis
NE	Holt, Rock
WI	Dane

Table 3. Counties where *Schoenoplectus hallii* has been documented within the last 25 years.

State	County
IL	Alexander, Cass, Kankakee, Mason, Morgan
IN	Daviess, Lake, Porter
KS	Harper, Reno
KY	Christian
MI	Allegan, Muskegon
MO	Howell, Scott
NE	Brown, Garfield, Holt, Loup, Rock, Wheeler
OK	Atoka, Comanche, Johnston
TX	Wise
WI	Dane

Table 4. Counties with documented records of *Schoenoplectus hallii* within the past five years.

State	County
IL	Mason
IN	Daviess, Lake
MO	Howell, Scott
NE	Brown, Holt, Rock, Wheeler
OK	Comanche
TX	Wise

Indiana DNR, pers. comm.), Ne McLemore 2004). It is likely that *S. hallii* has been extirpated from Massachusetts and possibly Georgia (McKenzie 1998; Smith 2002b; O'Kennon & McLemore 2004; NatureServe 2006).

Documented records of *S. hallii* suggest that it has always been a rare species in most states as reported by Schuyler (1969; pers. comm.) and S.G. Smith (pers. comm.). While this still may be the case, the lack

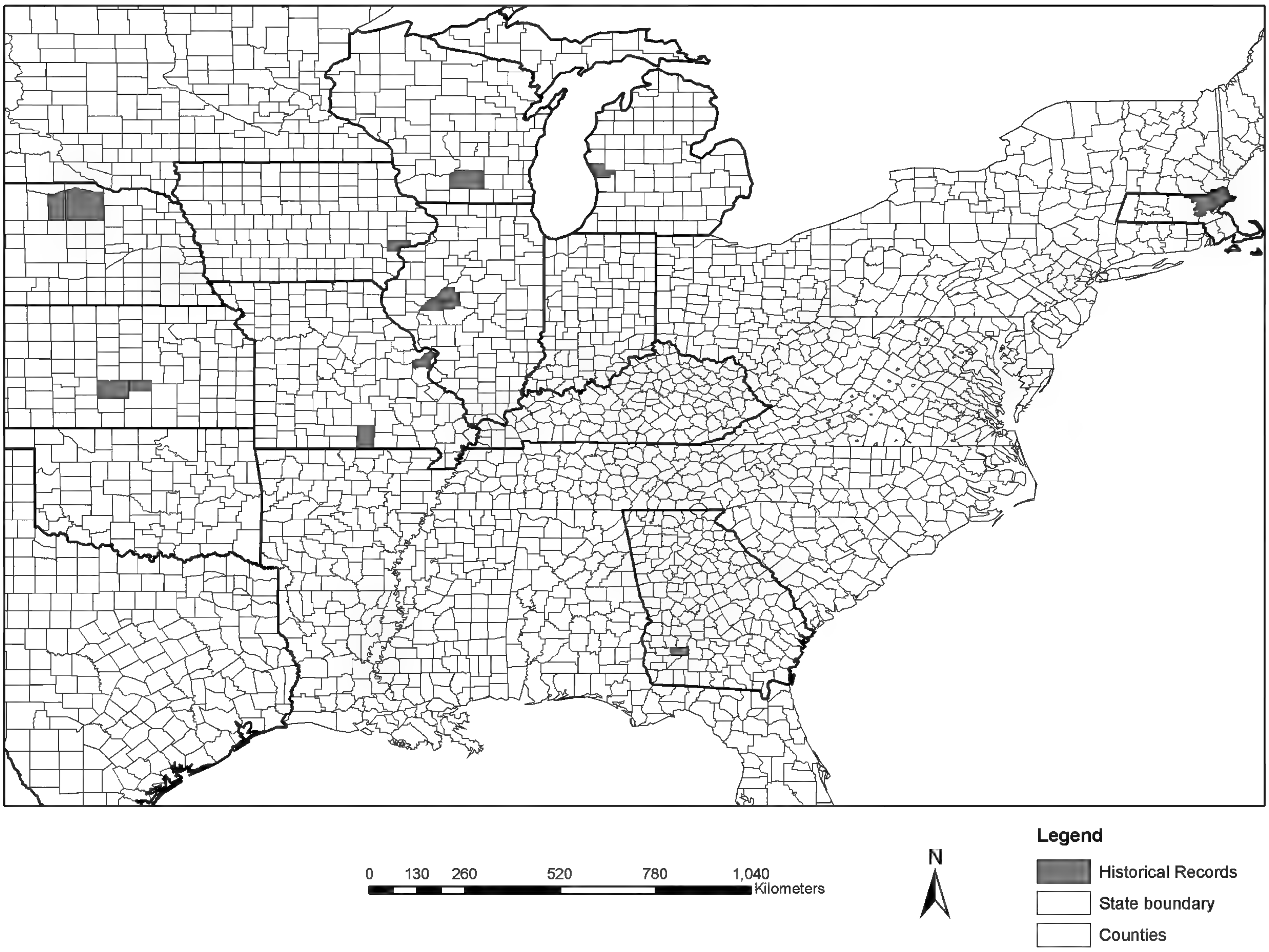

Fig. 1. Documented, historical county records of *Schoenoplectus hallii* in the United States prior to 1981.

of extensive surveys for the species in states where there is abundant available habitat, and during years when habitat conditions are suitable, prevents an accurate picture of the distribution of *S. hallii* in North America.

Habitat and Life History/ Ecology

Schoenoplectus hallii is an obligate wetland species (Reed 1988; Swink & Wilhelm 1994; McClain et al. 1997; McKenzie 1998; Penskar & Higman 2003; Beatty et al. 2004). Reported habitats are often characterized by fluctuating water levels (Ostlie 1990; Ostlie & Gottlieb 1992; McKenzie 1998; Beatty et al. 2004; O'Kennon & McLemore 2004). *Schoenoplectus hallii* has been described as a "specialized, primary successional plant with a narrow niche" (G. Yatskievych, MOBOT, pers. comm.) that colonizes "sandy pioneer habitat" (Schuyler 1969), and it is usually found on bare soil where fluctuating water levels may prevent the establishment of competing perennials (Schuyler 1969). It has been reported from the edges of ephemeral pools, sinkhole and sand ponds (Schuyler 1969; Robertson et al. 1994; McClain et al. 1997; McKenzie 1998; Smith 2002b; Beatty et al. 2004), sandy clay ponds (O'Kennon & McClemore 2004) and sand prairies (Schuyler 1969; McKenzie1998), sand pits (Bowles et al. 1990), ditches (Steinauer 2001a; Smith 2002b), wet places in cultivated fields (Smith 2002b), "silty, muddy flats" (Chester 1988), and "cattle trails that lead through shallow-water wetlands and other depressions" (Beatty et al. 2004). Occasionally, the species can be found in rocky or cobble habitat. Rocks are along the edges of the sinkhole pond habitat in Missouri (Schuyler 1969; McKenzie 1998) and the species was associated with "many cobbles" at the recent rediscovery site in Wisconsin (S.G. Smith, pers. obs.).

During years when spring rainfall or high river levels create suitable wetland habitat, *S. hallii* can often

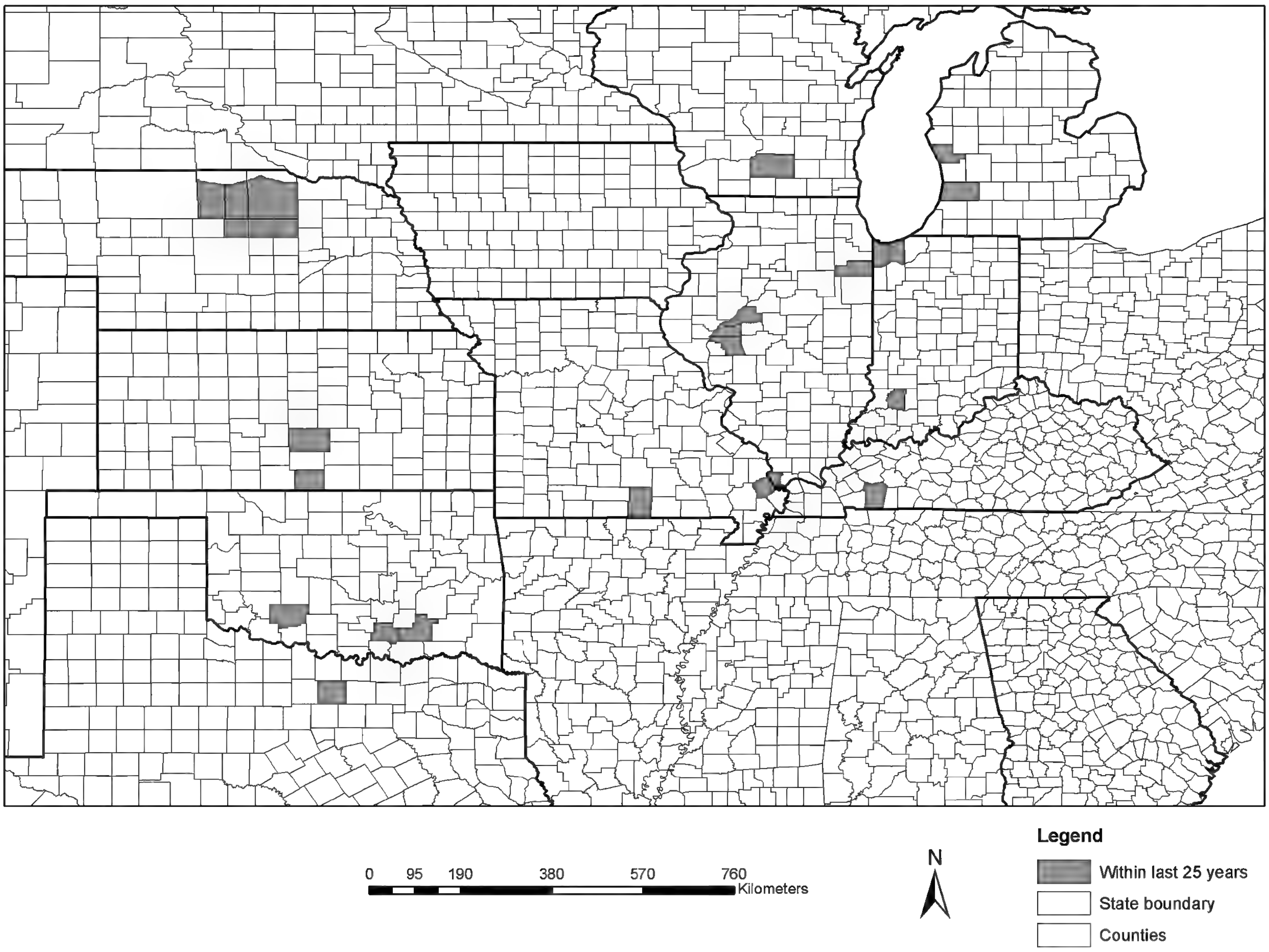

Fig. 2. Documented, county records of *Schoenoplectus hallii* in the United States within the last 25 years.

be found in abundance in the low depressions of cultivated fields in IL, KY, and MO (Chester 1988; Robertson et al. 1994; McClain et al. 1997; Missouri Natural Heritage Program 2006a). In drier years, these areas lack wetland habitat and are cultivated for crops (Chester 1988; Robertson et al. 1994; McClain et al. 1997). Although the species is usually associated with sandy soil, it can be found on exposed mud with a high silt content (Chester 1988). At one site in southern Missouri, Smith (2001) determined that *S. hallii* does not survive below 14% soil moisture and inhabits soils with a range of organic matter from 0.3–2.6%.

Schoenoplectus hallii germinates sporadically from year to year depending on the availability of wet, exposed habitat (Schuyler 1969; Penskar & Higmann 2003; Robertson et al. 1994). In some areas, the species can disappear for long periods only to reappear when conditions are favorable for germination and growth (Robertson et al. 1994; Chester 1988; McKenzie 1998; McClain et al. 1997; Penskar & Higman 2003). In Illinois, populations can vary from hundreds of thousands of plants covering extensive areas in one year to being entirely absent in other years (Robertson et al. 1994; McClain et al. 1997; McKenzie 1998; Beatty et al. 2004).

The exact mechanisms necessary to initiate seed germination and development of mature plants are only beginning to be understood. Smith (2001, 2002a, 2003) and Baskin et al. (2003) concluded that the species requires a combination of flooding, ethylene and light for germination, and that dormancy, which occurs in mature seeds, is more readily broken if flooded conditions occur in late spring and summer rather than late winter or early spring. Smith & Houpis (2004) investigated gas exchange in response to vapor pressure deficit in *S. hallii* and determined that the stomates of the species do not close in response

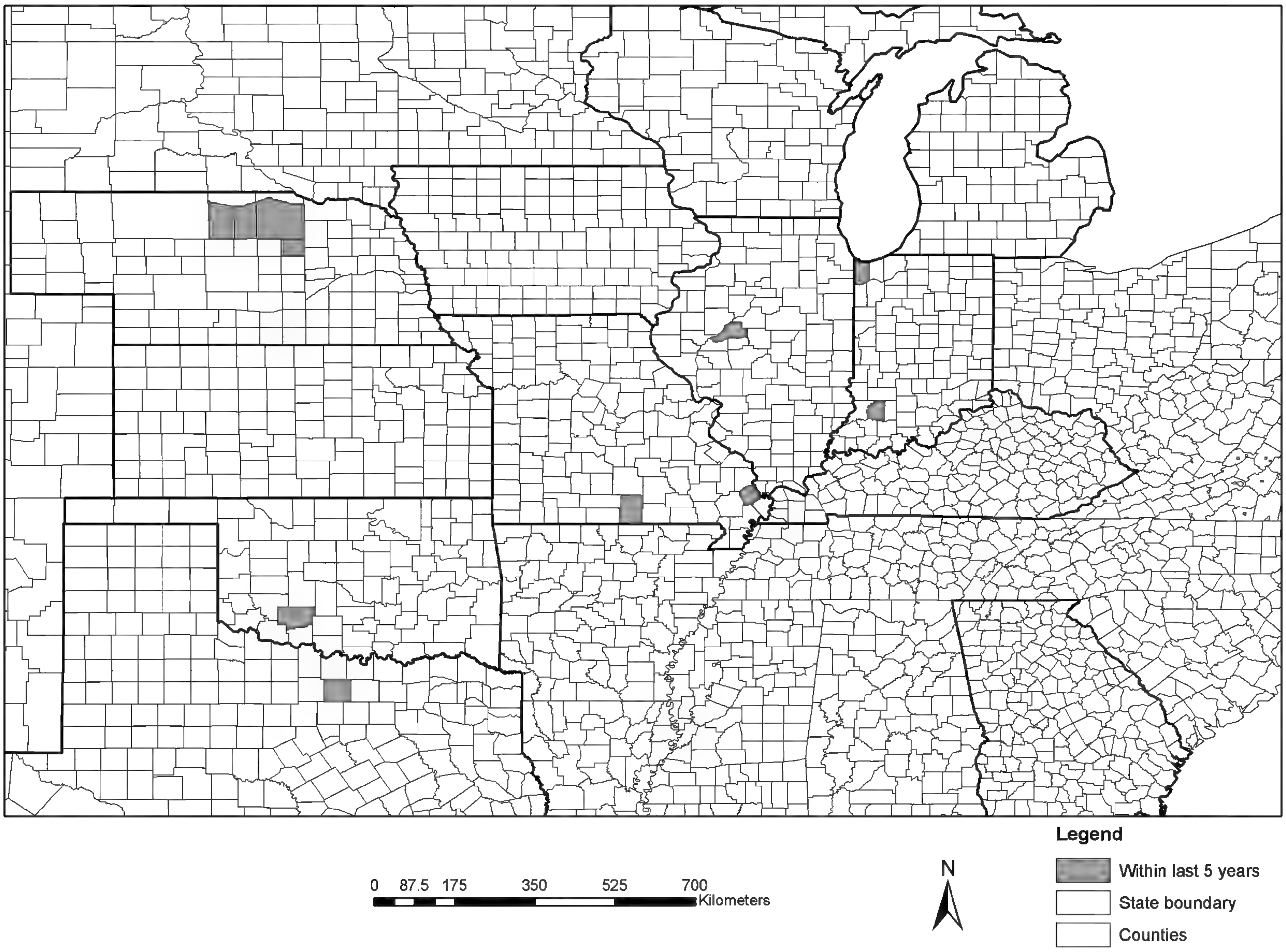

Fig. 3. Documented, county records of *Schoenoplectus hallii* in the United States within the last 5 years.

to increasing drought. This condition imposes a constraint on the species, requiring that it take advantage of optimal transient conditions to complete its lifecycle before conditions become unsuitable.

Studies by Smith (2001, 2002a, 2003) and Penskar & Higman (2003) have determined *S. hallii* can produce a seed bank containing thousands of achenes. These achenes apparently remain dormant for decades until conditions are optimal for germination and growth (Robertson et al.1994; McClain et al. 1997; McKenzie 1998; Beatty et al. 2004; NatureServe 2006). This is a strategy noted for other species of sedges (Baskin et al. 2000) and plants associated with desert environments (Venable & Lawlor 1980).

The biological and ecological significance of amphicarpy in *S. hallii* and other members of *Schoenoplectus* Section *Supini* have received little attention in the literature. Browning (1992) suggested that amphicarpy in the genus *Schoenoplectus* was environmentally induced due to a decrease in water levels. Others have postulated that amphicarpy has evolved to protect fruits from herbivory or changes in microclimate (Bruhl 1994; Magrath 2002).

The dispersal mechanism for the transport of achenes of *S. hallii* is not known, but some have suggested that the species is spread by migratory waterfowl (McClain et al. 1997; Beatty et al. 2004) that have been found to transport the seeds of other plant species long distances (deVlaming & Proctor 1968; Dunn and Knauer 1975; Powers et al. 1978; Kantud 1996). Magrath (2002) postulated that large herbivores such as cattle and bison were the likely dispersal agents for achenes of *S. hallii* on the Wichita Mountains Wildlife Refuge in Oklahoma, and Mike Homoya of the Indiana DNR hypothesized that the discovery of *S. deltarum* (Schuyler) Soják in Indiana was due to migrating waterfowl.

Associated Species

Schoenoplectus hallii is usually associated with other wetland-adapted plants. Although associates have not been provided for many sites, detailed data collected at others (e.g., Voss 1967; Robertson et al. 1994; Swink & Wilhelm 1994; McClain et al. 1997; Steinauer 2001a; Penskar & Higman 2003; O'Kennon & McLemore 2004) reveal the following commonality of wetland-adapted taxa: *Agrostis* spp., *Alisma* spp., *Ammania* spp., *Bacopa* spp., *Cyperus* spp., *Echinochloa* spp., *Eleocharis* spp., *Fimbristylis autumnalis* (L.) Roemer & Schultes, *Heterantha* spp., *Hypericum* spp., *Isoetes* spp., *Juncus* spp., *Leersia* spp., *Lindernia* spp., *Lipocarpha micrantha* (M.Vahl) G. Tucker, *Ludwigia* spp., *Lycopus* spp., *Polygonum* spp., *Rhexia* spp., *Rhynchospora* spp., *Rorippa* spp., *Rotala ramosior* (L.) Koehne, *Sagittaria* spp., *Schoenoplectus* spp., *Scirpus* spp., *Typha* spp., and *Xyris* spp. *Echinodorus tenellus* (Mart.) Buchenau var. *parvulus* (Engelm.) Fassett, a species for which the U.S. Fish & Wildlife Service (USFWS) has concern and which is listed as endangered in most mid-western states, has been recorded at *S. hallii* sites in GA, KY, MI, and at five sites in Missouri (Voss 1967; Chester 1988; Robertson et al. 1994; McKenzie 1998; Penskar & Higman 2003; Missouri Natural Heritage Program 2006a).

State Accounts

Alabama.—Previous reports of *S. hallii* in Alabama are referable to *S. erectus* (S.G. Smith, pers. comm.) and recent searches for the species have failed to document its occurrence in the state (A. Schotz, Alabama Heritage Program, pers. comm.).

Colorado.—Previously published accounts of *S. hallii*'s occurrence in the state (Harrington 1954; Small 1972; U.S. Fish & Wildlife Service 1993) are based on misdeterminations of *S. saximontanus* (Schuyler, pers. comm.; Smith 2002b).

Florida.—There are no documented records of this species in Florida and investigations by Smith (2002b) have determined that previous records of *S. hallii* from Florida are referable to *S. erectus*.

Georgia.—*Schoenoplectus hallii* has been documented solely from Dougherty County (Schuyler 1969; S.G. Smith, pers. comm.), and the species has not been collected in the state since 1966 (Patrick, pers. comm.). Previous reports from Decatur and Baker counties have proven to be *S. erectus* (Schuyler 1969). A specimen taken in Decatur County by Thorne [collection number 6553 and identified as *S. hallii,* has not been located (Patrick, pers. comm.)] nor examined by S.G. Smith (pers. comm.). Given that the specimen was collected close to a site (and apparently in the same year) where Thorne collected (collection number 6536), a specimen of *S. erectus* that was misidentified as *S. hallii* (S.G. Smith, pers. comm.), it is likely that the material is also *S. erectus*. Without knowing the correct identification of Thorne's collection number 6553 and with no recent surveys being conducted for *S. hallii*, the exact status of the species in this state is unclear (McKenzie 1998; O'Kennon & McLemore 2004).

Illinois.—The type specimens for *Schoenoplectus hallii* were taken in Illinois (Gray 1863; Winterringer 1959; Schuyler 1969; Mohlenbrock 1976), and more records of the species have been documented here than in any other state. It was historically recorded from Cass (Winterringer 1959; Schuyler 1969; Mohlenbrock & Ladd 1978), Mason (Winterringer 1959; Schuyler 1969; Mohlenbrock 1976; Mohlenbrock & Ladd 1978), and Menard (Winterringer 1959; Mohlenbrock 1976; Mohlenbrock & Ladd 1978) counties (Table 2). The species was discovered in Alexander County in 1993 (T. Kleninger, Illinois Natural Heritage Database, pers. comm.), and it was documented at 27 sites in Cass, Kankakee, Mason and Morgan counties following surveys in 1993 (Robertson et al.1994). Approximately 29 sites have been documented in the state within the last 25 years (Kleninger, pers. comm.) (Table 1). Populations ranged in size from "one plant to thousands of plants forming nearly pure stands and covering several acres" (Robertson et al. 1994). In 1995, when habitat was optimal for the species, some populations covered several acres and included hundreds of thousands of plants that were observed in flooded agricultural fields that were too wet for farm equipment (McClain et al. 1997; McKenzie 1998). Searches for *S. hallii* in Illinois in 1996 at the same sites yielded only one plant and none in 1997 (B. McClain, Illinois DOC, pers. comm.). It has apparently been observed at only one site in Mason County within the last five years (Bill McClain, pers. comm. 2006).

Indiana.—*Schoenoplectus hallii* was first discovered in Porter County in 1981 by Dritz et al. (Bowles et al.

1990; Swink & Wilhelm 1994). It was later discovered at one site in Lake County and at two additional sites in Porter County (Swink & Wilhelm 1994; Homoya, pers. comm.; R. Hellmich, Indiana DNR, pers. comm.). A sixth population was found in Daviess County in 2002 (Hellmich, pers. comm.). Population estimates at these sites range from "a few plants" to "10,000+" plants at the new site in Daviess County (Homoya, pers. comm.; Hellmich, pers. comm.). In 2006, the species was observed at the Daviess County site on 14 June, which is the earliest date recorded for this species in the Midwest. Because there are no active searches for *S. hallii*, it is not known if the species is more widely distributed in Indiana.

Iowa.—Iowa was mistakenly omitted from the range map for *S. hallii* in Smith (2002b). An 1890 record for Muscatine County (Davidson 1959; Guldner 1960; Roosa et al. 1989) was recently confirmed (S.G. Smith, pers. comm.). A very immature but identifiable Reppert s.n. collection taken from Muscatine County in 1890 was discovered and examined by S.G. Smith in 1997 at the Putnam Museum of History and Natural Science in Davenport, Iowa (S.G. Smith, pers. comm.). The specimen that is the basis for a 1960 report from Louisa County (Roosa et al. 1989), however, has not been located nor verified (S.G. Smith, pers. comm.; John Pearson Iowa DNR, pers. comm.). Although Roosa et al. (1989), Robertson et al. (1994), McKenzie (1998), and Beatty et al. (2004) reported that *S. hallii* was probably extirpated from the state, it is listed as a species of "Special Concern" (Iowa Department of Natural Resources 2007) and Pearson believes that there is still sand prairie habitat in Muscatine and Louisa counties that should be searched (pers. comm.).

Kansas.—Historically, *S. hallii* was reported from five counties (Great Plains Flora Association 1977); but it has only been documented from three counties based on correctly-identified voucher specimens: Harper, Harvey and Reno (R. McGregor, C. Freeman and C. Morse, University of Kansas, pers. comm.; S.G. Smith, pers. comm.). Population estimates range from "a few plants" to "abundant" (McGregor and Freeman, pers. comm.). The species has not been observed in the state since 1997 despite intensive surveys of sand prairie communities by several investigators (Freeman, pers. comm.).

Kentucky.—*Schoenoplectus hallii* was first discovered in Kentucky by Chester in 1983 in Christian County (Chester 1988). Since its original discovery, Chester has annually monitored the population at the only known site in the state, where the numbers of plants have been estimated in the thousands (Chester, Austin Peay State Univ., pers. comm.).

Massachusetts.—The occurrence of *S. hallii* in Massachusetts is based solely on historical collections made in Middlesex and Essex counties. The species was recorded from along the shoreline of Winter Pond in Middlesex County between 1876 (Schuyler 1969) and 1931 (Ostlie 1990). A second, undated specimen taken from Essex County by Horner at S. Georgetown and reported by Sorrie (1987) and Ostlie (1990) is housed at the New England Botanical Club herbarium and has been confirmed by Schuyler (pers. comm.). Sorrie (1987) reported that *S. hallii* has been extirpated from Massachusetts and stated that recent efforts to find suitable habitat for the species had failed. Consequently, the species is believed to have been extirpated in the state (McKenzie 1998; Smith 2002b).

Michigan.—First recorded at Carr Lake in Muskegon County in 1900 (Voss 1967), *S. hallii* has since been documented at four additional sites: two in Muskegon County and two in Allegan County (Brodowicz 1990; Penskar, Michigan Natural Features Inventory, pers. comm.; Penskar & Higman 2003). The species was last collected in Muskegon County in 1988 and in Allegan County in 2002 (Penskar, pers. comm.). In favorable years, *S. hallii* can be abundant at Michigan sites. Brodowicz (1990) estimated "hundreds of plants" at a Muskegon County site he visited in 1988 and Penskar (pers. comm.) reported that numbers at Michigan sites range from a few stems to tens of thousands of plants. Several years of intensive searching by experts have failed to yield any additional populations, but Penskar & Higman (2003) reported that suitable habitat exists that has not yet been surveyed. The failure to observe the species in Michigan since 2002 may be due to the drought that persists at some localities in the Midwest (Penskar & Higman 2003).

Missouri.—Historically, *S. hallii* was known from Howell and St. Louis counties (Steyermark 1963). The inscription "hills west of St. Louis" on a collection by Englemann in 1845 (five specimens in different herbaria), which was cited in the original description, provides documented evidence of the species' occurrence in St. Louis County (Yatskievych, pers. comm.). There are currently 10 extant sites in the state: three are located along the edges of sinkhole ponds in Howell County and seven are along the edges of sand depressions, swales, or ponds in Scott County (Missouri Natural Heritage Program 2006a). Population size fluctuates widely from year to year at most of the extant sites. As few as four plants have been documented at one of the sinkhole pond sites (T. Smith, Missouri DOC, pers. comm.), but hundreds of thousands of plants were estimated in 1998 and 2002 at sites in Scott County during years when conditions were optimal for the species (Missouri Natural Heritage Program 2006a). While sink-hole pond habitats in the state have been intensely surveyed, additional searches in appropriate sandy swale habitat in Butler, Clark, Lewis, Mississippi, New Madrid, Pemiscott, Ripley, Scott, and Stoddard counties are warranted. Only one population was located during a search of extant sites in Scott County in August 2006 (McKenzie, pers. obs.). The lack of occurrence at additional sites in 2006 is undoubtedly due to the dry conditions prevailing at the sites.

Nebraska.—Although The Great Plains Flora Association (1977) listed *S. hallii* from nine counties in Nebraska, Schuyler (1969) and Rolfsmeier (1995) determined that the species was historically known only from Holt and Rock counties. Other reported county records for Nebraska were based on misdeterminations of *S. saximontanus* (Rolfsmeier 1995; Schuyler, pers. comm.; S.G. Smith, pers. comm.). In 1999, two populations were discovered in Holt and Brown counties (Steinauer 2001a). Steinauer (2001a) subsequently conducted a survey for *S.hallii* in 2000 and found an additional 18 populations, where plant numbers ranged from 2 to 5,000+.

In 2001, Steinauer (2001b) discovered another four populations of *Schoenoplectus hallii*. Steinauer (2001a, b) established new county records for the species in Garfield, Loup, and Wheeler counties (Table 3). Twenty-seven extant sites of *S. hallii* have been documented in the state within the last 25 years, scattered throughout six counties in the sandhills region of northcental Nebraska (Table 1) (R. Schneider, Nebraska Natural Heritage Program, pers. comm.). Because it has been estimated that there are 19,300 square miles (Knue 1997) of sandy habitat within the sandhills region of the state, ongoing surveys are likely to yield additional new populations of this species (Steinauer 2001a). Further surveys are necessary before the status of this species in the state can be more accurately assessed.

Ohio.—A report that the species occurs in Ohio (NatureServe 2006) is in error.

Oklahoma.—Prior to 2000, there were five reports of *S. hallii* recorded for Oklahoma from Atoka, Comanche, Johnston, and Woods counties (Watson 1993; L.Watson, Oklahoma Biological Survey, pers. comm.; P. Hernandez, pers. comm.; L. Magrath, University of Science and Arts of Oklahoma, pers. comm.). Of these, three have been confirmed by S.G. Smith as *S. hallii*; one each from Atoka, Comanche, and Johnston counties (S.G. Smith, pers. comm.). The others, one from Comanche County and one from Woods County, were determined to be *S. saximontanus* (S.G. Smith, pers. comm.). In 2000, Magrath and refuge staff of the Wichita Mountains Wildlife Refuge conducted surveys for *S. hallii* and *S. saximontanus* at 134 ponds on the refuge (Magrath 2002). *Schoenoplectus hallii* was documented at 14 ponds, *S. saximontanus* at 10, and both species at four ponds. Plants were typically found on ponds that were subject to seasonal drawdowns, and population estimates ranged from one plant to several thousand (Magrath 2002). Despite being documented at 14 ponds, personnel of the Oklahoma Natural Heritage Inventory in Norman consider the Wichita Mountains Wildlife Refuge to have only one site until further examination of the populations on the Refuge can be undertaken (B. Hoagland, pers. comm.).

Magrath (2002) noted the destruction of some populations of *S. hallii* on the refuge by livestock, but acknowledged that such animals may benefit the species by transporting achenes to other sites. In 2001, the sites on the refuge were revisited to assess the status of *S. hallii* and *S. saximontanus*, and the predominance of abnormal and aborted achenes was noted in several plants of both species (Smith et al. 2004). In 2002, specimens of *S. hallii, S. saximontanus* and potential hybrids were collected (Smith et al. 2004) and those with unusual achenes were independently determined by S.G. Smith and Schuyler as the first putative hybrids recorded between *S. hallii* and *S. saximontanus* (Smith et al. 2004).

Further studies on the potential of hybridization of the two species on the Wichita Mountains Wildlife

Refuge are warranted, as the possibility of hybridization (Seehausen 2004) may threaten the continued existence of *S. hallii* in Oklahoma. Additional surveys should be conducted in Oklahoma populations and confirmed sites should be monitored. Until such investigations are conducted and the extent of hybridization is determined, the status of *S. hallii* in Oklahoma will remain unknown.

Oregon.—Koyama (1962) erroneously reported *S. hallii* from Oregon by misreading the label on a collection made by J. Zimmerman (3444) near the small town of Oregon in Dane County, WI (Schuyler 1969).

South Carolina.—Previous reports for this species in South Carolina were based on misdeterminations of *S. erectus* (S.G. Smith, pers. comm.).

South Dakota.—Previously published reports of *S. hallii* in South Dakota are based on misdeterminations of specimens of *S. saximontanus* (S.G. Smith, pers. comm.; Schuyler, pers. comm.).

Texas.—Prior to 2003, it was concurred that all historical records of *S. hallii* for Texas were referable to either *S. erectus* or *S. saximontanus* (S.G. Smith, pers. comm.; Schuyler, pers. comm.). The species was correctly reported in the state in 2003, when it was discovered in Wise County (O'Kennon & McLemore 2004). The species is known to persist at three ponds on the Lyndon B. Johnson National Grasslands between April and December (O'Kennon & McLemore 2004), but it may be present throughout the year (O'Kennon, pers. comm.). O'Kennon & McLemore (2004) noted that *S. hallii* occurred along the margins of sandy clay ponds that have widely fluctuating water levels. They estimated that there were ca. 200 individuals at each of the small ponds, which merge into one site during periods of high water. The site is managed by the Forest Service (O'Kennon & McLemore 2004).

Wisconsin.—*Schoenoplectus hallii* was first collected in Wisconsin in 1950 by J. Zimmerman at Lake Barney in Dane County and it was rediscovered at Lake Barney in 1996 by S.G. Smith and J. Dobberpuhl (S.G. Smith, pers. comm.). There were few plants at this small site in 1996 and they were apparently dwarfed due to grazing by cattle or horses. Without some means of properly managing this site, *S. hallii* is threatened with extirpation (S.G. Smith, pers. comm.). S.G. Smith, with J. Laatsch of the Wisconsin DNR, searched the shore of Lake Barney in 2006 and did not find *S. hallii*, perhaps because of turbid water that obscured much of the shore vegetation (S.G. Smith, pers. comm.).

Previous evaluations by the USFWS

Schoenoplectus hallii was listed as a category 2 candidate species in the USFWS's 1993 Plant Candidate Review for Listing as Endangered or Threatened Species (58 FR 51143-U.S. Fish & Wildlife Service 1993). Category 2 candidate species comprised taxa for which information indicated that a proposal to list as endangered or threatened was possibly appropriate, but for which conclusive data on biological vulnerability and threats were not currently available to support proposed rules. In 1995, the USFWS's Columbia, Missouri Field Office began a status review of *S. hallii* and solicited information from species experts and botanists throughout the range of the species. Data were summarized in an initial range-wide status assessment completed in 1998 (McKenzie 1998).

On 5 Dec 1996, the Director of the USFWS established new policy on the definition of candidate species (formerly category 1) and outlined how the USFWS would consider species for which they remained concerned (formerly category 2 or C2) (61 FR 64481-U.S. Fish and Wildlife Service 1996). Under the new policy, candidates are defined as those species for which the USFWS has on file sufficient information on biological vulnerability and threats to support issuance of a proposed rule to list as endangered or threatened, but issuance of the proposed rule is precluded by other listing actions.

Former C2 species for which the USFWS lacks sufficient information to classify as candidate species will no longer be enumerated on an official list. Nonetheless, other agencies that have developed extensive data bases on former C2 species (e.g., The Nature Conservancy; state natural heritage programs) will continue to monitor these species and maintain communication with the USFWS to help determine when sufficient information is available to warrant their addition to the USFWS's list of candidate species.

Summary of Threats

A. The present or threatened destruction, modification, or curtailment of the species' habitat or range.—Although a clear picture of the overall distribution of *S. hallii* is currently not possible without additional survey work being conducted during years when habitat is suitable, several known populations are subject to a multitude of threats. The greatest threats to Hall's bulrush involve the destruction and/or alteration of its wetland habitat (Ostlie & Gottlieb 1992; Robertson et al. 1994; McKenzie 1998; Penskar & Higman 2003; Beatty et al. 2004; NatureServe 2006). Range-wide, the lowering of water tables, depletion of ground water for irrigation, and changes to the hydrology supporting *S. hallii* habitat may be the most important factors that threaten the continued existence of the species (McKenzie 1998; Steinauer 2001a; Beatty et al. 2004). Any alteration to the hydrology that continually supports this habitat would disrupt the cycles necessary for this species' germination and establishment (Ostlie 1990; Robertson et al. 1994; Steinauer 2001a). Freeman (pers. comm. in Ostlie 1990; Morse, pers. comm.) postulated that groundwater depletion in Kansas may have lowered the water table such that wetland habitat favorable for the species is now being created less often than occurred historically, and Knue (1997) implied that ditching and pumping water from groundwater sources within the Nebraska sandhills for agriculture and domestic livestock may negatively impact wetland habitat. Many records of *S. hallii* for Nebraska are from this region of the state (Rolfsmeier 1995). The depletion of groundwater aquifers has also been identified as a threat to *S. hallii* in Illinois (S. Horn, Illinois TNC, pers. comm.). In Missouri, center-pivot irrigation may be lowering underground aquifers that contribute to flooded conditions in sand prairie swales (Bob Gillespie, Missouri DOC, pers. comm.). The alluvial aquifer in Missouri provides more than 7 billion gal of water per day for row crop agriculture in the area (Kleiss et al., 2000), resulting in a recession of groundwater from the shallow ponds in the region. Smith & Houpis (2004) determined that *S. hallii* did not respond physiologically to drought conditions, but continued to transpire until plants were desiccated. Because of this failure to respond to dry conditions, Smith (2003) concluded that for the species to complete its life cycle, groundwater levels must remain within 1 m of the surface throughout the growing season in Missouri, and Steinauer (2001a) suggested that elevated ground water levels in excess of 1 m above normal water levels were necessary to provide habitat in the Nebraska sandhills.

Schoenoplectus hallii thrives when fluctuating water levels create the temporary, wet habitat that prevents the establishment of competing perennials (Ostlie 1990; Robertson et al. 1994; McClain et al. 1997; Schuyler 1969). Robertson et al. (1994), however, noted that inundation will kill flowering plants of *S. hallii* if rising waters overtop the plants following germination and establishment. Schuyler (pers. comm.) postulated that the permanent inundation of the only known historical site in Massachusetts is responsible for the disappearance of the species there. Schuyler (1969) stated, "It appears that *S. hallii* grows in unstable habitats of sandy substrates, pioneer habitats from the standpoint of plant succession, which are well-suited for the growth of *S. hallii* but few other species of flowering plants. The restriction of *S. hallii* to this kind of unstable sandy pioneer habitat probably accounts for its unusual localized distribution."

The habitat of *S. hallii* is threatened by residential, commercial, agricultural, and recreational development (McClain et al. 1997; McKenzie 1998; Beatty et al. 2004). In Kentucky, the largest portion of the only known site in the state was recently destroyed during activities associated with a new truck stop adjacent to a major highway (D. White, Kentucky State Nature Preserves Commission, pers. comm.). The remaining portion of the site is also threatened from the tillage associated with planting crops (Chester 1988). Although Illinois supports the largest number of populations of *S. hallii* within its range, the species' existence in that state is threatened with the continued and widespread alteration of its habitat for agricultural and residential development (McKenzie 1998; Beatty et al. 2004; NatureServe 2006). The largest populations known for the species in 1995 were destroyed in Illinois due to tillage in 1996 and 1997, when drier conditions enabled farmers to plow wetland habitat (McClain et al. 1997; McKenzie 1998). Some sites in the state are threatened due to the filling of sand ponds for development and agriculture and the drainage of wet sand habitat to increase agricultural production (McClain et al. 1997).

Schoenoplectus hallii in Michigan is subject to threats in the state including dredging and filling operations associated with residential development (Crispin & Penskar 1990), off-road vehicle use and trail bikes, (Ostlie 1990; Penskar & Higman 2003), and the potential alteration of the natural hydrology of wetland habitat by local industries (Crispin & Penskar 1990; Penskar & Higman 2003). The only site in Porter County, IN is also threatened due to heavy recreational use (Homoya, pers. comm.), and Steinauer (2001a) identified ditch maintenance as a potential threat to populations in Nebraska that occur in road-side ditches. Penskar (pers. comm.) noted that one site on private property in Michigan is negatively impacted through shoreline modifications by heavy equipment.

Heavy grazing has been noted at sites in KS, MO, NE and WI, but it is not known whether this type of disturbance negatively impacts the species (Freeman, pers. comm.; Steinauer 2001a; Magrath 2002). Some populations of *S. hallii* are threatened from various chemical contaminants or herbicides. Portions of one of the larger Illinois' populations were destroyed in 1995 due to application of post-emergent herbicides (B. Meyers-Croteau, Illinois State University, pers. comm.). A historical site in Massachusetts was negatively impacted by storm-water runoff, septic effluent, and herbicides that were used to control unwanted species (Sorrie 1987; B. Sorrie, pers. comm., in Ostlie 1990). The application of numerous chemicals associated with agricultural practices throughout the species' range may inhibit achene germination (Rojas-Garciduenas et al. 1962; Kozlowski and Sasaki 1968), seedling development (Eliasson & Palen 1972) and growth (Musarrat & Haseeb 2000), or prevent sexual reproduction (Nartvaranant et al. 2004).

Woody encroachment and the spread of exotic plants have been identified as threats to *S. hallii* in various portions of the species' range (Sorrie 1987; McKenzie 1998; Steinauer 2001a; Beatty et al. 2004; Rolfsmeier & Weedon 2005). It is threatened by late-successional perennials in areas where early to mid-successional habitat is not maintained or regulated (Bowles et al. 1990; Robertson et al.1994). Purple loosestrife (*Lythrum salicaria* L.) was identified as a threat to *S. hallii* in Indiana, Massachusetts and Nebraska (Sorrie 1987; McKenzie 1998; Steinauer 2001a; Beatty et al. 2004; Rolfsmeier & Weedon 2005). Sorrie (pers. comm. in Ostlie 1990) suggested that the establishment of *Lythrum salicaria* at a historical Massachusetts site prevented any reestablishment of *S. hallii* there, and Bowles et al. (1990) asserted that a Lake County, IN site was also threatened by this exotic species. Rolfsmeier & Weedon (2005) noted that leafy spurge (*Euphorbia esula* L.) may be a potential threat to *S. hallii* in the future in Nebraska as this aggressive exotic is near extant sites. The species is also threatened by competition from reed-canary grass (*Phalaris arundinacea* L.) and various buckthorn (*Rhamnus*) species (S.G. Smith, pers. comm.).

An analysis was recently conducted in Missouri that outlined all known threats to sand prairies in the state, which included seven of the ten known *S. hallii* sites. Threats identified that were not discussed above included: 1) changes in ownership that could result in a lack of management, 2) land leveling associated with agricultural and industrial operations that modify or destroy sandy swale habitats, 3) disruption of overland flood events by flood control infrastructures (levees, ditches, berms, etc.), 4) reductions in the frequency of overland flood events necessary to create suitable habitat for germination and plant growth, 5) destruction of sandy habitats due to quarrying for sand or disposal of garbage or refuse, 6) pollution of groundwater or surface waters that support the species, 7) the loss of landowner agreements or management and support capabilities, 8) disinterest of landowners and conservation land managers in the development and implementation of management techniques necessary to maintain the habitat, and 9) the lack of outreach support to the public on the importance of maintaining sandy swale habitat (Gillespie, pers. comm.).

While the distribution of *S. hallii* is not well understood, the threats to many of the populations are of such magnitude that proper maintenance and management of habitat is needed to ensure the continued existence of this species.

B. Over-utilization for commercial, recreational, scientific, or educational purposes.—There is little evidence that this species is being negatively impacted due to over- utilization for commercial, recreation, scientific or educational purposes.

C. Disease or predation.—It has been postulated by S.G. Smith (pers. comm.) that *S. hallii* may be threatened by predation from increasing populations of mute swans (*Cygnus olor*) and Canada geese (*Branta canadensis*). These waterfowl species readily feed on the vegetation and achenes of bulrushes (Martin et al. 1951). In addition, climate models for the Midwest predict that the increasing incidence of extreme weather events will cause an increase in the number of insect pests that damage native vegetation (Rosenzweig et al. 2000).

D. The inadequacy of existing regulatory mechanisms.—*Schoenoplectus hallii* currently has a NatureServe ranking of G2 (globally imperiled because of rarity or some factor(s) making it very vulnerable to extinction or elimination) and is listed as S1 (critically imperiled) in all states where it is considered extant, except for Michigan, Missouri and Nebraska where it is listed as S2 (imperiled) (Missouri Natural Heritage Program 2006b; NatureServe 2006). These rankings, however, do not provide any regulatory protection for *S. hallii* or its habitat.

In some states, *S. hallii* is given special designations separate from the Nature Conservancy ranking. *Schoenoplectus hallii* is listed as endangered in Kentucky (Kentucky State Nature Preserves Commission 2007), a species of special concern in Iowa (Iowa Department of Natural Resources 2007), threatened in Illinois (Herkert & Ebinger 2002; Illinois Endangered Species Protection Board 2007), endangered in Indiana (Indiana Department of Natural Resources 2007), threatened in Michigan (Michigan Department of Natural Resources 2007; Michigan Natural Features Inventory 2007), status unknown in Oklahoma and Texas (Oklahoma Biological Survey 2007; The Nature Conservancy of Texas 2007), and endangered in Wisconsin (Wisconsin Department of Natural Resources 2007).

In Illinois, some protection is provided to any plant species that is state listed by the Illinois Endangered Species Protection Board (2007) following regulations outlined under the Illinois Endangered Species Protection Act (Illinois Department of Natural Resources 2007a; Michigan State University 2007). Under this statute, individuals are prohibited from: 1) taking state listed plants without the expressed written permission of the landowner or 2) selling or offering for sale plants or plant products of endangered species on the Illinois list (Illinois Department of Natural Resources 2007a; Michigan State University 2007). Additionally, consultation is required for any state funded project that could adversely affect state listed species (Illinois Department of Natural Resources 2007b).

Little protection is afforded *S. hallii* under Indiana law, but personnel with the Indiana Department of Natural Resources have an opportunity to provide input on state-funded projects that could negatively impact the species (Homoya, pers. comm.). Endangered or threatened plants can not be taken in Michigan without a permit (Penskar, pers. comm.), as they are protected under the Endangered Species Act 451 of 1994 (Part 365; Michigan Legislature 2007) of Michigan (Michigan Department of Natural Resources 2007; Michigan Natural Features Inventory 2007; Michigan State University 2007).

In Nebraska, *S. hallii* is listed as a Tier 1 At-Risk Species as part of the Nebraska Game and Parks Commission's Natural Legacy Project (Nebraska Game & Parks Commission 2007a). This program is part of the state's development of a Comprehensive Wildlife Strategy that has been initiated in all 50 states (Nebraska Game & Parks Commission 2007b). Nebraska's listing of *S. hallii* as Tier 1 At-Risk Species does not provide any regulatory protection status to the species, but the designation has heightened awareness of the species' management needs and the Nebraska Department of Roads proactively consults with the Nebraska Game and Parks Commission for highway projects that may impact the species (Schneider, pers. comm.). *Schoenoplectus hallii* can not be collected in the state without a permit (Schneider, pers. comm.).

A state listing as endangered provides little protection for *S. hallii* in Wisconsin under state statutes 29.604 and NR(Natural Resources) 27.03-NR27.07 (Wisconsin Legislature 2007a, b; Michigan State University 2007). Under Wisconsin law, the taking of *S. hallii* is prohibited without a permit under section 27.05. Permits are not required, however, for persons who want to take this or other state listed species: 1) on property which they own or lease or for which they have been granted landowner permission, except if the plants or their progeny are sold or processed, 2) on property that is being used for agriculture, construction, or forestry practices, or 3) on property that is being operated or maintained as a utility facility [Michigan State University 2007; Wisconsin Legislature 2007b- 27.05 (3)].

State endangered species statutes exist for IN, KS, MO, NE, OK, and TX but plants are not covered under state laws for these states. A summary of all state statutes is available at the Animal Legal & Historical Web Center of the Michigan State University College of Law (Michigan State University 2007).

E. Other natural or man-made factors affecting its continued existence.—*Population isolation*.—Because of human modification to the landscape (Robertson et al. 1994; McKenzie 1998; NatureServe 2006), suitable habitat for the species has been reduced to small, isolated transient wetlands. As a result, populations of *S. hallii* are small and often widely separated, some by several hundred miles. Reduction in population size is accompanied by loss of genetic variation, which reduces the ability of the population to adapt to changing environments and increases the risk of extinction (Barrett & Kohn 1991; Newman & Pilson 1997). Ellstrand & Elam (1993) concluded that in small populations, fitness is likely to decrease because of the fixation of deleterious recessive alleles. This was confirmed in a field study of *Lolium multiflorum* Lam., which had reduced vigor and reproductive capacity with decreasing population size (Polans & Allard 1989). The loss of fitness may not become evident until later stages in the species' life cycle. In small populations of *Gilia achilleifolia* Benth., inbreeding depression was expressed as decreased survivorship of seedlings, rather than in seed production or germination (Schoen 1983). Others (Frankel & Soule 1981; Holtsford & Ellstrand 1991) determined that inbreeding depression, and a greater threat of extinction, was higher in populations with an increased rate of selfing. Although the mating system of *S. hallii* has not been studied, the terminal flowers are perfect and have the potential for self fertilization. This subject warrants further study.

***Loss of seed bank integrity.*—**While populations of *S. hallii* are frequently isolated, in years optimal for germination, they may be extremely large, presumably due to the regeneration of the population from a persistent seed bank (McClain et al. 1997). A large, persistent seed bank, however, does not necessarily result in a restoration of the genetic variation or the vigor of the original population. Wienhold and van der Valk (1989) determined that the number and density of seeds in a seed bank decreases after 10 or more years when wetlands are drained for extended periods. It is likely that the same losses apply to habitats occupied by *S. hallii* during extended dry years and that such declines are accelerated by such agricultural practices as plowing, disking, or harrowing that damage seeds in the soil (Smith 2001).

It is generally accepted that older seeds have reduced viability (Roberts 1973) and increased chromosome breakage and gene mutation (Murata et al. 1982; Murata et al. 1984). Levin (1990) maintained that genetic and chromosomal changes associated with a long-lived seed bank provide novel genetic variation for the evolution of a species and are inherently beneficial. Others disagree with this assessment (e.g., Hamilton 1994) and empirical evidence is inclusive. Mean heterozygosity among plants derived from the seed bank was lower than that existing in surface plants of *Lesquerella fendleri* (A. Gray) S. Wats. (Cabin et al. 1998), while in *Clarkia springvillensis* Vasek, it was concluded that the seed bank could act as a buffer against the small population effect by supplying plants with greater heterozygosity than that existing in the aboveground population (McCue & Holtsford 1998). Populations regenerated from a seed bank sometimes show evidence of inbreeding depression and a decline in performance of seedlings. After restoration of a population of *Nymphoides peltata* (Gmelin) O. Kuntze from a seed bank, Takagawa et al. (2006) reported that there was a negative effect of inbreeding depression and noted that genetic variation and growth performance of seedlings derived from the seed bank were significantly reduced. It is, therefore, important to examine genetic makeup and chromosomal damage and their effects on survival and genetic composition of populations of *S. hallii*, as well as the longevity of seeds in the soil, before it can be assumed that the seed bank is representative of a viable population.

***Hybridization.*—**A threat of hybridization between *S. hallii* and *S. saximontanus* exists in Oklahoma (Smith et al. 2004) and one site in Kansas where the two species are sympatric (Freeman, pers. comm. 2006). Smith (2002b) also reported that a specimen taken from the coastal plain of Georgia was intermediate between *S.*

hallii and *S. erectus*. It is not known if anthropogenic practices have potentially altered the distribution of *S. hallii* in relation to its closely related congeners. Magrath (2002) noted that *S. hallii* and *S. saximontanus* co-occurred at four ponds on the Wichita Mountains Refuge and Smith et al. (2004) reported the first putative hybrids between the two species from material collected on the refuge. Although *S. hallii* and *S. saximontanus* were documented in 1997 from the same locality in Harper County, KS, a cursory examination of specimens of both species from the locality indicated no evidence of hybridization (Freeman, pers. comm. 2006). A more organized and thorough examination of individuals in the population at this locality may also reveal the presence of hybrids as occurred in Oklahoma (Smith et al. 2004). Because waterfowl are known dispersal agents for various sedges, including *S. hallii* (Dunn & Knauer 1975; McClain et al. 1997; Beatty et al. 2004), it is possible that the management of various wetlands/impoundments for waterfowl may increase the potential of *S. hallii* mixing with its more common congeners, *S. saximontanus* and *S. erectus*.

According to conservation geneticists, hybridization poses a serious threat to the survival of a rare species that hybridizes with a closely related congener (Levin et al. 1996). Although the extinction of rare species typically is attributed to systematic environmental change that renders the habitat unsuitable (Harrison 1991; National Research Council 1995), hybridization may have a profound effect on the persistence of a species (Rieseberg 1991; Ellstrand 1992; Rieseberg & Linder 1999).

Hybridization promotes the extinction of rare species by reducing the potential for plants to replace themselves, thereby inhibiting the growth of their populations—the lower the rate of growth, the greater the potential for extinction in a variable environment (Menges 1992). Hybridization may reduce a population's growth rate by adversely affecting its reproductive effectiveness, its competitive status and its interactions with herbivores (Levin et al. 1996).

The growth rate of a population may be retarded by the production of hybrid seed, which is produced in place of the rare species, i.e., resources are limited and an investment in hybrid seed reduces the amount of energy that can be allocated to conspecific seed. The outcome is the same whether the hybrid seeds abort or are viable. When hybrid seeds are produced by both a rare species and its abundant congener, a numerically small population will produce a higher percentage of hybrid seed than the more numerous related species when the two are intermixed (Felber 1991; Levin et al. 1996). Species have a number of defenses against interbreeding; however, closely related congeners often have weaker barriers to hybridization and a greater minority disadvantage (Levin et al. 1996).

The numerical disadvantage of a rare species is compounded by the proliferation of fertile hybrids. The addition of these plants to a population containing two related plants decreases the proportional representation of the rare species. In time, this backcrossing can result in the assimilation of the rare species whose genetic identity will become extinct (Rhymer & Simberloff 1996). Over evolutionary time, the DNA of the former rare species may be lost from the gene pool altogether (Rieseberg et al. 1996).

Climate change.—*Schoenoplectus hallii* can disappear from sites during periods of drought, only to reappear when flooded conditions exist (Robertson et al. 1994; McClain et al. 1997; Penskar & Higman 2003; McKenzie 1998; Beatty et al. 2004). Global warming and climate change could contribute to loss of wetland habitat required by this species by causing droughts to be more extensive and persistent, especially in the Midwest where drought conditions have persisted for several years, and are predicted to continue with increasing frequency in the future (Hansen 1989; Rosenzweig et al. 2000). Climate models indicate that high temperatures and an increase in pests (Rosenzweig et al. 2000) and other invasive species (Vitousek 1994) will accompany the increased frequency of droughts and other extreme events (Dai et al 1996). Global warming and climate change have increasingly been identified as factors which may contribute to the loss of biodiversity and extinction of imperiled species (Wilcove et al. 1998; Thomas et al. 2004; Maschinski et al. 2006), but only Beatty et al. (2004) have addressed the issue for *S. hallii*.

Changes in crop production and ethanol demand.—Habitat for *S. hallii* is threatened due to projected changes in agricultural development, especially corn production that is needed for increasing demands for ethanol production (Keeney and Mueller 2006; U.S. Department of Agriculture 2007). Keeney and Mueller

(2006) estimated a 254% increase in volume of water used in ethanol production from 1998 to 2008 for only one state in the Midwest. Corn production for ethanol plants is projected to increase in 2007 by 14.2% in Illinois (U.S. Department of Agriculture 2007), the state with largest number of extant sites for *S. hallii* (Table 1). Nebraska has the second largest number of extant sites for the species (Table 1) and large areas of unsurveyed habitat, but Keeney and Mueller (2006) postulated that increasing demand for ethanol production may result in competing water uses in that state. Increased demands for water from above ground sources and underground aquifers could prevent the formation of important wetland habitat needed by *S. hallii* throughout the Midwest.

Ownership, current protective status, habitat protections or management

Few of the extant sites of *S. hallii* in the United States receive protective status and only a small percentage of sites documented within the last 25 years are actively managed to maintain habitat for the species. Of the 84 sites recorded for the species within the last 25 years, approximately 16 (~ 19%) are under public ownership. The remaining 81% are privately owned, which could make them potentially vulnerable to habitat change that may threaten the species at these sites. The only known sites in Kansas and Kentucky are under private ownership, as are the majority of sites in Illinois, Missouri and Nebraska. The existence of *S. hallii* populations on public land, however, does not guarantee that the habitat will be properly managed and maintained to ensure the persistence of the species. The *S. hallii* site at Horseshoe Lake Conservation Area in Illinois is also under public ownership, but there is no management plan for the species (McClain, pers. comm. 1996).

Schoenoplectus hallii is protected and actively managed at four of the five sites in Michigan. Two sites on the Allegan State Game Area are under the jurisdiction of the Wildlife Division of the Michigan DNR. They are protected by barriers that control access, and are regularly patrolled and managed (Penskar, pers. comm. 2006). One site in Muskegon County is located within a dedicated Research Natural Area on the USFS's Huron-Manistee National Forest, and a second site is protected as part of a nature preserve owned by the Michigan Nature Association (Penskar, pers. comm. 2006). Three sites at the Indiana Dunes National Lakeshore are owned by the National Park Service; however, Bowles et al. (1990) reported that at least one site is threatened by succession and the spread of purple loosestrife.

The one site for *S. hallii* in Oklahoma is on a USFWS Wildlife Refuge, but the species is not covered under a management plan (C. Kimball, Wichita Mountains Wildlife Refuge, pers. comm.). Specific management actions may be included for the species when the refuge develops a 15-year Comprehensive Conservation Plan (CCP) (Kimball, pers. comm.), but the initiation of such a plan has not yet been scheduled (U.S. Fish & Wildlife Service 2007).

Two of the sinkhole pond sites in Howell County, MO are registered under the Nature Conservancy's Registry Program (T. Smith, pers. comm.), but the program is not regularly maintained (D. Ladd, Missouri TNC, pers. comm.). Landowner agreements that exist for two sites in Scott County, MO will likely maintain habitat for the species into the foreseeable future, but continued support for the agreement is unpredictable if there is a change in ownership (Gillespie, pers. comm.).

In Nebraska, two sites (South Pine WMA and Twin Lakes WMA) are on public land, but one of the sites is within a few miles of a population of purple loosestrife (Steinauer 2001a). The listing of *S. hallii* as a Tier 1 At-Risk Species will ensure that it is a priority for conservation efforts and a focus for various management plans (Schneider, pers. comm.; Nebraska Game & Parks Commission 2007c).

The only known *S. hallii* site in Wisconsin is on prison grounds, which is under public ownership, but the site has limited access (Anderson, pers. comm.). There is no management plan in place to benefit the species at this site (Anderson, pers. comm.).

The only known site in Texas is on the Lyndon B. Johnson National Grasslands, but no information on management actions for the species was identified by O'Kennon and McLemore (2004).

Management actions needed

While the management of *S. hallii* sites is probably necessary for its continued existence, the success of such efforts may be difficult due to the specific habitat requirements for this wetland-adapted plant (Bowles et al. 1990). Ostlie (1990) recommended that extant sites of the species should be protected from human disturbance and that the hydrological cycles necessary for the creation and maintenance of its habitat should be preserved. Robertson et al. (1994) suggested that the acquisition of extant sites should be a priority. In areas where land acquisition is not feasible, easements that incorporate various management agreements may be the best approach for maintaining and protecting *S. hallii* habitat. The Nature Conservancy's Registry Program could be an efficient method of managing populations on private land, but the lack of active participation due to limitations in time and personnel will limit the usefulness of the program. Various state-initiated landowner contact programs may also be helpful in managing the species over a long-term basis such as the Landowner Incentive Program (LIP) implemented in many states. The USFWS's Partners for Fish and Wildlife Program could be helpful in assisting landowners in the management of *S. hallii* on private land. Perhaps the greatest potential for managing habitat to benefit the species will be through the development and implementation of each state's comprehensive wildlife strategy similar to the one in Nebraska (Nebraska Game & Parks Commission 2007b).

Management plans should be developed for the few sites that are publicly owned. Such plans should include the following recommendations: 1) protect and maintain the hydrology essential to the species, 2) retard plant succession, 3) control competing perennials, especially aggressive exotics, 4) control off-road vehicle use, 5) develop active public outreach and education programs, and 6) support the development of long- term monitoring programs and active research on the species.

Research needs

Additional research on the life history and ecological requirements of *S. hallii*, as undertaken by Baskin et al. (2003), Penskar & Higman (2003), Smith (2001, 2002a, 2003), Smith & Houpis (2004), Smith et al. (2006), and as identified by Beatty et al. (2004), are needed to better understand the population dynamics of this species. Investigations that compare reproduction from achenes versus perennial growth from the species' short rhizomes need to be undertaken. Although initial germination and life history dynamics for terminal achenes have been established (Baskin et al. 2003; Penskar & Higman 2003; Smith 2001, 2002a, 2003; Smith et al. 2006), further research is warranted to more clearly pinpoint the environmental factors necessary for germination and establishment of *S. hallii* achenes. The role of amphicarpy in the life history of the species needs evaluation, including studies of the mating systems of both terminal and basal florets. Additional research should be initiated to determine the relationship of wetland hydrology to the population dynamics of *S. hallii*, especially the role of surface flooding and underground aquifers and groundwater in the creation of habitat for the species. Studies to identify the dispersal mechanisms that enable the species to colonize new areas would be valuable. The germination of achenes of *Schoenoplectus* spp. can apparently be enhanced when they pass through the digestive tracts of birds (deVlaming & Proctor 1968; Powers et al. 1978; Kantud 1996). Similar studies involving the achenes of *S. hallii* should be initiated to determine if birds help facilitate dispersal of this species.

Examinations of additional specimens are necessary to clarify the historical and current distribution of the species (e.g., specimens from GA, IA, and OK) (S.G. Smith, pers. comm.). Additional surveys are necessary to better delineate the range of *S. hallii*, provided they are conducted during years when habitat conditions are favorable to the species and specimens can be examined by experts who can accurately distinguish the species from its close relatives. An examination of precipitation patterns may be useful in predicting what years the species is more likely to emerge. Voucher specimens should be confirmed by either S.G. Smith or Ernie Schuyler. The communities and ecological associates that occur with *S. hallii* should be further characterized, which will enable researchers in the future to develop adequate search-images for the species.

Studies should be initiated that examine the effects of grazing, controlled burning and other types of disturbance (e.g., off-road vehicle use, trail bikes, burning, mowing, disking) on the species. Population genetics studies need to be conducted to determine the amount of variation and gene flow within and among populations. Studies of the population and genetic consequences of recruitment from a long-lived seed bank need to be conducted to clarify the current definition of "extant sites" as represented by the presence of achenes in the soil. Monitoring efforts need to be initiated for all extant populations, especially those populations that appear annually and are not as cyclic in their occurrence as at other sites within the species' range. The report of a putative hybrid between *S. hallii* and *S. saximontanus* at the Wichita Mountains Wildlife Refuge in Oklahoma (Smith et al. 2004) suggests that hybridization is a threat at sites where conspecifics are sympatric. Thus, further investigations that examine the extent of hybridization at Oklahoma and Kansas sites should be initiated to determine if *S. hallii* is threatened from genetic swamping or genetic dilution. *Schoenoplectus hallii* would benefit from additional seed viability studies and from research that examines genetic differences between and among populations. Finally, the impacts of global warming and climate change on the loss of wetland habitat for the species should be evaluated by conducting studies similar to analyses for other species (e.g., Hannah et al. 2002; Pearson & Dawson 2003) and incorporating the results into long-term management plans.

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BOOK REVIEWS

Markus Riederer and Caroline Muller (eds.). 2006. **Annual Plant Reviews, Volume 23: Biology of the Plant Cuticle.** (ISBN 1-4051-3628-X, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** www.blackwellprofessional.com, orders@ames.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $249.99 hbk., 438 pp., 6¼" × 9½".

This is another installment from Blackwell Publishing's noteworthy Annual Plant Review Series. As always, it includes chapters on the latest research on its subject written by experts in the field. This volume examines the biology of the plant cuticle in depth. The first chapter is an introduction written by one the book's editors: Professor Markus Riederer of the Julius-von-Sachs Institute in Wurzburg, Germany. Dr. Riederer opens with an interesting question put to him by a University search committee: "Does it make sense, and is it fun at all, to spend so much time with the outermost micrometer of a plant?" Dr. Riederer replies, "…it is fun indeed to study the plant cuticle and the plethora of processes related to it." He goes on to state that it is his hope and that of the volume's contributors that readers "…will find that it is worthwhile to invest time, brains and funds into this endeavor."

The plant cuticle is a continuous membrane covering a plant's surface that is composed of waxes and other extracellular substances. The plant cuticle has been an essential component of plant structure for millennia. The oldest cuticle found dates back to the late Silurian and early Devonian periods, about 400 million years ago. It protects plants from ultraviolet (UV) radiation and pathogens like fungi, and it can even control the behavior of hungry herbivores. The cuticle controls transpiration in cooperation with the stomata by preventing water loss. The importance of this function, especially in xeric environments, is obvious. In addition to preventing water loss, the cuticle protects the plant by preventing rainwater and its microbes and unwanted molecules from passing into the plant. Some cuticles even cause microbes, dust, and other small molecules to be removed along with the rainwater in a process known poetically as the Lotus effect. The resistant cuticle also prevents the loss and uptake of polar molecules like salts through the plant's surface, and controls the uptake of organic compounds, including environmental pollutants. During the time when the stomata are closed, the cuticle assumes complete control over the exchange of gases and vapors through the plant-atmosphere interface. In addition, the cuticle often provides important structural support to the plant, an essential factor in the dreaded tomato fruit cracking familiar to farmers and gardeners.

Some 2,300 publications about the plant cuticle have been published in the last ten years according to the database BIOSIS. This is the first experiment-based comprehensive scientific book devoted the plant cuticle since the 1970's that is not a compilation of conference proceedings. Many developments are covered, including new research on cuticular wax composition and biosynthesis, quantitative assessment of the transport of lipophilic organic compounds across the cuticle, and the cuticle's role in UV protection. Scientists have discovered new roles for the cuticle, including a role in pollen stigma-interactions. The cuticle's role in regulating interactions between plants and their environment is of interest to ecologists, environmental scientists, entomologists, and phytopathologists. In addition, practical information for horticultural and agricultural scientists is in included. This volume is excellent and long overdue source of information about the current research on the plant cuticle.—*Marissa N. Oppel, MS, Collections and Research Assistant, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

Kent J. Bradford and Hiroyuki Nonogaki (eds.). 2007. **Annual Plant Reviews, Volume 27: Seed Development, Dormancy, and Germination.** (ISBN 1-4051-3983-8, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** www.blackwellprofessional.com, orders@ames.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $199.99, 367 pp., 6¼" × 9½".

Seeds are not only vital to the life cycles of gymnosperms and angiosperms, they are also important staples in the human diet. The 27th volume of Blackwell Publishing's Annual Plant Reviews covers "seed biology from the point of view of the developmental and regulatory processes that are involved in the transition from a developing seed through dormancy and into germination and seedling growth." Ten years have passed since a book on this subject has been published, and there have been many advances in this field of research. The model system *Arabidopsis thaliana* has been the subject of much recent research and is featured prominently throughout this book and on its cover. The first two chapters cover the genetic control of seed development, including seed mass and seed coat development and dormancy. These chapters are followed by six chapters devoted to seed dormancy, including seed dormancy models, genetic aspects, lipid metabolism, and the roles of nitric oxide and abscisic acid. The final four chapters are focused on seed development and germination, including the roles of the abscisic acid and the gibberellins and the mechanisms, regulation, and genes involved in germination and the transition to seedling growth. The "current challenges and remaining questions for future research" are discussed, as well. This book is a resource for seed biologists, plant breeders, geneticists, plant developmental biologists, and graduate students.—*Marissa N. Oppel, MS, Irving, Texas, U.S.A.*

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A NOTE ON THE TYPE LOCALITY OF *OENOTHERA ARIZONICA* (ONAGRACEAE)

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ABSTRACT

The type locality for *Oenothera arizonica* (Munz) W.L. Wagner (Onagraceae), in the valley of the Santa Cruz River, north of Tucson, Arizona, USA, is elucidated based upon historic property records. Today, the area of the historic farm is the site of residential and industrial development and a highway interchange.

RESUMEN

La localidad del tipo *Oenothera arizonica* (Munz) W.L. Wagner (Onagraceae), en el valle del Río Santa Cruz, al norte de Tucson, Arizona, EEUU, está documentada en base a archivos históricos. Hoy, la área del rancho histórico es una zona de desarrollo residencial e industrial, y también el lugar de una intersección de autopista.

The desert evening primrose, *Oenothera arizonica* (Munz) W.L. Wagner, is a sprawling winter-spring annual that grows in sandy and floodplain soils at lower elevations of the Sonoran Desert in northwestern Sonora, Mexico, and southwestern Arizona, USA (Fig. 1A & 1B). This note presents geographical and historical context for its type locality:

Oenothera arizonica (Munz) W.L. Wagner, Novon 8:308. 1998. *Oenothera deltoides* Torr. & Frém. var. *arizonica* Munz, Amer. J. Bot. 18:315. 1931; *Oenothera californica* (S. Watson) S. Watson ssp. *arizonica* (Munz) W.M. Klein, Aliso 5:179. 1962; *Oenothera avita* (W.M. Klein) W.M. Klein ssp. *arizonica* (Munz) W.M. Klein, N. Amer. Fl. II, 5:116. 1965. Type: U.S.A. Arizona. Pima Co.: Grosetta [sic] Ranch near Tucson, Arizona, 2400 ft elev., 28 Apr 1903, *J.J. Thornber 509* (holotype: UC!; isotypes: ARIZ!, MO, US).

In addition to the type, cited above, four collections of *Oenothera arizonica* are known from the type locality: "along ditches," 5 Mar 1901, *Griffiths 2393a* (ARIZ!); 29 Apr 1902, *Mr. & Mrs. Thornber s.n.* (MO!); 20 Apr 1903, *Thornber 4931* (ARIZ!); 27 Apr 1903, *Mrs. Thornber 2983* (ARIZ!). Specimens at ARIZ document other species at Grossetta's ranch in 1902–1903: *Bromus diandrus* Roth, *Hordeum arizonicum* Covas, *Helianthus petiolaris* Nutt. var. *canescens* A. Gray, *Machaeranthera asteroides* Greene var. *asteroides*, *Malacothrix glabrata* (A. Gray ex D.C. Eaton) A. Gray, *Stephanomeria exigua* Nutt. ssp. *exigua*, *Eremalche exilis* (A. Gray) Greene, and *Gaura parviflora* Lehm.

Type localities for new species or infraspecific taxa described from historical collections are often poorly defined, primarily the result of limited data on specimen labels. In some cases, a place name is idiosyncratic to the era of the collection, whether or not it ever appeared on a map. The type locality of *Oenothera arizonica* is an example of the latter: a farm whose owners were known to the collector and in the community, but which did not become an enduring geographic entity. In the spring of 1891, the Tucson newspaper drew attention to local farming efforts, including "S.V. Grossetta, one among the few enterprising men of this valley, is preparing to try the efficacy of irrigating his lands down the Santa Cruz by means of pumps. If others have been successful Mr. Grossetta certainly will be" (Arizona Daily Star, 14 Apr 1891, pp.3). The paper undoubtedly meant *A.* (Antonio, or Anthony) V. Grossetta, who had moved to Tucson in 1880 and became a prominent proprietor and promoter of culture in the town (G. Grossetta, pers. comm., Dec 2003). The boundaries of Grossetta's ranch were legally recorded, even if the particular collection sites of *O. arizonica* within that parcel remain unknown.

The 120-acre Grossetta parcel included portions of sections 34-35, T.13S, R.13E (Pima County Recorder 1906), extending east across the floodplain of the Santa Cruz River for three-quarters of a mile, at about 2310-2340 ft (704-713 m) elevation (Fig. 1C). The northern boundary of the one-time parcel became the

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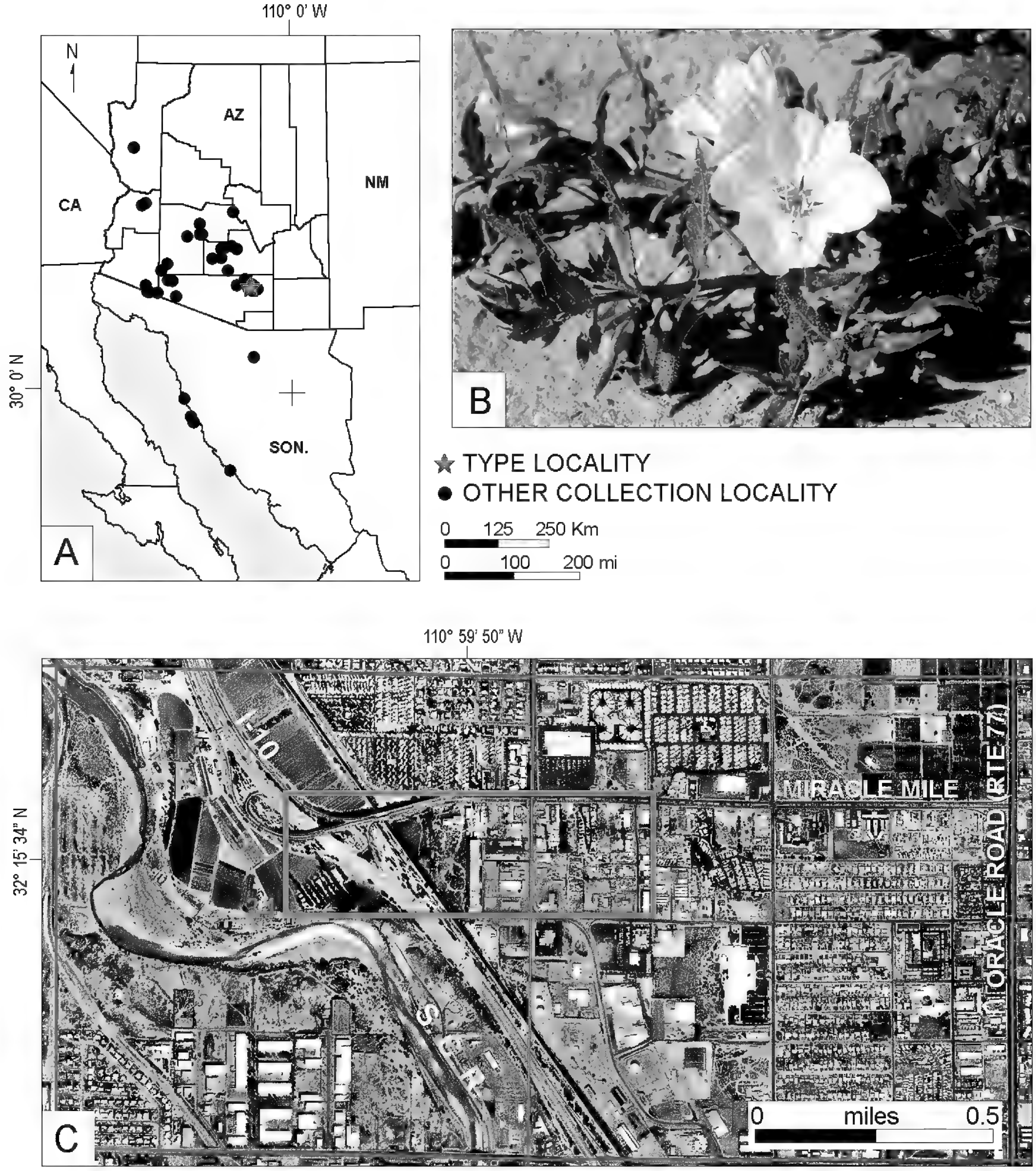

Fig. 1. ***Oenothera arizonica.*** **A—Location of the type locality in Pima Co., southern Arizona, within the geographic range documented by specimens at University of Arizona Herbarium (ARIZ) (modified from records available through the SEINET database, seinet.asu.edu). B—Trailing stems of the living plant (photo by the author, 25 Feb 2005, Eloy Basin, Pinal Co., Arizona). C—Type locality in 1992 aerial photography, showing the boundary of the 1891 Grossetta parcel (yellow) near the meandering Santa Cruz River (S.C.R.) and Interstate 10 (I-10) in northwest Tucson. Section lines are shown in red, and nearby major roads are labeled. Images are portions of USGS digital ortho quarter quadrangles (section 34, Jaynes SE; section 35, Tucson North SW) from Arizona Regional Image Archive (aria.arizona.edu). Maps are displayed in Universal Transverse Mercator projection (NAD83/zone 12); geographic coordinates at the parcel center are for the WGS84 datum.**

alignment for what is now called "Miracle Mile," originally part of the two-mile dogleg, built in 1937, joining U.S. Highway 80/89 and State Highway 84 (Anonymous 1937), and today the southern terminus of State Highway 77 where it meets U.S. Interstate 10. The modern interchange at Interstate 10 fills the western portion of the former ranch, near the University of Arizona Experimental Farm that also takes up part of the Grossetta's original parcel. East of the interstate, an industrial site, warehouses, and housing occupy the land.

Conservation concerns.—As a farm and orchard in the Grossetta's time, the type locality of *Oenothera* *arizonica* was near the eastern and upper elevation limits of the species' range as it has since been documented by other collections (Fig. 1A). This range corresponds closely to the Lower Colorado River Valley biogeographic subdivision of the Sonoran Desert (Shreve 1951). The river valleys associated with this biotic community, including those near Tucson, have in the past century been intensively utilized for agriculture where irrigation is available; in the past thirty years, the lowlands characterizing this subregion have experienced among the highest rates of population growth in the binational Sonoran Desert (Nabhan & Holdsworth 1998). Although the desert evening primrose may grow in fallow fields and along farm roads in agricultural areas (author's observations), widespread disturbance and replacement of low desert landcover—and of agricultural fields—with urban land uses may present a conservation concern for *O. arizonica* populations as the region continues to endure unprecedented development.

ACKNOWLEDGMENTS

I thank the curators at ARIZ, MO, and UC, whose collections were consulted in the preparation of this note, and colleague Hugo Rodríguez, who made suggestions for the Spanish abstract. The maps for this note were prepared, with permission, at the Arizona Remote Sensing Center, University of Arizona. The comments of reviewers are also appreciated.

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Shreve, F. 1951. Vegetation of the Sonoran Desert. In: F. Shreve and I.L. Wiggins. Vegetation and flora of the Sonoran Desert, vol. 1. Publication 591, Carnegie Institution of Washington, Washington, DC. Pp. 1–191.

BOOK REVIEWS

Robert H. Webb, Stanley A. Leake, and Raymond M. Turner. 2007. **The Ribbon of Green: Change in Riparian Vegetation in the Southwestern United States.** (ISBN 0-8165-2588-9, hbk.). The University of Arizona Press, 355 S. Euclid, Suite 103, Tucson, AZ 85719-6654, U.S.A. (**Orders:** www.uapress.arizona.edu, 520-621-3920, 520-621-8899 fax). $75.00, 462 pp., b/w photos, 9¼" × 12¼".

From the outside, this large book, with its gorgeous color photograph of the San Juan River on the cover, looks like a coffee-table book. It is actually a fascinating study of the riparian vegetation of the southwestern United States. Riparian vegetation accounts for one third of the vascular plants in this region and is home to many species of wildlife. Unlike many ecological books, this one actually contains some very welcome good news- riparian vegetation is increasing in many areas. This increase is due to many factors, including winter floods that allow the establishment of new species on disturbed areas, flood control, and favorable climatic conditions. The authors focus on factors that affect the woody riparian vegetation of major river valleys in Arizona, Utah, southern Nevada, and southeastern California. They use repeat photography and hydrological research to analyze changes in riparian vegetation in these areas. This long-term study encompasses 140 years of photographic history, and black-and-white photographs illustrate the book. The authors present an analysis of thousands of photographs, including early photographs by surveyors, scientists, explorers, and tourists, as well as modern-day repeat photographs of the same locations. Woody plants and identifiable perennials are the focus of the authors' photographic analysis. This book paints a surprising portrait of the changes in southwestern riparian ecosystems over the last century and a half.—*Marissa N. Oppel, MS, Irving, Texas, U.S.A.*

Ceiridwen Terrill Foreword by Gary Paul Nabhan. 2007. **Unnatural Landscapes: tracking invasive species.** (ISBN 0-8165-2523-4, pbk.). The University of Arizona Press, 355 S. Euclid Avenue, Sutie 103, Tucson, AZ 85719, U.S.A. (**Orders:** www.uaapress.arizona.edu). $17.95, 220 pp., 5 maps, 26 b/w photos, 6½" × 8".

Terrill's book on unnatural landscapes is a descriptive journey through various islands that have been impacted by invasive species in many ways. Ceiridwen picked four North American islands to study invasive species of birds, fishes, plants and mammals since "islands are excellent places for exploring the problem of invasive species because their native plants and animals are highly specialized, isolated organisms, often few in number, and highly susceptible to the negative effects of introduced species."

In reading this book, one can better understand why an exotic or an introduced species may become invasive and how it becomes detrimental to other species, and even more so to the entire ecosystem. For instance, the author points out that a horticultural flat of the African Hottentot fig (*Carpobratus edulis*) is sold for $12.99 without any warning about the potential invasive nature of the plant. Another concern is the introduction of exotic pets that can provoke a chain reaction through the introduction of unknown foreign parasites and diseases.

"Invasive species haven't just outcompeted natives for nutrients, space, and water. They also can change fire regimes, alter streams courses, prevent native plants from regenerating, negatively affect human health and local economies." One good example given by Mrs. Terrill is a crevice-dwelling freshwater crayfish in warm pools of Ash Meadows, Nevada. After introduction, the crevice-dweller (*Procambarus clarkii*) became a top carnivore and keystone species in the community. A keystone species has a key role in an ecosystem, affecting many other species, and whose removal leads to a series of extinctions within the ecosystem.

Even if a good question is raised, "extinction is a natural process, so what's the big deal?," Terrill states that one of the methods to deal with invasive species is to eradicate them. It is simpler on an island because there is less risk of reinvasion. Even after eradication, and exotic animals such as sheep are removed, it can sometimes take more than a decade for the landscape to fully recover. Eradication of certain plants may be achieved by reducing or eliminating essential minerals elements. For instance, Cheatgrass (*Bromus tectorum*) was successfully removed on Anaho Island National Wildlife Refuge (Nevada) by the removal of nitrogen. Invasive pigs on Santa Cruz Island (California) have been controlled through large-scale hunting, relocation on and off the island, and contraceptive measures.

Ceiridwen Terrill hopes people will begin to take personal action to stop or at least slow down the spread of exotic species, and in a larger political arena, she encourages people to influence public policy with their vote. I think this book is more about letting people know of the potential problems and dangers of invasive species. Education can go along way in prevention. An "*Ounce of prevention is worth a pound of cure*." Guidelines need to be implemented and prominently displayed and preventive equipment installed in more parks and natural areas for people to follow. Examples include,"Boot brushes on the mainland pier provide an opportunity for visitors to remove invasive seeds from their footwear before their trip to Santa Cruz Island." Also, visitors to this Island are encouraged not to hike through weed-infested areas, but to stay on trails to avoid disturbing soils and making it easier for invasive plants to establish.

We definitely need more people exposing the problem of invasive species to the general public. Terrill has done a marvelous job describing in simple terms, the problems and potential solutions of invasive species.—*Virginie H. Raquet, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4068, U.S.A., vraquet@brit.org.*

NOTES ON *CONOCARPUS ERECTUS* (COMBRETACEAE) IN THE BAJA CALIFORNIA PENINSULA, MEXICO

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ABSTRACT

Mangrove stands of *Conocarpus erectus* in the semi-arid southern part of the Baja California Peninsula are rare, since the species reaches here its northern limit of distribution in the northern and western hemispheres. Four populations are described. Occurrence of these stands is relevant because this species seems to have responded positively to heavy rains over the last two decades. The coastal areas that have been favored maintain suitable levels of soil moisture so that populations of this species have been able of colonize new areas or showing a vigorous growth.

Key Words: *Conocarpus erectus*, Baja California, mangrove, global change

RESUMEN

Las agrupaciones del mangle botoncillo *Conocarpus erectus* en el semi-árido sector sur de la Península de Baja California, México, son infrecuentes dado que en esta región la especie encuentra el límite norte de su distribución geográfica, tanto en los hemisferios norte y occidental. La presencia estas agrupaciones es relevante dado que los autores consideran que la especie a respondido positivamente a eventos que han dejado elevada humedad en el suelo de la franja costera de la zona en las últimas dos décadas, hecho que ha permitido a pequeñas poblaciones de esta especie colonizar nuevos puntos o reiniciar un activo crecimiento.

Palabras Clave: *Conocarpus erectus*, Baja California, manglar, cambio global

Primary environmental conditions required for establishing mangroves include water currents of low kinetic energy and a relatively high water temperature, i.e., higher than 20°C as the mean annual temperature (Lugo 1998). Along the west coast of the Baja California Peninsula, low winter temperatures and cold ocean currents seems act as the main controls for the spread of mangroves. Hence, mangroves on the Gulf of California side of the peninsula occur to 29°N at Bahía de Los Angeles (BA in Fig. 1) and near 27°N on the Pacific coast side at Laguna San Ignacio of the Estero El Coyote (EC in Fig. 1).

Mangrove species in the Baja California Peninsula are *Rhizophora mangle* L. (red mangrove, Rhizophoraceae), *Laguncularia racemosa* (L.) Gaertn. (white mangrove, Combretaceae), and *Avicenia germinans* (L.) L. (salty mangrove, Aviceniaceae). These three species typically grows as an association. Typically *R. mangle* and *L. racemosa* are permanently in touch with seawater and *A. germinans* grows landward in wet soil (Turner et al. 1995).

The button mangrove (*Conocarpus erectus* L., Combretaceae) is a common member of the mangrove association in tropical and subtropical zones in the Western Hemisphere. The species extends from the Caribbean Islands, including Bermuda and The Bahamas, through central Florida and northeastern Mexico and southward along the Atlantic coast to Brazil. On the Pacific coast, it extends from northern Mexico to northwestern Peru, including the Galapagos Islands. Also, it is found in western tropical Africa from Senegal to Zaire. The button mangrove is one of the more terrestrial mangrove species because it grows landward from the typical mangrove stands where soils are occasionally flooded. As with other mangroves, it is also present where the annual mean isotherm is above 20°C, avoiding near freezing temperatures (Robertson & Alongi 1992; Dawes 1998).

Typically, this species grows in brackish or saline silt along depositional coasts, behind mangrove stands immediately above the intertidal belt, as well as in coastal marshes, estuaries, inlets, and mudflats. It usually grows to a height of 8–10 m as an arborescent form (Tomlinson 1986). On the Pacific coast, button man-

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grove extends marginally towards northwestern Mexico. Wiggins (1980) and Turner et al. (1995) recorded solitary individuals or small clumps on the Baja California Peninsula, south of 24°N at sites designated with cross marks (+) in Figure 1.

Compiling information about locations from vouchers of *C. erectus* in our herbarium and visiting these locations in recent years, as well as populations that were seen by informants, we present the following account of four sites where well structured populations of this species occur. In general terms, analysis is interesting because the southern part of the Peninsula (especially the Cape Region) is the northern limit of the geographical distribution in the northern and western hemisphere.

In the last decade, this area has received larger-than-typical volumes of rain (four hurricanes in six years: two 2001, one 2003, one 2006), which brought a few months of flooding and high water to the mouths of arroyos, estuaries, and salt marshes, typical habitats where the species has been collected. Our findings and analyses suggest that this species is currently undergoing population and regional expansion.

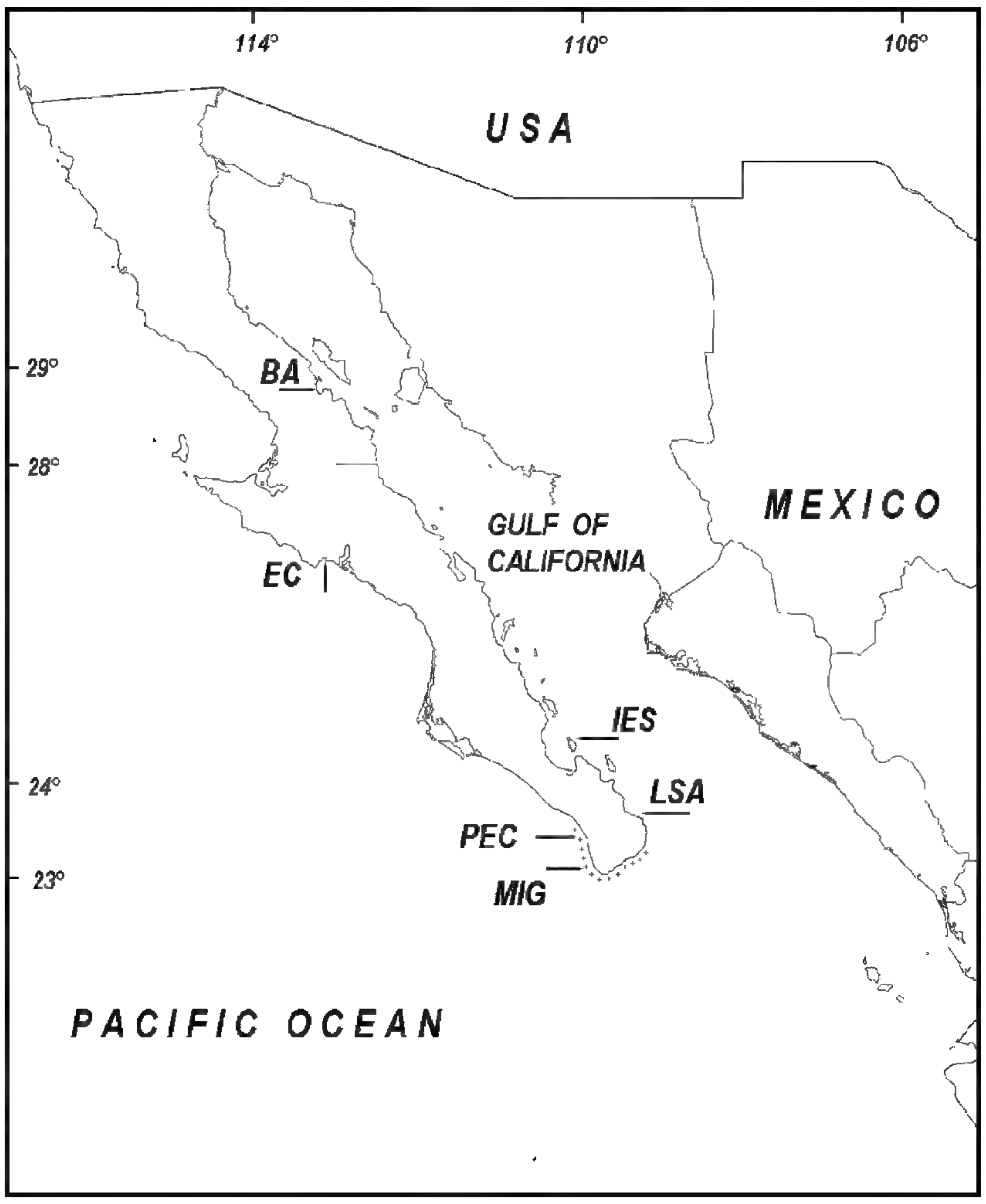

Fig. 1. Limits of four species of mangroves along the western coast of North America. Gulf of California shore line: BA = Bahía de Los Angeles (Rhizophora mangle, Avicenia germinans, and Laguncularia racemosa). Pacific shore line: EC = Estero El Coyote (R. mangle and L. racemosa). Stands of pure Conocarpus erectus in the Peninsula: IES = Isla Espiritu Santo, PEC = Plutarco Elías Calles, MIG = Migriño, and LSA = La Salina. Previously, isolated trees of C. erectus were reported on sandy beaches along the southwestern tip of the Baja California Peninsula (+).

Site 1: Isla Espíritu Santo (24°30'57.7" N, 110°23'11.4" W; IES in Fig. 1).

In the summer of 2002 (El Mezteño Cove), Felix Pico et al. (2005) found a stand of tree-like button mangrove on a narrow strip of land (130 m long) between a mudflat of sand and alkaline, clayey silt on the sea side and a colluvial, rocky soil with desert scrub on the land side. On a recent survey, the site contained a population of 87 plants. Measurements of height, two canopy diameters, and the basal perimeter of the trunk are shown in Table 1.

This is an old population because the community contains a majority of mature specimens with basal trunk circumference of up to 0.45 m, which suggests an age of several decades. No other mangrove species, of any size or age, is present near this cove.

Hurricanes strike this area irregularly. During summer 2001, Hurricane Juliette brought high seas that flooded the coves and bays on the west side of the island. At El Mezteño Cove, a break in the barrier beach allowed continuous ebb and flow of seawater through the new channel, which initiated expansion of the mangrove population, a condition that is clearly noticeable to visitors. Before 2001, the population seemed inconspicuous, probably from lack of an adequate water supply. During the summers of 2003 and 2006, Hurricanes Ignacio, Marti, and John renewed the tidal channel flow system, but the button mangrove did not show the vigorous growth seen in 2001–02.

Site 2: Plutarco Elías Calles (23°12'36.9"N, 110°08'24.8"W; PEC in Fig. 1)

This site is on the relatively cold Pacific coast side of the Baja California Peninsula in a salt marsh bordered with a strand of coastal dunes. This population is composed of tall individuals of shrubby habit with basal branching occupying an area bordering a mudflat. According to informants from the early 1990s, this population appears to be relatively young. This aspect is supported by the homogeneous basal perimeter of the

Table 1. Structural characteristics of the four stands of button mangrove *Conocarpus erectus* known in the southern Baja California Peninsula, Mexico. Name of each stand is followed by the estimated surface area and number of individuals.

Name of button mangrove stand	max	min	Population Canopy Cover (m^2)
1. Isla Espíritu Santo (1,420 m^2; 87 plants)			
Height (m)	4.30	0.90	
Canopy cover (m^2)	17.71	0.12	795.83
Basal trunk circumference (m)	0.45	0.04	
2. Plutarco Elías Calles (16,362 m^2; 280 plants*)			
Height (m)	9.10	1.30	
Canopy cover (m^2)	51.62	0.56	9,100.60
Basal trunk circumference (m)	0.62	0.08	
3. Migriño (7,500 m^2; 225 plants*)			
Height (m)	5.10	1.40	
Canopy cover (m^2)	12.87	0.30	8,257.50
Basal trunk circumference (m)	0.94	0.09	
4. La Salina (27,000 m^2; 2,160 plants*)			
Height (m)	4.30	0.90	
Canopy cover (m^2)	15.58	0.66	38,017.20
Basal trunk circumference (m)	0.59	0.11	

* Inference based on 20 x 10 m^2 sampling and Google Earth (2007) view analysis

main stem in most of the population (the larger mangroves) and the meager accumulation of deadwood and few dead plants. Freshwater draining from a neighboring area used for cattle grazing seems to contribute to suitable soil humidity. Measurements of height, two canopy diameters, and the basal perimeter of the trunk are shown in Table 1.

Site 3: Migriño (23°01'48.7"N, 110°04'54.9"W; MIG in Fig. 1)

This is a peculiar site, located 45 m above sea level along the banks of a sandy arroyo in a strip of pure mangrove vegetation that is 250 m long. A freshwater spring is located immediately above the upper tip of the strip, and this is probably the basis for this patch of vegetation. The shore is almost 1 km west of this site.

According to informants, this is an ancient population. An accumulation of litter and deadwood prevails throughout the patch and some dead trunks are >0.60 m in circumference. Young mangrove grows along the borders of the stand and in the downstream edge of the stand. The stand is actively growing and the thick canopy, which blocks sunlight reaching the interior, prevents seedlings from growing. Main trunks are continuously being buried by bed load sandy sediments deposited after heavy rains.

Site 4. La Salina (23°35'08.1"N, 109°32'12.3"W; LSA in Fig. 1)

This is the biggest and undoubtedly the oldest button mangrove stand on the Peninsula. It is located in a salt marsh on the Gulf of California coast that is irregularly flooded. The salt marsh has a perimeter of about 2.2 km with a surface area of about 6 hectares. No other species of mangrove is present. This population receives a small inflow of freshwater to this micro-basin. Occasionally, sea swells break through the dune strand and introduces seawater to the marsh. Deposits of detritus border the deeper part of the lagoon. During a recent flood, water reaching 2 m in depth remained for 2–3 months and killed the foliage of the covered button mangrove. This strip of mangrove is 900 m long.

In summary, this species has responded positively to the recent events of heavy rains and the decade of the 1990s with two "El Niño" events that impacted the Peninsula. Even more recently, four hurricanes have brought flooding. The coastal areas have been favored with suitable levels of soil moisture that enabled this species to colonize new areas or trigger vigorous growth.

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REDESCUBRIMIENTO DE *AXINIPHYLLUM SAGITTALOBUM* (ASTERACEAE) EN LA SIERRA MADRE DEL SUR Y NOTAS DE LAS ESPECIES DE ESTE GÉNERO QUE HABITAN EN EL ESTADO DE GUERRERO, MÉXICO

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RESUMEN

Axiniphyllum sagittalobum, especie endémica a la Sierra Madre del Sur de Guerrero, México y que fue descrita por B.L. Turner con base en una sola colecta de Hinton (1939), fue recolectada con flores, por primera vez desde su descripción, en el bosque de pino del municipio de San Miguel Totolapan. Otras dos especies de *Axiniphyllum* se registran habitando en el estado de Guerrero, *A. corymbosum* y *A. pinnatisectum*. Se ofrecen claves de identificación de estas tres especies, descripciones mas amplias, datos de distribución geográfica, información acerca del hábitat y referencias de herbario. Durante nuestro reciente trabajo de campo no encontramos a *A. pinnatisectum,* especie también muy rara con solo dos especímenes representados en herbarios del extranjero; esta especie también es endémica a la Sierra Madre del Sur. Se sugiere emprender recolectas de campo para buscar esta especie con detenimiento, ya que en el caso de que no sea colectada durante los próximos años, podrá considerarse como extinta. Ninguna de las especies antes mencionadas está considerada dentro de la Norma Oficial Mexicana vigente (NOM-059-ECOL-2001).

ABSTRACT

Axiniphyllum sagitalobum, a strict endemic of the Sierra Madre del Sur, Guerrero, Mexico, was described by B.L. Turner on basis of a single collection of Hinton in 1939. It has been recently collected with flowers, in the pine forests of San Miguel Totolapan municipality, for the first time since is description. Two other species of *Axiniphyllum* are reported from the Mexican state of Guerrero: *A. corymbosum* and *A. pinnatisectum*. An identification key for these three species, expanded species descriptions, geographic distributions, habitat information, and herbarium, which is known only from the type collection; this species is also endemic to the Sierra Madre del Sur. None of the three species of *Axiniphyllum* is considered in the recent Norma Oficial Mexicana (NOM-059-ECOL-2001).

Los estudios florísticos de la familia Asteraceae en México se han abordado a nivel regional o estatal (e.g., Villaseñor 1982, 1987, 1989; McVaugh 1984; Villarreal et al. 1996; Ortiz & Villaseñor 1998; Balleza & Villaseñor 2002; Villarreal & Villaseñor 2004; Villaseñor et al. 2004). Uno de los estados con mayor diversidad florística de México es Guerrero; dentro de los límites de su territorio se estima que existen aproximadamente 666 especies, incluyendo taxones subespecíficos (Villaseñor et al. 2004) incluidos en 143 géneros, 14 de ellos endémicos a México (Villaseñor et al. 1998). Existen pocos estudios florísticos de la familia en el estado, aunque se ha intentado realizar un inventario de las especies que lo habitan. Villaseñor (1987) publicó uno de los inventarios más completos de Asteraceae a nivel genérico para la Cuenca del Río Balsas, donde incluye un total de 131 géneros para el área.

El género *Axiniphyllum* está integrado por cinco especies, con una distribución restringida a los bosques templados del occidente de México, en los estados de Durango, Guerrero, Nayarit y Oaxaca. La descripción de *Axiniphyllum* fue hecha por Bentham (1872), en la cual incluyó dos especies que carecían de flores radiadas, *A. corymbosum* Benth. distribuida en Guerrero y Oaxaca y *A. tomentosum* Benth., con un área de distribución restringida a las zonas montañosas de Oaxaca; la última especie había sido descrita anteriormente bajo el nombre de *Polymnia scabra* por Zuccarini (1832), sin embargo Blake (1930) realizó la transferencia de esta última al género *Axiniphyllum*.

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Desde que el género fue descrito por Bentham y por más de un siglo, no se descubrieron nuevas especies y *Axiniphyllum* se mantuvo como un género con solo dos especies. Más tarde, Turner (1978) adicionó dos especies a partir de colectas hechas en el estado de Guerrero: *A. sagittalobum* B.L. Turner y *A. pinnatisectum* (P.G. Wilson) B.L. Turner, ésta última descrita al principio como *Rumfordia pinnatisecta* P.G. Wilson. Por último *A. durangense* B.L. Turner, del sur del estado de Durango y Nayarit, es la especie descrita más recientemente (Turner 1987).

El interés en *Axiniphyllum* se basa principalmente en el pobre conocimiento que se tiene de él, ya que las colectas realizadas de las especies de este género son escasas y por lo tanto su representación en los herbarios es pobre, lo que hace pensar que sus poblaciones son pequeñas. Dado lo anterior, es necesario el estudio de las especies de este género, sobre todo de aquellas con una distribución restringida. El objetivo de este trabajo es ofrecer una descripción detallada de las especies de *Axiniphyllum* en el estado de Guerrero, así como datos de su distribución geográfica conocida, datos ecológicos y poblacionales y una clave taxonómica, con la finalidad de contribuir al conocimiento florístico del estado y ahondar en el conocimiento de las Asteraceae mexicanas. Todas las especies del género tienen una distribución restringida al país.

MATERIAL Y MÉTODOS

Se recopilaron los datos de distribución de ejemplares de herbario del género *Axiniphyllum* depositados en los siguientes herbarios: Herbario Nacional de México, Instituto de Biología, UNAM (MEXU), Herbario de la Escuela Nacional de Ciencias Biológicas, IPN (ENCB), Herbario de la Facultad de Ciencias, UNAM (FCME) y Herbario de la Universidad Autónoma de Guerrero (UAGC). Las especies de este género no están representados en herbarios extranjeros a excepción de algunos ejemplares de *A. corymbosum* y los ejemplares tipo.

Debido a la escasez de ejemplares de herbario de *A. pinnatisectum* y *A. sagittalobum*, se realizaron dos salidas a campo a las localidades tipo durante los meses de septiembre y octubre de 2005, con el objetivo de obtener mas datos sobre su morfología externa y llevar a cabo observaciones de las poblaciones y su hábitat.

RESULTADOS

El trabajo realizado en campo se enfocó a la recolección de ejemplares de *Axiniphyllum pinnatisectum*, el cual solo cuenta con dos ejemplares colectados por Hinton en 1936 y 1937, depositados en los herbarios K, NY y US y *A. sagittalobum*, el cual solo era conocido a partir del ejemplar tipo colectado por Hinton en 1939, depositado en el herbario TEX-LL y cuyos isotipos se encuentran en MICH, NY y US. Sólo se encontró una pequeña población de *A. sagittalobum* (menos de 100 individuos), por lo que se recolectó un único ejemplar de respaldo que está en proceso de ser depositado en los herbarios FCME, UAGC, MEXU, TEX-LL y NY. *Axiniphyllum pinnatisectum* no fue encontrada en campo.

Las localidades tipo de estas dos especies se encuentran en poblados relativamente cercanos entre sí. Estas zonas actualmente están sujetas a fuerte acción antropogénica, por lo que el bosque ha sido convertido, en la mayoría de los casos, en campos de cultivo. La colecta de *A. sagittalobum* permitió elaborar una descripción más completa de la especie, en comparación con la realizada por Turner (1978).

En el estado de Guerrero se encuentran representadas tres especies: *A. corymbosum*, con una distribución amplia dentro del estado y *A. pinnatisectum* y *A. sagittalobum*, ambas endémicas al estado, con una distribución conocida restringida a la Sierra Madre del Sur, en lo que se conoce como la región administrativa conocida como “tierra caliente” (Fig. 1).

La revisión de las colecciones de los herbarios permitió corroborar que existe un escaso número de ejemplares de las especies de *Axiniphyllum*; MEXU es el herbario que contiene una mayor cantidad de especímenes con 31 ejemplares, seguida de ENCB con cinco.

A continuación se presenta la descripción de las tres especies registradas para el estado de Guerrero.

TRATAMIENTO TAXONÓMICO

Axiniphyllum Benth., Hooker’s Icon. Pl. 12:16, t. 1118. 1872. Especie tipo: *Axiniphyllum corymbosum* Benth.

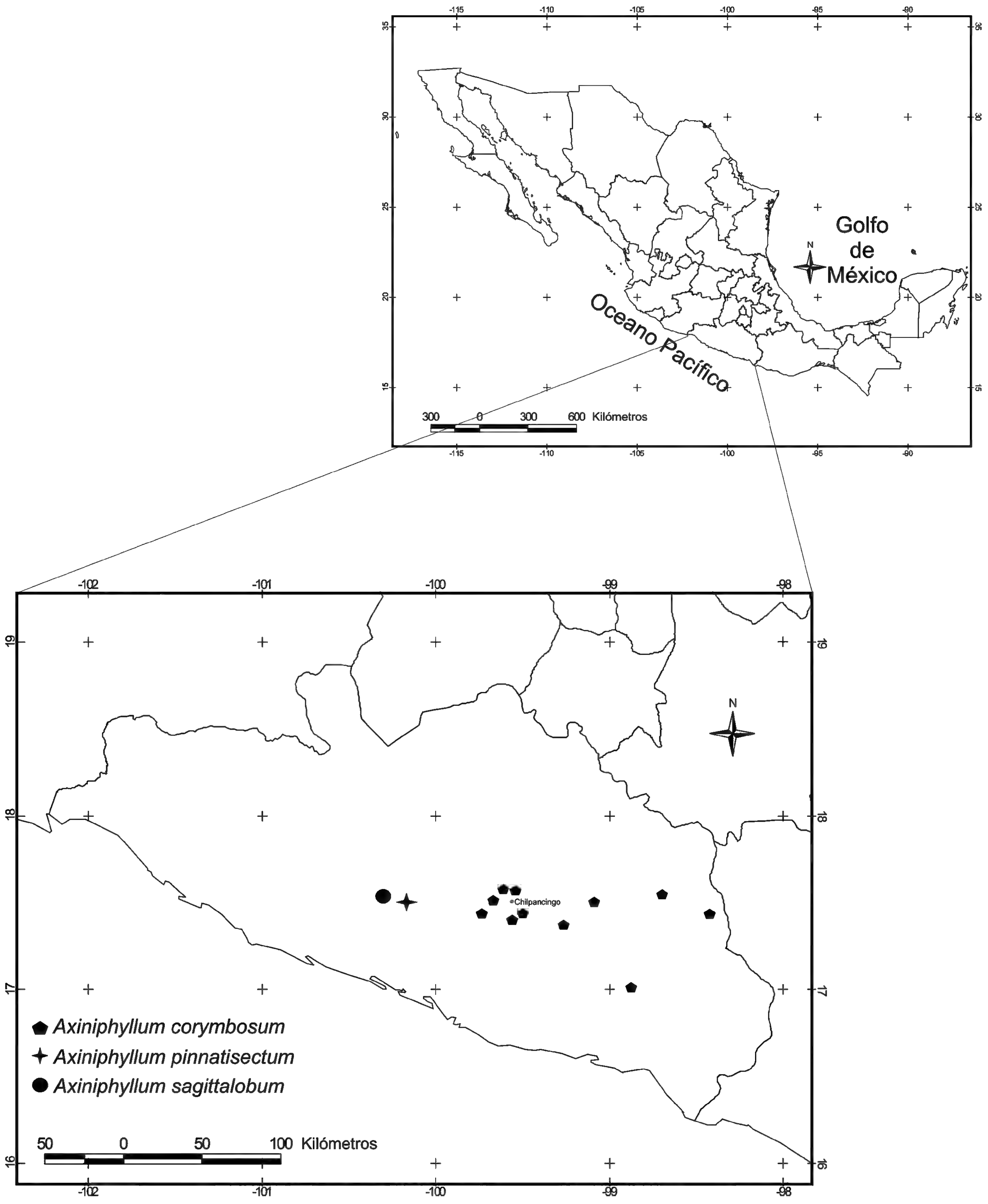

Fig. 1. Distribución del género Axiniphyllum en Guerrero.

Hierbas perennes erectas, de 0.5 a 1.5 m alto; rizoma fibroso tipo cormo; tallo rojizo, piloso en la base volviéndose glabro, 1.5–3.6 mm diam.; hojas opuestas, en ocasiones concentrándose en la parte basal formando un tipo de roseta, triangulares, sagitadas o sagitadas tripartitas, 2.7–16 cm longitud, 3–9.1 cm ancho; haz con pubescencia pilosa de tricomas multicelulares septados uniseriados, en ocasiones mezclados con glandulares en toda la superficie; envés con pubescencia pilosa de tricomas multicelulares septados uniseriados o glandulares principalmente a lo largo de las venas; lámina entera, trilobulada o pentalobulada, márgenes enteros, aserrados o lobados a veces ligeramente revoluto, lóbulo terminal entero, ondulado, lobulado, aserrado o crenado; base sagitada a atenuada decurrente, ápice agudo, nervación acródroma imperfecta basal, con 3 venas de primer orden más una en cada lóbulo; pecíolo alado connado-perfoliado, con pubescencia y tipo de tricomas iguales que en la lámina, 1–9.1 cm longitud. Sinflorescencia politélica, un dicasio, el internodo basal 15–58 cm longitud, pedúnculos 2.1–13.6 cm longitud, glabros o con pubescencia pilosa de tricomas glandulares mezclados con no glandulares multicelulares septados uniseriados, brácteas con las mismas características de las hojas delimitando la sinflorescencia y los paraclados, 3–33 mm longitud, 0.7–15 mm ancho; involucro 4.8–17 mm longitud, 9.4–28 mm ancho; brácteas involucrales imbricadas en 2–3 series, las más externas con margen entero, coriáceas, ápice agudo, pubescencia pilosa de tricomas multicelulares septados uniseriados o glandulares mezclados con no glandulares 4–7.8 mm longitud, 0.5–2.7 mm ancho, las internas 4.2–8.8 mm longitud, 0.5–2.1 mm ancho, papiráceas, ápice agudo, amarillentas. Flores radiadas presentes o ausentes, cuando están presentes 5–8, pistiladas y fértiles, amarillo pálido, lígulas 3-lobadas en el ápice, 7–12 mm longitud, 3–6 mm ancho, tubo densamente pubescente piloso, 0.8–3 mm longitud, 0.4–2 mm ancho, ramas del estilo amarillas, glabras, apéndices agudos, ca. 1.1 mm longitud. Aquenios negros, glabros, 4-costillas, cuadrangulares, 1.5–2 mm longitud, 0.9 mm ancho. Flores del disco hermafroditas, fértiles, amarillas, 5-lobuladas, 1.5–7 mm longitud, 0.4–2.3 mm ancho, pubescencia pilosa en toda la superficie concentrándose en la base del tubo, tubo 0.2–2.1 mm longitud, limbo 2.3–5.1 mm longitud, lóbulos 0.2–1.3 mm longitud, ápice agudo. Anteras amarillas, 1.6–4.9 mm longitud, glabras, base truncada, ápices del estilo apendiculado; ramas del estilo amarillo ocre, 0.5–5.3 mm longitud, pilosas en la superficie exterior comenzando desde un poco debajo de la bifurcación, con tricomas unicelulares, apéndices del estilo agudos. Aquenios glabros, negros, epaposos, 4-costillas, 1.1–3.3 mm longitud, 0.3–1.4 mm ancho, cuadrangulares.

CLAVE PARA LAS ESPECIES DE *AXINIPHYLLUM* EN GUERRERO, MÉXICO

1. Flores radiadas presentes.
   2. Lámina pentalobulada, lóbulo terminal cuando no entero aserrado ____ **A. pinnatisectum**
   2. Lámina entera o trilobulada, lóbulo terminal cuando no entero crenulado ____ **A. sagittalobum**
1. Flores radiadas ausentes ____ **A. corymbosum**

1. Axiniphyllum corymbosum Benth., Hooker's Icon. Pl. 12:17. 1872. Tipo: MÉXICO. Oaxaca: "woods in the province of Oaxaca, at an elevation of 7500 ft," Sep 1840, *H. Galeotti 2089* (holotipo: K; foto en MEXU!).

Hierba de 0.55–0.85 m alto; tallo 1.6–3.4 mm diám.; hojas triangulares en ocasiones formando una roseta basal, 2.7–8.5 cm longitud, 3.5–9.1 cm ancho; lámina entera a ligeramente trilobulada, margen entero a aserrado, lóbulo terminal aserrado o entero; pecíolos 1–8.1 cm longitud. Internodo basal de la sinflorescencia 15–20.5 cm longitud, pedúnculos 2.1–12.1 cm longitud; brácteas 9–33 mm longitud, 1.4–15 mm ancho; involucro 4.8–7.8 mm longitud, 9.4–13.7 mm ancho; brácteas involucrales externas 4.1–7.6 mm longitud, 0.5–2.5 mm ancho, las más internas 4.2–8.6 mm longitud, 0.5–1.7 mm ancho. Flores radiadas ausentes. Flores del disco 4.1–7 mm longitud, 0.4–2.3 mm ancho. Anteras 1.6–3.4 mm longitud; ramas del estilo 0.5–2.3 mm longitud. Aquenios 1.1–2.6 mm longitud, 0.4–1.4 mm ancho.

Distribución y altitud.—bosque de pino-encino de Guerrero y Oaxaca, desde los 1800 hasta 2500 m snm.

Floración.—septiembre a noviembre.

Especímenes examinados: **MEXICO. Municipio de Alcozauca:** "Cerro Azul," 3 km al SO de Alcozauca, Oct 1989, *F.J. Díaz P. SN* (MEXU). Municipio de Atlixtac: km 13 del camino que va de Alzacoalaya a Heuycatenango, 4 Oct 1981, *F.G. Lorea 1680* (MEXU; FCME). **Municipio de Chilapa de Álvarez:** km 70-71 de la carretera Chilpancingo-Chilapa-Tlapa, 13 Oct 1991, *J.L. Panero 2458* (MEXU). **Municipio de Chilpancingo:** Cima del Cerro Alquitrán, 21 Nov 1968, *H. Kruse 2032(b)* (MEXU); aproximadamente 3 km al E de Amojileca, camino Chilpancingo-Omiltemi, 30 Oct 1982, *F.G. Lorea 2628* (MEXU); Mazatlán, falda E del Cerro Alquitrán, 7 Nov 1969, *H. Kruse 2666* (MEXU; ENCB); Mazatlán, falda E del Cerro Alquitrán, 8 Oct 1968, *H. Kruse 2032* (MEXU); near Huapango on road to San Vicente S of Omiltemi, 18 Oct 1984, *D.E. Breedlove 61873* (MEXU); km 70-71 of the road Chilpancingo-Chilapa-Tlapa, across from microwave station (S side) along an intermittent creek approximately 200 m from the road, 7 Nov 1990, *J.L. Panero 2040* (MEXU); Microondas road up Cerro Alquitrán, marked "El Tejocote" on hwy 95 W of Mazatlán, ca. 7.2 km W of hwy 95, 30 Sep 1983, *W.R. Anderson et al. 12905* (MEXU; CHAPA); 3 km antes de Chilpancingo a Omiltepec, *J. Gutiérrez y A. Terán 32* (MEXU; FCME). **Municipio de Quechultenango:** 3 km al S de Quechultenango al O del camino a Tlayolapa, 28 Sep 1982, *A. Nuñez 1101* (MEXU; FCME). **Municipio de San Luis Acatlán:** aproximadamente 1 km al SE de Mixtecolapa, sobre el camino a Tres Cruces-Pascala de Oro, 26 Oct 1989, *F.G. Lorea 4869* (MEXU; FCME).

2. Axiniphyllum pinnatisectum (P.G. Wilson) B.L. Turner, Madroño 25:50. 1978. *Rumfordia pinnatisecta* P.G. Wilson, Kew Bull. 1958. 164. Tipo: MÉXICO. Guerrero: Mina Dist., Agua Zarca-File, pine forest, 30 Nov 1937, *Hinton et al. 11289* (holotipo: K; isotipos: foto en http://www.nybg.org/bsci/hcol/vasc/ NY!; foto en http://ravenel.si.edu/botany/types/jstaxa/typeFrames.cfm US!; foto en http://www.biosci.utexas.edu/prc/databases.html TEX-LL!).

Hierba perenne de 1–1.5 m alto; hojas triangulares 3–16 cm longitud, 5 cm ancho; envés con tricomas glandulares; lámina pentalobulada, margen irregularmente dentado a casi lobado, por lo que Wilson (1958) y Turner (1978) la citan como pinnatilobada, la mitad inferior más angosta, lóbulo terminal aserrado o entero. Internodo basal de la única sinflorescencia visible 20 cm longitud; brácteas 3–10 mm longitud; involucro ca. 10 mm longitud, 20–28 mm ancho; brácteas involucrales externas ca. 4 mm longitud, las más internas no vistas. Flores radiadas 5–8, lígulas ca. 11 mm longitud, 5 mm ancho, tubo piloso ca. 2 mm longitud. Aquenios ca. 2 mm longitud; flores del disco ca. 1.5 mm longitud, el limbo ca. 4 mm longitud. Anteras ca. 4 mm longitud; ramas del estilo ca. 2 mm longitud. Aquenios ca. 2.5 mm longitud, 1.1 mm ancho.

Distribución y altitud.—conocida sólo de los ejemplares tipo provenientes del estado de Guerrero, a los 2300 m snm.

Floración.—octubre a noviembre.

3. Axiniphyllum sagittalobum B.L. Turner, Madroño 25:50. 1978. (**Fig. 2**). Tipo: MÉXICO. Guerrero: Distrito Mina, Municipio de San Miguel Totolapan, Toro Muerto, 2800 m, 30 Oct 1939, *G.B. Hinton et al. 14761* (holotipo: foto en http://www.biosci.utexas/edu/prc/databases.html TEX-LL!; isotipos: MICH, foto en http://www.nybg.org/bsci/hcol/vasc/ NY!; foto en http://ravenel.si.edu/botany/types/jstaxa/typeFrames.cfm US!).

Hierba hasta de 1.5 m alto; diámetro del tallo 1.5–3.6 mm; hojas triangulares, sagitadas, las basales arrosetadas y grises cuando muertas, 4.4–8.3 cm longitud, 3–6.7 cm ancho; lámina entera a trilobulada; margen ligeramente revoluto aserrado cada serración con un mucrón y una glándula apical color pardo claro, lóbulo terminal crenulado; pecíolos 4.7–9.1 cm longitud. Pedúnculos 3–13.6 cm longitud; brácteas 4.1–9.4 mm longitud, 0.7–4 mm ancho; involucro 9–17 mm longitud, 11–17 mm ancho; brácteas involucrales externas 6.3–7.8 mm longitud, 0.9–2.7 mm ancho, las internas 6.1–8.8 mm longitud, 1.4–2.1 mm ancho. Flores radiadas presentes, lígulas 8, tubo ca. 0.4 mm ancho. Aquenios ca. 1.5 mm longitud. Flores del disco 4.9–6.8 mm longitud, 0.9–1.3 mm ancho, el tubo 1.1–2.1 mm longitud, el limbo 3.8–4.7 mm longitud, los lóbulos 0.8–1.1 mm longitud. Anteras 4.5–4.9 mm longitud; ramas del estilo 4.5–5.3 mm longitud. Aquenios 2.7–3.3 mm longitud, 0.3–0.7 mm ancho.

Distribución y altitud.—endémica del noreste de Guerrero, en bosque de pino, 2800 m snm.

Floración.—octubre a noviembre.

Especímenes examinados adicionales: **MEXICO. Municipio de San Miguel Totolapan:** Toro Muerto, 200 m después del aserradero, camino a Puerto del Gallo, 24 Oct 2005, *A. González-Zamora et al. 117* (MEXU; FCME; UAGC; TEX-LL; NY).

El conocimiento florístico de las plantas mexicanas, en especial de las especies endémicas y amenazadas, siempre ha sido considerado como importante para los planes de conservación de su diversidad biológica. Turner & Nesom (1998) calculan que 31% de las especies mexicanas de Asteraceae presentan áreas de distribución restringidas, por lo que muchas de ellas pueden considerarse amenazadas. Tal es el caso de *Axiniphyllum*, el cual no ha sido objeto de una evaluación del riesgo por las instancias adecuadas, lo cual puede constatarse ya que no está listada dentro de la Norma Oficial Mexicana vigente (NOM-054-ECOL-2001) y menos aún dentro de las listas rojas de especies amenazadas de la IUCN (2006). Las especies de este género están pobremente representadas en los herbarios porque sus poblaciones son muy pequeñas. El trabajo de campo permitió observar el deterioro y la destrucción del hábitat donde viven estas especies (bosques de

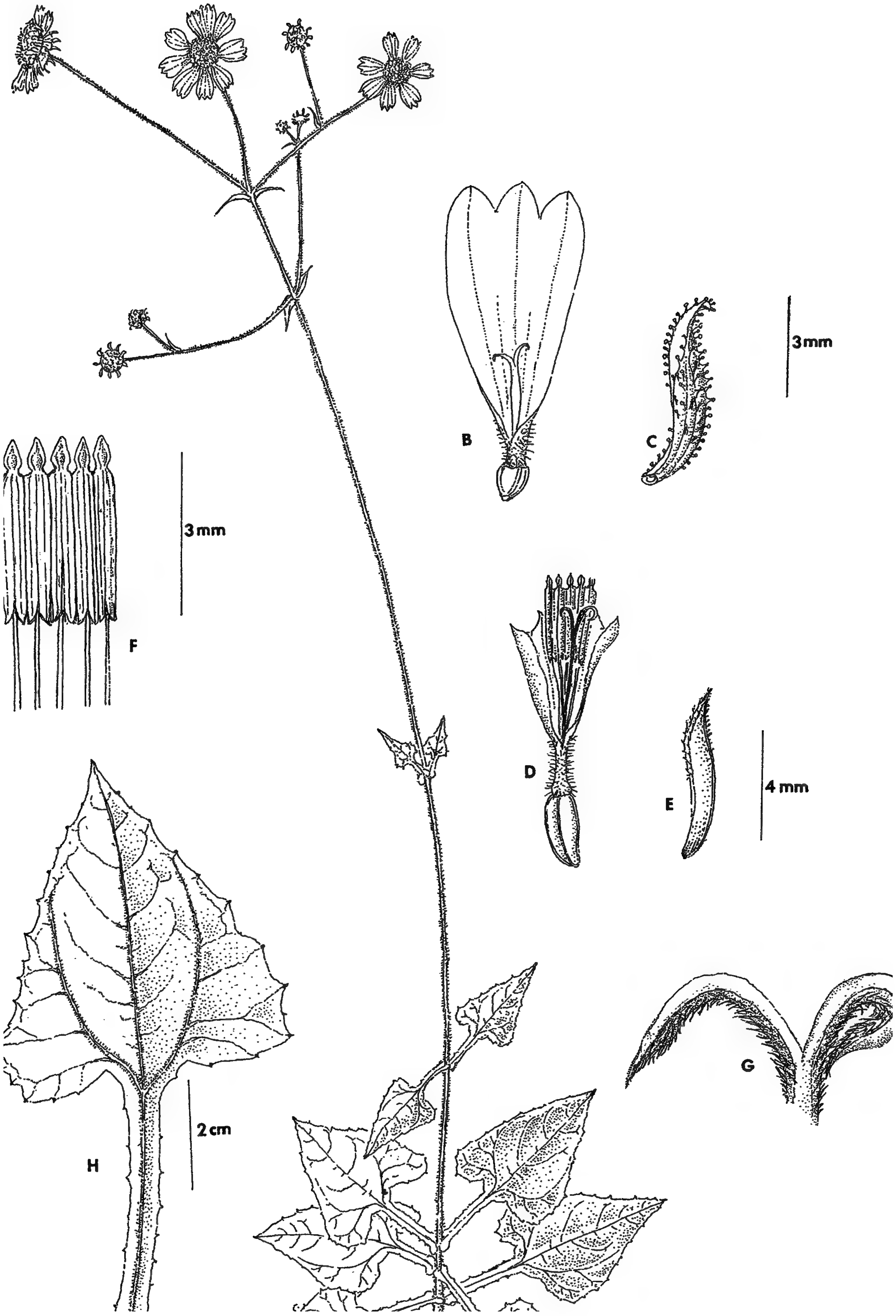

Fig. 2. *Axiniphyllum sagittalobum* Benth. A. Aspecto general de la planta; B. Flor radiada; C. Bráctea involucral externa; D. Flor del disco; E. Bráctea involucral interna; F. Estambres; G. Ramas del estilo de las flores del disco; H. Hoja madura (*de González-Zamora et al. 117*, MEXU, FCME, UAGC, TEX-LL, NY).

pino), lo cual permite asegurar que al menos dos de las especies reportadas para el estado de Guerrero se encuentran en peligro de desaparecer a corto y mediano plazo si siguen operando los factores que inciden desfavorablemente en su supervivencia. Es urgente que un estado tan rico en diversidad biológica establezca zonas de protección que tomen en cuenta la rareza de la flora en estas regiones de difícil acceso. El caso de *A. pinnatisecta* merece atención inmediata, ya que después de casi 70 años de haberse colectado los dos únicos ejemplares existentes, el tipo de vegetación donde habita parece haber desaparecido por completo (bosques de *Pinus herrerai* Martínez, *P. ayacahuite* Schltdl. var. *ayacahuite* y *P. douglasiana* Martínez) y si en un futuro cercano no se vuelve a colectar deberá considerarse como una especie extinta más, por lo que se sugiere emprender recolectas de campo para buscar esta especie con detenimiento. Ambas especies deben incluirse dentro de la Norma Oficial Mexicana vigente (NOM-059-ECOL-2001) y en las listas rojas de la IUCN (2006) y deben emprenderse estudios demográficos de *A. sagittalobum*.

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INVENTORY AND DISTRIBUTION OF *AGAVE* (AGAVACEAE) SPECIES IN JALISCO, MEXICO

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ABSTRACT

In order to review and update the list of *Agave* species previously reported for Jalisco, Mexico, an extensive botanical exploration was done throughout representative areas of the state. Twenty-three species were registered; from which 7 represent new records for Jalisco, and 3 proposed as new species. Fifty per cent of the listed species were found in pine and pine-oak forests, whereas 29% were found in the tropical deciduous forest. Among the many factors that might affect the distribution of agaves, edaphic factors and moreover physiography, can play an important role.

RESUMEN

Con la finalidad de hacer una revisión y actualizar el listado de especies de *Agave* previamente reportadas para Jalisco, se realizó una extensa exploración botánica por el estado. Se registraron 23 especies, de las cuales 7 representan nuevos registros para Jalisco y 3 se proponen como nuevas especies. El cincuenta por ciento de las especies enlistadas se encontró en los bosques de pino y pino-encino, mientras que el 29% prospera en bosque tropical caducifolio. Entre los diversos factores que pueden afectar la distribución de los agaves, se plantea que los edáficos y en especial la fisiografía pueden jugar un papel importante.

INTRODUCTION

In Mexico, the genus *Agave* L. is of great importance since many of its species are used for food, in the manufacture of fibers for threads and textile industry, as ornamental plants, and mainly in the production of different types of alcoholic beverages such as tequila and mezcal (Gentry 1982; Valenzuela 1997; Nobel 1998.). This genus comprehends more than 200 species, from which 75% are in Mexico, which is considered as the center of origin (Granick 1944; García-Mendoza 2002).

In Jalisco, the study of the genus *Agave* has focused basically on *Agave tequilana* Weber var. *azul*. Because of its importance as the only species allowed by the Official Mexican Standard for tequila production, the alcoholic beverage traditionally associated with Mexico, and in particular Jalisco (Cedeño 1995; DOF 1997). In contrast, the study of other non-cultivated agaves many of which are useful species that occur throughout the State, has been neglected.

For Jalisco, Gentry (1982) reports 14 species, whereas McVaugh (1989) reports 18, considering some of them as "doubtful" and "excluded" due to the lack of herbarium specimens and information about wild populations. Thus, based on our collections, the aim of this study was to update the list of species, corroborate in the field McVaugh and Gentry's reports, and contribute to the knowledge of *Agave* species distribution in Jalisco.

Site Description

Located in the western region of Mexico, Jalisco is one of the largest states consisting of 80,000 Km^2 and 4 physiographic provinces: a) Western Sierra Madre, in the northern part of the state, b) Central Plateau, northeast region, c) Trans-Volcanic Belt (Eje Neo-volcanico), central region of the state, and d) Southern Sierra Madre, southwest region (INEGI 2003). Igneous rock soils constitute 79% of its surface, which is favored by several vegetation types, such as conifer and oak forests, tropical subdeciduous forest, tropical deciduous

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forest, tropical savanna, gallery forest, alpine tundra, thorn forest, and cloud forest. The topography ranges from 0–4360 m above sea level (INEGI 2003). All of these geographical and geological characteristics contribute to its floristic diversity, which is estimated to be 7000 plant species (Cházaro & Lomelí 1995).

MATERIALS AND METHODS

Twenty field trips were carried out throughout representative areas of the state of Jalisco in 2002 and 2003. Identification of the species was done according to Gentry's (1982) and McVaugh's (1989) descriptions and/or taxonomic keys. Vegetation types were registered as well as altitude and geographical coordinates by means of a global positioning system (GPS *Magellan 320*). Plants were collected and documented for herbarium specimens deposited at IBUG and IEB herbaria.

RESULTS AND DISCUSSION

Out of 102 collected specimens 23 species were identified, from which seven of them represented new records for the state and three were treated as new species (Table 1). Description of the species *Agave* sp. nov. ined. ("Colimilla" ravine) and *Agave* sp. nov. ined. (Tequila municipality) are in preparation, whereas *Agave vazquezgarciae* is in press (Cházaro et al. in press).

From Gentry's (1982) and McVaugh's (1989) reports, *Agave stringens* Trel., *A. hookeri* Jacobi, *A. cantala* Roxb., *A. impressa* Gentry and *A. longisepala* Todaro, were not located. *A. stringens* was reported by Gentry based on a Trelease collection in Rio Blanco (Zapopan municipality) (Gentry 1982). At the cited location we only found *A. guadalajarana* Trel., (Fig. 1), however according to the vegetation type and Trelease original plant description (Trelease 1920), we assume *A. stringens* could be a form of *A. angustifolia* Haw.

McVaugh (1989) cites a Diguet`s collection for *A. hookeri* from Cerro Viejo (Tlajomulco and Jocotepec municipalities). It is likely that Diguet identified incorrectly the specimen, since the only species found there, was the closely related *A. inaequidens* Koch which spreads throughout the oak and pine-oak forests in the "Sierra del Tigre" (Fig. 2). Gentry (1982) reported a collection for *A. hookeri* south of Jalisco near Jiquilpan (Michoacan state); it appears this species has been introduced from Michoacan state as a cultivar.

With regard to *Agave cantala*, we could not find it near Villa Guerrero as reported by Gentry (1982) who was unsure about the identification of the plant he collected. Perhaps this is a species related to *A. tequilana* Weber, as suggested by Trelease (1920) and Valenzuela and Nabhan (2003), who treat it as a synonym of *A. vivipara* L. *Agave impressa* was not found in the "Sierra de los Huicholes" (Bolaños) as Gentry was informed (Gentry 1982). Probably there was confusion with the common name since he was given the name "masparillo" for this agave in the type locality (Escuinapa, Sinaloa); the same name is used for *A. maximiliana* Baker, abundant in the "Sierra de los Huicholes". For *A. longisepala*, McVaugh (1989) concluded there was uncertainty about its identity and taxonomic position, and Gentry (1982) knew the species only from an illustration. This could be a synonymous for *A. tequilana* since Trelease (1920) reported it as a related species cultivated near Tequila, Jalisco.

Whereas *Agave americana* L. var. expansa (Jacobi) Gentry and *A. tequilana* were found as cultivated species, *A. salmiana* Otto ex Salm, ssp. crassispina (Trel.) Gentry, was found as wild populations in northeast Jalisco (Sierra Cuatralba) (Fig. 3). McVaugh (1989) had reported it as a cultivated species. Considered by Gentry (1982) as a relatively rare species, *A. attenuata* Salm-Dyck was found in "Rincón de Manantlán," south of Jalisco (Fig. 2). We could corroborate the presence of large stems in this species, clearing the uncertainty about this agave's feature reported by McVaugh (1989) (Fig. 4).

The higher number of species was found in the pine and pine-oak forests, being the tropical deciduous forest the second one in harboring the highest diversity (Fig. 5). Hence, the distribution of *Agave* species based on physiographic provinces shows that they are mainly concentrated in southern Sierra Madre and Trans-Volcanic Belt (Eje Neovolcanico), which are two areas whose main vegetation types are tropical deciduous forest and pine and pine-oak forests, respectively (Figs. 1–3, 6).

These results are similar to those presented by García-Mendoza (2002) who reports that in Mexico,

TABLE 1. *Agave* species in Jalisco, México. New record for Jalisco §. New species ¤.

Group	**Species**
Rigidae	*Agave angustifolia* Haw.
	§ *Agave rhodacantha* Trel.
	Agave tequilana Weber
Crenatae	*Agave inaequidens* Koch.
	Agave maximiliana Baker
Marmoratae	*Agave gypsophila* Gentry
	Agave valenciana Cházaro & A. Vazquez,
Parryanae	*Agave guadalajarana* Trel.
	§ *Agave parryi* Engelm.
Ditepalae	§ *Agave wocomahi* Gentry
Salmianae	§ *Agave salmiana* Otto ex Salm-Dyck
Total for subgenus *Agave*	11
Amolae	*Agave pedunculifera* Trel.
	Agave attenuata Salm-Dyck
	Agave vilmoriniana Berger
	¤ *Agave vazquezgarciae* Cházaro, Valencia & Lomelí, sp. nov.
Filiferae	*Agave colimana* Gentry
	Agave schidigera (Lem.) (sensu Gentry)
	§ *Agave filifera* Salm-Dyck (sensu Gentry)
	§ *Agave geminiflora* (Tagl.) Ker-Gawler
Marginatae	§ *Agave angustiarum* Trel.
	¤*Agave* sp. nov. ined. ("Colimilla" ravine, municipalities of Tonalá and Zapotlanejo)
	¤ *Agave* sp. nov. ined. (municipality of Tequila)
Striatae	*Agave rzedowskiana* P. Carrillo, R. Vega & R. Delgad.
Total for subgenus *Littaea*	**12**
Total species	**23**

tropical deciduous forests and coniferous and oak forests are among the vegetation types with the highest number of *Agave* species, only surpassed by deserts and chaparrales. Nevertheless, it was found that several species are not exclusive or restricted to a certain vegetation type since they can either thrive in two or more types or can be found in ecotones (Table 2). Soil characteristics can play an important role in the distribution of agaves as has been suggested by Nobel & Berry (1985), who conclude that although soil types have not been systematically related to the distribution of agaves, edaphic factors may affect their seedling establishment. In this study, the two physiographic provinces with the highest number of *Agave* species (Southern Sierra Madre and Neo-Volcanic Belt) are conformed mainly by igneous rocks, a soil type previously reported as favored by these plants (Álvarez de Zayas 1989; García-Mendoza 2002).

Agave angustifolia Haw., *A. schidigera* Lem. (sensu Gentry) and *A. maximiliana* Baker, were the most widely distributed species, thriving in many different vegetation types in a broad range of altitudes and latitudes throughout the state (Table 2; Figs. 1, 3 & 6). This could reflect their ample tolerance limits to each of the several environmental factors, based on high levels of genetic diversity as reported for *A. angustifolia* (Colunga-GarcíaMarín et al. 1999). In contrast, *A. gypsophyla* Gentry and *A. geminiflora* (Tagl.) Ker-Gawler, were found in small areas associated to specific geographical and ecological conditions such as soil type and vegetation. Only a small population of *A. geminiflora* was observed, thriving in an oak woodland along a rocky brook 1814 m above sea level, in the central region of Jalisco (municipality of Tequila). In the other hand, *A. gypsophyla* could be found only in rocky gypsum soils (whence the name) south of the state, municipality of Pihuamo (Fig. 2).

Agaves in the subgenus *Agave* were found likely to thrive in flatlands, whereas agaves in the subgenus

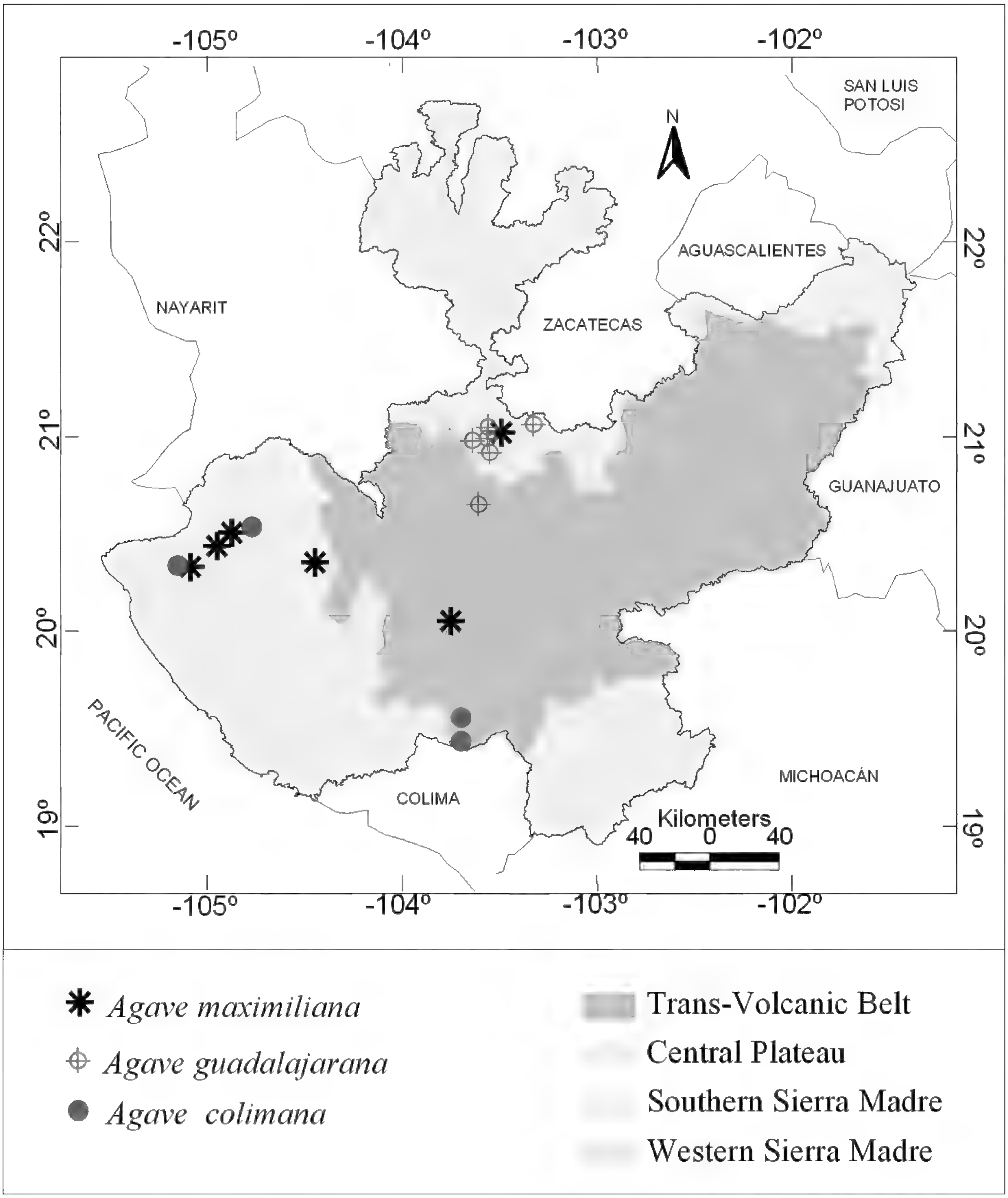

Fig. 1. Distribution of *Agave maximiliana, A. guadalajarana,* and *A. colimana.*

Littaea, appear to grow mainly in sharp rocky cliffs (66% of this subgenus specimens were found exclusively in this habitat). Gentry (1982), suggests that the subgenus *Littaea* could represent the phylogenetic and geologically older form of agaves, predominantly diploid with more "primitive" leaf and habit characteristics (Granick 1944). Hence, thriving in sharp rocky slopes could represent a "primitive" growth habit, relying more on their toxic substances in the leaves and inaccessible cliff sites for survival than on defensive armor. Most in the subgenus *Littaea*, lacked of marginal spines or "teeth," or if present, they were fragile and brittle

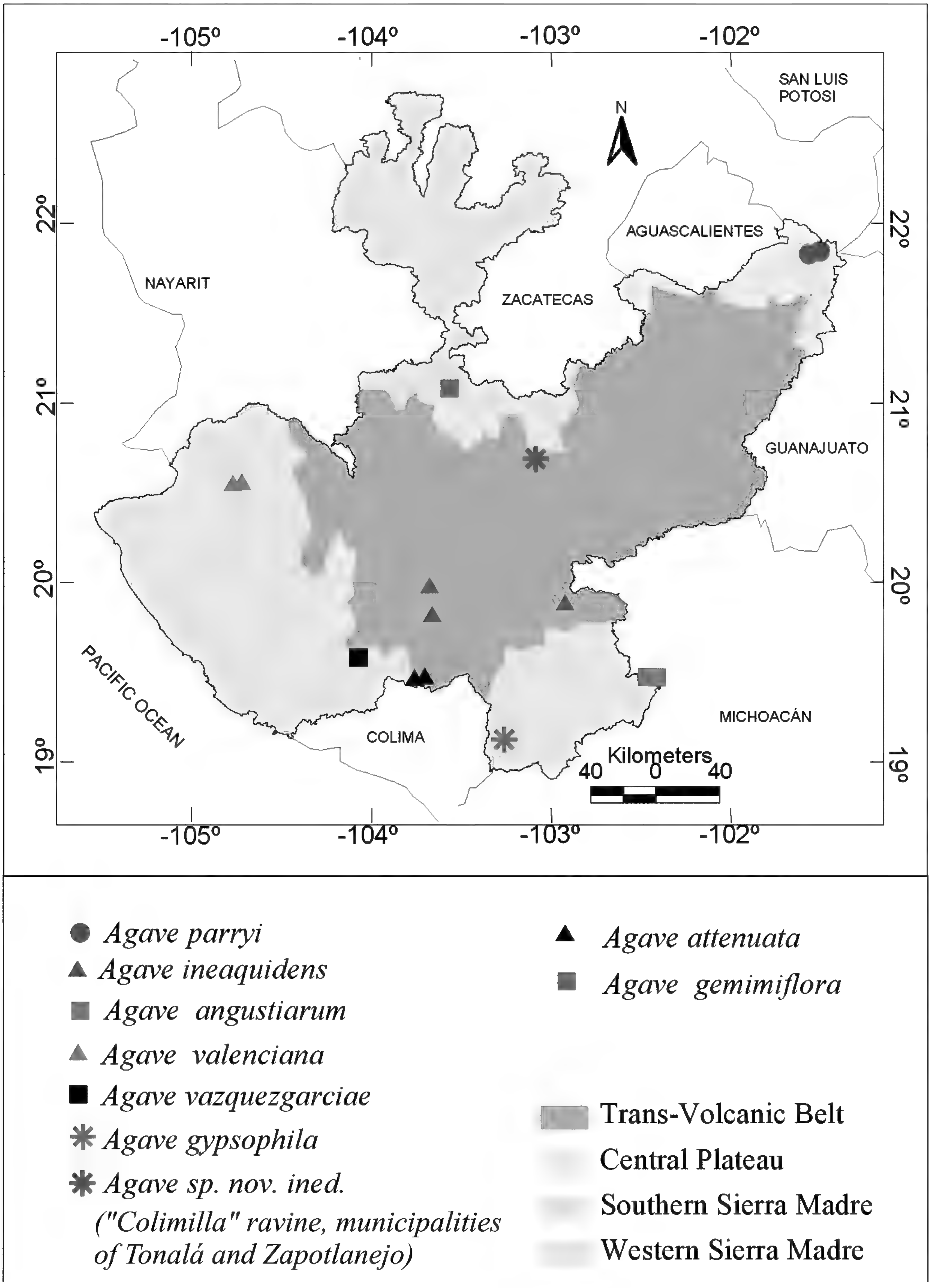

Fig. 2. Distribution of *Agave parryi, A. inaequidens, A. angustiarum, A. valenciana, A. vazquezgarciae, A. gypsophila, A. attenuata, A. geminiflora,* and *Agave* sp. nov. ined. ("Colimilla" ravine).

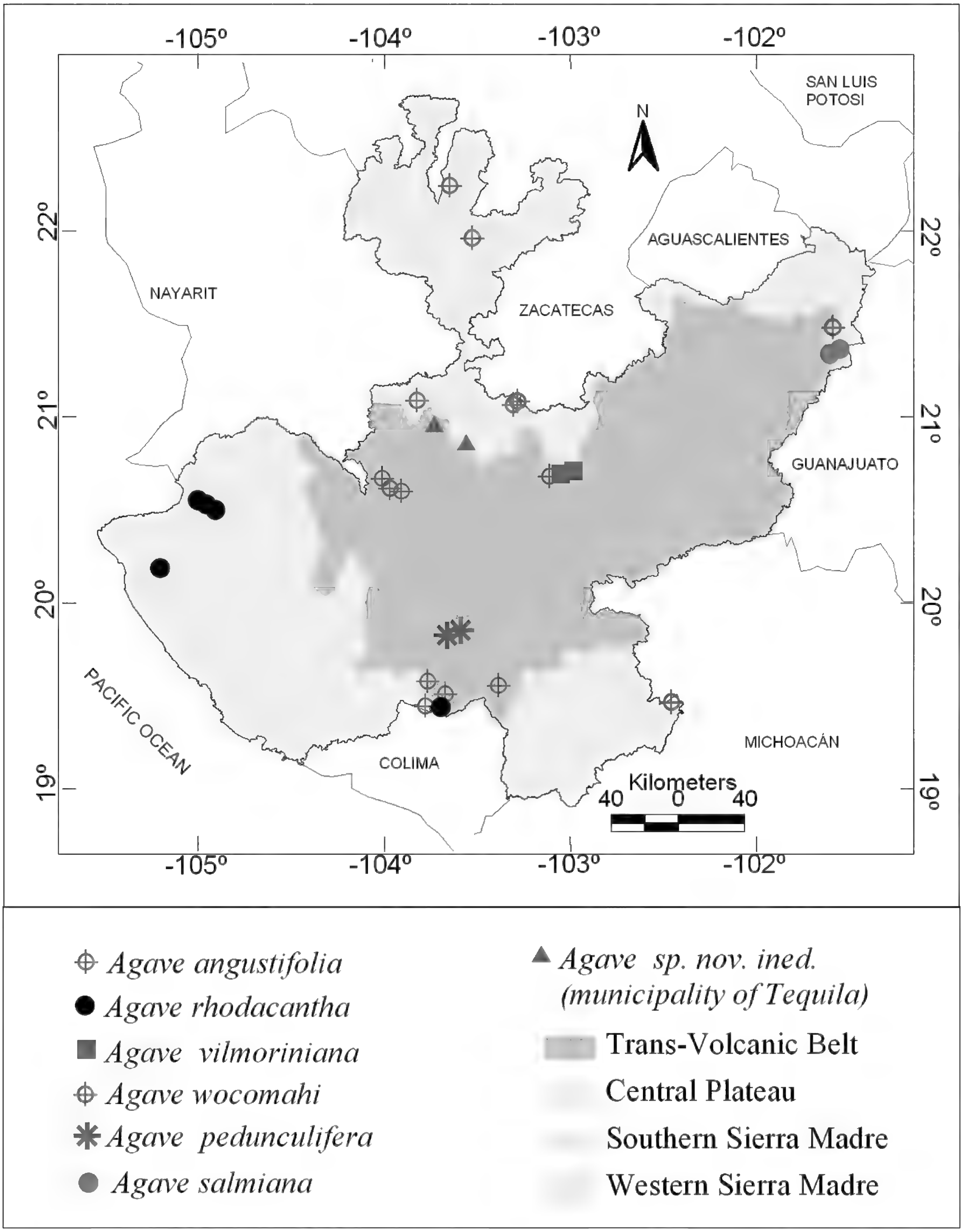

Fig. 3. Distribution of *Agave angustifolia, A. rhodacantha, A. vilmoriniana, A. wocomahi, A. pedunculifera, A. salmiana,* and *Agave* sp. nov. ined. (municipality of Tequila).

Fig. 4. *Agave attenuata* thriving in rocky cliffs at 1 700 m above sea level in Sierra de Manantlán south of Jalisco. The arrows show the long stems developed by this species. Photo: Piet Van der Meer.

based on collected specimens. As suggested by Gentry (1982), the ecological importance of these cliff-dwelling species appears to be their contribution to soil building and soil-holding capabilities on the steep rocky slopes.

Richness and Conservation Status

With 23 species of *Agave* known so far as wild plants, Jalisco state stands second place in agaves diversity in Mexico, only surpassed by Oaxaca state where García-Mendoza (2004) reported 30 species. We believe 2 more species could be present in Jalisco, namely *Agave durangensis* Gentry and *Agave striata* Zucc. The first one in Huejuquilla region, since we have collected it in the adjacent Valparaiso municipality in Zacatecas state, whereas *Agave striata* has been seen and photographed at Sierra del Laurel (Esperanza Quezada, pers. comm.), a mountainous range at Calvillo municipality in Aguascalientes state. The eastern slopes of these mountains belong to Jalisco; hence, we predict it occurs at Sierra del Laurel in the Jaliscan side, a region which has remained unexplored. On the other hand, the botanist Pablo Carrillo recently found *Agave ornithobroma* (pers. comm.) in Mezquitic municipality, into de Huichol indians region north of Jalisco. Further explorations in the zone will be necessary.

The geographic distribution of *Agave* species in Jalisco is uneven; some cover an ample range, such as the *Agave angustifolia* complex, whereas others like *A. valenciana, Agave* sp. nov. ined. (Municipality of Tequila), *A. vazquezgarciae,* and *A. geminiflora* are endemic to small areas. Among the 18 *Agave* species in Mexico that are considered within some status of protection by the Federal Government (DOF 1994), only *A. gypsophyla* and *A. ornithobroma* occur in our study area; however with the data gathered so far, we consider

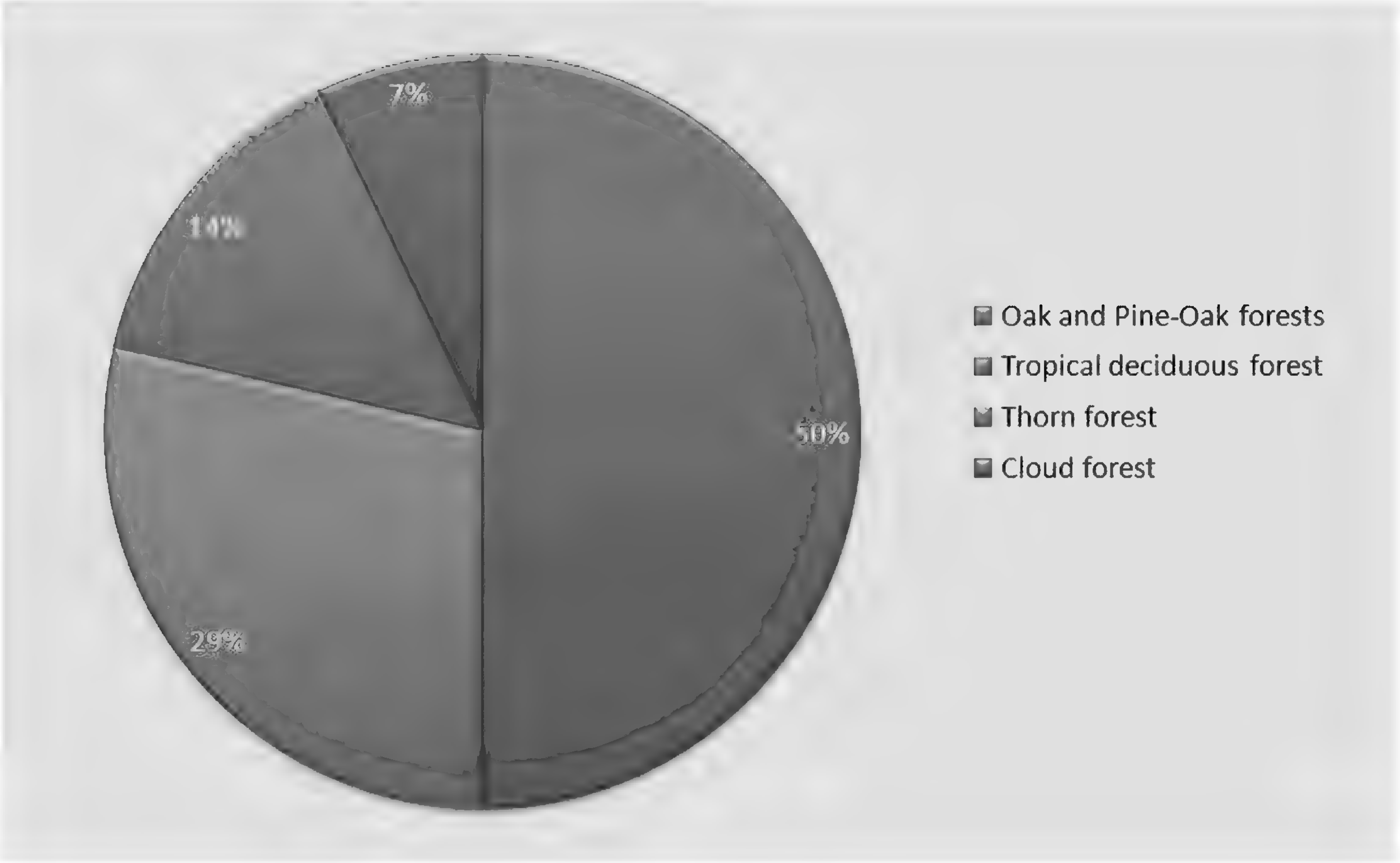

Fig. 5. Percentage of *Agave* species by vegetation type in Jalisco, Mexico.

the following taxa should be added to the list (the first three of them endemic to Jalisco): a) *Agave valenciana*, restricted to small areas of the Mascota river canyon and the Talpa river, b) *Agave* sp. nov. ined., restricted to the Santiago river basin ravines next to Tequila, c) *A. vazquezgarciae*, from Sierras Manantlán and Cacoma, and d) *A. geminiflora*, previously known only from the type locality (Ocotillo, Nayarit); we found it near "El Salvador," municipality of Tequila.

CONCLUSIONS

A thorough botanical exploration of Jalisco resulted in the corroboration and update of previous reports of *Agave* species in the state. The great diversity of *Agave* species in Jalisco is related to the geographical and geological characteristics of the state. To the authors' knowledge, this is the first extensive botanical exploration of *Agave* species in Jalisco. Documented specimens with exact geographical coordinates will provide a reliable source of information on these plants for further research. We consider that basic botanical research is essential as a preliminary step for a better understanding and rational management of plants and thus, habitat.

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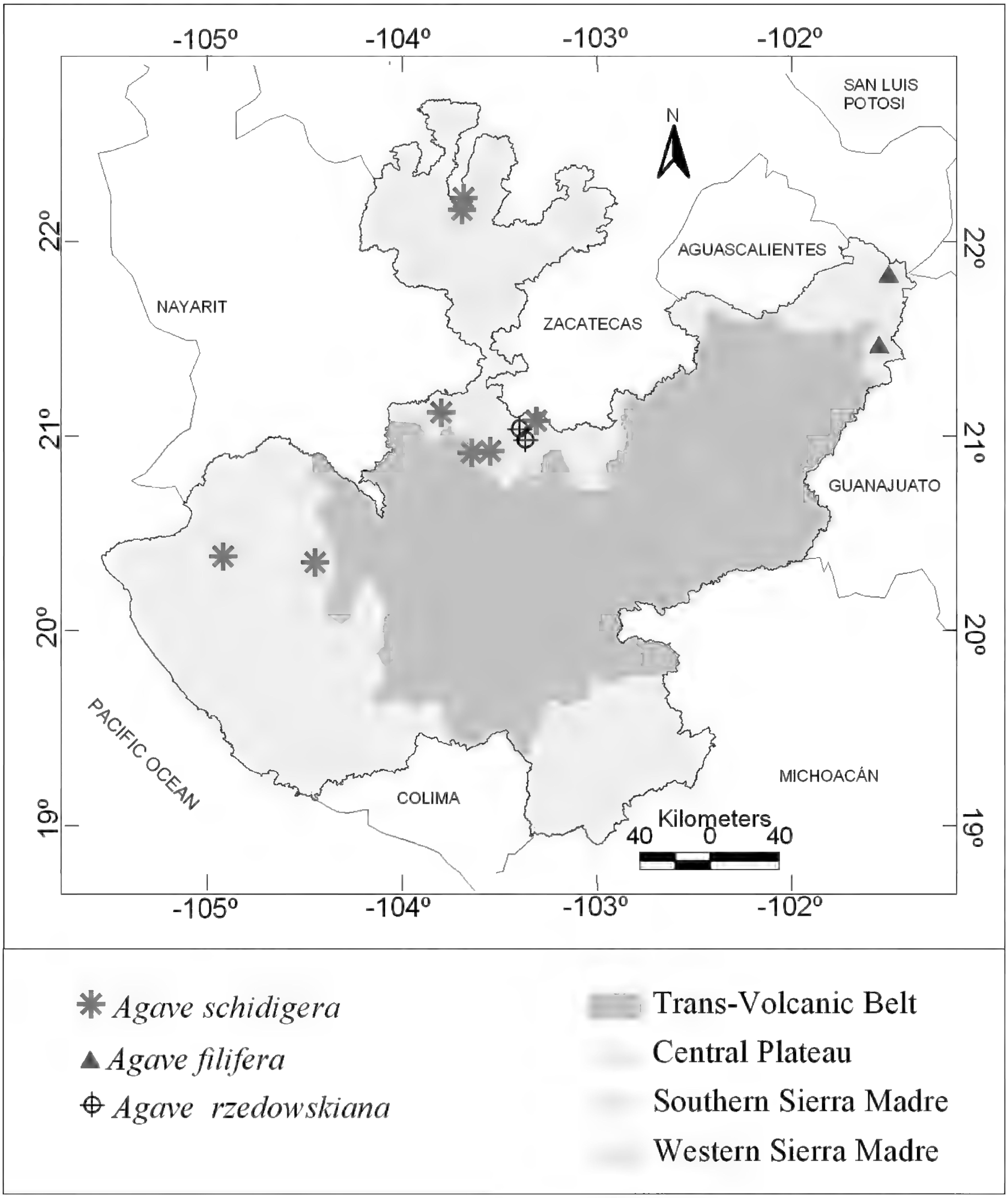

Fig. 6. Distribution of *Agave schidigera, A. filifera, and A. rzedowskiana.*

Carrillo-Reyes, P., R. Vega Aviña, and R. Ramírez-Delgadillo. 2003. *Agave rzedowskiana*, a new species in subgenus Littaea (Agavaceae) from western Mexico. Brittonia 55:240–244.

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Table 2. Ecological distribution of *Agave* in Jalisco, Mexico.

Species	**Vegetation Type**	**Altitude (m above sea level)**
Agave angustifolia	Tropical deciduous forest/Pine-oak forest and the ecotone from both/Thorn forest/	707–1,845
Agave rhodacantha	Oak forest/Tropical deciduous and subdeciduous forests/Ecotone oak forest–Tropical subdeciduos forest	250–1,133
Agave tequilana var. *azul*	Only cultivated	
Agave inaequidens	Oak and pine-oak forests	1,910–2,319
Agave maximiliana	Oak and pine-oak forests/Ecotone oak forest–Tropical deciduous forest	1,086–1,987
Agave gypsophila	Tropical deciduous forest	590–600
Agave valenciana	Ecotone oak forest–Tropical deciduous forest	1,182
Agave guadalajarana	Oak forest and ecotone with Tropical deciduous forest	1,689–1,850
Agave parryi	Thorn forest, *Yucca* sp. forest	2,364
Agave wocomahi	Thorn forest	1,975
Agave salmiana	Oak forest	2,532
Agave pedunculifera	Oak forest	1,910
Agave attenuata	Ecotone oak forest–Tropical deciduous forest	1,699
Agave vilmoriniana	Tropical deciduous forest	1,275
Agave vazquezgarciae, sp. nov.	Ecotone oak forest–cloud forest	1,613
Agave colimana	Tropical deciduous forest/Oak forest/ Ecotone pine-oak forest–cloud forest	801–1,167
Agave schidigera	Oak and pine-oak forests/Tropical deciduous forest/Ecotone oak forest–Tropical deciduous forest	875–2,178
Agave filifera	Thorn forest/*Yucca* forest/ Oak-Juniperus forest	2,341–2,450
Agave geminiflora	Oak forest	1,814
Agave angustiarum	Oak forest/Tropical deciduous forest	914–979
Agave sp. nov. ined. ("Colimilla" ravine, municipalities of Tonalá and Zapotlanejo)	Tropical deciduous forest	1,270-1,300
Agave sp. nov. ined. (municipality of Tequila)	Tropical deciduous forest	1,055–1,531
Agave rzedowskiana P. Carrillo, R. Vega & R. Delgad.	Oak forest	1,689

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BOOK REVIEWS

Richard Wilford. 2006. **Tulips: Species and Hybrids for the gardener.** (ISBN 13: 978-0-88192-763-4, hbk.). Timber Press Inc, 133 S.W. Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, mail@timberpress.com, 503-227-2878, 1-800-327-5680, 503-227-3070 fax). $34.95, 211 pp., 103 color photos, 2 b/w illustrations, 2 maps, 6¼" × 9¼".

Windmills, Dutch girl with a white hat over her blond pigtails, a blue skirt, wooden shoes and TULIPS! Children's flower drawings often depict a cup shaped single flower on a straight stem with two long thin leaves—a tulip, the well known flower from the Netherlands? Hybrid tulips are the ones most of us know and love for springtime gardens and Easter gift giving.

The author, Richard Wilford, currently the Collections Manager at the Royal Botanic Gardens, Kew, responsible for alpines, bulbs and herbaceous perennials, introduces the reader to many *species* tulips.

Chapters include geography, the tulip plant, cultivation, history and classification and species descriptions. The subject of each chapter is thoroughly discussed leaving very little to the imagination.

Tulips are found growing in the wild on three continents—Asia, Europe and Africa. By trying to replicate the conditions found where the species are growing in the wild, gardeners in many parts of the world can have success with tulips. The ideal climactic conditions can be as diverse as the species. An environment that has cold winters, wet springs and dry summers is ideal for good bulb growth and flower production.

Tulip species are found from western Himalaya through the Caucasus Mountains, Iran, and Turkey and as far as the Iberian Peninsula. They are found in southern Siberia, west to Crete and northern Africa. They were introduced to Europe in the sixteenth century and their cultivation began among gardeners and botanists. Some tulips were scattered accidentally and readily became naturalized in areas where they are now erroneously considered natives.

The tulip plant characteristics are fully described by the author. The differences in the species flowers, leaves, and bulbs provide ongoing discussion among botanists as well as the naming and renaming of various plants. There is still confusion in the genus/species names.

Mr. Wilford mentions many botanists who were interested in classifying and describing the tulip—starting with Linnaeus. Swiss, French, German and Russian botanists—de Candolle, Reboule, Koch and Regel were involved in naming the species.

Cultivation—by bulbs and seeds is described by the author in great detail—from the types of pot and soil, to the watering and temperature best for growing tulips. Mr. Wilford considers planting the bulbs and/or seeds in pots as his preferred method. As the plants bloom and then go dormant, the pots are easily transported in the garden. Depending on you particular climate, watering is a constant concern. Too much water can cause soggy soil and rotting bulbs, too little water does not provide the moisture necessary to make new bulbs. Good drainage is essential for tulips. After you have read the chapter on cultivation, you will be an expert. Your neighbors will be astounded and envious!

In the chapter on species descriptions, Mr. Wilford provides a plethora of species descriptions with beautiful color photographs. You will be amazed at the variations in flower shapes and colors.

The garden hybrid tulips were bred in Persia and Turkey in the fifteenth and sixteenth centuries. In the past 400 years, Holland has made a made a name for itself in the hybridizing and purveying of tulips (bulbs and plants).

Tulips: species and hybrids for the gardener is a text full of information, for botanical explanation, exploration and practical gardening—and is a visual delight.—*Ann Schrader, Herbarium Volunteer, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

Celestine L. Duncan and Janet K. Clark (eds.). 2005. **Invasive Plants of Range and Wildlands and Their Environmental, Economic, and Societal Impacts.** ISBN 1-891276-42-5, pbk.). Weed Science Society of America, http://www.wssa.net/. (**Orders:** Weed Science Society of America, 810 10th Street, Lawrence, KS 66044-8897, U.S.A.). $20.00, 222 pp., illustrated, 6" × 9".

This study assesses the economic and environmental losses caused by invasive plants on range and wildlife areas. The authors have focused on 16 key plants in the contiguous 48 states and estimate the current area infested by them. Fourteen of the species occur on range, pasture, or open woodland habitats while two occur in riparian or wetland habitats.

The sixteen species include: Russian knapweed, musk thistle, diffuse knapweed, yellow starthistle, spotted knapweed, Canada thistle, hawkweed, perennial pepperweed, leafy spurge, Sericea lespedeza, purple loosestrife, downy brome, medusahead, Dalmatian toadflax, tropical soda apple, and Tamarisk or saltcedar. Taxonomy, botanical characteristics, susceptible habitats, plant distribution, and spread and reproduction are summarized for each species.

Each species has its own chapter which summarizes eight categories of impacts, including: livestock and wildlife; plant communities; rare, sensitive, and threatened species; community function; soil and water resources; human health; economics; and value and use. An extensive 'Literature cited' section concludes each chapter.

Scientists, weed control specialists, resource planners and policy makers will welcome the comprehensive information provided in this valuable reference work.—*Gary Jennings, Library, Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

J. Bot. Res. Inst. Texas 1(1): 510. 2007

DIVERSIDAD Y DISTRIBUCIÓN DE LA FLORA VASCULAR ACUÁTICA DE TAMAULIPAS, MÉXICO

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RESUMEN

Los ambientes acuáticos (humedales) son uno de los ecosistemas más amenazados y con su biodiversidad pobremente conocida. Como una primera fase hacia el conocimiento de la flora vascular acuática del noreste de México, en este trabajo se presenta información sobre la diversidad y distribución de las hidrófitas (plantas acuáticas) de Tamaulipas, uno de los tres estados que conforman la región noreste de México y que contiene la mayor cantidad de cuerpos de agua. Las especies se clasificaron por tipo de planta acuática, forma biológica y forma de vida. En los humedales de Tamaulipas se registraron 426 especies pertenecientes a 213 géneros y 85 familias de plantas vasculares; tal riqueza representa 57% del total conocido para México. Un 22.8% de las especies son acuáticas estrictas, 43.7% son subacuáticas y 33.5% tolerantes. Por su forma biológica, 88.5% de las especies son herbáceas, 6.1% arbustos y 5.4% árboles. Por su forma de vida dominan las hidrófitas enraizadas emergentes (376 especies, 88.3%). Un alto porcentaje de especies son de amplia distribución, conocidas en toda América o alcanzando regiones del Viejo Mundo; solamente se identificaron nueve especies como endémicas de México (una de ellas endémica de Tamaulipas). El estado destaca como un reservorio importante de plantas asociadas a humedales y constituye una zona biogeográficamente relevante, al encontrarse en su territorio el límite de distribución geográfica de un buen número de elementos boreales y meridionales.

ABSTRACT

The aquatic environments (wetlands) are among the more threatened ecosystems, with their biodiversity poorly known. As a first step toward a better knowledge of the aquatic vascular plant diversity of northeastern Mexico, in this paper the diversity and distribution of the aquatic plants (hydrophytes) recorded and documented in the state of Tamaulipas are discussed. It is one of the three states comprising the northeastern of Mexico and includes the largest area of wetlands. The species are classified by type, biological form and life form. A number of 426 species, belonging to 213 genera and 85 families are recorded; such a figure represents 57% of the total vascular plants species recorded in all Mexico. True aquatics represented 22.8% of the species, as marginal aquatics 43.7%, and wetland tolerants 33.5%. By habit, 88.5% of the species are herbs, 6.1% shrubs and 5.4% trees; on the other hand, the dominant life form was emergent rooted hydrophytes (376 species, 88.3%). A high percentage of species are widespread, distributed either all along America or reaching part of the Old World; only nine species were recorded as endemic to Mexico (one endemic to Tamaulipas). The state of Tamaulipas is an important reservoir of species associated with wetlands and constitutes a relevant biogeographic area, due to the fact that in its territory the geographic limit of a number of boreal and meridional elements is found.

INTRODUCCIÓN

Los humedales (ambientes acuáticos), no obstante su importancia ecológica y económica, constituyen uno de los ecosistemas más amenazados, principalmente por su destrucción, conversión, fragmentación y contaminación (Jain 1990; Amezaga et al. 2002; Santamaría y Klaassen 2002; Saunders et al. 2002; Abellán et al. 2005; Fitzsimons & Robertson 2005). Desafortunadamente, su biodiversidad es poco conocida, lo que dificulta el establecimiento de estrategias para su conservación, tanto a escala regional como global. Hasta ahora, no existe un inventario de las plantas acuáticas del mundo, a pesar de que Cook et al. (1974) y Cook (1990) han realizado esfuerzos encaminados a revertir esta deficiencia. Existen pocos países con inventarios de plantas que crecen en humedales; Estados Unidos es uno de ellos, donde se reportan un poco más de 6,000 especies (Reed 1988, 1997).

En México, los magros esfuerzos por inventariar la flora vascular acuática se han enfocado a las familias de angiospermas estrictamente acuáticas, aquellas en las que todas sus especies son hidrófitas (Lot et al. 1986, 1999); tal grupo consta de 24 familias estrictamente acuáticas, que incluyen 118 especies. Esfuerzos

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adicionales han permitido documentar 747 especies de plantas vasculares acuáticas en México (Lot et al. 1999). Un trabajo regional, realizado por Bonilla-Barbosa (2004) registró 134 especies de plantas vasculares acuáticas en la Sierra Madre Oriental. A nivel estatal solamente dos entidades federativas han publicado información exclusivamente sobre su flora vascular acuática, Aguascalientes (Siqueiros 1989) y Morelos (Bonilla-Barbosa et al. 2000). Hasta ahora solamente 15 estados cuentan con inventarios publicados de su flora (Villaseñor 2004); sin embargo, poco o ningún énfasis han puesto en las especies de plantas acuáticas.

El Noreste de México, región que comprende los estados de Coahuila, Nuevo León y Tamaulipas (Fig. 1), representa una porción del país florísticamente importante, que de manera natural extiende sus límites hasta el suroeste de Texas en Estados Unidos (Villaseñor 1990; Rzedowski 1991a, 1991b, 1993). Al cruzar en su territorio el Trópico de Cáncer, en esta porción se combinan tanto especies del trópico como de las regiones boreales, especialmente de Norteamérica. La flora vascular registrada hasta la fecha en esta región alcanza 6,062 especies (Villaseñor datos no publicados), lo que representa casi la cuarta parte de la Flora de México (Villaseñor 2003); en el caso de la flora que se ha colectado en humedales, esta región contiene unas 844 especies, de las cuales 50.5% se encuentra en el estado de Tamaulipas.

De los tres estados que conforman el Noreste de México, Tamaulipas contiene la mayor proporción de cuerpos de agua (Palacio-Prieto et al. 2000). Esto se debe a que en su territorio, que colinda en la parte oriental con el Golfo de México, llegan escurrimientos de las zonas montañosas que constituyen la Sierra Madre Oriental, aunado al deficiente drenaje que presentan los suelos de la planicie costera que ha permitido la formación de numerosos humedales, tanto continentales como costeros. De hecho, Tamaulipas es únicamente superado por Tabasco (1.9% de su superficie total), en proporción de superficie de cuerpos de agua (1.6%). Varios de estos humedales (algunos fuertemente afectados por problemas de contaminación y eutroficación, Cruickshank y Tamayo 1976), son considerados sitios prioritarios a nivel nacional por la CONABIO (Arriaga et al. 1998, 2002) e internacional por la Convención Ramsar (Ramsar Bureau 2001), como es el caso de la Laguna Madre y el sistema lagunario del río Tamesí. La posición estratégica de Tamaulipas ha permitido la conformación de una flora compleja, repartida en diferentes regiones y provincias florísticas que forman parte tanto del Reino Holártico como del Reino Neotropical (Rzedowski 1978). En su superficie, por ejemplo, se asienta prácticamente todo el territorio de la Provincia Florística de la Planicie Costera del Noreste (Rzedowski 1978) y diversos autores han ubicado a parte del estado como miembro de una región biogeográfica particular, la Provincia Biótica o Biogeográfica Tamaulipeca (Dice 1943; CONABIO 1998; Morrone et al. 2002).

En Tamaulipas se han realizado trabajos vegetacionales y florísticos generales (Puig 1968, 1970, 1976; González-Medrano 1972; Martínez & González-Medrano 1977; Johnston et al. 1989; Briones 1991; Valiente-Banuet et al. 1995; Hernández et al. 2005) aunque pocos son los estudios que hacen referencia a su flora acuática vascular. Lot et al. (1993) reconocen para el estado 34 especies de familias estrictamente acuáticas; Martínez & Novelo (1993), al estudiar la vegetación de los cuerpos de agua de Tamaulipas, registran 167 especies y Mora-Olivo & Novelo (2005) mencionan la existencia de 175 especies de ambientes acuáticos en la Reserva de la Biosfera El Cielo. En conjunto, dichos trabajos registran 278 especies de plantas asociadas a humedales. Trabajo de campo llevado a cabo en los últimos años ha revelado la existencia de un número muy superior al reconocido hasta ahora, por lo que se considera necesario presentar un inventario actualizado y lo más completo posible de esta riqueza vegetal.

Dado que muy probablemente la mayor riqueza de flora acuática del noreste de México se concentre en Tamaulipas, como una primera fase del estudio de las plantas propias de ambientes acuáticos de esta región, se desarrolló el presente trabajo, cuyo objetivo es proporcionar una lista actualizada de las especies de plantas vasculares acuáticas de este estado. Un objetivo adicional es la evaluación de su distribución geográfica, con el fin de determinar la importancia que los humedales de Tamaulipas tienen en la conservación de la riqueza vegetal especializada a vivir en ambientes acuáticos.

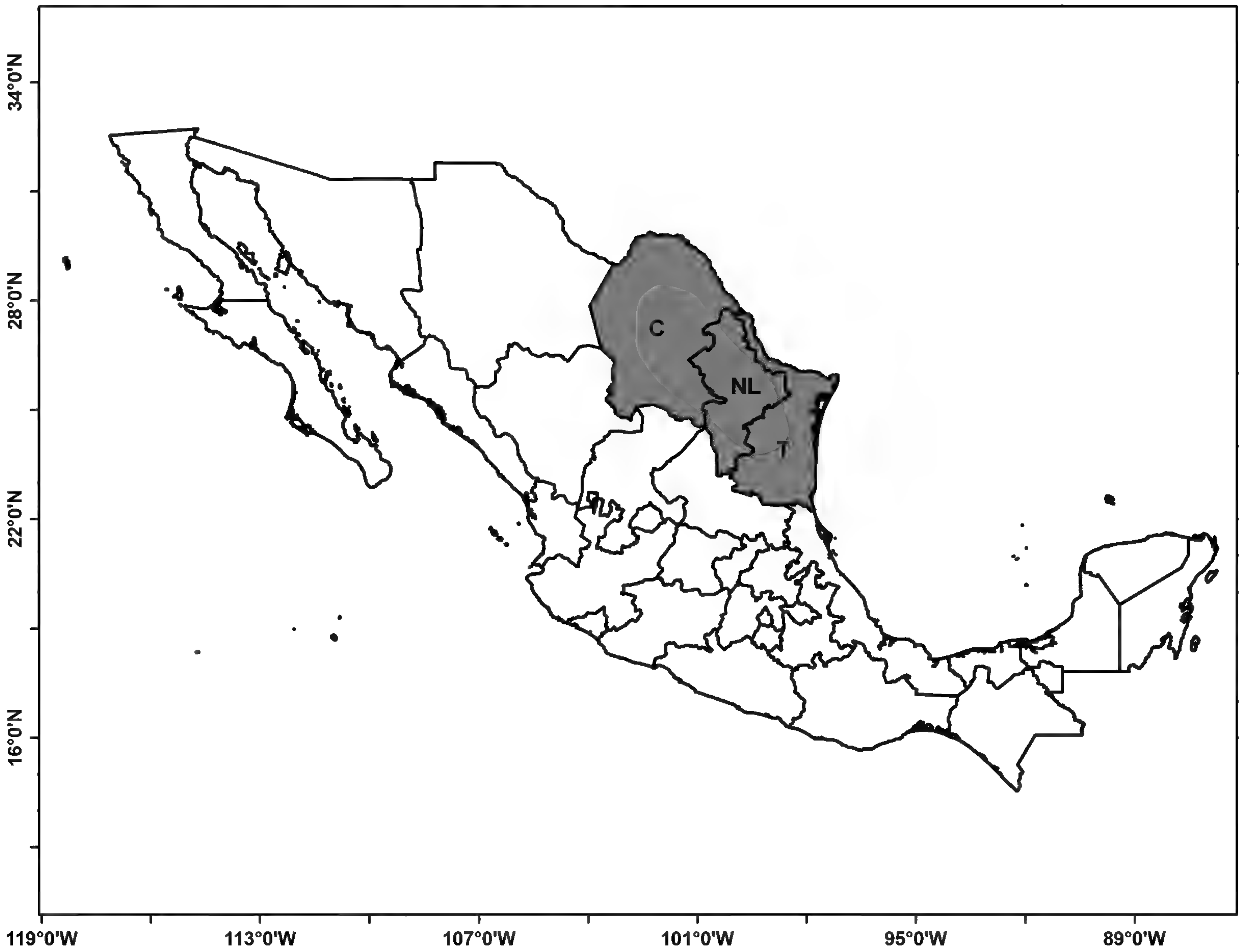

Fig. 1. Localización del noreste de México en la República Mexicana. C = Coahuila, NL = Nuevo León, T = Tamaulipas.

MATERIALES Y MÉTODOS

Área de estudio

Tamaulipas tiene una superficie de 78,380 km² y se localiza entre los paralelos 22° 12' 31" y 27° 40' 42" de latitud Norte y los meridianos 97° 08' 38" y 100° 08' 52" de longitud Este. Colinda al norte con el estado de Texas de los Estados Unidos, al sur con los estados de Veracruz y San Luis Potosí, al este con el Golfo de México y al oeste con el estado de Nuevo León (Fig. 1). La mayor parte del territorio tamaulipeco se eleva poco sobre el nivel del mar, con excepción de la Sierra Madre Oriental, que en su parte más alta alcanza los 3,000 m. Por su localización geográfica y orografía, Tamaulipas presenta una diversidad de climas, que va desde los sub-húmedos y húmedos, con lluvias en verano en la zona sur-sureste, hasta los templados en el Altiplano Tamaulipeco y serranías, que varían de húmedos a secos según la altitud (INEGI 2001). Se ha reportado para el estado la presencia de manglares, tulares y carrizales (Miranda & Hernández 1963), además de la vegetación característica de ríos, presas, canales, lagunas y charcos (Martínez & Novelo 1993).

Concepto de planta acuática

Aunque se han propuesto muchas definiciones y clasificaciones de plantas acuáticas (Raunkiaer 1934; Weaver & Clements 1938; Muenscher 1944; Cook et al. 1974; Cook 1990; Daubenmire 1979; Novelo & Gallegos 1988; Lot et al. 1993), para efectos de este estudio, las especies consideradas como hidrófitas o plantas acuáticas son aquellas que se desarrollan en agua o sobre un substrato que está al menos periódicamente anaerobio debido al exceso de agua (Tiner 1991). Dado que las condiciones de humedad pueden variar y las plantas que viven en estos ambientes húmedos tienen diferentes adaptaciones, se dividió a las hidrófitas en tres categorías: acuáticas estrictas, subacuáticas y tolerantes (Lot et al. 1993). Sólo que en este caso, cada categoría representa la zona que ocupan las plantas en un cuerpo de agua, en una adaptación a la clasificación de humedales de Tiner (1991) (Fig. 2). Es posible que, dentro del concepto de planta acuática utilizado en este trabajo, se incluyan algunas especies que para otros autores no sean acuáticas, especialmente en el caso de las tolerantes, que pueden incluir plantas que soportan el disturbio, frecuentemente como malezas. Las especies también se clasificaron por su forma biológica (hierba, arbusto o árbol) y siguiendo a Dalton & Novelo (1983) y a Sculthorpe (1985), por su forma de vida (enraizada emergente, enraizada de hojas flotantes, enraizada de tallos postrados, enraizada sumergida, libre flotante y libre sumergida).

Métods

El catálogo de especies es el resultado de un intenso trabajo de campo, realizado en la mayor cantidad de ambientes acuáticos presentes en el estado, como ríos, lagunas, presas, canales, cuerpos de agua temporales y áreas con suelos saturados. El primer autor ha recolectado alrededor de 4,000 números de plantas acuáticas en los últimos veinte años, material que está depositado en los herbarios UAT, MEXU, ENCB, XAL y TEX (abreviaciones de acuerdo a Holmgren et al. 1990). Adicionalmente se revisaron ejemplares depositados en los herbarios mencionados. La información obtenida con estas actividades se complementó con la consulta a bases de datos públicas (como la REMIB y W3TROPICOS) y personales (Novelo, inédito) y la revisión de literatura especializada, como son revisiones y monografías taxonómicas, además de estudios florísticos. Entre los trabajos nacionales que se consultaron destacan los de *Potamogeton* (González 1989), *Cyperus* (Tucker 1994), *Utricularia* (Olvera 1996), Podostemaceae (Novelo & Philbrick 1997) y Marsileaceae (Pérez-García et al. 1999). El arreglo del catálogo se hizo siguiendo las clasificaciones utilizadas por Mickel & Smith (2004) para helechos y plantas afines, por Brummitt (1992) para las gimnospermas, y las propuestas por Dahlgren et al. (1985) para monocotiledóneas y por Cronquist (1981) para dicotiledóneas. De los taxa se obtuvo información sobre su distribución a nivel mundial, para lo cual se utilizó la misma bibliografía y bases de datos mencionadas.

RESULTADOS

Diversidad

Un total de 426 especies (con 48 taxa infraespecíficos), pertenecientes a 213 géneros y 85 familias de plantas vasculares se registraron en los humedales de Tamaulipas (Tabla 1, Anexo). La riqueza de monocotiledóneas y dicotiledóneas más o menos está balanceada, siendo las segundas un poco más diversas (49.3%), con 54 familias, 128 géneros y 210 especies. Las monocotiledóneas comprenden 46.5%, con 23 familias, 76 géneros y 198 especies. Los helechos y gimnospermas acuáticas son raras, representando menos del 5% de la riqueza.

Las diez familias con mayor riqueza en el estado (Tabla 2) incluyen en conjunto 43.2% de los géneros y 54.5% de las especies. De ellas, solamente Alismataceae es una familia con miembros estrictamente acuáticos. Otras familias estrictamente acuáticas que se encuentran en México están bien representadas en el estado de Tamaulipas. Por ejemplo, en su territorio se registran todas las especies mexicanas conocidas de Cymodoceaceae (2), Najadaceae (3), Zannichelliaceae (1), Nelumbonaceae (1), Salviniaceae (2) y Taxodiaceae (1). Familias que tienen la mitad o más de sus especies en el estado, son Equisetaceae (66%, 2 especies), Potamogetonaceae (60%, 6), Hydrocharitaceae (57%, 4), Cabombaceae (50%, 1), Ceratophyllaceae (50%, 1) Menyanthaceae (50%, 1), Nymphaeaceae (50%, 5), Parkeriaceae (50%, 1), Ruppiaceae (50%, 1) y Typhaceae (50%, 1).

La mayoría de las plantas acuáticas registradas son herbáceas (377, 88.5%), un porcentaje menor son arbustos (26, 6.1%) o árboles (23, 5.4%). Como acuáticas estrictas se reconocen 97 especies (22.8%), 186 (43.7%) son subacuáticas y 143 (33.5%) son tolerantes (Tabla 3). La mayoría de las plantas herbáceas son subacuáticas (44%), siguiendo en orden decreciente las tolerantes (31.6%) y, en menor cantidad, las acuáticas estrictas (24.4%). Entre los arbustos no se registran acuáticas estrictas; se observa en cambio una repartición homogénea entre las subacuáticas y las tolerantes. Finalmente, sólo cinco especies de árboles se consideran hidrófitas estrictas, una gimnosperma (*Taxodium mucronatum*), una monocotiledónea (*Acoelorraphe wrightii*)

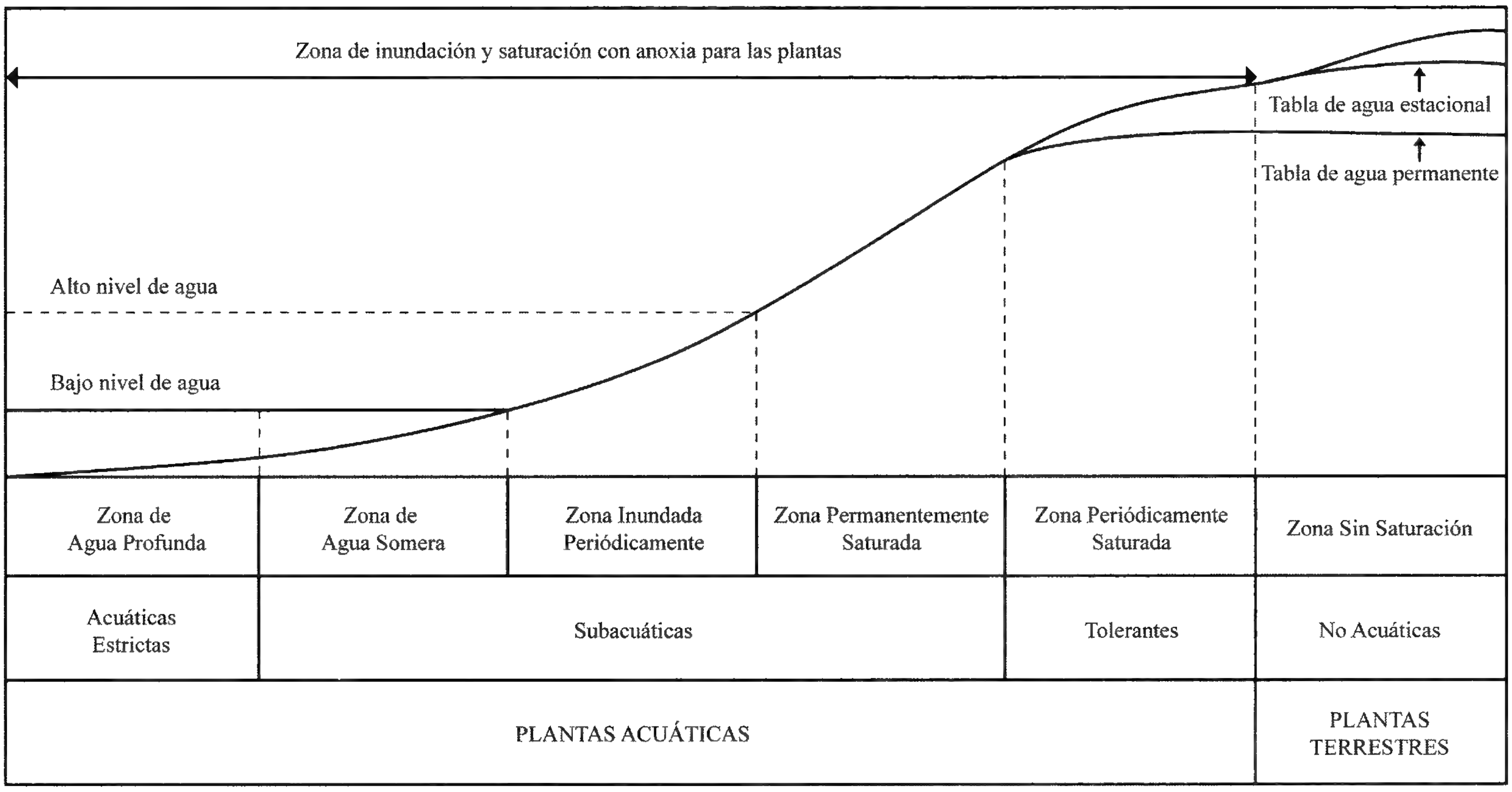

Fig. 2. Esquema que ilustra los tres tipos de hidrófitas consideradas en este trabajo, de acuerdo con su nivel de inundación y saturación (Basado en Tiner 1991).

y tres dicotiledóneas (*Rhizophora mangle, Laguncularia racemosa* y *Annona glabra*), las otras especies son subacuáticas (9) o tolerantes (9).

La forma de vida dominante en la flora acuática de Tamaulipas es la de enraizadas emergentes (376 especies, 88.3%), siendo las dicotiledóneas las más frecuentes (Tabla 4). Un pequeño número de especies se registró como enraizadas de hojas flotantes (10, 2.3%), enraizadas de tallos postrados (3, 0.7%), enraizadas sumergidas (23, 5.4%), libres flotantes (11, 2.6%) y libres sumergidas (3, 0.7%). En el Anexo a cada taxón se le indica su forma de vida, su forma biológica y si es acuática estricta, subacuática o tolerante.

Distribución

La mayoría de las especies de hidrófitas que se registran en el estado de Tamaulipas presenta una amplia distribución geográfica (Tabla 5). Más del 60% de las especies se distribuyen tanto a lo largo de todo o casi todo el continente Americano, así como en el Viejo Mundo. Las especies con distribución neotropical (México a Centro y Sudamérica) ocupan el tercer lugar; de ellas, el elemento sudamericano (México hasta Sudamérica) supera ligeramente (8.9%) al elemento mesoamericano (México a Centroamérica, 5.2%). El elemento neártico (especies distribuidas de México a Norteamérica) es ligeramente menor (12.9 %) que el neotropical, aunque su influencia en la flora vascular acuática de la región es significativa. Un 9.3% de las especies registra una distribución desde Norteamérica (principalmente el sur de los estados Unidos) a Centroamérica; el 3% de tales especies alcanza además islas del archipiélago de la región del Mar Caribe.

El elemento Mexicano (especies endémicas de México) es notablemente escaso (2.1%), representado únicamente por 9 especies; de ellas, una restringe su distribución al estado de Tamaulipas (*Carex fructus*). Si se ampliara el concepto de endemicidad y se incluyera hacia el norte de México las regiones vecinas del suroeste de los Estados Unidos y hacia el sureste porciones de Belice y Guatemala, el número de especies de distribución restringida aumentaría en 18 especies más (6.3%). Entre las especies que exceden ligeramente los límites políticos al norte de México se pueden citar a *Eleocharis brachycarpa*, conocida solo de Tamaulipas y Texas o *Baccharis neglecta, Helenium elegans* var. *amphibolum, Justicia runyonii* o *Marsilea macropoda*, que se localizan también en Texas y en porciones de los estados mexicanos de Chihuahua, Durango o Hidalgo Otras especies se distribuyen hacia el sur, hasta Guatemala y Belice, como *Cyperus megalanthus, Helenium quadridentatum* o *Pluchea salicifolia*.

En los humedales de Tamaulipas predominan las especies subacuáticas y las tolerantes (Tabla 6); en

Tabla 1. Riqueza de la flora vascular acuática de Tamaulipas por grupos taxonómicos.

Grupo	Familias	Géneros	Especies
Helechos y plantas afines	7	8 (3.7%)	17 (4.0 %)
Gimnospermas	1	1 (0.5%)	1 (0.2%)
Dicotiledóneas	54	128 (60.1%)	210 (49.3%)
Monocotiledóneas	23	76 (35.7%)	198 (46.5%)
Total	**85**	**213 (100%)**	**426 (100%)**

Tabla 2. Las 10 familias con mayor número de especies en la flora vascular acuática de Tamaulipas.

Familias	Géneros	Especies
Cyperaceae	13 (6.1%)	80 (18.8%)
Poaceae	25 (11.7%)	56 (13.1%)
Asteraceae	23 (10.8%)	33 (7.7%)
Polygonaceae	2 (0.9%)	14 (3.3%)
Scrophulariaceae	8 (3.7%)	11 (2.6%)
Lythraceae	6 (2.8%)	10 (2.3%)
Fabaceae	5 (2.3%)	8 (1.9%)
Acanthaceae	4 (1.9%)	7 (1.6%)
Alismataceae	2 (0.9%)	7 (1.6%)
Mimosaceae	4 (1.9 %)	6 (1.4%)
Total	**92 (43.2%)**	**232 (54.5%)**

Tabla 3. Distribución de la flora vascular acuática de Tamaulipas por grupo taxonómico, tipo de planta acuática y forma biológica. H = Hierbas, R = Arbustos, B = Árboles.

	Acuáticas Estrictas			Subacuáticas			Tolerantes		
Grupo	H	R	B	H	R	B	H	R	B
Helechos y plantas afines	9	0	0	2	0	0	6	0	0
Gimnospermas	0	0	1	0	0	0	0	0	0
Monocotiledóneas	54	0	0	94	2	2	45	1	0
Dicotiledóneas	29	0	4	70	9	7	68	14	9
Total	**92**	**0**	**5**	**166**	**11**	**9**	**119**	**15**	**9**

Tabla 4. Distribución de la flora vascular acuática de Tamaulipas por grupo taxonómico y forma de vida. EE = Enraizada emergente, EH = Enraizada de hojas flotantes, ET = Enraizada de tallos postrados, ES = Enraizada sumergida, LF = Libre flotante, LS = Libre sumergida.

Grupo	EE	EH	ET	ES	LF	LS
Helechos y plantas afines	10	3	0	0	4	0
Gimnospermas	1	0	0	0	0	0
Monocotiledóneas	175	0	1	16	6	0
Dicotiledóneas	190	7	2	7	1	3
Total	**376**	**10**	**3**	**23**	**11**	**3**

Tabla 5. Distribución geográfica de las especies de hidrófitas vasculares presentes en Tamaulipas.

Región	Especies	%
México (endémicas)	9	2.1
México y Norteamérica	55	12.9
México y Centroamérica	22	5.2
México a Sudamérica	38	8.9
Norteamérica, México y Caribe	13	3.0
Norteamérica a Centroamérica	27	6.3
Norteamérica a Sudamérica	131	30.8
México y Viejo Mundo	131	30.8
Total	**426**	**100.0**

Tabla 6. Distribución geográfica de las especies de hidrófitas vasculares presentes en Tamaulipas de acuerdo con su a su grado de tolerancia al agua.

Región	Acuáticas Estrictas	Subacuáticas	Tolerantes
México (endémicas)	2	4	3
México y Norteamérica	7	18	30
México y Centroamérica	2	12	8
México a Sudamérica	5	16	17
Norteamérica, México y Caribe	2	9	2
Norteamérica a Centroamérica	6	14	7
Norteamérica a Sudamérica	33	58	40
México y Viejo Mundo	40	55	36
Total	**97**	**186**	**143**

conjunto constituyen 77.2% de su flora. El otro 22.8% lo conforman las acuáticas estrictas. En las tres categorías se observa una predominancia de especies de amplia distribución (América y Viejo Mundo), siguiendo en importancia el elemento neotropical. Destaca también entre las acuáticas estrictas el importante número de especies neárticas (7), mesoamericanas (6) y neotropicales (5), lo que pone de relieve el papel biogeográfico de los humedales del estado como zona de transición entre las regiones biogeográficas templadas y tropicales.

Al evaluar la distribución geográfica de las especies por formas de vida, se observa un amplio predominio de las enraizadas emergentes en todas las divisiones geográficas utilizadas (Tabla 7); nuevamente, las especies de amplia distribución muestran el mayor espectro de formas de vida. Con una distribución más restringida solamente se determinaron 9 especies (2.1%), ocho enraizadas emergentes y una enraizada sumergida (Tabla 7).

En Tamaulipas se encuentra el límite meridional de 13 especies (o taxa infraespecíficos) neárticas y el límite septentrional de 39 neotropicales o paleotropicales. Los taxa norteamericanos que encuentran su límite sur de distribución en Tamaulipas son *Ambrosia trifida*, *Cyperus acuminatus*, *Cyperus erythrorhizos*, *Cyperus floribundus*, *Eleocharis coloradoensis*, *Fimbristylis puberula*, *Funastrum cynanchoides*, *Justicia runyonii*, *Lythrum californicum*, *Nuphar advena* subsp. *advena*, *Phyla lanceolata*, *Polygonum hydropiperoides* var. *opelousanum* y *Ulmus crassifolia*. Los taxa neotropicales que encuentran su límite norte de distribución en Tamaulipas son *Acmella oppositifolia* var. *oppositifolia*, *Aeschynomenne scabra*, *Crinum erubescens*, *Cuphea hyssopifolia*, *Cyperus humilis*, *C. laxus*, *C. lundellii*, *C. manimae* var. *manimae*, *C. megalanthus*, *C. tenuis*, *Equisetum myriochaetum*, *Fleischmannia arguta*, *Fuirena camptotricha*, *Habenaria pringlei*, *Habenaria quinqueseta*, *Helenium mexicanum*, *Hymenachne amplexicaulis*, *Hypoxis decumbens*, *Juncus ebracteatus*, *Lythrum gracile*, *Nymphaea amazonum*, *Paspalum arundinaceum*, *Phyla dulcis*, *Pithecellobium lanceolatum*, *Polygonum acuminatum*, *Polygonum ferrugineum*,

Tabla 7. Distribución geográfica de la flora vascular acuática de Tamaulipas por forma de vida. EE = Enraizada emergente, EH = Enraizada de hojas flotantes, ET = Enraizada de tallos postrados, ES = Enraizada sumergida, LF = Libre flotante, LS = Libre sumergida.

Grupo	EE	EH	ET	ES	LF	LS
México (endémicas)	8	0	0	1	0	0
México y Norteamérica	51	4	0	0	0	0
México y Centroamérica	21	0	0	1	0	0
México a Sudamérica	36	1	0	0	1	0
Norteamérica, México y Caribe	11	0	0	2	0	0
Norteamérica a Centroamérica	24	0	0	3	0	0
Norteamérica a Sudamérica	114	4	1	8	4	0
México y Viejo Mundo	111	1	2	8	6	3
Total	**376**	**10**	**3**	**23**	**11**	**3**

Polygonum persicarioides, *Ruellia paniculata*, *Rhynchospora contracta*, *Salvinia auriculata*, *Solanum diphyllum*, *Spermacoce confusa* y *Steinchisma laxa*, mientras que los taxa paleotropicales son *Cyperus tenuis*, *Eleocharis mutata*, *Fimbristylis complanata*, *Hyptis capitata*, *Neptunia natans* y *Nymphoides indica*.

Entre las hidrófitas de los humedales de Tamaulipas se han identificado 34 especies no nativas (introducidas). Algunas de ellas se comportan como malezas acuáticas agresivas, causando serios problemas en presas, canales de riego y otros cuerpos de agua (Novelo & Martínez 1989; Mora 1997). Entre ellas se pueden citar a *Eichhornia crassipes* (lirio acuático), nativa de Sudamérica y actualmente distribuida en las regiones tropicales y subtropicales del mundo e *Hydrilla verticillata*, hidrófita enraizada sumergida originaria de Asia y ahora ocupando amplias regiones templadas y tropicales del planeta (Langeland 1996).

DISCUSIÓN

De los tres estados que conforman la región noreste de México, Tamaulipas es el que cuenta con la mayor riqueza de hidrófitas con 426 especies registradas hasta la fecha. Tal cifra constituye en este momento 57% de toda la riqueza vascular acuática reportada por Lot et al. (1999) para México, lo que indudablemente refleja la necesidad de incrementar el estudio de la flora vascular acuática de todo el país. Su flora es representativa de los humedales de esta región biogeográfica de México y es un reservorio potencial de biodiversidad para ser considerado en futuras acciones de conservación de este importante habitat mundialmente amenazado.

Tamaulipas ocupa el segundo lugar a nivel nacional, después del estado de Tabasco, por la superficie de humedales en su territorio, tanto naturales como artificiales (Palacio-Prieto et al. 2000). Por su extensión y posición geográfica, algunos humedales del estado han sido considerados a nivel nacional e internacional como áreas prioritarias para la conservación (Arriaga et al. 1998, 2002; Ramsar Bureau 2001); hoy se puede justificar su importancia de acuerdo con su biodiversidad de hidrófitas presentes. Estimaciones recientes (Mora & Villaseñor, resultados no publicados) indican que por su riqueza de hidrófitas, Tamaulipas ocupa el quinto lugar nacional (solamente superado por Chiapas, Oaxaca, Veracruz y Tabasco); sin embargo, también a nivel nacional, el estado ocupa el lugar catorce (de un total de 32) por su riqueza florística total (Villaseñor 2003, datos no publicados). Con la excepción de Tabasco (lugar 21), los otros tres estados son los que ocupan en México la mayor riqueza total a nivel estatal.

Rzedowski (1991b) estimó que 3% de la flora vascular de México está asociada a humedales. Datos preliminares (Mora & Villaseñor, resultados no publicados) muestran que la proporción es mayor, estimando un valor a nivel nacional de 5.4% y una media por estados de 14.1% (desviación estándar 5.2%). Para Tamaulipas se ha determinado hasta la fecha que alrededor del 15% de su flora está asociada con humedales, cifra cercana a la media estatal. Para Coahuila y Nuevo León, los otros dos estados que constituyen la región noreste de México, se ha estimado que su flora asociada a humedales es menor a 9%. Los altos valores de riqueza que presenta Tamaulipas con respecto a Nuevo León y Coahuila se pueden explicar, porque además de su mayor cantidad de cuerpos de agua continentales, el estado cuenta con amplios ambientes costeros, los cuales incluyen poco más del 14% (62 especies) de plantas halófitas características de humedales salobres, como los mangles, pastos marinos y otras hidrófitas.

Un alto porcentaje de especies asociadas a humedales son cosmopolitas o pantropicales, por lo que no es sorprendente advertir la amplia distribución geográfica de la mayoría de las hidrófitas encontradas en Tamaulipas. Aunque poco se ha discutido acerca de los factores históricos que determinaron la distribución actual de muchas hidrófitas, es evidente que un gran porcentaje de ellas deben su actual distribución a factores antropogénicos (Stuckey 1993; Sawada et al. 2003) o a la dispersión a larga distancia por aves (Figuerola & Green 2002; Green et al. 2002). Será interesante abordar en un futuro preguntas encaminadas a explicar los patrones de distribución de las plantas asociadas a humedales de Tamaulipas, especialmente con un enfoque histórico.

A nivel de país, en otros estudios se ha señalado el bajo nivel de endemismo de las plantas propias de humedales, como ha sido el caso de Nueva Zelanda (McGlone et al. 2001) y México (Rzedowski 1991b). Para el caso particular de Tamaulipas, aquí se dan a conocer valores igualmente bajos en sus ambientes acuáticos (0.2% de endemismo, una especie), el cual se incrementa a 2.1% si se considera al elemento endémico de México. En contraste, altos niveles de endemismo vegetal se han registrado en algunas regiones de Tamaulipas, como son sus zonas montañosas y sus zonas áridas (Rzedowski 1991b; Hernández et al. 2005; Martínez-Ávalos & Jurado 2005). Sin embargo, hasta la fecha ningún otro estado de México reporta un mayor número de endemismos acuáticos; de acuerdo con Lot et al. (1999), solamente Jalisco y Nayarit tienen una especie acuática estricta endémica dentro de sus límites políticos, *Oserya longifolia* y *Echinodorus virgatus* respectivamente.

La riqueza y endemismo de la flora acuática tamaulipeca se hace más relevante al considerar que en su territorio se registra un buen número de especies que encuentran su distribución marginal en el estado. En Tamaulipas encuentran su límite de distribución boreal o meridional poco más del 10% de las hidrófitas registradas; esto indica que sus humedales constituyen una zona de transición importante para las hidrófitas de las regiones templadas y tropicales. El estudio de las hidrófitas de la región apoya las propuestas de considerar a la región noreste de México como una zona biogeográfica de particular interés, claramente diferenciada de otras regiones del país, como lo han hecho Dice (1943), Rzedowski (1978), CONABIO (1998) o Morrone et al. (2002). Continuar con el estudio de las plantas asociadas a los humedales de Coahuila y Nuevo León permitirá conocer mejor la flora vascular acuática que se desarrolla en esta interesante región del país conocida como el noreste de México y ayudará a proponer mejores estrategias para su conservación.

ANEXO

CATÁLOGO DE LAS PLANTAS VASCULARES ACUÁTICAS DEL ESTADO DE TAMAULIPAS

A= Acuática estricta, **S**= Subacuática, **T**= Tolerante. **H** = Hierba, **R** = Arbusto, **B** = Árbol. **EE** = Enraizada emergente, **EH** = Enraizada de hojas flotantes, **ET** = Enraizada de tallos postrados, **ES** = Enraizada sumergida, **LF** = Libre flotante, **LS** = Libre sumergida. **ET** = Endémica de Tamaulipas, **EM** = Endémica de México, **NA** = México y Norteamérica, **MC** = México y Centroamérica, **MS** = México a Sudamérica, **NM** = Norteamérica, México y Caribe, **NS** = Norteamérica a Sudamérica, **VM** = Viejo Mundo.
***** = Introducidas

Helechos y plantas afines

Adiantaceae
Adiantum capillus-veneris L. T/H/EE/VM
Acrostichum aureum L. A/H/EE/VM
Acrostichum danaeifolium Langsd. & Fisch. A/H/EE/VM

Azollaceae
Azolla microphylla Kaulf. A/H/LF/NS

Equisetaceae
Equisetum hyemale L. var. *affine* (Engelm.) A.A. Eaton S/H/EE/NC
Equisetum myriochaetum Schltdl. & Cham. S/H/EE/MS

Marsileaceae
Marsilea ancylopoda A. Braun A/H/EH/NS
Marsilea macropoda A. Braun A/H/EH/NA
Marsilea vestita Hook. & Grev. subsp. *vestita* A/H/EH/NA

Parkeriaceae
Ceratopteris thalictroides (L.) Brongn. A/H/LF/VM

Salviniaceae
Salvinia auriculata Aubl. A/H/LF/MS
Salvinia minima Baker A/H/LF/NS

Thelypteridaceae
Thelypteris kunthii (Desv.) Morton T/H/EE/NS
Thelypteris ovata R.P. St. John var. *lindheimeri* (C. Chr.) A.R. Sm. T/H/EE/NC
Thelypteris pilosa (M. Martens & Galeotti) Crawford T/H/EE/NC
Thelypteris puberula (Baker) C.V. Morton var. *puberula* T/H/EE/MC
Thelypteris tetragona (Sw.) Small T/H/EE/NS

GIMNOSPERMAS

Taxodiaceae
Taxodium mucronatum Ten. A/R/EE/NA

ANGIOSPERMAS

MONOCOTILEDÓNEAS

Alismataceae
Echinodorus berteroi (Spreng.) Fassett. A/H/EE/NS
Echinodorus cordifolius (L.) Griseb. subsp. *cordifolius* A/H/EE/NS
Echinodorus grandiflorus (Cham. & Schltdl.) Micheli subsp. *aureus* (Fassett) R.R. Haynes & Holm-Niels. A/H/EE/MS
Sagittaria lancifolia L. subsp. *media* (Micheli) Bogin A/H/EE/NS
Sagittaria latifolia Willd. A/H/EE/NS
Sagittaria longiloba Engelm. ex J.G. Sm. A/H/EE/NC
Sagittaria platyphylla (Engelm.) J.G. Sm. A/H/EE/NC

Amaryllidaceae
Crinum erubescens Sol. A/H/EE/MS
Hymenocallis littoralis (Jacq.) Salisb. A/H/EE/VM
Zephyranthes pulchella J.G. Sm. A/H/EE/NA

Araceae
Pistia stratiotes L A/H/LS/VM
Xanthosoma robustum Schott A/H/EE/NS

Arecaceae
Acoelorraphe wrightii (Griseb. & H. Wendl.) H. Wendl. ex Becc. A/B/EE/NS

Cannaceae
Canna glauca L. A/H/EE/NS

Commelinaceae
Callisia micrantha (Torr.) D.R. Hunt S/H/EE/NA
Commelina communis L. T/H/EE/NA
Commelina diffusa Burm. f. S/H/EE/VM
**Murdannia nudiflora* (L.) Brenan T/H/EE/VM

Cymodoceaceae
Halodule wrightii Asch. A/H/ES/NS
Syringodium filiforme Kütz. A/H/ES/NS

Cyperaceae
Bolboschoenus robustus (Pursh) Soják A/H/EE/NS
Bulbostylis capillaris (L.) C.B. Clarke T/H/EE/NS
Bulbostylis juncoides (Vahl) Kük. ex Osten T/H/EE/NS
Carex fructus Reznicek T/H/EE/ET
Cladium jamaicense Crantz A/H/EE/NS
Cyperus acuminatus Torrey & Hooker S/H/EE/NA
Cyperus aggregatus (Willd.) Endl. T/H/EE/NS
Cyperus articulatus L. A/H/EE/VM
Cyperus haspan L. S/H/EE/VM
Cyperus canus C. Presl. S/H/EE/NS
Cyperus compressus L. S/H/EE/VM
Cyperus digitatus Roxb. subsp. *digitatus* S/H/EE/VM
Cyperus elegans L. S/H/EE/NS
Cyperus flavicomus Michx. S/H/EE/VM
Cyperus entrerianus Boeckeler S/H/EE/NS
Cyperus erythrorhizos Muhl. S/H/EE/NA
**Cyperus esculentus* L. T/H/EE/VM
Cyperus floribundus (Kük.) R.N. Carter & S.D. Jones T/H/EE/NA
Cyperus hermaphroditus (Jacq.) Standl. T/H/EE/NS
Cyperus humilis Kunth S/H/EE/MS
**Cyperus involucratus* Rottb. S/H/EE/VM
**Cyperus iria* L. S/H/EE/VM
Cyperus laevigatus L. S/H/EE/VM
Cyperus lanceolatus Poir. S/H/EE/VM
Cyperus laxus Lam. S/H/EE/VM
Cyperus ligularis L. T/H/EE/VM
Cyperus lundellii O'Neill S/H/EE/MS
Cyperus manimae Kunth var. *asperrimus* (Liebm.) Kük. T/H/EE/NS
Cyperus manimae Kunth var. *manimae* (Liebm.) Kük. T/H/EE/NS
Cyperus megalanthus (Kük.) G.C. Tucker S/H/EE/MC
Cyperus niger Ruíz López & Pavón S/H/EE/VM
Cyperus ochraceus Vahl S/H/EE/NS
Cyperus *odoratus* L. S/H/EE/VM
**Cyperus oxylepis* Steud. S/H/EE/NS
Cyperus polystachyos Rottb. S/H/EE/VM
Cyperus prolixus Kunth S/H/EE/VM
**Cyperus rotundus* L. T/H/EE/VM
Cyperus squarrosus L. S/H/EE/VM
Cyperus surinamensis Rottb. S/H/EE/NS
Cyperus tenuis Swallen S/H/EE/VM
Cyperus virens Michx. S/H/EE/NS
Eleocharis acicularis (L.) Roem. & Schult. A/H/EE/VM
Eleocharis albida Torr. A/H/EE/NA
Eleocharis atropurpurea (Retz.) J. Presl & C. Presl S/H/EE/VM
Eleocharis brachycarpa Svens. A/H/EE/NA
Eleocharis cellulosa Torr. A/H/EE/NS
Eleocharis coloradoensis (Britton) Gilly A/H/EE/NA
Eleocharis flavescens (Poir.) Urban A/H/EE/NS
Eleocharis geniculata (L.) Roem. & Schult. S/H/EE/VM
Eleocharis interstincta (Vahl) Roem. & Schult. A/H/EE/NS
Eleocharis macrostachya Britt. A/H/EE/NS
Eleocharis minima Kunth A/H/EE/NS
Eleocharis montevidensis Kunth S/H/EE/NS
Eleocharis mutata (L.) Roem. & Schult. A/H/EE/VM
Eleocharis parvula (Roem. & Schult.) Link ex Bluff, Nees & Schauer A/H/EE/VM
Eleocharis radicans (A. Dietr.) Kunth A/H/EE/NS

Eleocharis rostellata (Torr.) Torr. A/H/EE/NS
Fimbristylis annua (All.) Roem. & Schult. S/H/EE/VM
Fimbristylis caroliniana (Lam.) Fernald. S/H/EE/NM
Fimbristylis castanea (Michx.) Vahl S/H/EE/NC
Fimbristylis complanata (Retz.) Link A/H/EE/VM
Fimbristylis cymosa (Lam.) R. Br. S/H/EE/VM
Fimbristylis dichotoma (L.) Vahl S/H/EE/VM
Fimbristylis puberula (Michx.) Vahl S/H/EE/NA
Fimbristylis spadicea (L.) Vahl S/H/EE/MS
Fimbristylis vahlii (Lam.) Link S/H/EE/NS
Fuirena camptotricha C. Wright S/H/EE/MC
Fuirena simplex Vahl S/H/EE/NS
Killinga brevifolia Rottb. S/H/EE/VM
Killinga odorata Vahl S/H/EE/VM
Killinga pumila Michaux S/H/EE/VM
Lipocarpha micrantha (Vahl) G. Tucker S/H/EE/VM
Oxycarium cubense (Poepp. & Kunth) Lye A/H/EE/VM
Rhynchospora colorata (L.) H. Pfeiffer T/H/EE/NS
Rhynchospora contracta (Nees) Raynal S/H/EE/NS
Schoenoplectus americanus (Pers.) Volkart ex Schinz & R. Keller A/H/EE/NS
Schoenoplectus californicus (C.A. Mey.) Soják A/H/EE/NS
Schoenoplectus erectus (Poir.) Palla ex J. Raynal subsp. *raynalii* (Schuyler) Lye A/H/EE/VM
Schoenoplectus pungens (Vahl) Palla A/H/EE/VM
Schoenoplectus saximontanus (Fernald) J. Raynal A/H/EE/NA
Schoenoplectus tabernaemontani (C.C. Gmel.) Palla A/H/EE/VM

Hydrocharitaceae
Halophila engelmannii Asch. A/H/ES/NC
**Hydrilla verticillata* (L.f.) Royle A/H/ES/VM
Thalassia testudinum Banks ex König A/H/ES/NS
Vallisneria americana Michx. A/H/ES/VM

Hypoxidaceae
Hypoxis decumbens L. var. *decumbens* T/H/EE/MS

Iridaceae
Cipura campanulata Ravenna S/H/EE/MS
Cipura paludosa Aublet S/H/EE/MS
Sisyrinchium angustifolium Mill. T/H/EE/NA
Sisyrinchium biforme E.P. Bicknell T/H/EE/NA

Juncaceae
Juncus arcticus Willd. var. *mexicanus* (Willd.) Baslev S/H/EE/NS
Juncus dichotomus Elliott S/H/EE/NS
Juncus ebracteatus E. Mey S/H/EE/MS
Juncus nodosus L. S/H/EE/NA

Lemnaceae
Lemna aequinoctialis Welw. A/H/LF/VM
Lemna gibba L. A/H/LF/VM
Spirodela polyrhiza (L.) Schleid. A/H/LF
Wolffia brasiliensis Weddell A/H/LF/NS
Wolffiella lingulata (Hegelm.) Hegelm. A/H/LF/NS

Marantaceae
Thalia geniculata L. A/H/EE/VM

Najadaceae
Najas guadalupensis (Spreng.) Magnus var. *guadalupensis* A/H/ES/NS
Najas marina L. A/H/ES/VM
Najas wrightiana A. Braun A/H/ES/NC

Orchidaceae
Bletia purpurea (Lam.) DC. T/H/EE/NS
Habenaria pringlei B.L. Rob. S/H/EE/MC
Habenaria quinqueseta (Michx.) Sw. T/H/EE/MC
Habenaria repens Nutt. A/H/EE/NS

Poaceae
Andropogon glomeratus (Walter) Britton, Sterns & Poggenb. S/H/EE/NS
Arundinella berteroniana (Schultes) A. Hitch. & Chase T/H/EE/MS
**Arundo donax* L. T/R/EE/VM
Distichlis spicata (L.) Greene var. *spicata* S/H/EE/NS
**Echinochloa colona* (L.) Link S/H/EE/VM
**Echinochloa crus-galli* (L.) P. Beauv. S/H/EE/VM
Echinochloa crus-pavonis (Kunth) Schult. S/H/EE/VM
Echinochloa polystachya (Kunth) Hitchc. S/H/EE/VM
**Echinochloa pyramidalis* (Lam.) Hitchc. & Chase S/H/EE/VM
Eragrostis cilianensis (All.) Vignolo ex Janch. T/H/EE/VM
Eragrostis hypnoides (Lam.) Britton, Sterns & Poggenb. S/H/EE
Eragrostis reptans (Michx.) Nees T/H/EE/NA
Eragrostis secundiflora C. Presl. T/H/EE/NS
Eriochloa acuminata (J. Presl) Kunth S/H/EE/NA
Eriochloa punctata (L.) Desv. S/H/EE/NC
Guadua angustifolia Kunth subsp. *angustifolia* T/B/EE/MS
**Hemarthria altissima* (Poir.) Stapf & C.E. Hubb. T/H/EE/VM
Hymenachne amplexicaulis (Rudge) Nees A/H/EE/VM
Leersia hexandra Sw. A/H/EE/VM
Leptochloa fusca (L.) Kunth subsp. *fascicularis* (Lam.) N.W. Snow S/H/EE/NS
Leptochloa fusca (L.) Kunth subsp. *uninervia* (Presl.) Hitchc. & Chase S/H/EE/NS
Leptochloa panicea (Retz.) Ohwi subps. *brachiata* (Steud.) N. Snow T/H/EE/NS
Leptochloa nealleyi Vasey S/H/EE/NM
Lithachne pauciflora (Sw.) P. Beauv T/H/EE/MS
Monanthochloë littoralis Engelm. S/H/EE/NM
Panicum hirsutum Sw. T/H/EE/NS
Panicum trichoides Sw. T/H/EE/NS
Panicum virgatum L. S/H/EE/NS
Paspalidium geminatum (Forssk.) Stapf A/H/EE/VM
Paspalum arundinaceum Poir. S/H/EE/MS
Paspalum conjugatum P.J. Bergius T/H/EE/VM
Paspalum conspersum Schrad. S/H/EE/NS
Paspalum denticulatum Trin. S/H/EE/NS
Paspalum distichum L. A/H/EE/NS
Paspalum harwegianum Fourn. T/H/EE/NC
Paspalum langei (Fourn.) Nash T/H/EE/NS
Paspalum monostachyum Chase T/H/EE/NA
Paspalum pubiflorum Rupr. T/H/EE/NC
Paspalum setaceum Michx. var. *setaceum* S/H/EE/NS
Paspalum squamulatum Fourn. S/H/EE/MC

***Paspalum urvillei* Steud. S/H/EE/VM
Paspalum virgatum L. S/H/EE/NS
Paspalum vaginatum Sw. S/H/EE/VM
**Pennisetum purpureum* Schum. T/H/EE/VM
Phragmites australis (Cav.) Trin. subsp. *australis* S/R/EE/VM
**Polypogon monspeliensis* (L.) Desf. T/H/EE/VM
**Polypogon viridis* (Gouan) Breistr. S/H/EE/VM
Setaria magna Griseb. S/H/EE/NS
Setaria parviflora (Poir.) Kerguélen T/H/EE/VM
Spartina patens (Aiton) Muhl. S/H/EE/NC
Spartina spartinae (Trin.) A. Hitchc. S/H/EE/NS
Sporobolus airoides (Torr.) Torr. T/H/EE/NA
Sporobolus pyramidatus (Lam.) Hitchc. T/H/EE/NS
Sporobolus virginicus (L.) Kunth S/H/EE/VM
Sporobolus wrightii Munro ex Scribn. T/H/EE/NA
Steinchisma laxa (Sw.) Zuloaga S/H/EE/MS
**Urochloa mutica* (Forssk.) T.Q. Nguyen S/H/EE/NS

Pontederiaceae
**Eichhornia crassipes* (C. Martius) Solms-Laub. A/H/LF/VM
Heteranthera dubia (Jacq.) MacMill. A/H/ES/NS
Heteranthera limosa (Sw.) Willd. A/H/EE/NS
Heteranthera mexicana S. Watson A/H/EE/NA
Heteranthera rotundifolia (Kunth) Griseb. A/H/EE/NS

Potamogetonaceae
Potamogeton foliosus Raf. subsp. *foliosus* A/H/ES/NS
Potamogeton illinoensis Morong A/H/ESNS
Potamogeton nodosus Poiret A/H/EH/VM
Potamogeton pusillus L. var. *pusillus* A/H/ES/VM
Stuckenia pectinata (L.) Börner A/H/ES/VM
Stuckenia striata (Ruiz & Pav.) Holub A/H/ES/NS

Ruppiaceae
Ruppia maritima L. A/H/ES/VM

Typhaceae
Typha domingensis Pers. A/H/EE/VM

Xyridaceae
Xyris ambigua Beyr. ex Kunth S/H/EE/NC
Xyris jupicai Rich. S/H/EE/NS

Zannichelliaceae
Zannichellia palustris L. A/H/ES/VM

DICOTILEDONEAS

Acanthaceae
Blechum pyramidatum (Lam.) Urb. T/H/EE/NS
Dicliptera sexangularis (L.) Juss. T/H/EE/MS
Justicia runyonii Small T/H/EE/NA
Ruellia coerulea Morong T/H/EE/NS
Ruellia inundata Kunth T/H/EE/MS
Ruellia malacosperma Greenm. T/H/EE/MS
Ruellia paniculata L. T/H/EE/MS

Aizoaceae
Sesuvium maritimum (Walter) Britton, Sterns & Poggenb. T/H/EE/MC
Sesuvium portulacastrum L. T/H/EE/VM
Sesuvium verrucosum Raf. T/H/EE/NA
Trianthema portulacastrum L. T/H/EE/VM

Amaranthaceae
Alternanthera obovata (M. Martens & Galeotti) Standl. S/H/EE/MC
Amaranthus australis (Gray) Sauer SH/EE/NC
Blutaparon vermiculare (L.) Mears T/H/EE/NS
Tidestromia lanuginosa (Nutt.) Standl. subsp. *lanuginosa* T/H/EE/NM

Annonaceae
Annona glabra L. A/B/EE/VM

Apiaceae
**Centella erecta* (L. f.) Fernald S/H/EE/NS
Eryngium nasturtiifolium Juss ex Delar f. S/H/EE/NC
Hydrocotyle bonariensis Lamarck S/H/EE/NS
Hydrocotyle mexicana Schltdl. & Cham. T/H/EE/MC
Hydrocotyle umbellata L. S/H/EE/NS
Hydrocotyle verticillata Thunb. var. *triradiata* (A. Rich.) Fernald S/H/EE/VM
Hydrocotyle verticillata Thunb. var. *verticillata* S/H/EE/VM

Apocynaceae
Rhabdadenia biflora (Jacq.) Müll. Arg. T/H/EE/MS

Asclepiadaceae
**Cryptostegia grandiflora* Roxb. ex R. Br. T/H/EE/VM
**Cryptostegia madagascariensis* Bojer ex Decne. T/H/EE/VM
Funastrum clausum (Jacq.) Schltr. S/H/EE/NS
Funastrum cynanchoides (Dcne.) Schltr. var. *cynanchoides* S/H/EE/NA

Asteraceae
Acmella oppositifolia (Lam.) R.K. Jansen var. *oppositifolia* S/H/EE/NS
Ambrosia trifida L. T/H/EE/NA
Aster subulatus Michx. var. *subulatus* SH/EE/NS
Baccharis neglecta Britton & A. Brown T/R/EE/NA
Baccharis salicifolia (Ruiz & Pav.) Pers. S/R/EE/NS
Barkleyanthus salicifolius (Kunth) H. Rob. & Brettell T/R/EE/NA
Borrichia frutescens (L.) DC. S/H/EE/NA
Chloracantha spinosa (Benth.) G.L. Nesom S/H/EE/NC
Conoclinium betonicifolium (Mill.) R.M. King & H. Rob. S/H/EE/NA
Coreopsis tinctoria Nutt. T/H/EE/NS
Eclipta prostrata (L.) L. S/H/EE/VM
Egletes liebmanni Sch. Bip. S/H/EE/MC
Egletes viscosa Less. S/H/EE/NC
Flaveria trinervia (Spreng.) C. Mohr T/H/EE/VM
Fleischmannia arguta (Kunth) B.L. Rob. T/H/EE/MC
Fleischmannia porphyranthema (A. Gray) R.M. King & H. Rob. T/H/EE/EM
Gymnocoronis latifolia Hook & Arn. A/H/EE/MC
Helenium elegans DC. var. *amphibolum* (A. Gray) Bierner S/H/EE/EM
Helenium mexicanum Kunth S/H/EE/MC
Helenium microcephalum DC. var. *microcephalum* S/H/EE/NA
Helenium microcephalum DC. var. *ooclinium* (A. Gray) Bierner S/H/EE/NA
Helenium quadridentatum Labill. S/H/EE/MC

Jaegeria hirta (Lag.) Less. T/H/EE/MS
Laennecia coulteri (A. Gray) G.L. Nesom T/H/EE/NA
Melanthera nivea (L.) Small T/H/EE/NS
Mikania cordifolia (L. f) Willd. S/H/EE/NS
Mikania micrantha Kunth S/H/EE/NS
Mikania scandens (L.) Willd. S/H/EE/NS
Packera tampicana (DC.) C. Jeffrey T/H/EE/NA
Pluchea carolinenesis (Jacq.) G. Don T/R/EE/VM
Pluchea odorata (L.) Cass. S/H/EE/NS
Pluchea salicifolia (Mill.) S.F. Blake S/H/EE/MC
Solidago velutina DC. T/H/EE/NA
Trichocoronis wrightii (Torr. & A. Gray) Gray var. *wrightii* A/H/EE/NA

Bataceae
Batis maritima L. S/H/EE/VM

Bignoniaceae
Chilopsis linearis (Cav.) Sweet T/H/EE/NA

Boraginaceae
Heliotropium curassavicum L. var. *curassavicum* T/H/EE/NS

Brassicaceae
Cakile geniculata (Robins.) Millsp. T/H/EE/NA
Cakile lanceolata (Willd.) O.E. Schulz subsp. *pseudoconstricta* Rodman T/H/EE/NC
**Cardamine hirsuta* L. T/H/EE/VM
**Nasturtium officinale* R. Br. A/H/ET/VM
Rorippa teres (Michx.) Stuckey S/H/EE/NC

Cabombaceae
Cabomba paleaformis Fassett A/H/ES/MC

Capparidaceae
Crateva tapia L. T/B/EE/MS

Ceratophyllaceae
Ceratophyllum demersum L. A/H/LS/VM

Chenopodiaceae
Salicornia bigelovii Torr. S/H/EE/NC
Salicornia virginica L. S/H/EE/VM
Suaeda conferta (Small) I. M. Johnston S/H/EE/NM
Suaeda linearis (Elliott) Moq. S/H/EE/NM
Suaeda nigra (Raf.) J.F. Macbr. S/H/EE/NM
Suaeda tampicencis (Standl.) I. M. Johnst. S/H/EE/NM

Chrysobalanaceae
Chrysobalanus icaco L. S/R/EE/VM

Combretaceae
Conocarpus erectus L. T/R/EE/VM
Laguncularia racemosa (L.) C.F. Gaertn. A/B/EE/VM

Convolvulaceae
Ipomoea carnea Jacq. subsp. *fistulosa* (Mart. ex Choisy) D. Austin T/H/EE/MS
Ipomoea rubens Choisy T/H/EE/VM

Elatinaceae
Bergia texana (Hook.) Seub. ex Walp. S/H/EE/NA

Euphorbiaceae
Caperonia castaneifolia (L.) A. St.-Hill. S/H/EE/MS
Caperonia palustris (L.) A. St.-Hil. S/H/EE/VM

Fabaceae
Aeschynomene indica L. S/H/EE/VM
Aeschynomene rudis Benth. S/H/EE/MS
Aeschynomene scabra G. Don S/H/EE/MS
Dalbergia brownei (Jacq.) Urban S/R/EE/NS
Desmodium triflorum (L.) DC. T/H/EE/VM
Sesbania drummondii (Rydb.) Cory T/R/EE/NA
Sesbania herbacea (Mill.) McVaugh S/H/EE/NS
Vigna luteola (Jacq.) Benth. S/H/EE/VM

Gentianaceae
Centaurium calycosum (Buckley) Fernald T/H/EE/NA
Eustoma exaltatum (L.) Salisb. subsp. *exaltatum* S/H/EE/NC
Eustoma exaltatum (L.) Salisb. subsp. *russellianum* (Hook.) Kartez S/H/EE/NA
Halenia plantaginea (Kunth) G. Don T/H/EE/EM
Sabatia arenicola Greenm. T/H/EE/NA
Sabatia stellaris Pursh S/H/EE/NM

Haloragaceae
**Myriophyllum aquaticum* (Vell.) Verdc. A/H/ES/VM
Myriophyllum hippuroides Nutt. ex Torr & A. Gray A/H/ES/NC

Hydrophyllaceae
Hydrolea spinosa L. A/H/EE/NS

Juglandaceae
Carya illinoinensis (Wangenh.) K. Koch T/B/EE/NC
Carya myristiciformis (F. Michx.) Nutt. T/B/EE/NA
Carya palmeri W.E. Manning T/B/EE/EM

Lamiaceae
Clinopodium brownei (Sw.) Kuntze S/H/EE/NS
Hyptis capitata Jacq. T/H/EE/VM
Hyptis verticillata Jacq. T/H/EE/NS

Lentibulariaceae
Utricularia foliosa L. A/H/LS/VM
Utricularia gibba L. A/H/LS/VM

Lobeliaceae
Lobelia cardinalis L. subsp. *cardinalis* S/H/EE/NS
Lobelia purpusii Brand. A/H/EE/EM

Loganiaceae
Mitreola petiolata (J.F. Gmel.) Torr. & A. Gray S/H/EE/NS

Lythraceae
Ammannia auriculata Willd. S/H/EE/VM
Ammannia coccinea Rottb. S/H/EE/VM
Ammannia robusta Heer & Regel S/H/EE/NS
Cuphea hyssopifolia Kunth T/H/EE/NS
Heimia salicifolia Link S/R/EE/NS
Lythrum alatum Pursh. var. *lanceolatum* (Elliott) Rothr. S/H/EE/NM
Lythrum alatum Pursh. var. *linearifolium* A. Gray S/H/EE/EM
Lytrum californicum Torr. & A. Gray S/H/EE/NA
Lythrum gracile Benth. S/H/EE/MC
Nesaea palmeri S.A. Graham S/H/EE/EM
Rotala ramosior (L.) Koehne A/H/EE/VM

Malvaceae
Kosteletzkya depressa (L.) O.J. Blanch., Fryxell & D.M. Bates T/H/EE/MS

Malachra alceifolia Jacq. T/H/EE/MS
Malachra capitata (L.) L. T/H/EE/MS

Menyanthaceae
Nymphoides indica (L.) Kuntze A/H/EH/VM

Mimosaceae
Inga vera Willd. S/B/EE/NS
Mimosa pigra L. S/R/EE/VM
Neptunia natans (L. f.) Druce A/H/LF/VM
Neptunia plena (L.) Benth. S/H/EE/VM
Neptunia pubescens Benth. var. *pubescens* S/H/EE/NS
Pithecellobium lanceolatum (Humb. & Bonpl.) Benth. T/B/EE/MS

Molluginaceae
Glinus radiatus (Ruiz & Pav.) Rohrb. T/H/EE/NS
**Mollugo verticillata* L. T/H/EE/VM

Moraceae
Ficus insipida Willd. S/B/EE/MS

Nelumbonaceae
Nelumbo lutea (Willd.) Pers. A/H/EH/NS

Nymphaeaceae
Nuphar advena (Aiton) W.T. Aiton subsp. *advena* A/H/EH/NA
Nymphaea amazonum Mart. & Zucc. subsp. *amazonum* A/H/EH/MS
Nymphaea ampla (Salisb.) DC. A/H/EH/NS
Nymphaea elegans Hook. A/H/EH/NA
Nymphaea jamesoniana Planchon A/H/EH/NS

Oleaceae
Fraxinus berlandieriana DC. S/B/EE/NA

Onagraceae
Ludwigia leptocarpa (Nutt.) H. Hara S/H/EE/VM
Ludwigia octovalvis (Jacq.) P.H. Raven S/H/EE/VM
Ludwigia palustris (L.) Elliott A/H/ES/NM
Ludwigia peploides (Kunth) P.H. Raven A/H/ET/NS
Ludwigia repens J.R. Forst. A/H/ES/NM

Plantaginaceae
**Plantago major* L. T/H/EE/VM

Platanaceae
Platanus rzedowskii K. Nixon & Poole S/B/EE/EM

Podostemaceae
Oserya coulteriana Tul. A/H/ES/EM
Tristichia trifaria (Bory ex Willd.) Spreng. A/H/ES/VM

Polygonaceae
Polygonum acuminatum Kunth A/H/EEMS
Polygonum ferrugineum Wedd. S/H/EE/MS
Polygonum glabrum Willd. S/H/EE/VM
Polygonum hydropiperoides Michx. var. *hydropiperoides* S/H/EE/NS
Polygonum hydropiperoides Michx. var. *opelosanum* (Riddell ex Small) J.S. Wilson S/H/EE/NS
**Polygonum lapathifolium* Willd. S/H/EE/VM
Polygonum pensylvanicum L. S/H/EE/VM
**Polygonum persicaria* L. S/H/EE/VM
Polygonum persicarioides Kunth S/H/EE/MS
Polygonum punctatum Ell. S/H/EE/NS
Polygonum segetum Kunth S/H/EE/MS
Rumex chrysocarpus Moric. S/H/EE/NA
**Rumex crispus* L. T/H/EE/VM
**Rumex obtusifolius* L. S/H/EE/VM
**Rumex pulcher* L. subsp. *pulcher* S/H/EE/VM

Primulaceae
Anagallis minima (L.) E.H.L. Krause S/H/EE/VM
Samolus ebracteatus Kunth var. *ebracteatus* T/H/EE/MC
Samolus parviflorus Raf. S/H/EE/NS

Rhizophoraceae
Rhizophora mangle L. A/B/EE/NS

Rubiaceae
Cephalanthus occidentalis L. S/R/EE/NC
Cephalanthus salicifolius Bonpl. S/R/EE/MC
**Pentodon pentandrus* (Schumach. & Thonn.) Vatke T/H/EE/VM
Spermacoce confusa Rendle T/H/EE/MS
Spermacoce glabra Michx. T/H/EE/NS
Spermacoce tenuior L. T/H/EE/NS

Salicaceae
Populus mexicana Wesmael var. *mexicana* S/B/EE/EM
Populus tremuloides Michx. T/H/EE/NA
Salix thurberi Nutt. S/R/EE/NA
Salix humboldtiana Willd. S/B/EE/NC
Salix nigra Marshall S/B/EE/NA
Salix taxifolia Kunth S/R/EE/NC

Scrophulariaceae
Bacopa monnieri (L.) Wettst. A/H/EE/VM
Calceolaria mexicana Benth. T/H/EE/MS
Capraria biflora L. T/H/EE/VM
Capraria mexicana Moric. ex Benth. T/H/EE/MC
Lindernia dubia (L.) Pennell S/H/EE/NS
Mecardonia procumbens (Mill.) Small T/H/EE/VM
Mecardonia vandellioides (Kunth) Pennell S/H/EE/NS
Mimulus glabratus Kunth var. *glabratus* S/H/EE/NS
Stemodia durantifolia (L.) Sw. S/H/EE/NS
Stemodia schottii Holz. S/H/EE/NA
Veronica peregrina L. S/H/EE/NS

Solanaceae
Calibrachoa parviflora (Juss.) D'Arcy T/H/EE/NS
Lycium carolinianum Walter var. *quadrifidum* (Dunal) Hitchc. T/H/EE/NA
Solanum campechiense L. T/H/EE/NS
Solanum diphyllum L. T/H/EE/MC
Solanum tampicense Dunal A/H/EE/NC

Tamaricaceae
**Tamarix gallica* L. T/R/EE/VM
**Tamarix chinensis* Lour. T/R/EE/VM

Ulmaceae
Celtis laevigata Willd. T/B/EE/NA
Ulmus crassifloia Nutt. T/B/EE/NA

Urticaceae
Boehmeria cylindrica (L.) Sw. T/H/EE/NS

Verbenaceae

Avicennia germinans (L.) L. S/B/EE/VM
Clerodendrum ligustrinum (Jacq.) R. Br. S/R/EE/MC
Lippia alba (Mill.) N.E. Br. T/H/EE/VM
Phyla dulcis (Trevir.) Moldenke T/H/EE/VM
Phyla lanceolata (Michx.) Greene S/H/EE/NS
Phyla nodiflora (L.) Greene T/H/EE/VM
Phyla stoechadifolia (L.) Small S/H/EE/NS/NS
Phyla strigulosa (M. Martens & Galeotti) Moldenke T/H/EE/NS

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BOOK NOTICES

Sandra Perrin. 2002. **Organic Gardening in Cold Climates (rev. ed.).** (ISBN 0-87842-451-2, pbk.). Mountain Press Publishing Company, P.O. Box 2399, Missoula, MT 59806, U.S.A. (**Orders:** www.mountain-press.com, info@mtnpress.com, 406-728-1900, 406-728-1635 fax, 800-234-5308). $12.00, 142 pp., b/w illustrations, 5½" × 8½".

The author, an organic gardener in Missoula, Montana, says that she wants this book to be a "simple explanation of good organic gardening." The map indicates that the northern half of the U.S.A., Canada, and Alaska are included in the purview of the discussion.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

Susan H. Munger (Text), Charlotte Stuab Thomas (Illustrations), and Verlyn Klinkenborg (Foreword). 2003. **Common to this Country: Botanical Discoveries of Lewis and Clark.** (ISBN 1-57965-224-7, hbk.). Artisan, 708 Broadway, New York, NY 10003, U.S.A. (**Orders:** www.artisanbooks.com, 212-254-5900, 212-677-6692 fax). $22.95, 128 pp., 25 watercolor illustrations, color photos, 7" × 9".

The author gives interesting and quickly readable discussion of the history and significance of 25 of the species collected by Meriwether Lewis of the Lewis & Clark Expedition: *Amelanchier alnifolia*, *Angelica arguta*, *Arctostaphylos uva-ursi*, *Camassia quamash*, *Clarkia pulchella*, *Coreopsis tinctoria*, *Echinacea angustifolia*, *Erythronium grandiflorum*, *Geum triflorum*, *Lewisia rediviva*, *Lilium philadelphicum*, *Linus lewisii*, *Lonicera involucrata*, *Lupinus sericeus*, *Maclura pomifera*, *Mahonia aquifolium*, *Mimulus guttatus*, *Oenothera cespitosa*, *Opuntia polyacantha* and other species, *Penstemon fruticosus*, *Philadelphus lewisii*, *Pinus ponderosa*, *Quercus macrocarpa*, *Symphoricarpos albus*, and *Xerophyllum tenax*. A full page illustration accompanies each species. "This illustrated botanical guide will appeal to natural history buffs and gardeners alike." With the nicely written introduction and excellent map of the expedition's route, it is a fine, popular introduction to this fascinating piece of history.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

W. Dale Nelson. 2003. **Interpreters with Lewis and Clark: The Story of Sacagawea and Toussaint Carbonneau.** (ISBN 1-57441-165-9, hbk.). University of North Texas Press, PO Box 311336, Denton, TX 76203-1336, U.S.A. (**Orders:** www.unt.edu/untpress, 940-565-2142, 940-565-4590 fax, 1-800-826-8911). $24.95, 184 pp., 22 illustrations, 2 maps, 6¼" × 9¼".

The author has written "a well-documented account of the lives of two near-mythical figures in Western history, Sacagawea [Shoshone Indian] and her husband Toussaint Charbonneau [French Canadian fur trader]. From the Lewis and Clark accounts and from all other available resources, he has extracted key references in recreating the fascinating life stories of these two intriguing people. ... [He] follows the couple from their diverse origins through their history-making travels with Lewis and Clark and on through the rest of their lives. ... In writing the story, the author carefully examines the numerous conflicting tales to give readers a balanced account of these interpreters with Lewis and Clark" (comments by Philip J. Roberts, from the book introduction).—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

Barry G. Hall. 2008. **Phylogenetic Trees Made Easy: A How-to Manual, Third Edition.** (ISBN 978-0-87893-310-5, pbk.). Sinauer Associates, Inc., 23 Plumtree Road, Sunderland, MA 01375-0407, U.S.A. (**Orders:** orders@sinauer.com, www.sinauer.com, 413-549-4300, 413-549-1118 fax). $39.95, 233 pp., illustrated, 9" × 9¼".

Contents.—**1)** Read Me First! **2)** Tutorial: Create a Tree! **3)** Acquiring and Aligning the Sequences. **INTERLUDE I. Major Methods for Estimating Phylogenetic Trees. 4)** Neighbor-Joining Trees. **5)** Drawing Phylogenetic Trees. **6)** Parsimony. **7)** Maximum Likelihood. **8)** Bayesian Inference of Trees with MrBayes. **INTERLUDE II. Which Method Should You Use? 9)** Reconstructing Ancestral Sequences. **10)** Detecting Adaptive Evolution. **11)** Working with Various Computer Platforms. Appendices, Literature Cited, Index.

THE CACTACEAE OF THE NATURAL MUNICIPAL PARK OF PRAINHA, RIO DE JANEIRO, BRAZIL: TAXONOMY AND CONSERVATION[1]

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ABSTRACT

This paper contains the floristic inventory for the Cactaceae occurring in the Natural Municipal Park of Prainha, located at 23° 02' 41"S 43° 30' 40"W, in the Rio de Janeiro Municipality, Rio de Janeiro State, Brazil. The area is a threatened native Atlantic Forest remnant with no floristic inventory. Ten Cactaceae genera occur in the Park, which are *Pereskia* Mill. (1 sp.), *Brasiliopuntia* (K. Schum.) A. Berger (1 sp.), *Opuntia* Mill. (1 sp.), *Epiphyllum* Haw. (1 sp.), *Hylocereus* (A. Berger) Britton & Rose (1 sp.), *Lepismium* Pfeiff. (1 sp.), *Rhipsalis* Gaertn. (5 spp.), *Cereus* Mill. (1 sp.), *Coleocephalocereus* Backeb. (1 sp.) and *Pilosocereus* Byles & Rowley (1 sp.). For the 14 taxa found in the survey we provide data on morphology, taxonomy, ecology and conservation that were obtained through field and literature research. Among the studied species, five are classified under threat categories and 54% are endemic to Brazil. A large floristic similarity was found between this Park and other coastal areas that have been surveyed in the Rio de Janeiro State.

Key words: Brazil, Cactaceae, Atlantic Forest, Conservation Units, Taxonomy

RESUMEN

Este papel contiene el inventario florístico para las Cactaceae del Parque Natural Municipal de Prainha, situado en 23° 02' 41"S 43° 30' 40"W, en el municipio de Río de Janeiro, estado de Río de Janeiro, Brasil. El área es un amenazado remanente del Bosque Atlántico nativo, con la ausencia de inventarios florísticos. Diez géneros de Cactaceae ocurren en el Parque, los cuales, *Pereskia* Mill. (1 sp.), *Brasiliopuntia* (K. Schum.) A. Berger (1 sp.), *Opuntia* Mill. (1 sp.), *Epiphyllum* Haw.(1 sp.), *Hylocereus* (A. Berger) Britton & Rose (1 sp.), *Lepismium* Pfeiff. (1 sp.), *Rhipsalis* Gaertn. (5 spp.), *Cereus* Mill. (1 sp.), *Coleocephalocereus* Backeb. (1 sp.) e *Pilosocereus* Byles & Rowley (1 sp.). Para los 14 taxones encontrados en el examen proporcionamos datos en morfología, taxonomía, ecología y conservación, que fueron obtenidos a través de las actividades científicas a campo y del estudio de la literatura. Entre las especies estudiadas, cinco presentan algún grado de amenaza y 54% son endémicos al Brasil. Una semejanza florística grande fue encontrada entre este parque y otras áreas costeras que se han examinado ya en el estado de Río de Janeiro.

INTRODUCTION

The Cactaceae family comprises about 100 genera and 1500 species distributed in four subfamilies: Opuntioideae, Pereskioideae, Maihuenioideae and Cactoideae (Hunt 1999). The species are restricted to the new world, with the exception of *Rhipsalis baccifera* (Mill.) Stearn, and can be recognized for the presence of the areole with spines and trichomes, succulent photosynthetic stems, absence of conspicuous leafs and flowers with receptacular epiginy (Barthlott & Hunt 1993). Cacti have a great economic importance and are widely spread as ornamental plants, but they also have many other uses as for medicine, as food, as cattle fodder, as fences, as fiber and filling, as furniture and as building material (Anderson 2001).

In Brazil occur 30% of the Cactaceae genera distributed in three of the four Cactaceae subfamilies: Opuntioideae, Pereskioideae and Cactoideae (Taylor & Zappi 2004). The species inhabit various vegetation formations as the *Cerrado* (Savanna), the *Caatinga* (Savannic Steppe) and the Atlantic Rain Forest, the latter being the main vegetation at the Natural Municipal Park of Prainha (Joly et al. 1999).

The Atlantic Forest has an estimated floristic diversity of 20000 species, and 6000 of them are endemic,

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[1] This work is part of the MSc. dissertation developed at the Programa de Pós-graduação em Ciências Biológicas (Botânica) of the Museu Nacional/ Universidade Federal do Rio de Janeiro.

however, this vegetation today is restricted to only 6% of the originally occupied area (Mittermeier et al. 2000). At the Rio de Janeiro State the original Atlantic Forest formations have been devastated by an intense human interference, especially by the coast, where are located the most populated areas in Brazil.

This study provides the floristic inventory for the Cactaceae at the Natural Municipal Park of Prainha (NMPP), an Atlantic Forest remnant located at the Rio de Janeiro city coast. Morphologic, taxonomic and ecological data on species and information that can be used to help the conservation of the NMPP and of the species are provided.

STUDY AREA

The Area named Prainha integrated the rural properties known as Camorim, Vargem Pequena e Vargem Grande Farms. In 1990 the Area of Environmental Protection (APA) of Prainha was created to save the natural scenario and to implement an ecological park at the region with the objectives of promoting the sustainable use through ecological tourism and recreation associated to environmental education activities. The Natural Municipal Park of Prainha (NMPP), originally named Ecological Municipal Park of Prainha was created in 1999 and today is under guard of the Municipal Secretariat of Environment—SMAC (Rio de Janeiro 1999). The park is located at S 23° 02' 41"W 43° 30' 40", at the Rio de Janeiro City, Brazil, between the Recreio dos Bandeirantes district and the APA of Grumari, and has 126.30 hectares (Fig. 1). In the park, a short extension beach is delimited by the coastal sides of the Caeté and Boa Vista hills and the Pedra dos Cabritos rock, building a natural amphitheater with the hillside varying from 0 to 460 m of altitude (Fig. 2).The part of the park located above 100 ms.m. is also included inside the area of the Pedra Branca State Park (Prefeitura da Cidade do Rio de Janeiro 1998).

The region is occupied by the Brazilian Atlantic Rain Forest (i.e. Dense Ombrophylous Atlantic Forest) in the hillsides and for the *restinga* vegetation (sandy coastal plane with pioneer communities) in areas near the beach (Ministério das Minas e Energia 1983; Joly et al. 1999). The existing forest at the area of study is mainly secondary in advanced process of natural regeneration with some scattered small more preserved areas of putative primary origin.

The steep hillsides and the hilltops are frequently dominated by gneiss-granite rock outcrops and those are colonized by a diverse rupicolous flora composed mostly from Cactaceae, Bromeliaceae and Velloziaceae taxa. The rock outcrop referred on the bibliography (Prefeitura da Cidade do Rio de Janeiro 1998) and also in this study as *Pedra dos Cabritos* (Cabritos Rock) is popularly named *Morro da Boa Vista* (Boa Vista Hill) and is the most visited site inside the park (Fig. 2).

METHODS

Botanical material was collected during 17 field excursions to 18 localities at the NMPP from April of 2003 to October of 2004 (Fig. 2). The specimens collected were prepared according with the usual herbarium techniques (Fidalgo & Bononi 1984) and incorporated in the Santa Úrsula University Herbarium (RUSU) and in the National Museum Herbarium (R). The following herbaria collections of the Rio de Janeiro State were consulted to obtain data: FCAB, GUA, HB, R, RB, RBR, RFA e RUSU (Holmgren et al. 1990). The basinonyms were cited when applied and the synonyms were only cited when published recently (after 2000) or when they are names still being used erroneously in herbaria collections.

The conservation statuses for the Rio de Janeiro State species were obtained in Calvente et al. (2005). The categories were accessed according with the IUCN 3.1 version (2001). The floristic similarity between the NMPP and the other areas in the Rio de Janeiro State was analyzed with the software BioDiversity Pro Version 2/1997 (The Natural History Museum & Scottish Association for Marine Science) that was used for the production of a presence and absence matrix, the calculation of the Jaccard distance equation and for the creation of a dendogram using the Group Average.

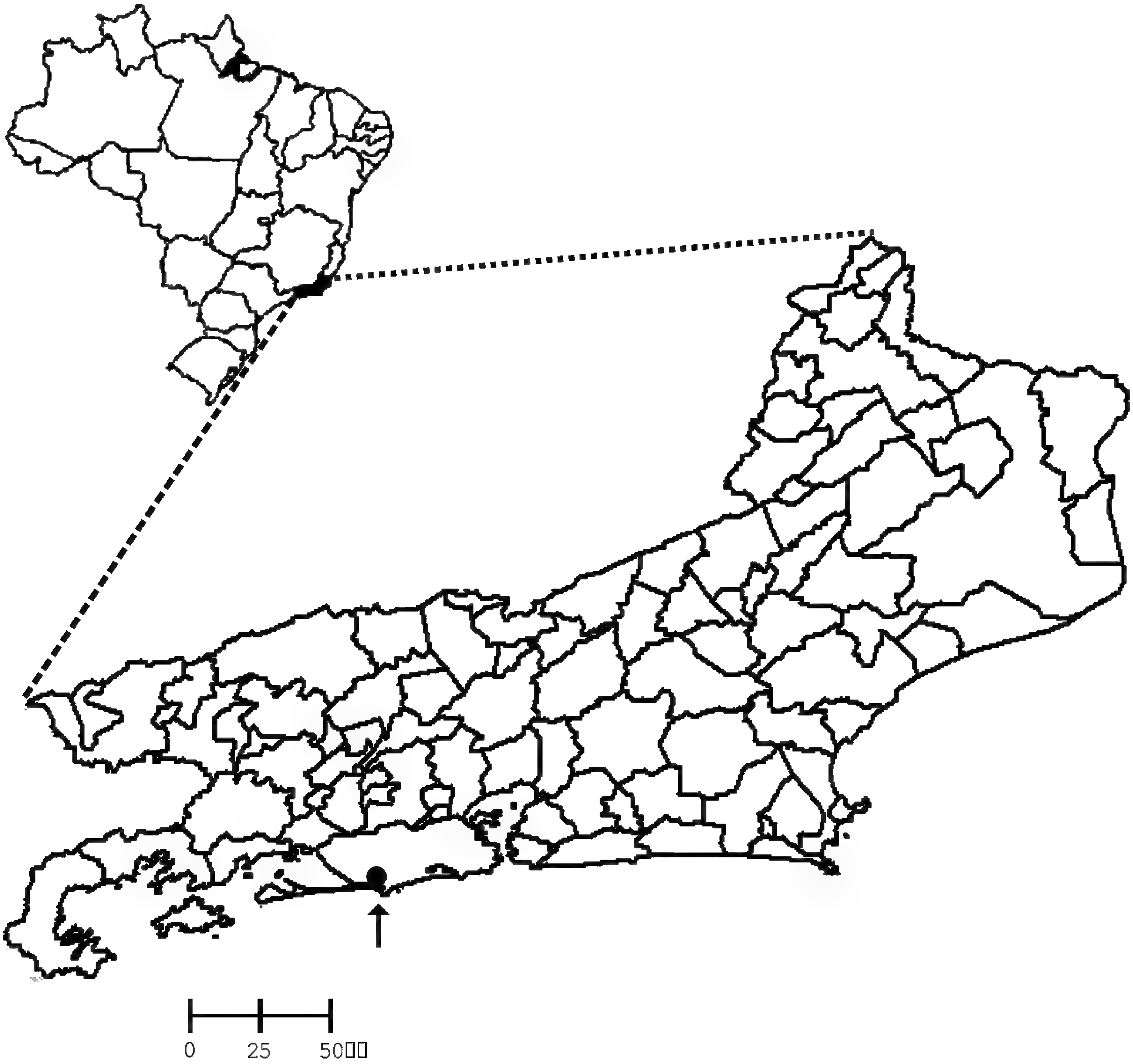


Fig. 1. Location of the Natural Municipal Park of Prainha, RJ (IPP, 1999a).

KEY TO CACTACEAE TAXA IN THE NATURAL MUNICIPAL PARK OF PRAINHA

1. Branches with well-developed leafs; pedunculated flowers. (Pereskioideae) **1. Pereskia aculeata**

1. Branches leafless or with minute scale-like, persistent or deciduous leafs; sessile flowers.

  2. Glochids present. (Opuntioideae - Opuntieae)

    3. Tree with dimorphic stems, primary segments cylindrical and secondary segments flattened; perigonium segments all yellow; fruit globose **2. Brasiliopuntia brasiliensis**

    3. Shrub with monomorphic stems, primary and secondary segments flattened; perigonium segments externally deep red and internally yellow; fruit turbinate **3. Opuntia monacantha**

  2. Glochids absent. (Cactoideae)

  4. Columnar tree or shrub with 4–15 ribs. (Cereeae)

    5. Stem segments with 9–15 ribs; fruit dehiscent by a basal pore **13. Coleocephalocereus fluminensis** subsp. **fluminensis**

    5. Stem segments with 4–6 ribs; fruit dehiscent by a longitudinal or lateral slit.

      6. Flowers 17–23 cm long; fruit dehiscent by a longitudinal slit **12. Cereus fernambucensis** subsp. **fernambucensis**

      6. Flowers 6–9 cm long; fruit dehiscent by a lateral slit **14. Pilosocereus arrabidae**

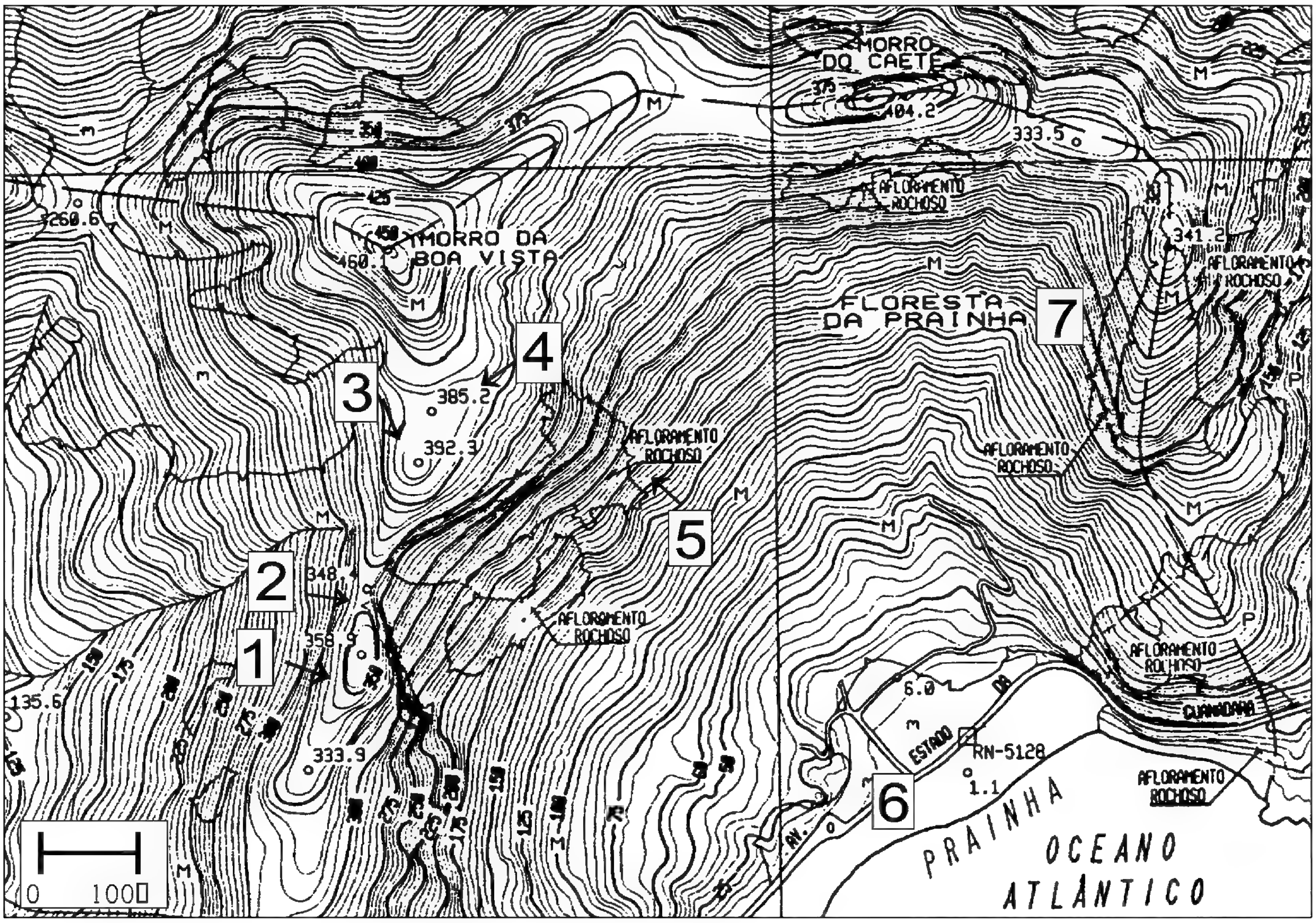


Fig. 2. Areas visited at the Natural Municipal Park of Prainha, RJ. 1. Pedra dos Cabritos; 2. Bosque das Mirtáceas; 3. Cruzeiro do Sul; 4. Bosque das Brasiliopuntias; 5. Afloramento central; 6. Restinga; 7. Afloramento Leste. (IPP, 1999b).

4. Non-columnar epiphyte or scandent plants with stems cylindrical, flattened or with 3–5 wings.
  7. Flower-tube 10–20 cm long, pericarpel and flower-tube with bract-scales. (Hylocereeae)
    8. Stem segments 3-winged, areoles with 3–4 conical spines; flowers infundibuliform, 25–35 cm long **5. Hylocereus setaceus**
    8. Stem segments flattened, areoles glabrous; flowers hypocrateriform, 19–24 cm long **4. Epiphyllum phyllanthus** subsp. **phyllanthus**
  7. Flower-tube less than 0.5 cm or absent, pericarpel and flower-tube glabrous. (Rhipsalideae)
    9. Stem segments flattened or 3–5 winged.
      10. Branching mesotonic; segment areoles with copious pilose hairs **6. Lepismium cruciforme**
      10. Branching acrotonic or subacrotonic; segment areoles glabrous or with scarce pilose hairs, tomentose hairs or bract scales.
        11. Wings discontinuous in the same stem segment **9. Rhipsalis paradoxa** subsp. **paradoxa**
        11. Wings continuous in the same stem segment.
          12. Stem segments flattened, rarely 3-winged; perigonium segments golden yellow, fruit oblong purple **7. Rhipsalis elliptica**
          12. Stem segments 3–5-winged; perigonium segments white; fruit depressed-globose white or pinkish **11. Rhipsalis triangularis**
    9. Stem segments cylindrical.
      13. Stem segments all of determinate growth; flowers 2.5–3 cm diam. **8. Rhipsalis grandiflora**
      13. Primary stem segments of indeterminate growth and secondary segments of determinate growth; flowers 0.9–1 cm diam. **10. Rhipsalis teres** f. **heteroclada**

1. Pereskia aculeata Mill., Gard. dict. ed. 8. 1768. (**Fig. 3 A–C**).

Shrub, scandent, terricolous or rupicolous, glochids absent. **Stem** brown or purplish, woody, cylindrical, ca. 0.5 cm diam. **Leafs** alternate, elliptic, rarely obelliptic, 6–9 × 2.5–3 cm, slightly bicolor, purplish

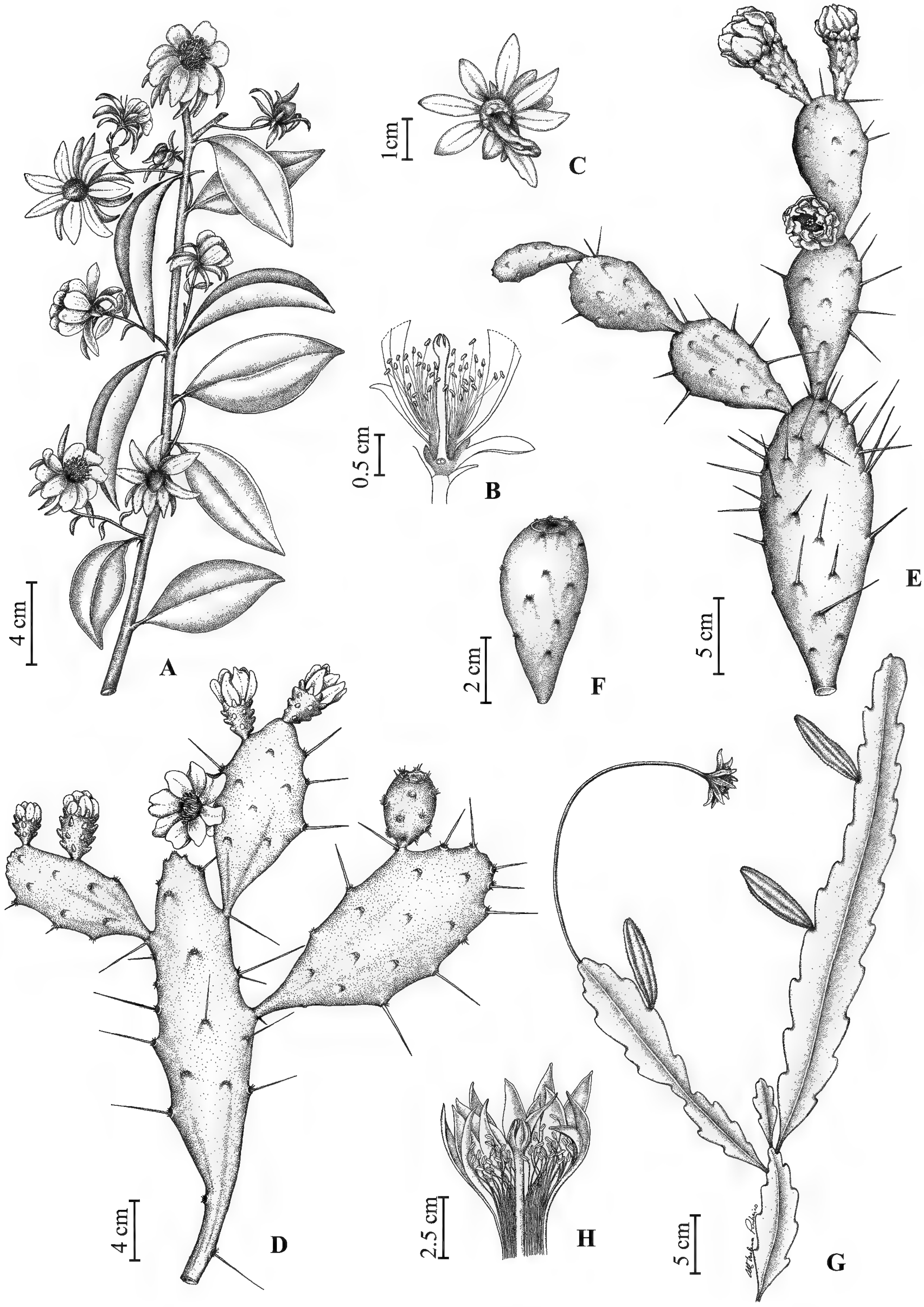


Fig. 3. A–C. *Pereskia aculeata* Mill. A. Branch with flowers, B. Longitudinal section of flower, C. Fruit. D. *Brasiliopuntia brasiliensis* (Willd.) A. Berger, flattened branch with flowers and fruits. E–F. *Opuntia monacantha* Haw.; E. Branch with flowers, F. Fruit. G–H. *Epiphyllum phyllanthus* (L.)Haw. subsp. *phyllanthus*; G. Branch with flower and immature fruits, H. Longitudinal section of flower.

green, venation inconspicuous. Areoles in the axils of leafs; spines 2, geminate, deltoid, retrorse, curve, ca. 2 cm long, sometimes absent. **Flower** diurnal, solitary or in inflorescences formed by the growing of one flower at the previous flower pedicel, rotate, 4–6 × 4 cm; pedicel 2–5.5 cm long; pericarpel ca. 0.5 × 0.5 cm. Pericarpel and pedicel areoles with 1 fleshy lanceolate basal bract-scale; hairs tomentose; spines 2–3 fine, acicular, 0.5–1.0 cm long, stiff. Perigonium external segments 5, deltoid, ca 0.2 × 0.2 cm, fleshy, green, apex acuminate; internal segments 13, obdeltoid to oblong, ca. 1.5 × 0.8–1.0 cm, membranaceous, white or greenish, apex mucronate or emarginate; filament white, anther golden yellow; ovary semi-inferior, stigma with 3–5 lobes; nectary a ring around the style base. **Fruit** globose, ca. 1.0 × 0.8 cm, orange, indehiscent, with persistent perigonium; fruit areoles with 1 fleshy lanceolate basal bract-scale (deciduous when ripe), tomentose hairs, (1–)2–3 acicular spines.

Heliophyte species commonly inhabiting the rock outcrops at the NMPP. The stigma frequently can be anomalous, exhibiting the fusion of two lobes or the short development of one lobe that becomes black and wilted. Flowers annually from February to April and fruits from April to August. **Conservation status:** Least Concern (LC).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, 23° 05'S 43° 29'W, elev. 5 ms.m., 20 Jul 1995, *Scheinvar 6272* (RB); Pedra dos Cabritos (topo do morro da Boa Vista), ca. 359 ms.m., 10 Apr 1996, *Braga & Bovini 3320* (RUSU, RB); ibidem, 12 Apr 2003, *Calvente et al. 34* (RUSU); ibidem, 29 Jan 2004, (25 Mar 2004, fl. cult.), *Calvente & Versieux 85* (RUSU).

2. Brasiliopuntia brasiliensis (Willd.) A. Berger, Entwicklungslin. Kakt. 94. 1926. (**Fig. 3 D**). *Cactus brasiliensis* Willd., Enum. pl. suppl. 33. 1814. *Opuntia brasiliensis* (Willd.) Haw., Suppl. pl. succ. 79. 1819.

Tree, 3–6 m, terricolous or rupicolous. **Trunk** woody, fleshy at apex. Areoles borne around the trunk; spines 6–25, acicular, 1.5–4.0 cm long. **Stem** segments dimorphic; primary segments cylindrical, 22–40 × 0.8–2.5 cm, fleshy, green; secondary segments flattened, elliptic to oblong, 6–15(–18) × 3–5(–5.5) cm, fleshy, bicolor, green, sometimes yellowish. Stem segments areoles with short tomentose hairs; glochids numerous, deciduous; spines 0–1(–2), acicular, 1–3 cm long. Young stem segments areoles with 1 minute deltoid deciduous fleshy bract-scale; spines 1–2, acicular, 0.1–0.5 cm long. **Flower** diurnal, 0–1 per areole, sessile, rotate, 2.5–3.5 × 2.5–4.5 cm; pericarpel depressed-obovate, 1.2–1.6 × 0.7–1.4 cm, with areoles similar to the stem segments areoles but with 1 fleshy minute deltoid basal bract-scale; perigonium segments 15–17, obelliptic, 1.0–1.6 × 0.5–0.7 cm, spreading, yellow; ovary inferior, stigma with 4–5 lobes. **Fruit** globose, ca. 3.5 cm diam., greenish yellow, indehiscent; fruit areoles with copious short tomentose hairs, numerous glochids; seed 2, 1 cm long, with copious, long, lanate hairs.

At the NMPP this species is sciophyte inside the forested areas where it can reach greater heights but it is shorter while growing as heliophyte on forest gaps. Many individuals are found growing close together, if one falls horizontally usually it will produce new shoots that grow vertically. Anomalous styles were frequently observed presenting a protuberance close to their apex, probably caused by the fusion of stamens parts or the fusion of the anther with style regions during the floral development. The flowers are visited by bees which are supposed to be the pollinators and by hemipterans which possibly feed perforating the stems. *Brasiliopuntia* was previously considered a synonym of *Opuntia* but today it is considered a separate genus based on molecular evidences (Wallace & Dickie 2002) and morphological apomorphies such as the heteromorphic stems (Taylor et al. 2002) and pollen grains with distinct ornamentation (Leuenberger 1976). Flowers annually during October, and usually the flowering is abundant and synchronic among the specimens. Immature fruits were observed from April to October. The fruits last many months to mature and were found semimature fallen to the ground during the following year flowering season. **Conservation status:** Least Concern (LC).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, Morro da Boa Vista, 30 Sep 1996, *Braga & Bovini 3519* (RUSU); Bosque das Mirtáceas, 12 Apr 2003, *Calvente et al.* 33 (RUSU); Bosque das Brasiliopuntias, 17 Oct 2003, *Calvente et al.* 62 (RUSU); ibidem, 28 Oct 2003, *Calvente & Bocayuva 65* (RUSU); ibidem, 10 Oct 2004, *Calvente & Versieux 109, 110, 111* (RUSU).

3. **Opuntia monacantha** Haw., Suppl. pl. succ. 81. 1819. (**Fig. 3 E–F**).

Shrub non columnar, erect, 1–3 m, terricolous. **Trunk** woody formed by the secondary growth of the basal stem segments. Areoles borne around the trunk; spines 3–12 acicular, ca 4 cm long, stiff. **Stem** segments monomorphic, flattened, obovate to elliptic, (7–)15–46 × (3.5–)8–15 cm, fleshy, green. Stem segments areoles with 1 minute deciduous fleshy basal bract-scale; hairs tomentose, short; glochids numerous; spines 1–2 acicular, 2–4(–5.5) cm long, stiff. **Flower** diurnal, 0–2(–3) per areole, sessile, rotate, 6–8 × 5–6 cm, many grouped in poorly defined floriferous regions; pericarpel turbinate, 4.0–6.0 × 2.0–2.5 cm, with areoles similar to the stem segments areoles but with only 1 acicular, ca. 0.7 cm long spine; perigonium segments ca. 29, deltoid to obovate, 1.5–3.0 × 1.0–1.5 cm, spreading, apex mucronate; external segments fleshy, purplish; internal segments membranaceous, yellow; stamens sensitive; ovary inferior, stigma with 6–7 lobes. **Fruit** turbinate, ca. 7 × 4 cm, reddish green, indehiscent; fruit areoles with short tomentose hairs, numerous deciduous glochids.

This is a frequent heliophyte species on the open *restinga* vegetation near the beach. The population occurring at the NMPP is not of great size and the number of young specimens around well established mature individuals suggests that this population is on a recovering stage and that this species may have a great clonal reproduction capacity. The flowers are visited by bees which are supposed to be the pollinators, by hemipterans and are predated by coleopterans that feed on the stamens after the anthesis. *Opuntia monacantha* was found sometimes erroneously misidentified as *O. vulgaris* Mill. on herbaria collections. This name is considered today a synonym of *O. ficus-indica* (L.) Mill. (Taylor et al. 2002). Flowering is annual, abundant and synchronic among individuals at the NMPP during February and from May to October. Immature fruits occur during almost the whole year and were found ripe in January. **Conservation status:** Least Concern (LC).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, 27 Feb 1987, *Giordano & Ferreira 230* (RB); vegetação de restinga próxima à praia, 06 Jun 2003, *Calvente et al. 43* (RUSU); ibidem, 28 Oct 2003, *Calvente & Bocayuva 69* (RUSU); ibidem 15 May 2004, *Calvente & Versieux 92* (RUSU); Sede do Parque, próximo aos sanitários, 10 Oct 2004, *Calvente & Versieux 101* (RUSU).

4. **Epiphyllum phyllanthus** (L.) Haw. subsp. **phyllanthus**, Syn. pl. succ. 197. 1812. (**Fig. 3 G–H**). *Cactus phyllanthus* L., Sp. pl. 1:469. 1753.

Epiphyte, glochids absent, branches ca. 1.5 m long, erect or with pendent apex. **Stem** segments flattened, somewhat oblong with lateral strangulations, 20–60 × 0.5–5 cm, leafless, fleshy, green, margin serrate or crenate. Areoles borne at the stem segments margins indents, glabrous. **Flower** nocturnal, 0–1 per areole, sessile, hypocrateriform, 19–24 × 3–4 cm; pericarpel oblong, ca 2.0 × 0.7 cm, with few sparse deltoid bract-scales; flower-tube long, 16–20 × 0.4 cm, with few sparse bract-scales; perigonium segments oblong, 1.0–1.2 × 0.3–0.4 cm, spreading, apex acute; external segments ca. 6, green; internal segments ca. 16, pinkish white; filament white, anther brown; ovary inferior, stigma with 9 lobes; nectar-chamber along the interior of the flower-tube. **Fruit** oblong, ca. 8.5 × 3 cm, green when immature, with few sparse oblong bract-scales.

This species can be semiheliophyte to sciophyte. It is probably pollinated by moths because of the long and slender flower-tube. According with Bauer (2003) the fruit when ripe is magenta and dehiscent by a lateral slit. It is a plant very frequent in its area of occurrence, inhabiting tropical forests and dryer forests such the ones in the northeast and middle west of Brazil. It flowers during October also when immature fruits were found. Kimnach (1964) distinguishes six varieties for this species (var. *phyllanthus*, *rubrocoronatum*, *hookeri*, *guatemalense*, *pittieri*, and *columbiense*), however, Bauer (2003) recognizes for *Epiphyllum phyllanthus* only the typical subspecies and the *E. phyllanthus* subspecies *rubrocoronatum* (Kimnach)Ralf Bauer, which are differentiated principally by the color of stamens, white on the former and red or orange to purple on the latter. The remaining varieties of Kimnach (1964) are considered subspecies of *E. hookeri* Haw. on Bauer's synopsis (2003), due to morphological and geographical aspects. **Conservation status:** Least Concern (LC).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, subida para o Morro da Boa Vista, ca. 200 ms.m., 09 Oct 1996, *Braga & Lira Neto 3559* (RB); Bosque das Brasiliopuntias, 28 Oct 2003, *Calvente & Bocayuva 66* (RUSU).

5. Hylocereus setaceus (Salm-Dyck ex DC.) Ralf Bauer, Cactaceae Syst. Init. 17:29. 2003. (**Fig. 4 A–B**). *Cereus setaceus* Salm-Dyck ex DC., Prodr. 3:469. 1828. *Selenicereus setaceus* (Salm-Dyck ex DC.) Werderm., Bras. Säulenkakt. 87. 1933. *Selenicereus rizzinii* Scheinvar, Rev. Brasil. Biol. 34:249. 1974.

Shrub, scandent or prostrated, rupicolous, glochids absent. **Stem** segments 3-winged, (20–)35–120 × (2–)3–5 cm, leafless, fleshy, sometimes with woody parts, green, margin entire, lobed or faintly serrate. Areoles borne at the wings margins indents with short tomentose hairs; spines 3–4, lateral, conic, short, 0.4–0.5 cm long, stiff, pungent. **Flower** nocturnal, 0–1 per areole, sessile, infundibuliform, 25–35 × 6–8 cm, lateral; pericarpel ca. 4 × 2 cm. Pericarpel areoles borne on top of tubercles, with 1 oblong basal bract-scale with acute apex; hairs short, tomentose; spines 4–5, acicular, 6–8 cm long, slightly stiff, purplish. Flower-tube long, ca. 10 × 3 cm with areoles similar to the pericarpel areoles but gradually towards the flower apex with hairs and spines scarcer and longer bract-scales; perigonium segments ca. 40, erect to suberect, oblong; external segments 2–9 × 1 cm, fleshy, green, apex acute; internal segments ca. 9 × 2 cm, membranaceous, white, apex rounded; ovary inferior, stigma with 18 lobes; nectar-chamber along the interior of the flower-tube. **Fruit** ovoid, ca. 7.0 × 3.5 cm, purplish, indehiscent, perigonium black persistent. Fruit areoles with pilose hairs; spines 6–14, acicular, 0.5–0.8 cm long.

It is a heliophyte species very frequent on rock outcrops. Sometimes the stem segments have expanded conspicuous wings. It is probably pollinated by moths because of its long flower-tube. Recently, Bauer (2003) transferred this species from *Selenicereus* (L.) Britton & Rose to *Hylocereus* so it is common to find specimens at the herbaria still identified as *S. setaceus*. It flowers annually in October and fruits were observed from January to March. **Conservation status:** Least Concern (LC).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro. Parque Natural Municipal da Prainha, Pedra dos Cabritos, 28 Oct 2003, *Calvente & Bocayuva 68* (RUSU); Cruzeiro do Sul, 29 Jan 2004, *Calvente & Versieux 80* (RUSU); ibidem, 10 Oct 2004, *Calvente & Versieux 105, 106* (RUSU).

6. Lepismium cruciforme (Vell.) Miq., Bull. Sci. Phys. Nat. Néerl. 49. 1838. (**Fig. 5 A**). *Cactus cruciformis* Vell., Fl. flum. 207. 1829. icon. 5:tab.29. 1831. nom. cons.

Epiphyte, prostrated, mesotonically branched, glochids absent. **Stem** segments all of indeterminate growth 3-winged, 9–24 × 2–3 cm, leafless, fleshy, green, wings continuous in the same stem segment, margin crenate or serrate, extremes attenuate. Areoles borne at the wings margins indents, with copious long white pilose hairs. **Flower** diurnal, 0–2(–3) per areole, sessile, ca. 1 × 0.7 cm, lateral or subapical; pericarpel immerse in the areole, glabrous; flower-tube short, less than 0.5 cm, glabrous; perigonium segments 5–7, yellowish green to whitish, purple spotted; stamen pale yellow; ovary inferior, style purplish, stigma white with 3–4 lobes. **Fruit** globose, 0.5–0.6 cm diam, magenta, glabrous, indehiscent, perigonium deciduous.

Only one specimen was collected within the NMPP, growing as sciophyte without flowers, so its description here is based on additional specimens. Fruits were observed in October. **Conservation status:** Least Concern (LC).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, 10 Oct 2004, *Calvente & Versieux 108* (RUSU); Mun. Maricá, Restinga de Maricá, 24 Oct 1986, *Giordano et al. 179* (RB). **São Paulo:** Mun. Londrina, entre a represa Chavantes e Jurumim, 20 Oct 1966, *Linderman & Haas 3163* (RB).

7. Rhipsalis elliptica G. Lindb. ex K. Schum. in Martius, Fl. Bras. 4(2):293. 1890. (**Fig. 5 B–C**).

Epiphyte, branches ca. 60 cm long, acrotonically or rarely subacrotonically branched, glochids absent. **Stem** segments all of determinate growth, leafless, fleshy, green, margin crenate or incised; primary segments 1–3 subsequent, flattened, 9.5–23 × 0.4–2.0 cm, base semicylindrical; secondary segments 1–2(–3) in each branching axis, flattened, elliptic, oblong or obelliptic, rarely 3-winged, 4–16 × 1–5 cm, wings continuous at the same segment, margin sometimes undulate. Areoles borne at the wings margins indents, glabrous;

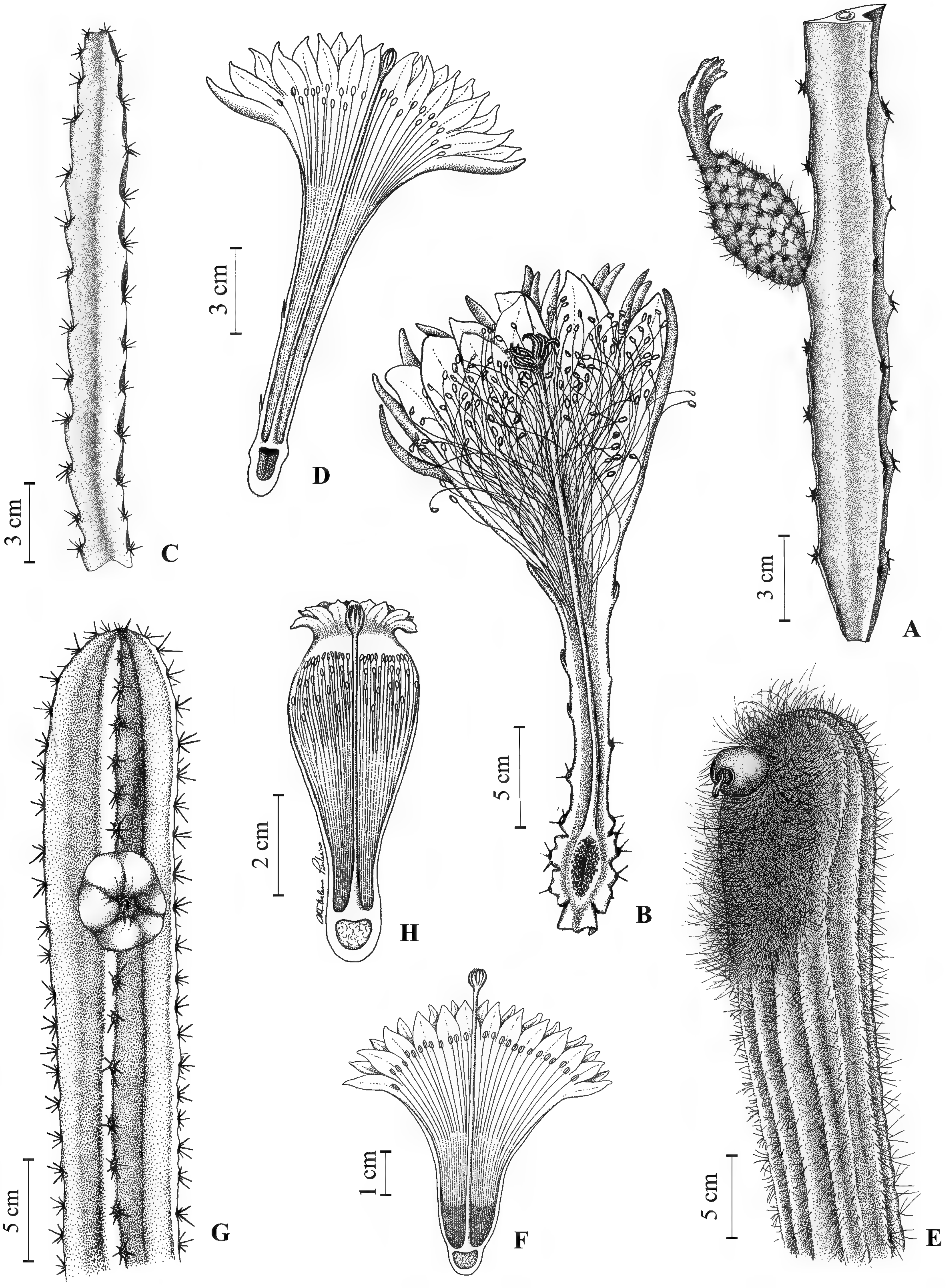


Fig. 4. A–B. *Hylocereus setaceus* (Salm-Dyck ex DC.) Ralf Bauer; A. Branch with immature fruit, B. Longitudinal section of flower. C–D. *Cereus fernambucensis* Lem. subsp. *fernambucensis*; C. Branch, D. Longitudinal section of flower. E–F. *Coleocephalocereus fluminensis* (Miq.) Backeb. subsp. *fluminensis;* E. Branch with fruit, F. Longitudinal section of flower. G–H. *Pilosocereus arrabidae* (Lem.) Byles & Rowley; G. Branch with fruit, H. Longitudinal section of flower.

when on reproductive phase with scarce pilose hairs; 0–3(–5) bract-scales. **Flower** diurnal, 0–1(–2) per areole, sessile, rotate, 1.0 × 1.4 cm, lateral or subapical, flower-tube absent; pericarpel 0.5–0.6 × 0.3–0.4 cm, glabrous; perigonium segments golden yellow, membranaceous, conspicuously reflexed at anthesis involving the pericarpel; external segments 3, deltoid to oblong, 0.05–0.4 × 0.05–0.3 cm; internal segments 5, oblong to obelliptic, 0.6–0.7 × 0.2–0.5 cm; ovary inferior, stigma with 5 lobes; nectary a ring around the style base. **Fruit** oblong, ca. 0.6 × 0.4 cm, purple, glabrous, indehiscent, perigonium deciduous.

This species is sciophyte and the margin of the stem segments can be lacerate by predation or wearing. Flowers annually and synchronically among the individuals in August. Fruits in November. The flowering period is short (ca. 1 week) and few fruits develop completely. It is endemic of the Brazilian Atlantic Forest. **Conservation status:** Least Concern (LC).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, trilha para a pedra dos cabritos (morro da Boa Vista), 09 Oct 1996, *Braga 3554* (RUSU); ibidem, 22 Aug 2003, *Calvente et al. 50* (RUSU); ibidem, 11 Jun 2004, *Calvente & Versieux 96* (RUSU); trilha para o Cruzeiro do Sul, 22 Aug 2003, *Bocayuva et al. 46* (RUSU).

8. Rhipsalis grandiflora Haw., Suppl. pl. succ. 83. 1819. (**Fig. 5 D–E**).

Epiphyte, branches ca. 2.5 m long, acrotonically branched, glochids absent. **Stem** segments all of determinate growth, leafless, fleshy or woody, grayish green, cylindrical, 6.5–13 × 0.5–0.8 cm, 1–3 (–4) in each branching axis. Areoles borne around the stem segments, glabrous. Young stem segments areoles purplish with 0–1 deltoid minute bract-scale. When on reproductive phase stem segments areoles with 1–2 falcate bract-scales. **Flower** diurnal, 0–2 per areole, sessile, rotate, 1.5 × 2.5–3.0 cm, lateral, perpendicular to the stem segments, flower-tube absent; pericarpel ca. 0.2 × 0.4 cm, glabrous, slightly immersed in the areole; perigonium segments spreading or reflexed; external segments 5–6, deltoid, 0.1–0.6 × 0.1–0.2 cm, semifleshy, greenish, apex acute; internal segments 8–9, oblong, 0.7–1.2 × 0.4–0.6 cm, membranaceous, pinkish or yellowish white, apex rounded slightly involute; ovary inferior, stigma with 5 lobes; nectary a ring around the style base. **Fruit** globose, white, glabrous, indehiscent, with persistent black perigonium.

This species is heliophyte or semiheliophyte. The stem segments frequently have lacerated regions. The flowers have a sweet smell and are visited by bees which are supposed to be the pollinators. Flowers in October and fruits in November. Few fruits were observed on specimens from NMPP. *Rhipsalis grandiflora* when sterile is similar to *R. teres* f. *heteroclada* (Britton & Rose) Barthlott & N.P. Taylor but can be distinguished because it has all the stem segments of determinate growth and lacks composite terminal areoles. The purplish areoles in its young stem segments is a feature also present in other species such as *R. neves-armondii* K. Schum. which can be distinguished by its pinkish flowers with golden yellow stamens and conspicuously erumpent flower buds borne in wooly areoles. In general *R. grandiflora* is stouter than all the similar species and its flowers are conspicuously large and showy. It is endemic of the Brazilian Atlantic Forest and its habitat is reducing due to the urbanization. **Conservation status:** Near threatened (NT).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, Bosque das Mirtáceas, 12 Apr 2003, *Calvente et al.* 32 (RUSU); Trilha para o Cruzeiro do Sul, 11 Jun 2004, *Calvente & Versieux 95* (RUSU); ibidem, 10 Oct 2004, (17 Oct 2004, fl. cult.), *Calvente & Versieux 117* (RUSU).

9. Rhipsalis paradoxa (Salm-Dyck ex Pfeiff.) Salm-Dyck subsp. **paradoxa** in Cact. Hort. Dyck. 1849:228. 1850. (**Fig. 5 F**).

Lepismium paradoxum Salm-Dyck ex Pfeiff. in Enum. Diagn. Cact. 140. 1837.

Epiphyte, branches ca. 2 m long, acrotonically branched, glochids absent. **Stem** segments all of indeterminate growth, leafless, fleshy, green, 9–21(–26) × 1–2 cm, 1–3 in each branching axis, 3-winged in transversal section; wings 3.0–7.5 × 0.4–0.6(–1.0) cm, discontinuous in the same segment, subsequent to the areoles. Areoles borne around the stem segments, glabrous. **Flower** diurnal, sessile, rotate, 1.5 × 2.0 cm, white, lateral, flower-tube absent; pericarpel ca. 0.4 × 0.4 cm, glabrous; perigonium segments ca. 8, oblong, 0.7–1.2 × 0.15–0.3 cm, apex rounded; ovary inferior, stigma with 5 lobes. **Fruit** depressed-turbinate, 0.4–0.8 cm diam., white, glabrous, indehiscent, perigonium deciduous.

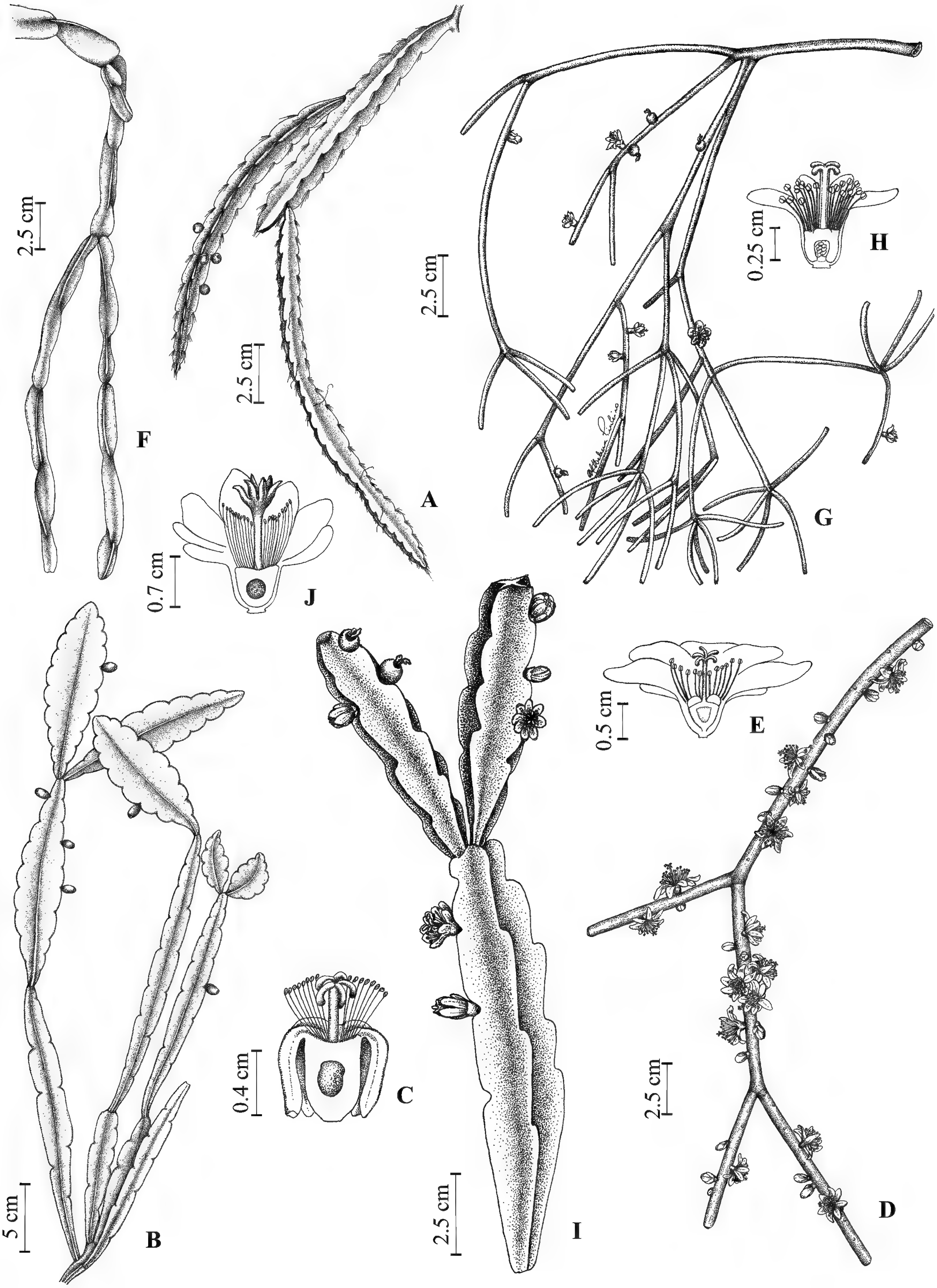


Fig. 5. A. *Lepismium cruciforme* (Vell.) Miq., branch with fruits. B–C. *Rhipsalis elliptica* G. Lindb. ex K. Schum.; B. Branch with fruits, C. Longitudinal section of flower. D–E. *Rhipsalis grandiflora* Haw.; D. Branch with flowers, E. Longitudinal section of flower. F. *Rhipsalis paradoxa* (Salm-Dyck ex Pfeiff.) Salm-Dyck subsp. *paradoxa*, branch. G–H. *Rhipsalis teres* f. *heteroclada* (Britton & Rose) Barthlott & N.P. Taylor; G. Branch with flowers and fruits, H. Longitudinal section of flower. I–J. *Rhipsalis triangularis* Werderm.; I. Branch with flowers and fruits; J. Longitudinal section of flower.

This is a sciophyte species that in the NMPP was not found fertile so the flowers and fruits are described here according with additional specimens. It is endemic of the Brazilian Atlantic Forest and its habitat is reduced due to the deforestation and urbanization. *Rhipsalis paradoxa* subsp. *septentrionalis* N.P. Taylor & Barthlott occurs in Pernambuco, Bahia, Minas Gerais and Espírito Santo states and is distinguished from the typical subspecies due to its darker yellow flowers and slender stem segments with 0.7–1.1 cm (Barthlott & Taylor 1995). **Conservation status:** Near Threatened (NT).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, *Cardoso (s.n., RUSU 14317)*; Bosque das Brasiliopuntias, 10 Oct 2004, *Calvente & Versieux 116* (RUSU); Mun. Mangaratiba: Reserva Rio das Pedras, Rio Grande, 21–22 Dec 1996, *Lira Neto et al. 522* (RUSU); trilha para o cambucá, 200–300ms.m, 20 Oct 1996, *Bovini et al. 1090* (RUSU).

10. Rhipsalis teres f. **heteroclada** (Britton & Rose) Barthlott & N.P. Taylor, Bradleya 13:65. 1995. (**Fig. 5 G–H**). *Rhipsalis heteroclada* Britton & Rose, Cact. 4:224. 1923.

Epiphyte, branches 1–1.5 m long, acrotonically or subacrotonically branched, glochids absent. **Stem** segments cylindrical, leafless; primary segments long, of indeterminate growth, 8.0–22 × 0.3 cm, 1–2 subsequent, usually woody, grayish; secondary segments short, of determinate growth, 2.0–7.0 × 0.1–0.3 cm, 2–7 in each branching axis, fleshy, green. Areoles borne around the stem segments, usually glabrous, areoles terminal in the stem segments composite and with pilose hairs. Young stem segments areoles with scarce pilose hairs and 1 deltoid minute bract-scale. When on reproductive phase stem segments areoles with 1–2 falcate bract-scales ca. 0.1 cm long. **Flower** diurnal, 0–2 per areole, sessile, rotate, 0.6–0.8 × 0.9–1.0 cm, lateral, sub-apical or apical, slightly oblique to perpendicular to the stem segments, flower-tube absent; pericarpel ca. 0.3 cm diam, glabrous; perigonium segments suberect to spreading, membranaceous, greenish to reddish; external segments 4, deltoid, ca. 0.1 cm long or shorter, the apex slightly reflexed; internal segments 5, triangular to oblong, 0.4–0.6 × 0.1–0.2 cm, apex rounded, sometimes with the margins involute; ovary inferior, stigma with 4 lobes; nectary a ring around the style base. **Fruit** depressed-globose, ca. 0.4 cm diam, greenish white, glabrous, indehiscent, with persistent black perigonium.

This species is frequent at the NMPP as sciophyte to semisciophyte. It is distinct from the other forms of *Rhipsalis teres* (Vell.)Steud. due to the stouter stem segments and larger flowers. The young apical shoots are slender then the mature basal segments. The *Rhipsalis teres* f. *heteroclada* is very hard to be differentiated from the *R. teres* f. *teres* in herbaria, especially in those cases when only the slender apical shoots are collected. For that reason, more detailed studies must be done to establish a more precise morphological differentiation among them. *Rhipsalis teres* f. *heteroclada* is endemic and frequent in the Brazilian Atlantic Forest. It flowers from June to October and fruits from July to November. The fruit mature rapidly. **Conservation status:** Least Concern (LC).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, trilha para a pedra dos Cabritos (morro da Boa Vista), ca. 150 ms.m. 09 Oct 1996, *Braga & Lira Neto 3557* (RUSU, RB); ibidem, 29 Oct 2003, *Braga et al. 7232* (RB); ibidem, 15 May 2004, *Calvente & Versieux 86, 91* (RUSU); Bosque das Mirtáceas, 23° 02' 41,2"S 43° 30' 40,5"W, 09 Jul 2003, *Calvente et al. 49* (RUSU); trilha para o Cruzeiro do Sul, 03 Oct 2003, *Bocayuva 70 et al.* (RUSU); ibidem, 17 Oct 2003, *Calvente et al. 61* (RUSU); Bosque das Brasiliopuntias, 11 Jun 2004 (10 Oct 2004, fl. cult.), *Calvente & Versieux 94* (RUSU).

11. Rhipsalis triangularis Werderm., Feddes Repert. Spec. Nov. Regni Veg. 1071–1080: 3. 1937. **(Fig. 5 I–J)**.

Shrub non columnar, rupicolous or epiphyte, acrotonically branched, glochids absent. **Stem** segments all of determinate growth, leafless, fleshy, 6–24 × 1–4(–6) cm, 1–5 in each branching axis, pale green or yellowish green, margin serrate or crenate usually reddish, 3–4(–5) winged, wings continuous at the same segment. Areoles 1,5–2,5 cm apart at the wings margins indents, with short tomentose hairs; bract-scales 0–5, stiff, vestigial from the reproductive phase, similar to spines. When on reproductive phase or young stem segments areoles with 0–8 linear bract-scales. **Flower** diurnal, 0–3 per areole, sessile, rotate, ca. 1.5 × 2.5 cm, lateral, sub-apical or apical, flower-tube absent; pericarpel 0.4–0.6 × 0.4–0.6 cm, glabrous; perigonium segments reflexed or spreading, white; external segments 3–4, deltoid, 0.2–0.4 × 0.4–0.6 cm, slightly fleshy, apex rounded; internal segments 9–10, oblong, 0.5–0.9 × 0.2–0.4 cm, membranaceous, apex rounded slightly involute; ovary inferior, stigma with 5–7 lobes; nectary a ring around the style base. **Fruit** depressed-globose, 0.6–0.7 × 0.7–0.8 cm, pinkish when immature and white when ripe, glabrous, indehiscent, with persistent grayish black perigonium.

This is a heliophyte or semiheliophyte species which forms large populations at the rock outcrops and probably reproduces vegetatively. The basal stem segments sometimes have the margins lacerated. The flowers are visited by bees which are supposed to be the pollinators, ants and moths. The flowering is abundant and synchronic among the individuals during April to June and scarce in October. Fruits were observed in November and April. Werdermann (1937) described *Rhipsalis triangularis* from a cultivated material which was sent from the Rio de Janeiro Botanical Garden to the Dahlem Botanical Garden and the original habitat of this species was unknown for the author. *Rhipsalis triangularis* during many years was considered a problematic taxa because of the absence of the type material and new collections with the features described by Werdermann (Barthlott & Taylor 1995). However the specimens found at the NMPP fit perfectly in the original description of *R. triangularis* with the exception of few differences which can be attributed to different environmental conditions or to the fact that Werdermann (1937) based his description in one specimen with only 3 stem segments. These few differences are that the specimen described by Werdermann had faintly indented serrate margins, absence of aerial roots and pale green pericarpel while the NMPP populations have in general crenate or serrate margins, presence of aerial roots and brownish green or pinkish magenta pericarpel. *Rhipsalis agudoensis* N.P. Taylor is similar to *R. triangularis* but is distinct for its magenta pink fruits and is referred to a distant site, the city of Agudo at the Rio Grande do Sul State (Taylor 2003). Further field studies are necessary to better evaluate the relation between *Rhipsalis agudoensis* and *R. triangularis*. **Conservation status:** Critically Endangered (CR).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, Pedra dos Cabritos, 340 ms.m., (mirante Boa Vista), 06 Jun 1996, *Braga & Bovini 3357* (RUSU); ibidem, 17 Apr 2003, *Calvente & Bocayuva 37, 38* (RUSU); ibidem, 12 Dec 2003, *Cardoso & Zaldini 51* (RB); ibidem, 15 May 2004, *Calvente & Versieux 87, 89, 90* (RUSU); Cruzeiro do Sul, 06 Jun 2003, *Calvente et al. 42* (RUSU); Bosque das Brasiliopuntias, 10 Oct 2004, *Calvente & Versieux 107a, 112* (RUSU).

12. **Cereus fernambucensis** Lem. subsp. **fernambucensis**, Cact. gen. sp. nov. 58. 1839. (**Fig. 4 C–D**).

Cereus obtusus Haw., Rev. pl. succ. 70. 1821.

Shrub, columnar, prostrated or erect, terricolous or rupicolous, glochids absent. Stem segments leafless, fleshy, 12–26 x 3–5 cm, 2–3(–4) in each branching axis, grayish green; ribs 4–5, 1–2 cm wide, ca. 1 cm thick, margin entire, faintly crenate or incised. Areoles borne at the ribs margins indents, with short tomentose hairs; central spines 1–3, acicular, 1.0–3.2 cm long, stiff; lateral spines 2–5, acicular, 0.4–1.5 cm long, stiff. Flower nocturnal, 0–1 per areole, sessile, infundibuliform, 17–23 × 13–17 cm, lateral; pericarpel ca. 1.5 × 1.2 cm; flower-tube 9–12 × 1 cm; pericarpel with bract-scales deltoid, ca. 0.2 cm long, apiculate, green, towards the flower-tube apex gradually becoming purple, oblong, ca. 1.5 cm long with apiculus absent; perigonium external segments ca. 14oblong, 2.0–5.5 × 0.7–0.9 cm, slightly fleshy, purplish green, spreading, apex acute; internal segments ca. 30, obelliptic or oblong, 3.8–5.0 × 1.0–2.0 cm, membranaceous, pinkish white, suberect, base attenuate, apex rounded; ovary inferior, stigma with 13 lobes; nectar-chamber ca. 7 cm long. Fruit depressed-oblong, ca. 6 × 5 cm, magenta, glabrous, dehiscent by a longitudinal slit, perigonium deciduous.

In the NMPP this species is frequent as heliophyte in the open restinga vegetation and on the rock outcrops close to the beach and its altitudinal distribution reaches 100 ms.m at the most. Small coleopterans feed on the androecious after the anthesis. It flowers annually from September to October and fruits from October to March. Few fruits are produced after flowering and those were found ripe on the following year flowering season. It is endemic of the Brazilian Atlantic Forest. In the Rio de Janeiro State occur *Cereus fernambucensis* subsp. *sericifer* (F.Ritter) N.P. Taylor & Zappi and the typical subspecies, which is distinguished by its coastal distribution and magenta pink fruits, while *C. fernambucensis* subsp. *sericifer* has an inland distribution and yellows fruits (Taylor & Zappi 2004). **Conservation status:** Least Concern (LC).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, sob pedra na praia, 10 Sep 2003, *Calvente & de Paula 51* (RUSU); ibidem, 1 Oct 2004, *Calvente & Versieux 102, 103, 104* (RUSU).

13. Coleocephalocereus fluminensis (Miq.) Backeb. subsp. **fluminensis,** Jahrb. Deutsch. Kakteen-Ges. 1941(2):53. 1942. (**Fig. 4 E–F**). *Cereus fluminensis* Miq., Bull. Sci. Phys. Nat. Neérl. 48. 1838.

Shrub, columnar, 50–130 cm, erect or semidecumbent, rupicolous, glochids absent. Stem segments leafless, fleshy, sometimes woody at base, 60–180(–240) × 10 cm, green; ribs 9–15, ca. 1.5 cm wide, 1–2 cm thick, margin entire. Areoles borne at the ribs margins, with short tomentose hairs; spines 3–7, acicular, 1.5–3.0 cm long, flexible, gray, yellowish at the apex, usually 1 central e the others lateral. Cephalium lateral, 10–15(–30) × 5–7 cm, with copious long, lanate hairs; spines acicular, 3–5 cm long, sometimes undulate or curve, flexible, golden yellow with brownish apex. Flower nocturnal, borne on the cephalium, 1–2 in each flowering, sessile, infundibuliform, ca. 7 × 5 cm, pink; pericarpel ca. 0.8 × 0.8 cm, glabrous; flower-tube with minute bract-scales sometimes involute; perigonium segments ca 65, triangular to oblong, 1.0–2.0 × 0.3–0.6 cm, membranaceous, spreading, apex acute sometimes involute; ovary inferior, stigma with 13 lobes; nectar-chamber 1.2 cm long. Fruit obconic, ca. 2.6 × 2.1 cm, magenta, glabrous, dehiscent by a basal pore, with persistent black perigonium.

In the NMPP this taxon is frequent on the rock outcrops as heliophyte commonly growing on mosses. The flowers are supposed to be bat pollinated because of its morphology and the fruits are frequently visited by lizards and ants which are supposed to be the dispersers. It flowers synchronically in January, April, June, August and October. The fruits were observed from March to November and are ripe almost during the whole year, being released gradually by the cephalium. The specimens are threatened by the fire on the rock outcrops and inhabit areas with hiking and climbing tracks where they are regularly destroyed. This is a Brazilian Atlantic Forest endemic taxa vulnerable at the Rio de Janeiro State. It is distinguished of *Coleocephalocereus fluminensis* subsp. *decumbens* (F.Ritter)N.P. Taylor & Zappi, which is a Minas Gerais State endemic species, mainly due to its green grayish stem segments and dark brown spines (Taylor & Zappi 2004). **Conservation status:** Vulnerable (VU).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, Pedra dos Cabritos (morro da Boa Vista), 359 ms.m., 06 Jun 1996, *Braga & bovini 3342* (RUSU, RB); ibidem, 17 Apr 2003, *Calvente & Bocayuva 36* (RUSU); ibidem, 29 Jan 2004, *Calvente & Versieux 81* (RUSU); Cruzeiro do Sul, 28 Oct 2003, *Calvente & Bocayuva 67* (RUSU).

14. Pilosocereus arrabidae (Lem.) Byles & Rowley, Cact. Succ. J. Gr. Brit. 19:66. 1957. (**Figs. 4 G–H**). *Pilocereus arrabidae* Lem., Rev. Hort. 34:429. 1862.

Shrub, columnar, 1–2 m, erect, rupicolous, glochids absent. **Stem** segments 30–150 × 5–7 cm, leafless, fleshy, rarely woody at base, green; ribs 5–6, 1.4–2.0 cm wide, ca. 2.5 cm thick, margin entire. Areoles borne at the ribs margins, with short tomentose hairs; lateral spines 5–10, acicular, 0.2–1.0 cm long; central spines 1–3, acicular, 1.0–2.0(–3.0) cm long; areoles at the stem segment apex with scarce, long, pilose hairs. **Flowers** nocturnal, 0-1 per areole, sessile, infundibuliform, 6–7(–9) × 3–4 cm, lateral; pericarpel ca. 0.9 × 1.9 cm, with 2–3 sparse bract-scales; flower-tube with 0–2 sparse fleshy deltoid bract-scales; perigonium segments deltoid, apex acuminate; external segments (0.5–)1.0–1.4 × 0.7–1.0 cm, fleshy , greenish, suberect; internal segments 1.4–2.2 × 0.5–1.0 cm, membranaceous, white, spreading; ovary inferior, stigma with 9 lobes; nectar-chamber ca. 0.9 cm long. **Fruit** depressed-globose, 2–4 × 3–4.5 cm, magenta red, glabrous, dehiscent by a lateral slit, with persistent black perigonium.

It is a heliophyte species rare at NMPP but common at the adjacent *restinga* of Grumari. It is probably pollinated and dispersed by bats due to its flowers and fruits morphology. It flowers and fruits in October. *Pilosocereus arrabidae* is a Brazilian Atlantic Forest endemic usually inhabiting the coastal *restingas*. The Rio de Janeiro State is the southern limit of its geographic distribution where its natural habitat is threatened by human interference. **Conservation status:** Near Threatened (NT).

Specimens examined: **BRAZIL. Rio de Janeiro:** Mun. Rio de Janeiro, Parque Natural Municipal da Prainha, Cruzeiro do Sul, 28 Oct 2003, *Calvente & Bocayuva 70* (RUSU).

FLORISTIC ASPECTS

The Cactoideae subfamily was the most diverse at the NMPP, with 79% of the inventoried species and is followed by Opuntioideae (14%) and Pereskioideae (7%). Four tribes of Opuntioideae and Cactoideae occur at the area of study: Opuntieae, Hylocereeae and Rhipsalideae with 2 genera each and Cereeae, the largest one with 3 genera. The Pereskioideae is monogeneric and only one species belonging to this subfamily occur at the NMPP, *Pereskia aculeata*. The richest genus is *Rhipsalis*, with five species, while the other genera present only one species each (Fig. 6, Table 1).

In the NMPP, 50% of the taxa are strictly terrestrial and among them 43% are only rupicolous, 43% are rupicolous or terricolous and 14% are only terricolous. The exclusive epiphytes correspond to 36% of the inventoried species and they belong mostly to Rhipsalideae. The 14% remaining species can be either epiphytic or terrestrial (Figs. 7, 8).

Three main vegetation physiognomies can be recognized in the NMPP, the coastal ombrophilous forest (Atlantic Rain Forest), the *restinga* vegetation (beach or scrub and herbaceous vegetation at plain sands dunes) and the rock outcrops. Most of the taxa (36%) occur only in forested areas as epiphytes, however, 29% of the species can be found either in forested areas or on rock outcrops and 21% inhabit exclusively the rock outcrops. *Opuntia monacantha* is restricted to the *restinga* and *Cereus fernambucensis* subsp. *fernambucensis* can occur either in the *restinga* or on rock outcrops, both cases correspond to 7% of the studied species (Fig. 9).

It can be observed that the species present habit plasticity, what is especially true concerning the taxa present at the rock outcrops. Taxa as *Pilosocereus arrabidae* that are usually found as terricolous in *restinga* vegetation or others as *Rhipsalis elliptica* that are preferably epiphytes at forested areas are found as rupicolous at the rock outcrops, this also indicates that some particular conditions, such as high solar irradiation, water stress and temperature could be common both to those terrestrial, rupicolous and epiphytic habitats, however, more accurate studies are necessary.

The comparative analyses of the Cactaceae floristic results of this work with other areas at the Rio de Janeiro State demonstrate greater similarity of the NMPP with other coastal areas represented by APA of Cairuçu, APA of Maricá, National Park of the Restinga of Jurubatiba and APA of Massambaba (Table 2, Fig. 10). These areas have taxa that are characteristic of *restinga* pioneer formations as *Pereskia aculeata*, *Brasiliopuntia brasiliensis*, *Opuntia monacantha*, *Hylocereus setaceus* e *Cereus fernambucensis* subsp. *fernambucensis*. In spite its location inside the Rio de Janeiro City, the area of the Vista Chinesa Forest Reserve is less similar with the costal areas (Table 2, Fig. 10). This area comprises only Atlantic Forest formations lacking the *restinga* vegetation characteristic taxa. The same applies to the Macaé de Cima Reserve, located in the mountains of the Órgãos range in the Rio de Janeiro State, which can be even more differentiated in floristic aspects due to altitudinal and climate peculiarities (e.g. Lima & Guedes-Bruni 1997; Rocha et al. 2003; Calvente et al. 2005).

CONSERVATION

The taxa occurring in the NMPP are grouped under four threat categories: Critically Endangered (CR), Vulnerable (VU), Near Threatened (NT) and Least Concern (LC).

Rhipsalis triangularis is considered Critically Endangered because of its restricted populations only currently known to occur in small areas at the NMPP and because of the fragility of its habitat. *Coleocephalocereus fluminensis* subsp. *fluminensis* inhabits exclusively rock outcrops at the Rio de Janeiro State and is the only taxa evaluated as Vulnerable (VU) in the NMPP, corresponding to 7% of the total number of taxa (Fig. 11). This species suffer with the urbanization, pollution and human interference manifested through vandalism, fire and lack of planning for the use of rock outcrops areas. This results in the decline of their population and in the decrease of habitat quality and for that reason the conservation of populations of this species in the NMPP must be strongly assured.

Rhipsalis grandiflora, *R. paradoxa* subsp. *paradoxa,* and *Pilosocereus arrabidae* are considered Near Threatened (NT) corresponding to 21% of studied taxa (Fig. 11). Their habitat is decreasing because of the great

Table 1. Cactaceae taxa occurring at the Natural Municipal Park of Prainha, RJ.

Subfamily	Tribe	Genus	Specific & infraspecific taxa	Conservation status
Pereskiodeae	—	*Pereskia*	*P. aculeata*	LC
Opuntioideae	Opuntiaea	*Brasiliopuntia*	*B. brasiliensis*	LC
	Opuntia	*O. monacantha*	LC	
Cactoideae	Hylocereeae	*Epiphyllum*	*E. phyllanthus* subsp. *phyllanthus*	LC
	Hylocereus	*H. setaceus*	LC	
Rhipsalideae	*Lepismium*	*L. cruciforme*	LC	
	Rhipsalis	*R. elliptica*	LC	
		R. grandiflora	NT	
		R. paradoxa subsp. *paradoxa*	NT	
		R. teres f. *heteroclada*	LC	
		R. triangularis	CR	
Cereeae	*Cereus*	*C. fernambucensis* subsp. *fernambucensis*	LC	
		Coleocephalocereus subsp. *fluminensis*	*C. fluminensis*	VU
		Pilosocereus	*P. arrabidae*	NT
Total	**3**	**4**	**10**	**14**

Table 2. Similarity values between the inventoried areas for the Cactaceae family at the Rio the Janeiro State (Freitas 1990/92, 1996,1997; Rizzini et al. 1990; Scheinvar et al. 1996; Moura & Costa 2001), greater values are shown in bold.

	PNMP	Macaé de	Cairuçu Cima	Maricá	Vista	Jurubatiba Chinesa	Massambaba
PNMP	*	9.5238	**59.26**	56	42.8571	**60.8696**	**59.2593**
Macaé de Cima	*	*	10	0	28.5714	0	0
Cairuçu	*	*	*	**66.67**	**59.2593**	**63.6364**	**69.2308**
Maricá	*	*	*	*	40	**80**	**75**
Vista Chinesa	*	*	*	*	*	43.4783	44.4444
Jurubatiba	*	*	*	*	*	*	**72.7273**
Massambaba	*	*	*	*	*	*	*

pressure caused by the deforestation and urbanization expansion. If their conservation is not guaranteed they may be more threatened in the future, this is particularly important to *P. arrabidae* because it inhabits the *restinga* vegetation, which is more threatened every day because of the aggressive urbanization and tourism development in the coast of the Rio de Janeiro State (Joly et al. 1999). Conservation units located in those coastal regions like the NMPP and the APA of Grumari must be in greater number, more protected and controlled by the government to assure the preservation of their biological diversity.

Taxa under Low Risk (LC) are *Pereskia aculeata*, *Brasiliopuntia brasiliensis*, *Opuntia monacantha*, *Epiphyllum phyllanthus* subsp. *phyllanthus*, *Hylocereus setaceus*, *Lepismium cruciforme*, *Rhipsalis* elliptica and *R. teres* f. *heteroclada*, corresponding to 65% of sampled taxa. They are usually more frequent or widely distributed in the Rio de Janeiro State and their populations are in a less priority situation in spite the reduction of their habitat (Fig. 11).

Many *Coleocephalocereus fluminensis* subsp. *fluminensis* specimens were seen burned and dead inside

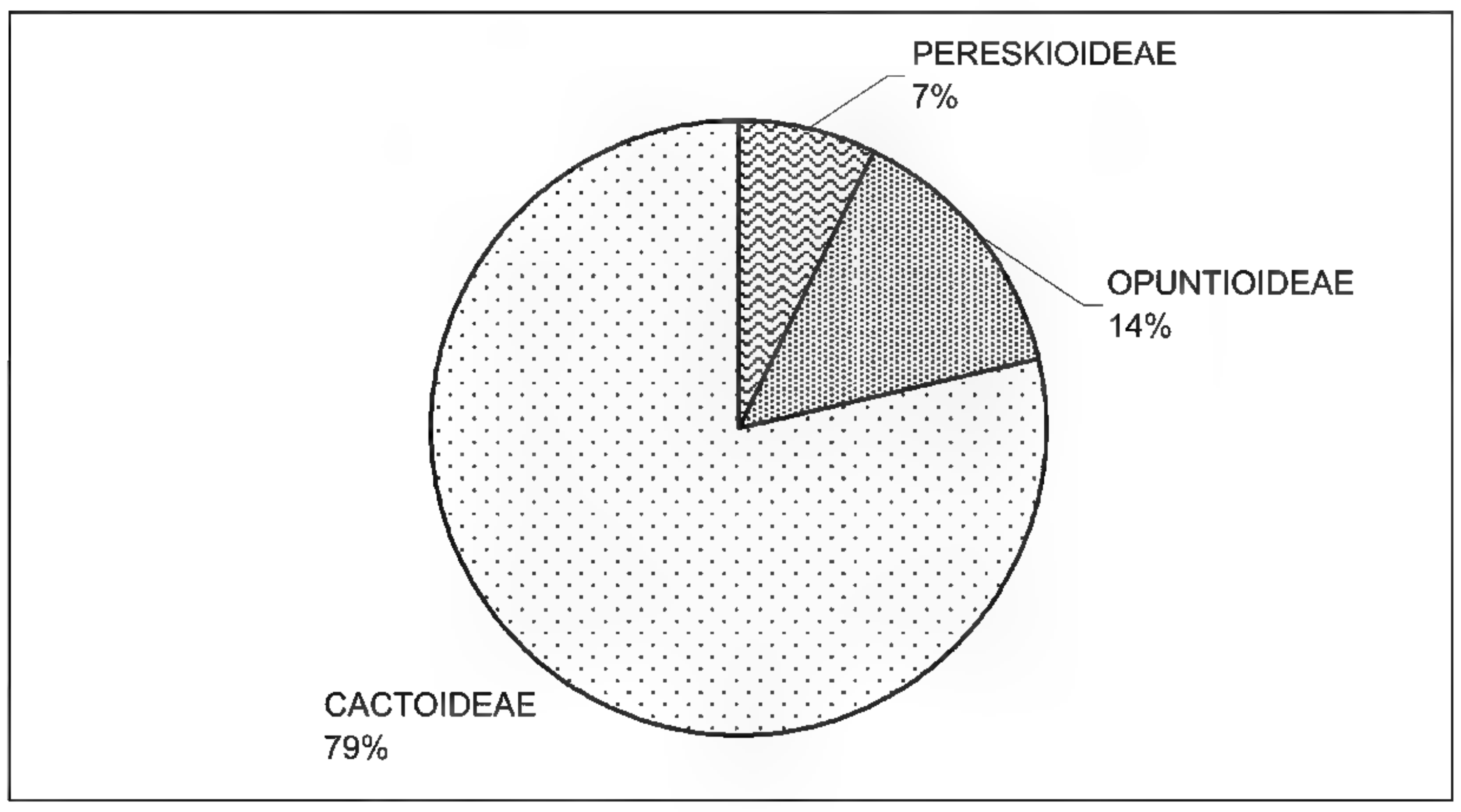


Fig. 6. Percentage of each subfamily of Cactaceae at the Natural Municipal Park of Prainha, RJ.

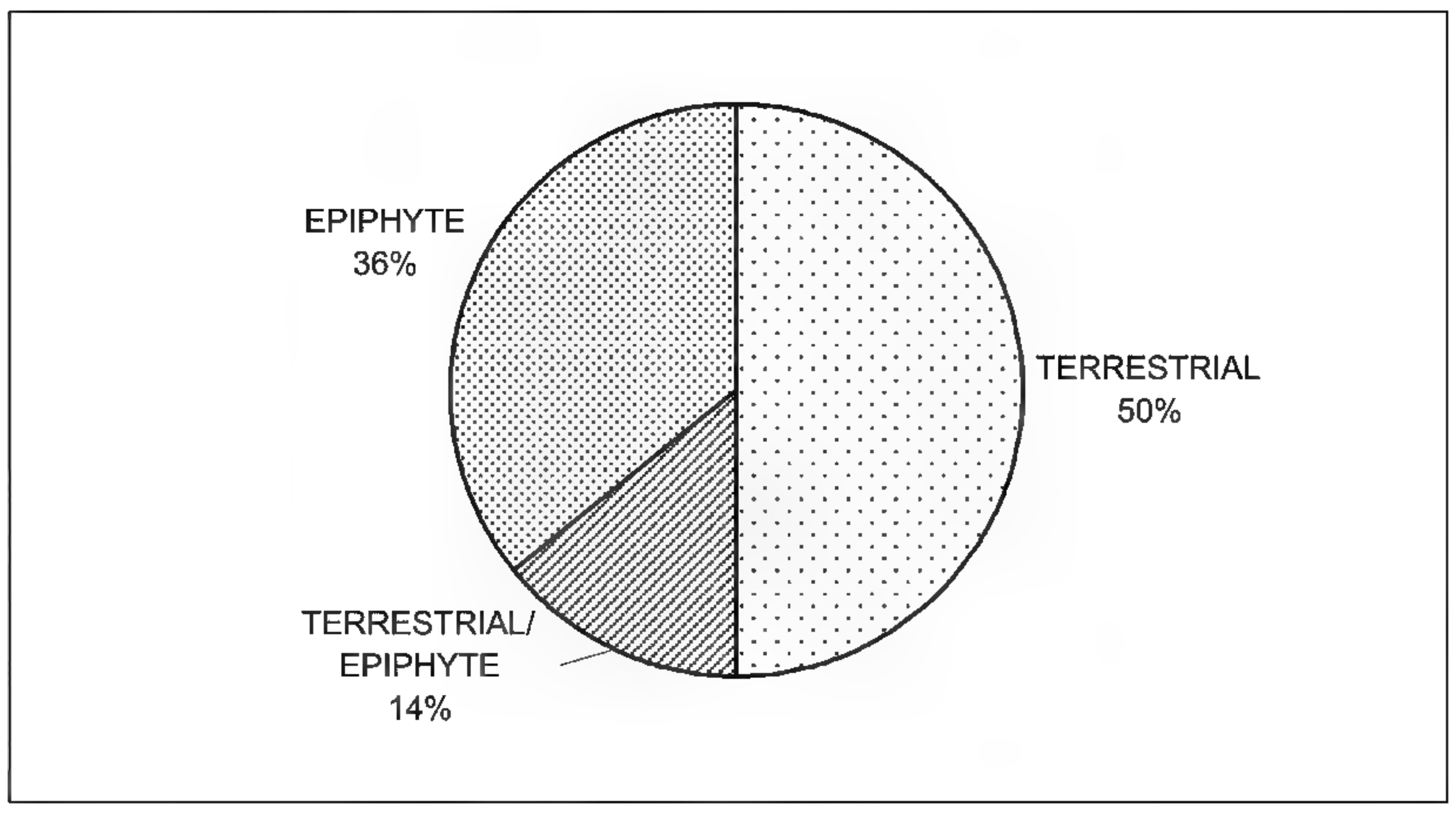


Fig. 7. Percentage of each Cactaceae habit at the Natural Municipal Park of Prainha, RJ.

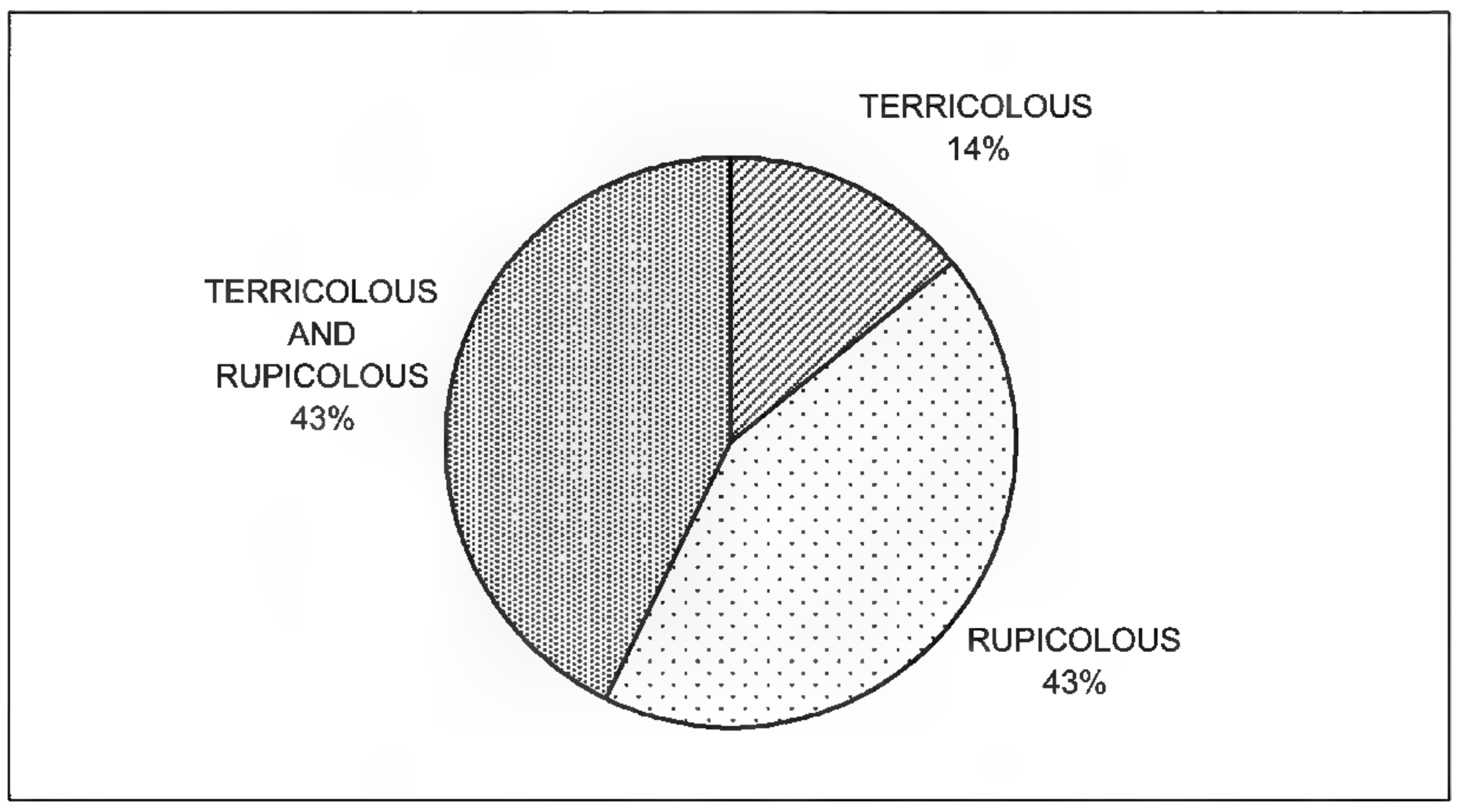


Fig. 8. Percentage of each Cactaceae terrestrial habit at the Natural Municipal Park of Prainha, RJ.

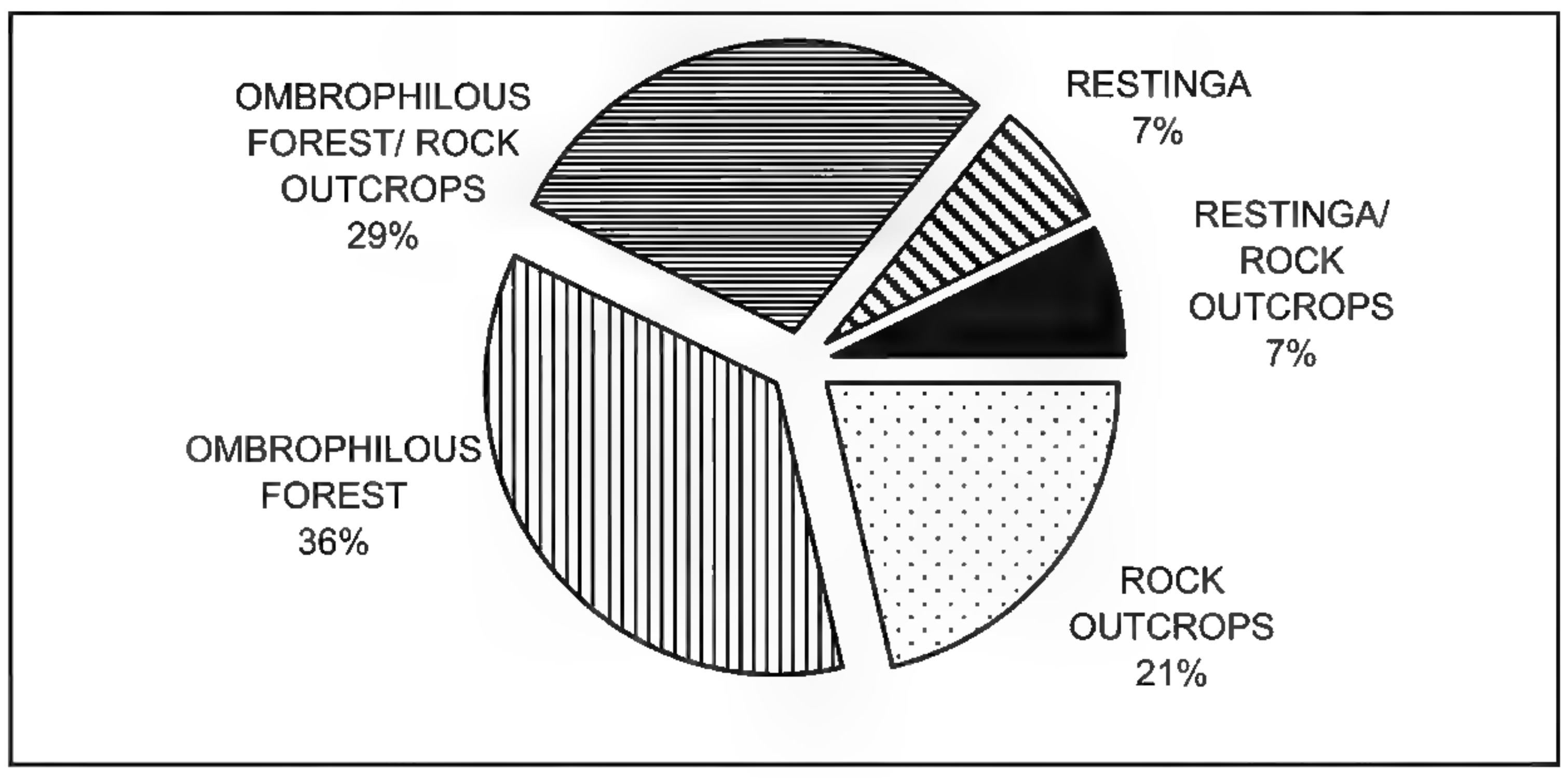


Fig. 9. Percentage of each habitat occupied by the Cactaceae at the Natural Municipal Park of Prainha, RJ.

areas damaged by fire on the rock outcrops in the NMPP. The Cactaceae taxa are highly resistant to water stress and to high solar irradiation, however they do not have any structures that can protect them against fire and once they are burned they hardly regenerate (Gibson & Nobel 1986). The invasion of alien gramineous species of *Panicum* L. and *Melinis* Beauv. can aggravate the situation because they are easily flamed, dispersing the fire to the individuals around them.

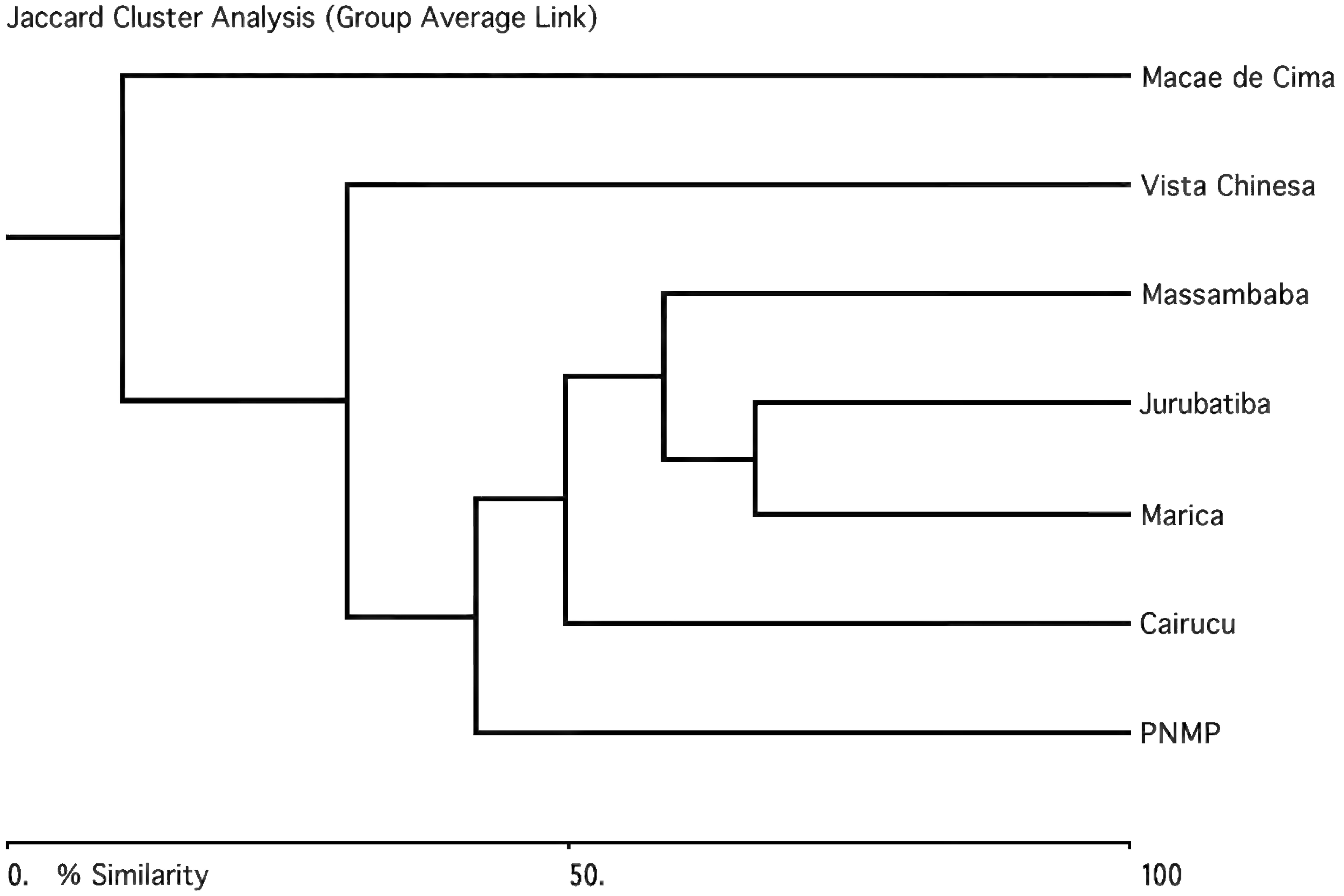
The occurrence of climbing paths and tracks on all the extension of the rock outcrops can also represent a threat to the inhabitant taxa of these areas. The Cactaceae individuals are particularly disturbed by this because they are frequently damaged or removed for their prickly stems that are consider a threat by the eyes of visitors. The ideal action was to restrict and signalize specific areas at the rock outcrops to be used for ecological tourism and at the same time develop an education work with the visitors teaching the importance of these species and how to act on the behalf of their conservation.

Porembski et al. (1998) observed the advantages on the colonization of the rock outcrops by the Cactaceae, Bromeliaceae and Velloziaceae. The harsh environmental conditions in these habitats make difficult the establishment of seedlings originated of sexual reproduction, however, the high capacity of clonal growth of these plants raises the chance of a perpetual colonization because the establishment of only one individual result on the formation of great populations in isolated areas.

According with Meirelles et al. (1999) effective actions have to take place in order to protect the rock outcrops. These ecosystems are naturally characterized by high rarity, endemism and fragility values that alone can justify their conservation. Besides that, factors caused by human interference such as pollution, vandalism and fire increase their vulnerability which can result in local extinction.

Banana plant populations were observed in forest areas inside the NMPP and on its surroundings, especially at the APA of Grumari. These populations should be controlled and even removed if necessary because they can disturb the integrity of the original vegetation.

Rocha et al. (2003) listed the main pressures against the conservation of the Pedra Branca State



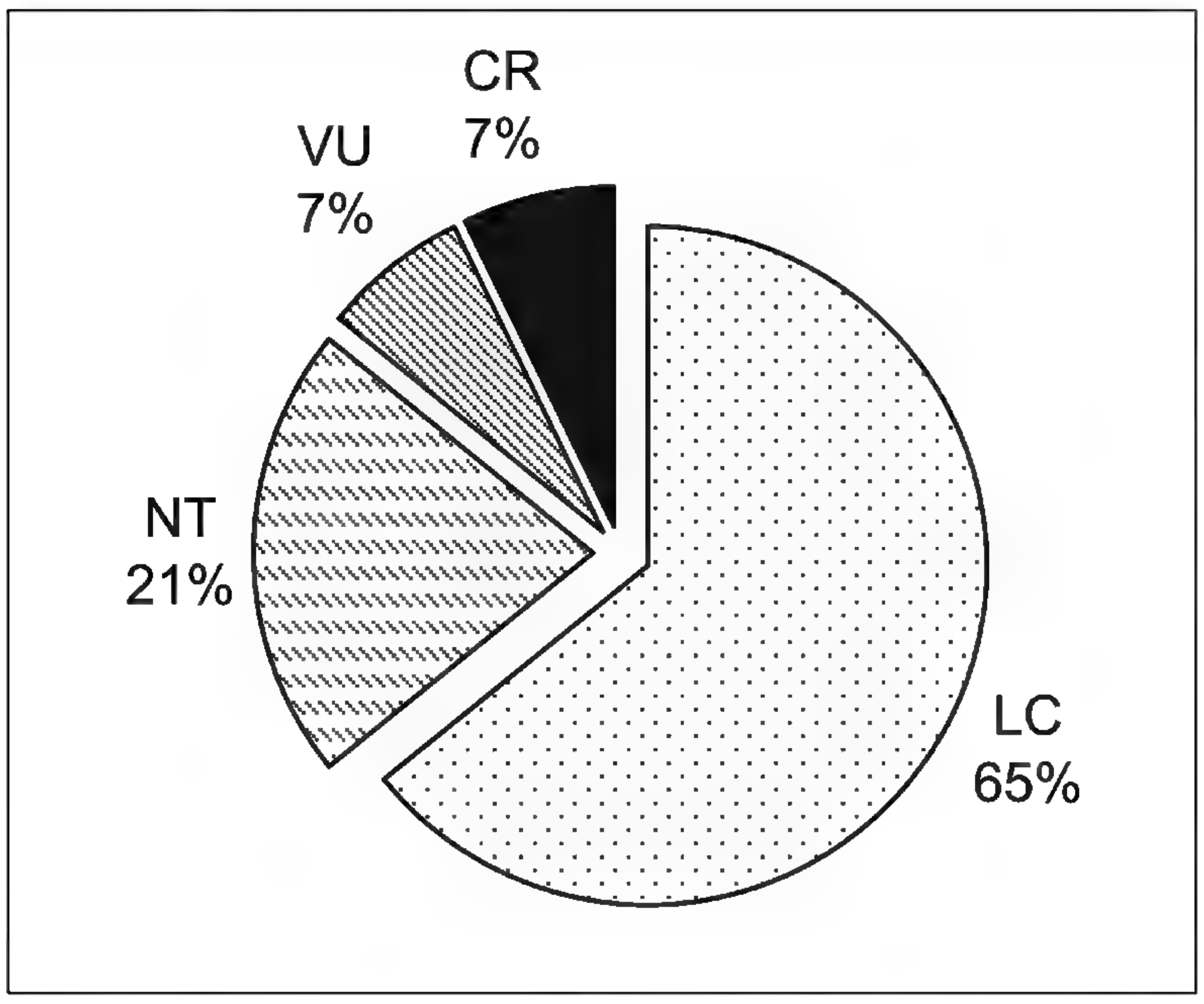


Fig. 10. (Above) Similarity between the inventoried areas for the Cactaceae family at the Rio de Janeiro State (Freitas 1990/92, 1996, 1997; Rizzini et al. 1990; Scheinvar et al. 1996; Moura & Costa 2001)

Fig. 11. Percentage of each conservation statuses evaluated for the Cactaceae taxa at the Natural Municipal Park of Prainha, RJ..

Park and among them is the removal of the original forests for the establishment of monocultures as the banana.

Visitors and people that work at the NMPP reported de occurrence of the extraction of ornamental plants including cacti probably with the objectives of commercialization or cultivation in private properties. Traps and camping signs suggest the action of hunters at the NMPP what compromises not only the animal species but also the plant species because the opening of many new tracks disturbs the regenerating native vegetation. Authority measures must be taken to eliminate these noxious activities at the NMPP.

It is possible to observe that the NMPP is still under many threats regardless of being a Conservation Unit. One important step for the resolution of these problems would be the creation of a management plan capable of assuring that the resolutions listed on the NMPP creation decree are effectively implemented. Among them, the planning of a well directed ecological tourism at the area and the precise delimitation of the zone for environmental regeneration and of the intangible zone, which is to be designated exclusively for the preservation of the natural resources would be critical.

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ASSESSMENT OF PLANT BIODIVERSITY IN WECHIAU COMMUNITY HIPPOPOTAMUS SANCTUARY IN GHANA

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ABSTRACT

A study was conducted in the Wechiau Community Hippopotamus Sanctuary in Ghana in order to assess the plant biodiversity found in the sanctuary. The study was conducted over a period of three years (2000–2003) through botanical inventories and using sample plots. A total number of 227 species of plants belonging to 72 families were identified and three vegetations types: Riverine forest, Floodplain and Upland flora were found in the sanctuary. Many of the species of plants were Mesophanerophytes and Thereophytes whereas a paucity of the species was Heleophytes, Hydrophytes, Hemicryptophytes and Chamaephytes. The results of the study are discussed and recommendations made for further research to support the conservation and sustainable use of plants in the sanctuary.

Key Words: Plant biodiversity, Wechiau, Hippopotamus, Ghana, conservation

RESUMEN

Se realizó un estudio en el Wechiau Community Hippopotamus Sanctuary en Ghana para valorar la biodiversidad vegetal presente en el santuario in. El estudio se realizó durante un periodo de tres años (2000–2003) mediante inventarios botánicos y usando parcelas de muestreo. Se identificaron un total de 227 especies de plantas pertenecientes a 72 familias y tres tipos de vegetación: bosque de rivera, llanuras de inundación y tierras altas en el santuario. Muchas de las especies de plantas fueron mesofanerófitos y terófitos mientras que las especies minoritarios fueron helófitos, hidrófitos, hemicriptófitos y caméfitos. Se discuten los resultados del estudio y se hacen recomendaciones para investigaciones posteriores con vistas a la conservación y el uso sostenible de las plantas en el santuario.

INTRODUCTION

The Wechiau Community Hippopotamus Sanctuary is a community-based initiative in the Upper West Region of Ghana to protect the remaining unprotected hippopotamus (*Hippopotamus ampbibius*) population in the Black Volta River, which would help to develop the ecotourism potential for the area. The other population of hippopotamus in Ghana is found in the Bui National Park, which is about 56 km from the present sanctuary. This population of hippopotamus in the park is under threat with the government's plan to develop a dam for hydro-electrical power generation. It is anticipated that the present population of hippopotamus in the Bui National Park will migrate to the sanctuary when the dam is finally developed.

The chiefs and people of Wechiau traditional area with technical assistance from a local non-governmental organization, Nature Conservation and Research Centre (NCRC) have decided to conserve the populations of hippopotamus and other biological resources in their area. They also hope to generate income through the promotion of ecotourism focused to improve the livelihood of the rural communities. The sanctuary is one of the two examples in Ghana where the local people are taking full control of the management of their biological resources through a Sanctuary Management Board (SMB). There is however no baseline information on the plant biodiversity in the sanctuary that will assist in making management decisions for the conservation and sustainable use of the plant resources in the sanctuary.

The present study was therefore conducted in order to assess the plant biodiversity in the Wechiau Community Hippopotamus Sanctuary in Ghana.

MATERIALS AND METHODS

Study area

The study was conducted at Wechiau about 40 km southwest of Wa in the Upper West Region of Ghana. The study area is positioned between latitudes 02°41'N and 02°49'N and between longitudes 09°43'W and

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09°53'W. The area has been demarcated and conserved as Wechiau Community Hippopotamus Sanctuary and occupies an area of about 40 Km^2 along the banks of the Black Volta River. The vegetation of the sanctuary is primarily Guinea savanna (Oteng-Yeboah & Asase 2002) and the terrain is mostly flat.

METHODS

The plant biodiversity in the sanctuary was assessed through botanical inventories and using sample plots over a period of three years (2000-2003). Botanical inventories entailed walking through different areas of the vegetation of the sanctuary whiles picking and identifying plants with identification aids. Each species of plant identified was monitored for its life form (sensu Raunkiaer 1934) throughout the period of the study. The botanical inventories were conducted through twelve field visits to the sanctuary and voucher specimens of the species of plants encountered were collected and have been deposited at the Ghana Herbarium (GC) at the Department of Botany, University of Ghana. The preliminary field identifications of the plants were checked using the *Flora of West Tropical Africa* (Hutchison & Dalziel 1954–1972) and by comparison with identified specimens at the GC herbarium.

In order to determine the species richness in the sanctuary, sample plots measuring 25 m × 25 m, 5 m × 5 m and 1m × 1m were randomly demarcated in the sanctuary. Forty-one of each plot size was studied. The 25 m × 25 m plot was used to study trees and 5 m × 5 m used to assess small trees and shrubs whereas the 1m × 1m plots was used to study the ground flora (herbaceous and grass species). The species richness was evaluated from the average number of species count for all the plots examined for each plot size.

RESULTS

Species richness and composition

A total of 227 species of plants belonging to 71 families were identified in the sanctuary. The mean numbers of species of trees was 7.62 in 5.3 families from the 25 m × 25 m plots and that of small trees and shrubs was 3.33 species in 2.62 families from the 5 m × 5 m plots whiles that of ground flora species was 4.10 species in 3.92 families from the 1 m × 1 m plots.

Many of the plant species in the sanctuary (85.5%) belong to the dicotyledonous group (Appendix 1). The monocot group contributed 14.1% of the species and only one species of Pteridophyte (*Ophioglossum costatum*) was identified from the sanctuary (Appendix 2 and 3). Within the dicotyledonous group, the family Papilionaceae contributed the largest number of genera (9.2%) and species (8.2%). The other dicotyledonous families that contributed many species and genera to the flora of the sanctuary were Rubiaceae, Asteraceae, Euphorbiaceae, Ceasalpinaceae, Mimosaceae, Verbanaceae, and Combretaceae.

The monocotyledonous group contained many genera and species of the families Poaceae, Liliaceae, Cyperaceae, Araceae, and Commelinaceae. However, the families Hypoxidaceae, Orchidaceae, and Zingiberaceae contributed only one genus and species each to the flora of the sanctuary.

Vegetation types and species composition

The vegetation of the sanctuary changes gradually from Riverine forest vegetation through Floodplain vegetation to Upland flora vegetation as one moves inland from the Black Volta River. The three vegetation types found in the sanctuary were largely based on their physiognomy and species composition.

Upland flora vegetation.—The appearance and species composition of this vegetation type is similar to the general characteristics of the Guinea Savanna vegetation. The species diversity is very high in this vegetation type compared to that of the other two vegetation types with species of trees from the families Sapotaceae (*Vitellaria paradoxa*), Mimosaceae (*Entada africana*, *Parkia biglobossa*), Caesalpinaceae (*Afzelia africana, Daniellia oliveri* and *Tamarindus indica*), Anacardiaceae (*Haematostaphis barteri*, *Lannea acida* and *Lannea kerstingii*), Bombacaceae (*Adansonia digitata, Bombax costatum*), Meliaceae (*Khaya senegalensis* and *Pseudocedrela kostchyi*), Simaroubaceae (*Hannoa undulata*), Papilionaceae (*Pterocarpus erinaceus*) and Combretaceae (*Terminalia avicennoides* and *Terminalia* species).

Smaller trees and shrubs were from the families Euphorbiaceae (*Bridelia ferruginea*), Cochlospermaceae

(*Coclospermum planchonii* and C. *tinctorium*), Combretaceae (*Combretum ghasalense, Combretum molle* and *Combretum* spp.), Celastraceae (*Maytenus senegalensis*), Chrysobalanaceae (*Parinari curattefollia* and *Parinari polyandra*), Olacaceae (*Ximenia americana*), Caesalpinaceae (*Piliostigma thonningi* and *Swatzia madacasgarensis*) and Polygalaceae (*Securidaca longepedunculata*).

The herbaceous flora also included species from the families Liliaceae s.l, but currently in Asparagaceae (*Asparagus flagellaris*), Hypoxidaceae (*Curculigo pilosa*), Euphorbiaceae (*Sapium grahamii, Euphorbia baga, Euphorbia ladermannniana*) and Zingiberaceae (*Kaempferia aethiopica*). Grass species were mainly *Andropogon gayanus, Hyparhennia subplumosa*, *Hyperthelia* spp., and *Ctenium newtonii*.

In areas where the vegetation has previously been intensively farmed, *Vitellaria paradoxa* and *Parkia biglobossa* were the main trees found and the herbaceous species consisted of ruderal plants from the families Asteraceae (*Ageratum conyzoides, Emilia* sp., *Tridax procumbens*), Rubiaceae (*Mitracarpus scaber, Borreria radiata*) and Euphorbiaceae (*Euphorbia hirta, Euphorbia heterophylla*).

Floodplain vegetation.—This vegetation was found next to the Upland flora vegetation towards the Black Volta River. The vegetation area is often flooded during the rainy season and the ground becomes patchy in the dry season. Trees and climbers were few but with a very dense grass cover in the rainy season. The main tree species were from the families Rubiaceae (*Mitragyna inermis*) and Mimosaceae (*Acacia nilotica* and *Acacia gourmaensis*). Other species of trees were from the families Balanitaceae (*Balanities aegyptiaca*), Rhamnaceae (*Ziziphus mauritianum*), Rubiaceae (*Crossopteryx febrifuga*), Combretaceae (*Terminalia macroptera*), Anacardiaceae (*Lannea acida* and *L. kerstingii*), Papilionaceae (*Pterocarpus erinaceus*) and Meliaceae (*Pseudocedrela kotschyi*).

The ground flora was predominated by members of the family Poaceae (including *Vetiveria fulvibarvis*, *Andropogon gayanus, Brachiaria jubata*, and *Hyparhhenia subplumosa*). Herbaceous species of the families Mimosaceae (*Cassia mimosoides*), Papilionaceae (*Crotalaria goorensis* and *Tephrosia platycarpa*), Amaryllidaceae (*Crinum humile*) Polygonaceae (*Polygonum senegalensis*), Commelinaceae (*Aneilema* sp., *Floscopa africana*, and *Murdannia simplex*), and Spenocleaceae (*Sphenoclea zeylanica*) were also common.

Riverine forest vegetation.—This vegetation type was found on either side of the Black Volta River. The vegetation was very dense as a result of large number of climbers and relatively tall trees that formed a canopy. Species of tree from the families such as Sterculiaceae (*Cola laurifolia*), Papilionaceae (*Pterocarpus santaliniodes*), and Bignoniaceae (*Kigelia africana*) that are found along permanent rivers were common. Other common trees were from Combretaceae (*Anogeissus leiocarpus*), Ulmaceae (*Celtis integrifolia*), Bombacaceae (*Ceiba pentandra*), and Ebenaceae (*Diospyros mespiliformis*).

Among the smaller trees and shrubs were members of the families: Caesalpinaceae (*Cassia sieberiana*), Papilionaceae (*Milletia zechiana*), Mimosaceae (*Endata abyssinica*), Flacourtiaceae (*Cassipourea congoensis, Dissomeria crenata*), Rutaceae (*Afraegle paniculata*), and Verbanaceae (*Vitex chrysocarpa*).

Climbers and herbaceous species were mainly from Sapindaceae (*Paullinia pinnata*), Passifloraceae (*Passiflora* sp.), Colchicaceae (*Gloriosa superba*), Annonaceae (*Monanthotaxis* sp.), Capparidaceae (*Capparis erythrocarpus*), Araceae (*Achomanes welwitchii*), Liliaceae s.l, but strictly in the family Anthericaceae (*Chlorophytum pusilium*), and Papilionaceae (*Aeschynomene afraspera*).

Life forms and species composition

The 227 plants identified in the sanctuary belong to 9 life-forms categories (Table 1). Many of the species of plants in the sanctuary were Mesophanerophytes and Thereophytes with few species of Heleophytes, Hydrophytes and Hemicryptophytes in the sanctuary. Many of the species of Thereophytes in the sanctuary were members of the families Rubiaceae, Asteraceae and Euphorbiaceae. Also the Mesophanerophyte and Microphanerophyte were made up of species from Caesalpinaceae, Meliaceae, Anacardiaceae and Mimosaceae. The Chamaephytes made up of species from the families Annonaceae, Aristolochiaceae and Cochlospermaceae whereas the species of Nanophanerophtes were from members of Sapindance and Verbenaceae. Geophytes were commonly members of the Amaryllidaceae and Commelinaceae.

TABLE 1. Life form composition of species of plants in Wechiau Community Hippopotamus Sanctuary in Ghana.

Life-form	Total number of species contributed	Contribution of life form to the flora of the sanctuary (%)
Thereophyte herb (ThH)	60	27.75
Thereophyte climbing herb (Thl)	3	
Chamaephyte herb (ChH)	5	7.05
Chamaephyte climbing herb (ChHl)	6	
Chamaephyte shrub (ChS)	5	
Hydrophyte herb (HyH)	3	1.32
Helophyte herb (HeH)	1	0.045
Geophyte herb (GrH)	26	11.45
Hemicryptohyte (Hcr)	8	3.52
Mesophanerophyte tree (MPT)	17	28.21
Mesophanerophyte shrub (MPS)	36	
Microphanerophyte shrub (mpS)	15	8.37
Microphanerophyte epiphye (mpE)	2	
Microphanerophyte liana (mpWl)	2	
Nanophanerophyte shrub (NpS)	21	11.89
Nanophanerophyte liana (NpWl)	6	

DISCUSSION

The present study is the first attempt to compile an authoritative checklist of the plant biodiversity in the Wechiau Community Hippopotamus Sanctuary and the study has shown that the composition of plant species in the sanctuary is similar to that of Guinea savanna vegetation (Hopkins 1974; Lawson 1985). The species richness and diversity in their life-forms of the plants in the sanctuary was also similar to Guinea savanna vegetation studied by Oteng-Yeboah (1996)

Bushfires impact on plant biodiversity and therefore it is important for the Sanctuary Management Board to make strategic management plans that will protect core areas of the sanctuary from bushfires and other human activities such farming. With the exception of few species of plants such as *Afraegle paniculata* (Schum. & Thonn.) Engl., *Commiphora dalzielli* Hutch. and *Ceiba pentandra* (L.) Gaertn, many of the species of plants identified in the sanctuary were generally very common. The Sanctuary Management Board could initiate species specific management programs such as the collection of seeds and other propagules of these uncommon species of plants for their subsequent cultivation in the sanctuary.

It is hoped that this information on the plant biodiversity in the sanctuary will serve as a baseline data for making management decisions for the conservation of the sanctuary resources and promotion of ecotourism activities in the area. It is however recommended that further research should investigate the quantitative abundance and distribution of the species of plants as well as the indigenous uses of the plants in sanctuary.

APPENDIX

Checklist of dicotyledonous plants in Wechiau Community Hippopotamus Sanctuary in Ghana. See Table 1 for definition of life-form.

Amaranthaceae
Celosia trigyna L.; ThH
Pandiaka involucrata (Moq.) B.D. Jackson; ThH

Anacardiaceae
Haematostaphis barteri Hook.f.; MPT
Ozoroa insignis Delile; MpS
Lannea acida A. Rich.; MPT
Lannea kerstiigii Engl. & K. Krause; MPT
Spondias mombin L.; MPS

Annonaceae
Annona glauca Schumach. & Thonn.; ChS
Annona senegalensis Pers.; ChS
Hexalobus monopetalus Engl. & Diels.; NpWl

Apocynaceae
Saba senegalensis (A. DC.) Pichon; mPWl
Strophanthus hispidus DC.; NpS

Aristolochiaceae
Aristolochia albida Duch.; ChHl

Asclepiadaceae
Calotropis procera (Aiton) W.T. Aiton; npS
Pachycarpus lineolatus (Decne) Bullock; npS

Asteraceae
Acanthospermum hispidum DC.; ThH
Ageratum conyzoides L.; ThH
Aspilia africana (Pers.) C.D. Adams; ThH
Blumea aurita DC.; ThH
Echinops longifolia A. Rich.; GrH
Gomphrena celosoides Mart.; ThH
Synedrella nodiflora Gaertn.; ThH
Tridax procumbens L.; ThH
Vernonia amygdalina Delile; npS
Vernonia perrottetii Sch.Bip. ex Walp.; ThH
Vernonia purpurea Sch.Bip.ex Walp.; ThH
*Vicoa leptoclada (*Webb) Dandy; ThH

Balanitaceae
Balanites aegyptiacus Delile; MPS

Bignoniaceae
Kigelia africana (Lam.). Benth.; MPT
Stereospermum kunthianum Cham.; MPS

Bombacaceae
Adansonia digitata L.; MPT
Bombax costatum Pellegr. & Vuillet; MPT
Ceiba pentandra (L.) Gaertn.; MPT

Boraginaceae
Heliotropium indicum L.; ThH

Burseraceae
Commiphora dalzielli Hutch.; mpS

Caesalpinaceae
Burkea africana Hook.; MPS
Cassia absus L.; ThH
Cassia mimmosoides L.; ThH
Cassia sieberiana DC.; MPS
Cassia tora L.; ThH
Dalium guineensis Willd.; MPS
Daniellia oliveria (Rolfe) Hutch. & Dalz.; MPT
Detarium microcarpum Guill. & Perr.; MPS
Isoberlina doka Craib & Stapf; MPT
Piliostigma thonningii (Schumach.) Delile-Redh.; mpS

Caesalpinaceae
Tamarindus indica L.; MPT
Senna occidentalis (L.) Link.; ThH

Capparaceae
Cleome viscosa L.; ThH
Cadaba farinosa Forssk.; ThH
Capparis erythrocarpos Isert; NpWl
Ritchiea reflexa Gilg & Benedict; NpWl

Celastraceae
Hippocratea africana Loes. ex Engl.; ThH
*Maytenus senegalensis (*Lam.) Exell.; npS

Chrysobalanaceae
Parinari curatellifolia Planch. ex Benth.; mpS
Parinari polyandra Benth.; mpS

Cochlospermaceae
Cochlospermum planchoni Hook. f.; ChS
Cochlospermum tinctorum A. Rich.; ChH

Combretaceae
Anogessius leiocarpus Guill. & Perr.; MPT
Combretum aculeatum Vent.; mpS
Combretum ghaselense Engl. & Diels.; mpS
Combretum hypopilinum Diels.; mpS
Combretum molle L. Br. ex G. Don.; mpS
Combretum nigricans Leprieur ex Guill. & Perr.; mpS
Combretum paniculatum Vent.; NpWl
Combretum sericeum G. Don.; ChH
Pteleopsis suberosa Engl. & Diel.; mpS
Quisqualis indica L.; MPS
Terminalia avicenoides Guill. & Perr.; mpS
Terminalia laxiflora Engl.; MPS
Terminalia macroptera Guill. & Perr.; mPT

Convolvulaceae
Evolvolus alsinoides L.; npS
Ipomoea sp.; NpWl

Cucurbitaceae
Zehneria halli Hook. f.; ThHl

Ebenaceae
Diospyros mespiliformis Hochst. ex A. DC.; MPT

Euphorbiaceae
Bridellia ferruginea Benth.; MPS
Euphorbia baga A. Chev.; ThH
Euphorbia convolvuloides Hochst ex Benth.; ThH
Euphorbia ladermaniana Pax & K. Hoffin.; ThH
Euphorbia macrophylla Pax.; ThH
Euphorbia poissonii Pax.; npS
Euphorbia sp.; npS
Hymenocardia acida Tul.; MPS
Jatropha curcas L.; npS
Jatropha gossypiifolia L.; npS
Phyllantus amarus Schum & Thonn.; ThH
*Sapium grahami*Prain.; ThH
Securinega virosa (Willd) Baill.; ChS
Tragia vogelii Keay.; ThH

Flacourtiaceae
Oncoba spinosa Forssk.; MPS

Lamiaceae
Ocimum canum Sims; ThH

Loganiaceae
Strychnos innocua Delile; MPS
Strychnos spinosa Lam.; MPS

Loranthaceae
Tapinanthus dodeneifolius (DC.) Danser.; mpE
Tapinathus bangwensis (Eng. & Krause) Danser.; mpE

Malvaceae
Hibiscus asper Hook.f.; ThH
Sida alba L.; ThH
Sida sp.; ThH

Meliaceae
Khaya senegalensis A. Juss.; MPT
Pseudocedrela kotschyi Harms.; mpT
Trichilia emetica Vahl; mpS

Menispermaceae
Cissampelos mucronata A. Rich.; ChHl

Mimosaceae
Acacia gourmaensis A. Chev.; MPS
Acacia hockii De Wild.; mpS
Acacia nilotica L. (Delile).; MPS
Acacia sp.; npS
Afzelia africana Sm.; MPT
Dicrostachys glomerata Chiov.; mpS
Entada abyssinica Steud.; mpS
Entada africana Guill. & Perr.; mpS
Mimosa pigra L.; ThH
Parkia biglobosa (Jacq.) R. Br. ex G. Don; MPT
Proposis africana Taub.; MPT

Moraceae
Ficus abutilifolia (Miq) Miq.; MPS
Ficus capensis Thunb.; MPS
Ficus platyphylla Del.; MPS

Moringaceae
Moringa oleifera Lam.; MPS

Myrtaceae
Eugenia subherbacea A. Chev.; ThH

Nyctaginaceae
Boerhavia diffusa L.; ThH

Olacaceae
Boerhavia diffusa L.; ThH

Opiliaceae
Opilia celtidifolia (Guill. & Perr.) Endl. ex Walp.; mPWl

Papilionaceae
Abrus precatorius L.; ThHl
Aeschynomene afraspera J. Leonard.; ThH
Alysicarpus ovalifolius J. Leonard.; ThH
Canavalia sp.; ThH
Crotalaria goreensis Guill. & Perr.; ThH
Erythrina senegalensis DC.; mpS
Lonchocarpus laxiflorus Guill. & Perr.; MPS
Lonchocarpus sericeus (Poir) H.B.K.; npS
Millettia zechiana Harms; npS
Ostryoderris stuhlmannii (Taub.) Dunn ex Harms; MPS
Pericopsis laxiflora (Benth. ex Baker) Meeuwen; MPS
Pterocarpus erinaceus Poir.; MPT
Pterocarpus santalinoides L'H'er ex DC.; MPT
Swarztia madagascarensis Desv.; MPS
Tephrosia platycarpa Guill. & Perr.; ThH
Uraria picta (Jacq) DC.; ThH

Passifloraceae
Passiflora foetida L.; ThH

Pedaliaceae
Sesamum alatum Thonn.; ThH
Sesamum indicum L.; ThH

Polygalaceae
Securidaca longepedunculata Fresen.; MPS

Polyonoaceae
Polygonum senegalensis Meisn.; Hy

Portulacaceae
Talinum trigulare (Jacq.) Willd.; ThH

Rhamnaceae
Ziziphus mauritiana Lam.; ChS

Rhizophoraceae
Cassipourea congoensis R. Br ex DC.; MPS

Rubiaceae
Borreria radiata DC.; ThH
Borreria scaber (Schum & Thonn.) K. Schum.; ThH
Chassalia sp.; mpS
Chrysanthellum americanum Rich.; ThH
Crossopteryx febrifuga (Afzel. ex G. Don) Benth.; MPT
Fadogia agrestis Schweinf. ex Heirn.; npS
Feretia apodanthera Del.; ThH
Gardenia ternifolia Schum. & Thonn.; npS
Mitracarpus scaber Zucc.; ThH
Mitragyna inermis (Willd). O. Ktze.; mPT
Nauclea latifolia Sm.; mpS
Oldelandia corymbosa L.; ThH
Polysphaeria arbuscula K. Schum.; npS

Rutaceae
Afraegle paniculata Engl.; mPT
Zanthoxylum xanthoxyloides (Lam.) Waterman.; nPS

Samydaceae
Dissomeria crenata Hook. f. ex Benth.; MPS

Sapindaceae
Allophyllus africanus P. Beauv.; NpWl
Blighia sapida König; MPT
Cardiospermum grandiflorum SW.; ThHl
Paullinia pinnata L.; NpWl

Sapotaceae
Malacantha alnifolia Pierre; MPT
Vitellaria paradoxa C.F. Gaertn. f.; MPT

Scrophulariaceae
Striga hermonthica Benth ; ThH
Striga linearifolia (Schumach. & Thonn.) Hepper.; ThH

Simaroubaceae
Hannoa undulata Planch.; MPT

Solanaceae
Datura metel L.; ThH

Sphenocleaceae
Sphenoclea zeylsnica Gaertn.; Hy

Sterculiaceae
Cola laurifolia Mast.; MPT
Sterculia setigeria Delile; MPS
Waltheria indica A. L. .; ChH

Taccaceae
*Tacca leontopetaloides (*L.) Kuntze.; GrH

Tiliaceae
Corchorus olitorius L.; ThH
Grewia carpinifolia Juss.; MpS
Grewia cissoides Hutch. & Dalziel; ChH
Grewia mollis Juss.; MpS

Ulmaceae
Celtis integrifolia Lam.; MPT
Trema orientalis Blume.; NpS

Verbenaceae
Clerodendron capitatum Schum. & Thonn.; NpS
Lantana trifolia L.; ThH
Lippia multiflora Moldenke; ChH
Stachtarpheta indica L.; ThH
Vitex chrysophylla Planch.; NpS
Vitex doniana Sweet; MPS

Vitaceae
Cissus flavicans Planch.; ChHl
Cissus populnea Guill. & Perr.; ChHl

APPENDIX

Checklist of monotyledonous in Wechiau Community Hippopotamus Sanctuary in Ghana. See Table 1 for definition of life-form.

Amaryllidaceae
Crinum humile A. Chev.; GrH

Araceae
Haemanthus rupestris Baker; GrH
Amorphophallus dracontioides N.E. Br.; GrH
Anchomanes welwitchii Rendle; GrH
Stylochiton lancifolium Kotschy & Peyr.; GrH

Commelinaceae
Aneilema setiferum A. Chev.; GrH
Floscopa africana C.B. Clarke; Cl.; GrH
Murdannia simplex (Vahl) Brenan; GrH

Cyperaceae
Cyperus ambilis Vahl; GrH
Fimbristylis sp.; Hcr
Kyllinga sp.; GrH
Mariscus foliosus C.B. Clarke; GrH

Hypoxidaceae
Curculigo pilosa (Schum. & Thonn.) Engl.; GrH

Liliaceae s.l. **Aloaceae**
Aloe buetteneri A. Berger; GrH

Asparagaceae
Asparagus flagellaris Baker; ChHl

Anthericaceae
Chlorophytum pusillum Schweinf. ex Baker; GrH

Hyacinthaceae
Scilla picta A. Chev. ex Hutch & Dalziel.; GrH

Orchidaceae
Eulophia cristata Lindl.; GrH

Poaceae
Andropogon gayanus Kunth; Hcr
Brachiaria lata (Schumach.)C.H. Hubb.; Hcr
Brachiaria sp.; Hcr
Ctenium villosum Berhaut.; GrH
Cymbopogon giganteus Chiov.; Hcr
*Cynodon dactylon (*L.) Pers.; Hcr
Dactyloctenium aegyptium Willd.; GrH
Digitaria sp.; GrH
Hyperrhenia sp.; Hcr
Hypethelia sp.; Hcr
Panicum maximum Jacq.; GrH
Saccharum spontaneum L.; HyH
Setaria sp.; GrH

Zingiberaceae
Kaempferia aethiopica Solms ex Engl.; GrH

Pteridophyte species in Wechiau Community Hippopotamus Sanctuary in Ghana. See Table 1 for definition of life-form.

Ophioglossaceae
Ophioglossum costatum R. Br.; GrH

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BOTANICAL COMPOSITION AND MULTIVARIATE ANALYSIS OF VEGETATION ON THE POTHOWAR PLATEAU, PAKISTAN

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ABSTRACT

Vegetation of Pothowar Plateau (32° 32' and 34° north latitude and 70° 17' and 73° 5' east longitude, annual rainfall 250 to 750 mm) was analyzed using ordination (DECORANA) and classificatory cluster analysis techniques. Five plant associations were recognized on the basis of the cluster analysis. The most noticeable feature indicated by this analyses was the separation of mountain-complex communities from the flat lowland community. Clearly disjunct patterns emerged from these analyses. The major axes brought out by the ordination were related to broad soil types. The application of the classification to the ordination allowed an interpretation of the vegetation variation in terms of topography, redistribution of rainwater, the nature of the bedrock and soil depth. The vegetation patterns revealed are discussed in relation to geo-morphological factors and problems of plant assemblage in vegetation of widely scattered plants.

Key Words: Vegetation analysis, plant communities, Pothowar Plateau, Pakistan

RESUMEN

La vegetación de la meseta de Pothowar (32° 32' y 34° latitud Norte 70° 17' y 73° 5' longitud Este, precipitación anual de 250 a 750 mm) se analizó mediante ordenación (DECORANA) y técnicas clasificatorias de análisis cluster. Se reconocieron cinco asociaciones de plantas en base al análisis cluster. La característica más notable señalada por este análisis fue la separación del complejo de comunidades de montaña de la comunidad de las zonas llanas bajas. De los análisis surgieron patrones claramente disyuntos. Los ejes principales que salen de la ordenación están relacionados con los grandes tipos de suelo. La aplicación de la clasificación a la ordenación permitió una interpretación de la variación de la vegetación en términos de topografía, redistribución de la precipitación, la naturaleza de la roca madre y la profundidad del suelo. Se discuten los patrones de vegetación en relación con los factores geo-morfológicos y problemas de inserción de plantas muy diseminadas en la vegetación.

INTRODUCTION

Studies on the arid and semi-arid areas of Pakistan and India have mainly been floristical and/or phytogeographical (Athar 2005; Champion & Sethi 1968; Chaudhuri 1960; Hussain 1969; Gupta 1975; Shaukat et al. 1976; Malik et al. 1988). The use of numerical approaches has been rare (Shaukat et al. 1990; Shaukat & Ahmad 1989), although these may be useful for summarizing the major gradients in data sets, assisting the formulation of hypotheses and testing their validity (Birks 1992; Odgaard & Rasmussen 2000). Modern synecological methods have developed techniques for use at local and regional level, seeking to reduce the complexity of field data sets by classification and ordination of floristic data and then relating the results to environmental information (ter Braak 1987). Such objective approaches have rarely been applied to the vegetation data of Pakistan.

The primary objective of this study was to explore the factors that determine the boundaries and composition of plant communities on the Pothowar Plateau. This was achieved by sampling all common species present within a complex vegetation mosaic coinciding with local gradients in topography and soil distribution. Numerical techniques were used to summarize the floristic data.

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MATERIALS AND METHODS

Study Area

The Pothowar Plateau is situated between 32° 32' and 34° north latitude and 70° 17' and 73° 5' east longitude. It covers an extensive area of 1.5 million hectares. In altitude it rises from about 250 m near the Indus River to 1,076 m in the west. The hills are detached and isolated from each other. They run mostly in an east west direction and consist of a series of serrated ridges. The slopes are gentle at first and then climb more steeply. The steepness of the slopes varies from 15° to 50° and is precipitous in some places. Elsewhere the gradient is flat to gently undulating. It runs across the northern part of the area as a wedge with its base resting the Indus, where it is 22 km wide. It tapers gradually over a length of 72 km to the east, and ends about 24 km north-west of Margalla Range.

Climate

The climate of the area is of an extreme nature. The western portion of tract is hotter and drier than the eastern and northern parts. The winter is bitterly cold while the summer is unbearably hot. The temperature rises first in April, than remains almost steady, due to windstorms from Balochistan, up to the middle of May when it shoots up again. June and July are the hottest months (average maximum temperature 42° C), while December and January are the coldest months (average minimum temperature 1.7° C). The monsoon starts by the third week of July and continues till the beginning of September when the nights get cooler. The cold weather sets in by the middle of October. During winter the days are bright, and the nights are clear. Early spring frosts are common and sufficiently severe to cause wide spread injury to plants, even to the indigenous tree growth in a fairly advanced stage of development. Preliminary analyses of weather data indicate that mean temperature decreases in a linear fashion with altitude (Champion et al. 1965). Frost may occur especially at the upper altitudinal limits and in valley bottoms.

Rainfall is scanty and uncertain, and its annual distribution is very uneven. The annual rainfall varies from 250 to 750 mm. Monsoons start late in July, and most of the annual rain is before September. Spring and fall rains are rare and uncertain. Winter rains start by the end of December. They stop by the end of February when the windstorms set in. Winter rains generally extend over a shorter period than the monsoons, followed by a prolonged period of dry weather. Humidity is also generally low, falling to about 15% in the summer afternoons, the annual mean being about 50% (Hussain & Ilahi 1991).

The ground water resources are limited. The sources of water for humans and livestock are wells and dugout ponds. The drainage is very satisfactory. The entire area is drained off to the west into the Indus River, largely through Soan River. Springs are mostly seasonal and flow only during the rains. Perennial springs are very few, and are found at only 14 places.

Geology, soils and topography

Geologically the area is divisible into Attock slate and limestone. Attock slates are Precambrian and contain gritty layers of an arenaceous type. On weathering they give rise to fertile loamy clay, which collects only in sheltered places. The major part of the area (Kala-Chitta forest area) is composed of limestone in age from Triassic to Liassic. It contains marls, ferruginous and bleached shales and sandstones belonging to the Eocene suit, ferruginous pisolite, variegated sandstone, soft sandy carbonaceous clays, and shales varying in age from Albian to Tithorian. Tertiary freshwater formations of sandstone, alternating with red and purple clays and shales, are also very common in the Pothowar Plateau. Soils are universally shallow and dry and may overlie a great variety of geological formations from limestone, shales and quartzites to crystalline rocks. The soil derived from sandstone is poor and less fertile than soil from limestone. It supports nothing except the most xerophyllous vegetation (Hussain & Ilahi 1991)

Vegetation

Champion et al. (1965) described the study area as dry sub-tropical broad-leaved forest. Rafi (1973), Beg (1975), and Hussain and Ilahi (1991) called it dry sub-tropical semi-evergreen forest. The trees and shrubs are mostly thorny and have leaves of moderate size resembling Mediterranean vegetation elsewhere in the world (Naqvi 1974). There is usually little ground-layer vegetation most of the year, but during the monsoon a fairly complete cover of grass and herbs may develop. Floristic composition varies continuously in response to small-scale altitudinal differences on the plateau, although most species show fairly broad distribution patterns at that scale. The limestone region has only scrub forest composed of odd stunted and mutilated *Acacia* with its associates. A few diminutive *Olea* and *Rhamnus* can also be observed on the northern slopes. The southern slopes are almost entirely devoid of tree growth. The shrubs include a great many genera and families, many of central Asian origin. Unpalatable species are favored by heavy grazing, and *Dodonaea*, *Rhazya,* and *Withania* become conspicuous with thorny *Carissa* and *Gymnosporia*.

Pothowar Plateau is especially interesting because its vegetation merges at lower elevations with tropical thorn forests and at higher elevations with subtropical pine and temperate forests. Because of its elevation, precipitation on the plateau can reach, or even some times exceed, 600 mm, thus making Pothowar a sort of enclave of the fringes of the arid areas in which the diversity of natural sites (wooded wadies, humid canyons, springs and rock pools) has allowed a number of relict species to persist. The very situation of the plateau thus makes it a sort of bio-geographical crossroad.

Vegetation Analysis

Attock district is representative of Pothowar Plateau. Twenty study sites were selected in Attock district to cover the range of vegetation variation on the plateau (Fig. 1). Selection of these sites was based on repeated surveys. Plant species were inventoried in 5 × 2 m quadrates. Field sampling procedures involved the random placement of quadrates within each of the eight 25 × 50 m cells into which each study site was divided. On each site, presence or absence of all species was recorded from a sample of 24 quadrates (three per cell). Presence or absence of plant species was converted to frequencies and used to classify and ordinate both sites and species by the reciprocal averaging (RA) procedure of Hill and Gouch (1980). Rare species were eliminated from the analyses since these species can severely distort ordinations produced by RA (Hacker 1983; Dasti & Agnew 1994). Rare species occurred only in a single stand with frequencies of 1% or less. Detrended correspondence analysis (DCA) was selected as an appropriate ordination method based on gradient length and preliminary correspondence analyses (Jongman et al. 1995). The default options of the program DECORANA were used for the analyses (Causton 1988; Hill 1979). DCA axes 1 and 2 were used to interpret the data.

Species frequencies were clustered using the monothetic information statistic procedure incorporating the Spearman rank order dissimilarity coefficient (Causton 1988; Hill 1979). Scatter of classification groups were plotted on overlays of the ordination axes to assess the compatibility of the two methods of data simplification (Dargie & El Demerdash 1991; Dasti & Agnew 1994; Dasti & Malik 1998). The relationships between soil characters and DCA axes 1 and 2 were determined using Spearman rank correlation (Causton 1988).

Soil Analysis

Soil samples (0–10 cm depth) were taken from each site at three different points and mixed into a composite sample. Soil depth to 2 cm was sampled in the hard clays because the main root zone occurred within the top 2 cm layer. Sandy soils were sampled up to 10 cm depth because the top layer of soil was very mobile and the rooting zone was deeper. The samples were air-dried and passed through a 2 mm sieve. Three subsamples were drawn from this composite sample. Soil texture, water holding capacity, and soil moisture content was determined using standard methods (Hussain 1989; Richards 1954). Soil pH was recorded from a pH meter (HM–10K Digital, England), and conductivity was determined by CM-30 ET digital conductivity meter. Organic carbon was estimated following Jackson (1958).

The Duncan multiple range test was used to detect and compare any significant difference between the means of different communities at the 5% level of significance. The percent data obtained from particle size analyses were normalized by an arcsine transformation and subjected to analyses of variance between the communities for each variable.

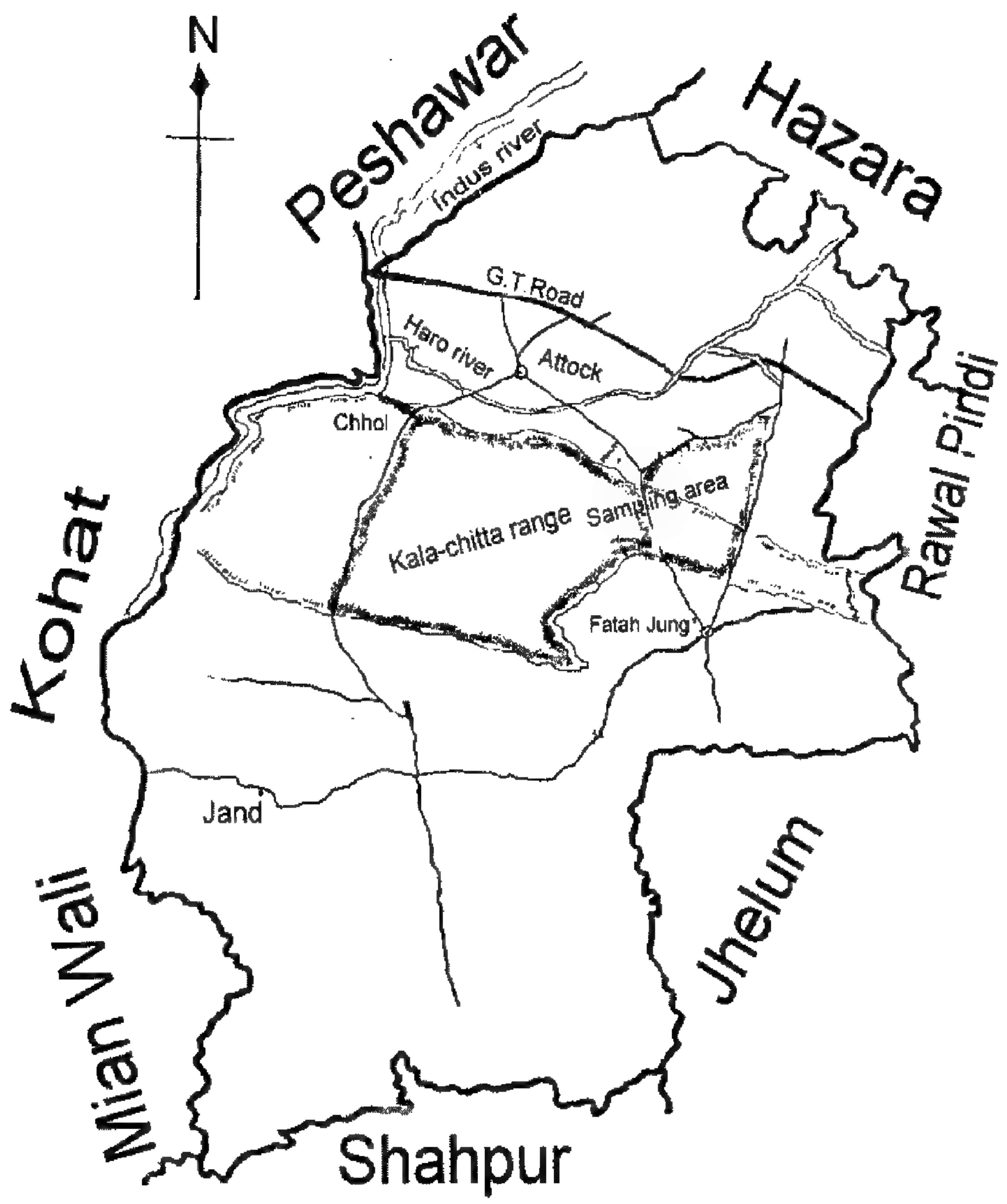

Fig. 1. Attock district map showing the sampling area on the Pothowar Plateau. The study region is marked with a broken boundary.

RESULTS

Classification

Five plant associations were recognized in the cluster analyses. The botanical composition of each association is presented in Table 1. These associations were delineated based on specifying three hierarchical levels (Fig. 2). The most noticeable feature indicated by this analysis was the separation of mountain-complex communities (Associations A-D) from the flat lowland community (Association E). The 55 samples of group E were separated from the other samples at the first level by *Chrysopogon aucheri*, and are characterized also by *Cyperus niveus* and *Dicanthium annulatum*. In the mountain-complex region, the limestone plateau communities (Associations A and B) were separated from those of the sandstone massif (Associations C and D) at level two by *Dodonaea viscosa*. As a result of three hierarchical levels four communities in the mountain complex were recognized:

1) Calcareous hilltops (Association A).
2) Interior rocky basins in the calcareous massif (Association B).
3) Sandstone massif (Association C).
4) Interior rocky basins on the sandstone massif (Association D).

The interior rocky basins on calcareous plateau (limestone strata) are characterized by *Olea cuspidata* that is altogether absent from such basins in sandstone strata. The enclosed basins with moderately to slightly

TABLE 1. Mean relative frequency values (%) of species in the 5 associations detected by normal cluster analyses.

Species	**A**	**B**	**C**	**D**	**E**
Acacia modesta Wall.	17.81	25.48	23.64	28.90	16.83
Acacia nilotica (L.) Debile	1.63	0.70	–	–	0.70
Anagalis arvensis L.	1.39	3.69	1.96	–	1.09
Asparagus gracilis Royle	0.40	–	–	–	–
Boerhaavia coccinea Mill.	–	2.37	–	–	3 .41
Capparis decidua (Forssk.) Edgew.	3.66	–	15.55	15.31	–
Carissa opaca Stapf ex Harines	0.64	–	–	–	3.69
Chrysopogon aucheri (Boiss.) Stapf.	–	–	–	–	49.60
Cymbopogon jawarancusa (Jones) Schult.	15.05	4.59	–	–	–
Cynodon dactylon (L.) Peris.	6.96	11.56	2.39	2.80	2.33
Cyperus niveus Retz.	–	–	–	–	7.37
Desmostachya bipinnata (L.) Stapf.	14.01	–	6.65	9.34	–
Dichanthium annulatum (Forssk.) Stapf.	–	–	–	–	5.55
Dodonaea viscosa (L.) Jacq.	23.34	12.01	–	–	19.26
Ehretia obtusifolia Hochst ex DC.	0.88	–	–	–	1.85
Eremopogon foveolatus (Del.) Stapf.	2.34	–	–	–	–
Erianthus griffithii (Munro) Hk. f.	29.87	5.84	0.80	–	1.94
Erodium cicutarium (L.) L'Herit ex Ait.	–	1.19	16.21	–	–
Evovulus alsinoides L.	–	0.97	–	–	3.62
Gnaphalium pulvinatum Del.	0.14	6.50	–	–	2.51
Grewia damine Gaertin	–	–	–	–	2.66
Grewia hirsuta Vahl	1.04	–	–	39.25	–
Grewia oppositifolia Roxb.	4.74	–	–	19.62	–
Grewia tenax (Forsk.) Aschers & Schweinf.	2.16	0.96	7.22	20.52	0.84
Grewia villosa Willd.	4.92	–	14.39	–	–
Gymnosporia royleana (Wall.) Lawson	9.75	21.24	21.08	8.09	18.67
Justicia peploides (Nees in Wall.) T. Anders	1.04	2.44	36.42	–	–
Linum strictum L.	7.30	–	–	–	4.47
Malcomia africana (L.) R.	0.25	0.92	4.28	19.62	1.12
Medicago laciniata (L.) Mill.	2.23	6.29	12.82	–	1.85
Melhania futteypoyensis Munro ex Mast	2.95	–	5.81	–	–
Myrsine africana L.	3.66	–	5.32	0.86	0.35
Olea cuspidata Wall. ex DC.	20.86	15.32	4.04	–	27.32
Oxalis corniculata L.	–	5.12	0.80	–	1.93
Periploca aphylla Dcne.	1.94	–	5.63	2.89	–
Plantago ciliata Desf.	–	2.37	–	–	1.93
Prosopis juliflora Swartz	0.09	7.37	12.64	–	–
Reptonia buxifolia Dcne.	7.23	7.52	–	–	–
Rhamnus pentapomica Parker	1.58	–	4.63	20.53	–
Rhazya stricta Dcne.	0.09	3.18	–	6.06	–
Sageretia theezans (L.) Brongn	–	–	–	–	6.24
Taraxacum officinale Wigg.	0.43	2.80	–	–	0.99
Tetrapogon villosus Desf.	–	–	–	–	2.61
Trachynia distachya (L.) Link	4.97	32.52	–	1.06	–
Ziziphus jujuba Mill.	3.69	5.93	–	–	–
Ziziphus nummularia (Brum. f.) Wight & Arn.	1.77	2.71	0.23	16.47	2.99

impeded run-off are dominated by various species of *Grewia*. Further subdivisions at lower information gains were regarded as minor variants, and were not considered. The vegetation communities are briefly described below in the context of the major discriminating species. For this purpose the area has been subdivided into five broad regions based on geomorphology.

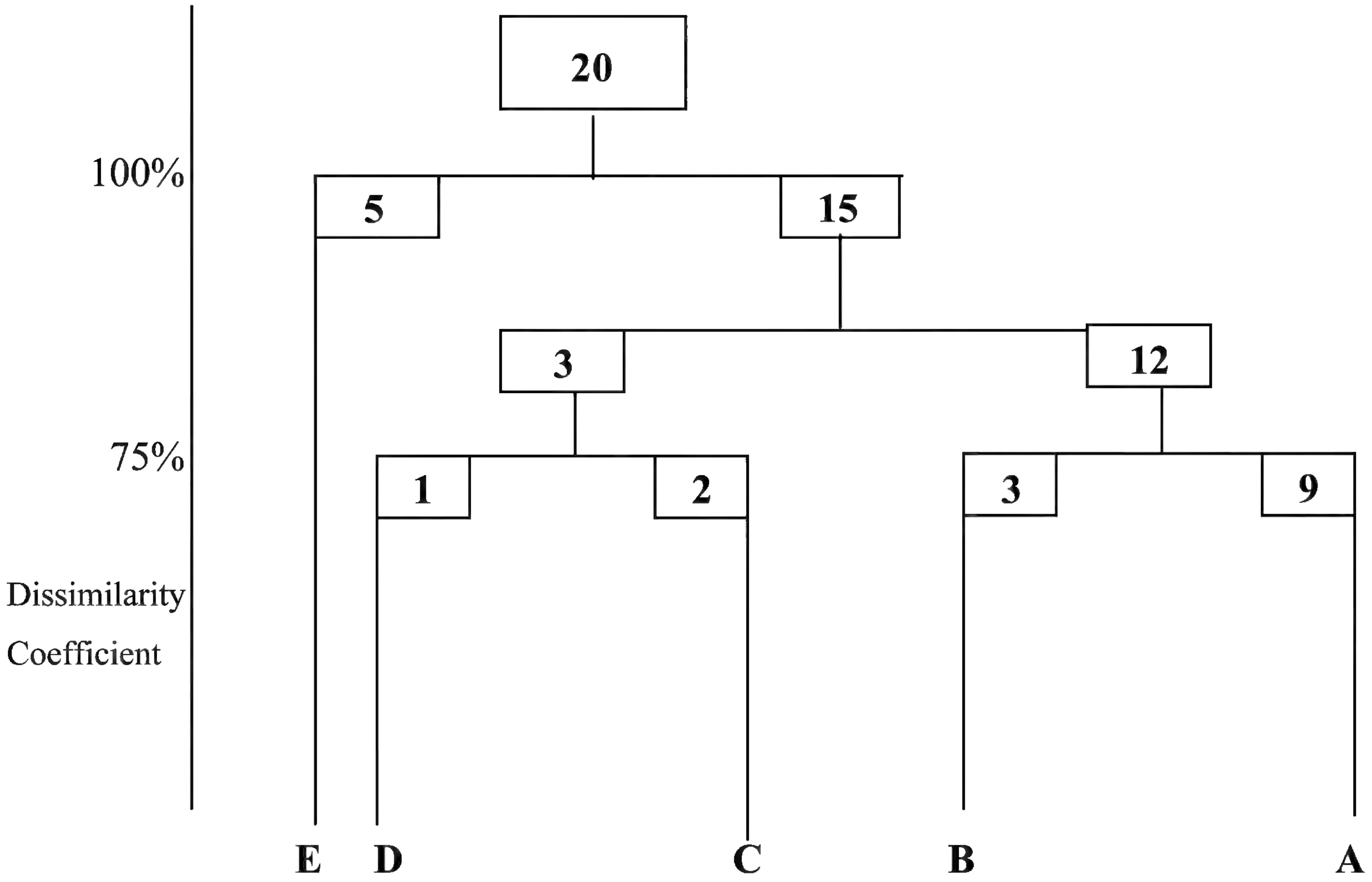

Fig. 2. Dendrogram for the cluster analyses of sampling sites, with 20 sites divided into five groups. The number of sites in each plant association is given in boxes.

1. Mountain-Complex Plant Communities

The mountain-complex communities represent the vast extensive rocky hillocks and scarps with a thin veneer of sediments. Skeletal soils of these habitats have no clear-cut profile. However, some minor rocky hollows (enclosed basins) strewn with stony material exist in hills and scarps where run-off accumulates during summer.

1.1. Limestone massif: ***Erianthus griffithii*** *community–Association A.*—This association dominates extensive areas in the limestone plateau and represents the characteristic vegetation of skeletal soils with no clear-cut profile. Such soils develop generally on calcareous parent material and support xerophytic species. *Acacia modesta, Dodonaea viscosa, Erianthus griffithii, Gymnosporia royleana,* and *Olea cuspidata* are the major species of this type of vegetation. The dominance of *E. griffithii*, along with other perennial grass such as *Cymbopogon jwarancosa* and *Desmostachya bipinnata*, gives this community a superficial resemblance to gramineous steppe.

1.2. Enclosed basins in calcareous massif: ***Trachynia distachya*** *community–Association B.*—This association represents the vegetation of depressions or hollows strewn with stony material with a lime incrustation. This association is dominated by *Acacia modesta, Dodonaea viscosa, Gymnosporia royleana* and *Olea cuspidate.* Compared with the former association, the contribution of *Cymbopogon jwarancosa, Eremopogon foveolatus* and *Erianthus griffithii* decreased remarkably. This association is marked by high average frequency of *Trachynia distachya* and a ground cover of *Cynodon dactylon, Malcomia africana,* and *Plantago ciliata.*

1.3. Enclosed basins in sandstone massif: ***Justicia peploides****–Association C.*—Association C includes the stands belonging to the northern inter-mountain depressions in sandstone strata. This association is distinctive because of the high dominance of *Acacia modesta, Capparis decidua, Erodium cicutarium, Grewia villosa, Gymnosporia royleana, Justicia peploides* and *Prosopis juliflora* and a few plants of *Olea cuspidate*

1.4. Sandstone plateau: ***Acacia modesta****–Association D.*—This association represents the southern slope of sandstone strata (Kala-Chitta range). The general vegetation is of the xeromorphic woodland type; the chief tree and shrub species are *Acacia modesta, Capparis decidua, Grewia hirsuta, G. oppositifolia, G. tenax, Rhamnus pentapomica,* and *Ziziphus nummularia.* The herbaceous vegetation is extremely short and includes annuals like *Malcomea africana* that appears during the short period of the rainy seasons.

2. Lowlands or playes (Wadi beds) communities

Lowlands receive run-off during rains and become dry thereafter. Wadi soils are formed from alluvial sediments carried down the slopes by run-off water. They are characterized by their heavier texture, high water-holding capacity, deeper profile and slightly to poor drainage. The alluvial playes are dominated by shrubs of *Olea cuspidata* associated with *Chrysopogon aucheri* (Association E) in more favorable habitats (oases), like runoff-fed depressions and runnels. Beside the dominant species (*Cyperus niveus* and *Dichanthium annulatum*), *Acacia modesta, Dodonaea viscosa,* and *Gymnosporia royleana* are common associates. The woody components of this association have large ranges and are generally found in oases as well as the plateau and scarps under the most arid conditions.

Gradient Analysis

Site and species ordination in the plane of first two axes are presented in Figures 3 and 4. The first DCA axis of the normal data set had an eigenvalue of 0.392 (13% of the variance explained). The eigenvalue for the second axis was 0.207 (8% of variance explained). Further axes each explained less than 7% of total variances.

Site ordination (Fig. 3) reveals a marked relationship between the first axis and the soil factors. There was a highly significant correlation ($P < 0.01$) between the sample scores along DCA axis 1 and the components of soil texture (sand, silt and clay) and moisture, r^2 values exceeded 0.4. Regarding axis 2, r^2 values of these edaphic factors were considerably low (< 0.03). Besides the soil physical characters, soil pH showed a significant positive correlation ($P<0.05$) with DCA axis 1, but not with axis 2. The availability of organic matter in the sample plots showed a significant correlation with both DCA axes (Table 2). In addition to these factors, the ordination axes (1 and 2) appeared markedly influenced by topography, redistribution of rainwater and soil depth. It is evident from Figure 3 that sites of the Wadi-beds (16-20, stands belonging to Association E) are clearly grouped at one end (high score) and those of mountain complex (1-15 sites belonging to Associations A-D) on the other end (low score) of DCA axis 1. However, among the mountain complex, several sites are separated from the others suggesting a degree of floral diversity within this group. Site 15 is strongly separated from rest of the sites suggesting again the operation of site-specific factors. Sites of the enclosed basins (2, 3 and 12) that collect the run-off water occupy an intermediate position along axis 1 reflecting the fair conditions of water and soil availability for plant growth. The distribution of the species along DCA axes 1 and 2 is presented in Figure 4. Several species had configurations similar to that evident for sites. However, some species do not follow the site distribution, suggesting that they are largely unaffected by the underlying topographic or edaphic factors.

Comparison of the site and species ordinations reveals that the separation of Wadi sites (16-20) as a distinct group at the resource-rich end of the gradient is due to the relative abundance of *Chrysopogon aucheri* and the presence of *Cyperus niveus, Dicanthium annulatum, Grewia damine,* and *Sageretia theezans.* These species are virtually absent from the plateau sites. The ordination positions of *Grewia tenax, Justicia peploides, Medicago laciniata, Prosopis juliflora,* and *Trachynia distachya* suggest that these species are characteristic of moderately xeric habitats. Both *Cymbopogon jawarrancusa* and *Desmostachya bipinnata* have maximum frequencies on the limestone massif. *Capparis decidua* defines the most xeric end of the gradient, while *Grewia hirsuta* and *Rhamnus pentapomica* display marked peaks in frequency on the eroded sandstone sites.

The remaining species occupy ordination positions that suggest a lack of any association to the site configuration along the gradient. These are identified as a group within the marked boundary of Figure 4. The distributions of *Acacia modesta, Dodonaea viscosa, Erianthus griffithii, Gymnosporia royleana, Olea caspidata,* and *Reptonia buxifolia* are particularly noteworthy. Among these species *G. royleana* and *O. cuspidata* show marked increases in frequency from plateau to lowland communities (Table 1). While *A. modesta* is able to

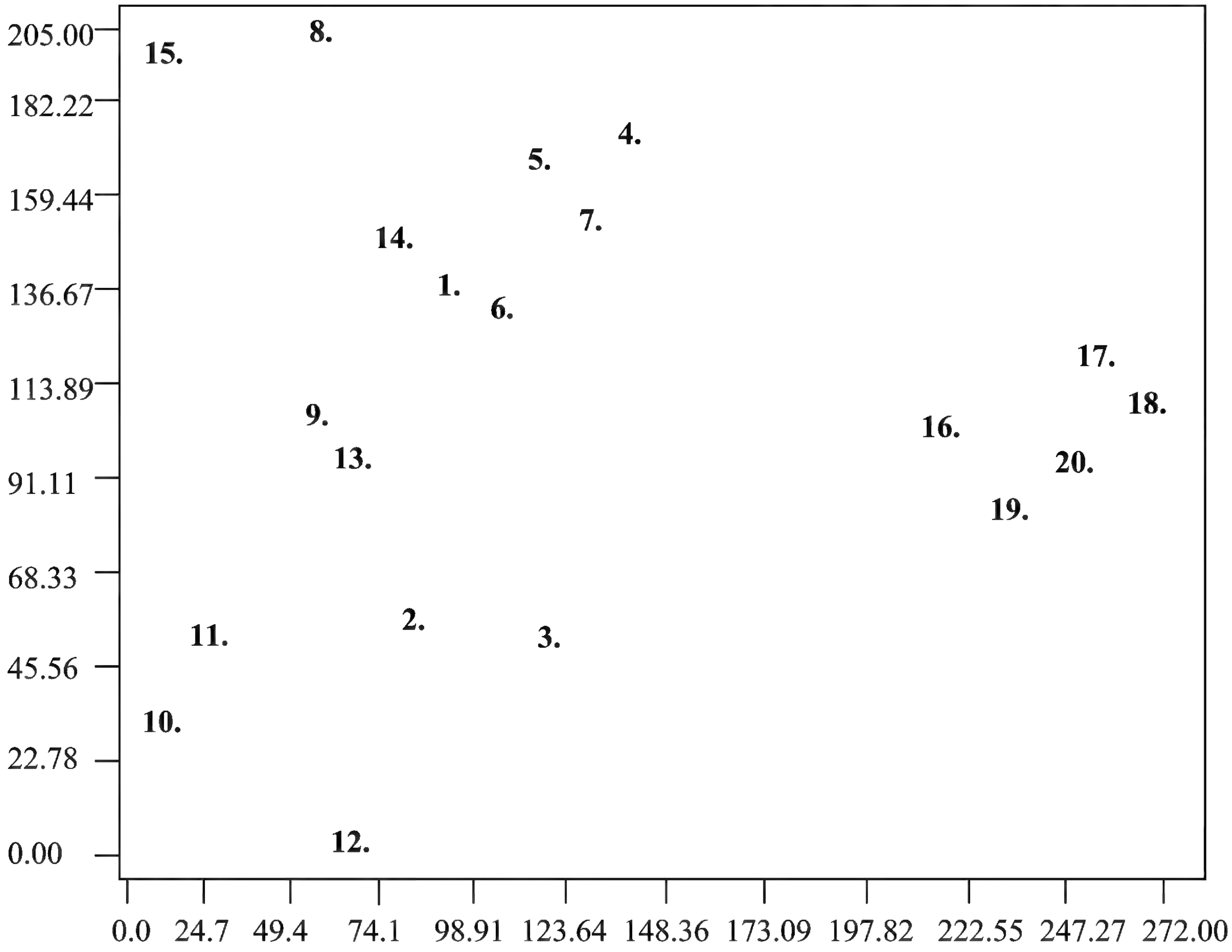

Fig. 3. Sites biplot of detrended correspondence analysis (DCA) axes 1 and 2 for the qualitative vegetation data obtained from Pothowar Plateau. The distributions of 20 sites along the DCA axes are numbered.

maintain relatively constant frequencies in all the sites, *D. viscosa, E. griffithii,* and *R. buxifolia* showed a pattern of increasing frequency of occurrence when extended to limestone plateau sites. In fact these species are absent from sandstone massif.

DISCUSSION

Plant assemblage and geomorphology

The results indicate that the landscape, nature of the rock and redistribution of rainfall water by run-off are the main sources of spatial variation in the study area. These geomorphological factors determine the boundaries and the composition of the plant communities. The species *Chrysopogon aucheri, Cyperus niveus, Dicanthium annulatum, Grewia damine,* and *Sageretia theezans* in Association E (Table 1) are most common in the flat or rolling lowlands that receive sufficient runoff water, and virtually absent from plateau sites. The species *Boerhaavia coccinea, Carissa opaca, Ehretia obtusifolia, Evovulus alsinoides,* and *Olea caspidata* reached maximum abundance in valley bottom sites and showed declining frequency of occurrence when extended into the plant communities on shallower soils of plateau sites (A-D). This pattern of distribution provides strong circumstantial evidence that dip and scarp slopes (topography) determine the differences in vegetation types through the distribution of run-off generated by rainwater. Depth and moisture of the soil again are important factors that exert influence on plant assemblages. On scarp slopes, the soil is shallow and quickly dries out representing the more xeric habitat as indicated by DCA.

In upper plateau sites, the boundaries and composition of plant communities are determined by a

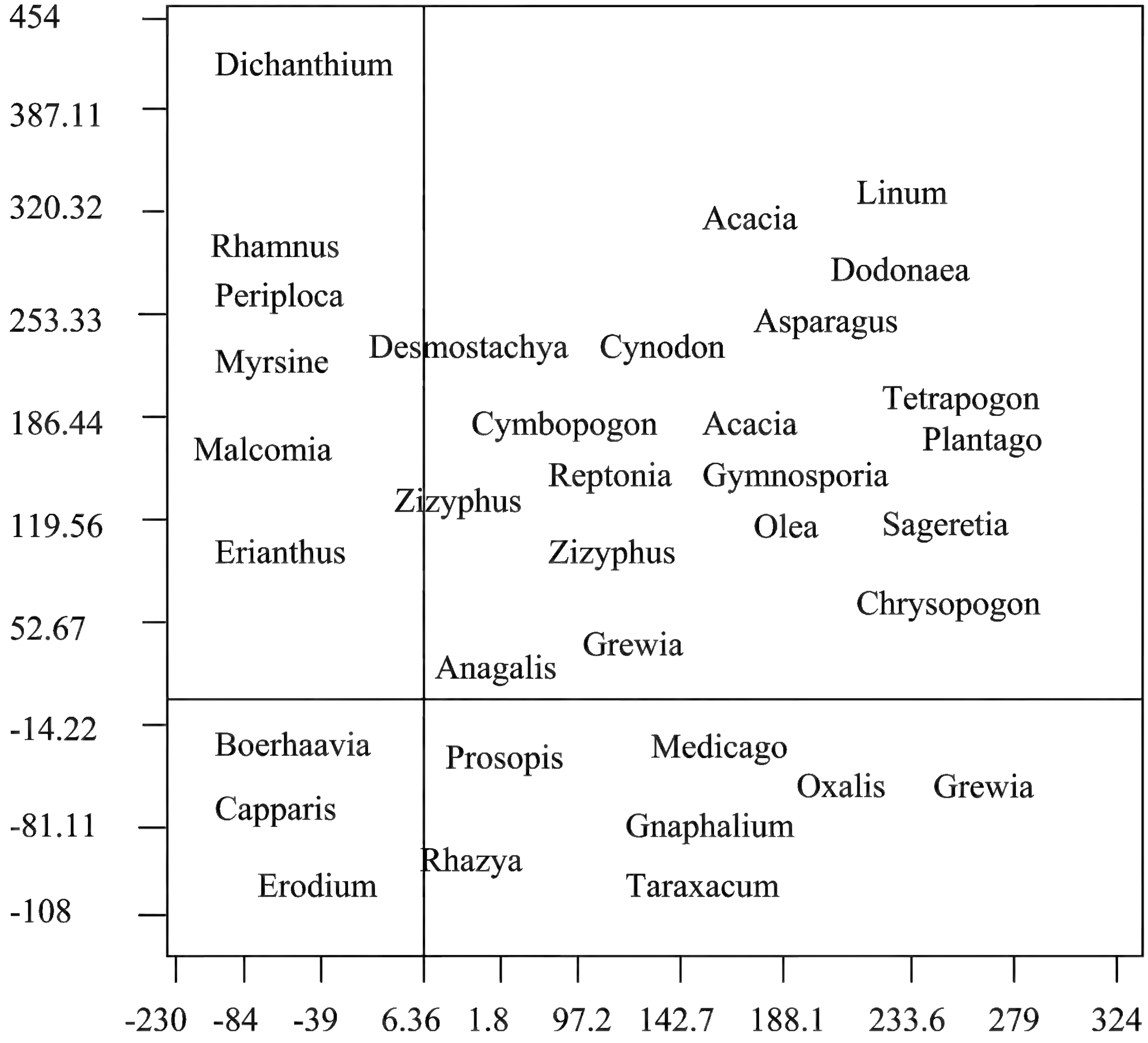

Fig. 4. Results of detrended correspondence analysis (DCA) for the distribution of the 46 species included in the vegetation analyses.

complex of factors including moisture, geology, soil and adjacent topography (Champion et al. 1960, 1965). The most influential factor in distribution of the vegetation appeared to be the geological substrate. For example, the species *Acacia nilotica, Asparagus gracilis, Cymbopogon jawarencusa, Dodonaea viscosa, Erodium cicutarium, Eremopogon foveolatus, Erianthus griffithii, Gnaphalium pulvinatum, Olea caspidata, Prosopis juliflora, Reptonea buxifolia,* and *Ziziphus jujuba* are associated with limestone strata (Association A). These species are altogether absent from the eroded sandstone plant communities (Association D). A fairly high available calcium status is possibly associated with the frequent occurrence of these species. Such species may be considered as lime tolerant (Hussain 1969). Besides these differences in species composition, species abundance also varies between the lime and sandstone sediments (Table 1). The majority of the plant species that are distributed over calcareous or non-calcareous rocks of the mountain complex showed a pattern of increasing frequency of occurrence when extended to sandstone plateau. This trend is common in *Acacia modesta, Capparis decidua, Grewia hirsuta, G. oppositifolia, G. tenax, Periploca aphylla, Rhamnus pentapomica, Rhazia stricta,* and *Ziziphus nummularia.*

Enclosed depressions in the limestone plateau form a marked transitional zone where the soil is mixed with rock fragments. Clay minerals of limestone-derived soils are largely inherited from the parent material.

TABLE 2. Spearman rank correlation coefficients between the detrended correspondence analysis (DCA) first and second axes.

Soil Parameters	Axes 1	2
Sand	-0.609**	0.089
Silt	-0.618**	0.161
Clay	0.744***	-0.176
EC (s cm^{-1})	0.313	0.393
pH	-0.543*	0.041
Organic matter	-0.407*	-0.456*
Water holding capacity	0.075	-0.619**
Moisture content	0.425*	-0.115

Level of significance: * P≤0.05, ** P≤ 0.01, *** P≤0.001.

The soils in the enclosed depressions remain exposed to continuous leaching, physical erosion and physicochemical changes without any rule by which a precise pattern of plant assemblage can be determined. However, *Acacia modesta, Gymnosporia royleana, Prosopis juliflora, Trachynia distachya* and other species are more frequent in depressions over limestone massifs while *Acacia modesta, Capparis decidua, Erodium cicutarium, Justicia peploides,* and *Prosopis juliflora* are frequent on sandstone massif (Association C). This may be interpreted as the variation in floristic composition on these strata that commonly reflects variations in the substrate which in-turn depends on the nature of the parent materials from which the soil is derived.

The vegetation environmental correlation

Apart from the fact that the landscape variables are indeed relevant for explaining the main vegetation types, the correspondence between the results of cluster analyses and DCA planes permit a direct interpretation of scores of stand data in DCA plane in relation to soil variables. The five associations produced by cluster analysis are plotted on first two axes as a scattered diagram (Fig. 5). The ordination axes may represent in some way the major substrate influences, which affects the stands in these data, and have been used as the plant and soil characteristics of the associations to discuss the most significant features of the environment (Table 2).

The importance of water holding capacity and organic matter as the environmental factors affecting plant species associations is not surprising, but has close relationship with water absorption and its retention. The present analyses and assessment of pattern and zonation along the first ordination axis suggest that the most important environmental gradient and boundaries across the landscape are associated with organic matter. The distribution of species along ordination axis 2 is significantly related not only to organic matter, but also to water holding capacity. However, it is difficult to assess the relative importance of these factors, but consistent negative interaction terms between these factors suggest that some combined effect is important. The reasons for these correlation must be hydrological, particularly the pattern of run-off generation and redistribution of organic matter of the study area, and probably are common to many arid mountain terrains (Dasti & Malik 1998).

Vegetation is a complex collection of substrate specialists and generalists. It may be concluded that both classification and ordination are able to delimit the plant associations according to their environments. Topographic heterogeneity at the local scale also is an important factor that governs the community structure in plateau habitat. The complex gradients in edaphic conditions associated with topography provide an opportunity to conduct further research, both in the laboratory and the field.

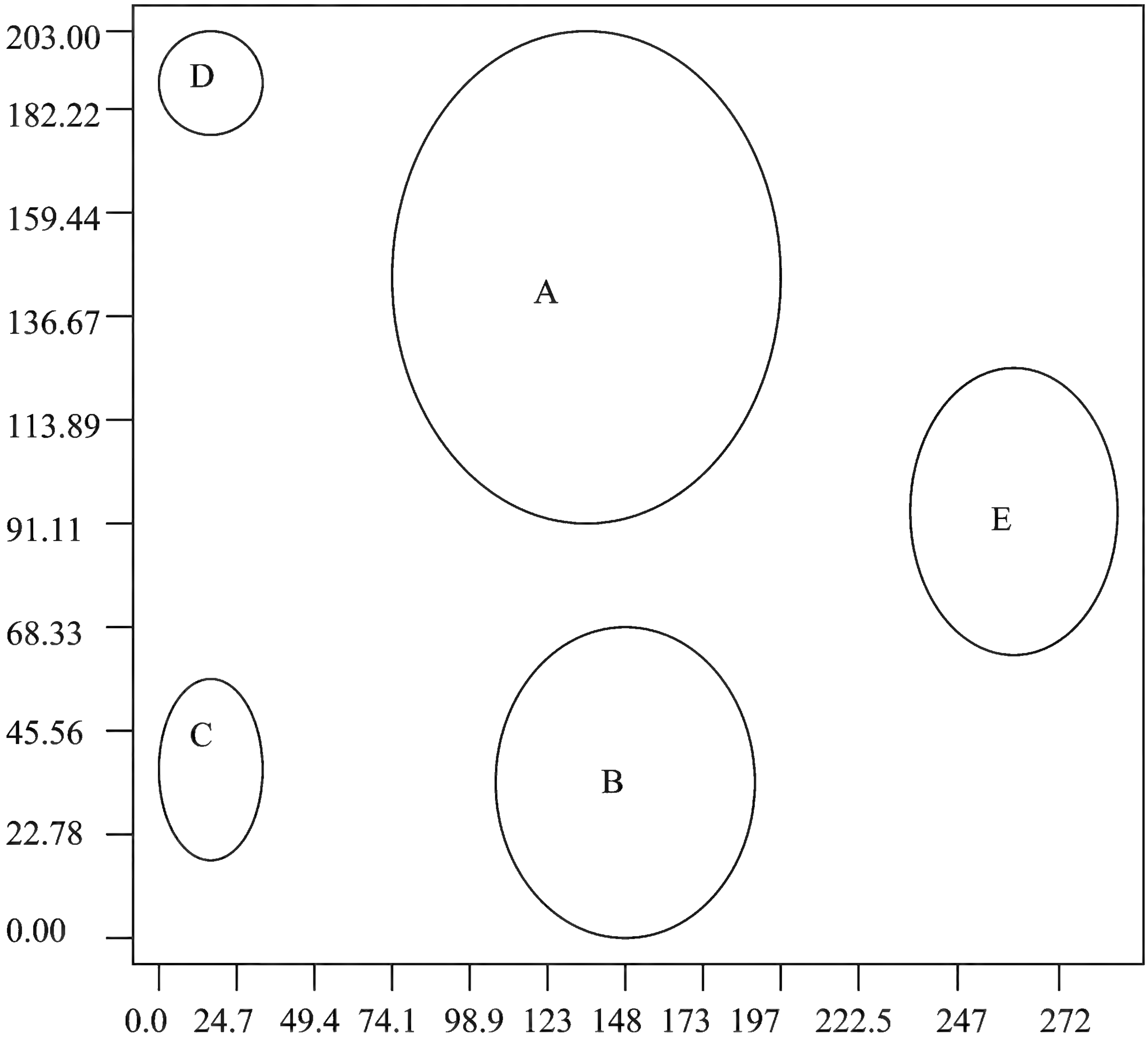

Fig. 5. Results of detrended correspondence ordination of the sites grouped by the associations produced by cluster analyses.

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SEED DISPERSAL AND SOIL SEED BANK OF *SERIPHIDIUM QUETTENSE* (ASTERACEAE) IN HIGHLAND BALOCHISTAN, PAKISTAN

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ABSTRACT

Seed dispersal and soil seed bank attributes of *Seriphidium quettense* were studied over two years in highland Balochistan. Seed dispersal started in early winter and continued till early spring. Primary dispersal agents were wind and water. Dispersal unit was capitulum, most often without outermost whirl of phyllaries. There was generally one achene per capitulum but occasionally two to three achenes may also be present. Mean dispersal distance was 23 to 40 cm from parent plant to ground surface. Majority of seeds (59–65%) fell under canopy of parent plants. Sampling of soil for seed bank was done before and after seed dispersal of *S. quettense*. Soil samples were collected from two depths (0–2 cm, 2–4 cm) and from two microhabitats (under adult individuals and open interspaces) by using soil cores. Seed bank status was determined by observing *S. quettense* seedling emergence in the pots. *Seriphidium quettense* exhibited persistent soil seed bank attribute. High seed densities were found under canopy of adult individuals and in upper soil layer. Persistent soil seed bank may help seeds to occupy safe sites as they develop over time.

Key Words: *Seriphidium quettense*, seed bank, seed dispersal

RESUMEN

Se estudió la dispersión de las emillas y el banco de semillas del suelo de *Seriphidium quettense* durante dos años en las tierras altas de Balochistan. La dispersión de semillas comenzó a principios del invierno y continuó hasta principios de primavera. Los agentes dispersantes primarios son el viento y el agua. La unidad de dispersión es el capítulo, la mayoría de las veces sin los filarios externos. Normalmente hay un aquenio por capítulo pero ocasionalmente pueden estar presentes ods o tres. La distancia media de dispersión fue de 23 a 40 cm desde la planta madre hasta la superficie del suelo. La mayoría de las semillas (59–65%) cayó bajo el dosel de las plantas madres. El muestreo del suelo para el banco de semillas se realizó antes y después de la dispersión de las semillas de *S. quettense*. Se colectaron muestras de suelo a dos profundidades (0–2 cm, 2–4 cm) y de dos microhábitats (bajo individuos adultos y en los espacios abiertos entre ellos) mediante núcleos de suelo. El estatus del banco de semillas se determinó observando la la aparición de plántulas de *S. quettense* en los puntos de muestreo. *Seriphidium quettense* muestra una persistencia de su banco de semillas. Se encontraron altas densidades de semillas bajo el dosel de los individuos adultos y el la capa alta del suelo. La persistencia del banco de semillas del suelo puede ayudar a las semillas a ocupar lugares seguros y desarrollarse tiempo después.

INTRODUCTION

About 93% of the total area of Balochistan is classified as rangelands and 90–95% feed requirements of sheep are met by these rangelands (Quraishi et al. 1993). About 87% of people of Balochistan derive their livelihood directly or indirectly from livestock rearing (Heymell 1989). However, rangelands of Balochistan are degrading very rapidly by overgrazing and removal of vegetation for fuel wood. Re-establishment of native plant species is one of the options to restore the productivity of degraded rangelands.

In arid and semiarid rangelands, re-establishment of native plant species is vital to maintain function, structure, diversity, and stability of the landscape. Native species have evolved under the prevailing stresses of the region and have the ability to exploit the limited available resources. *Seriphidium* and *Artemisia* species are the dominant dwarf shrubs of Balochistan. The genus *Seriphidium* comprises of 125 species distributed

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in North America, temperate Asia and Europe (Ghafoor 2002). *Seriphidium quettense* (Podlech) Ling. (Syn. *Artemisia quettensis* Podlech) provides forage for small ruminants when other range species are in short supply particularly under drought conditions. Shrubs provide many benefits to humans and animals including fodder for livestock and wildlife, functioning of rangeland ecosystems, erosion control, industrial products and medicines (McKell 1989).

Regeneration of most range species depends on seed production, seed dispersal, seed predation, soil seed bank, suitable environmental conditions, and presence of suitable microsites (Chambers & MacMahon 1994; Watkinson 1978). Seed dispersal can determine size, structure and composition of plant population and diversity of plant community (Askew et al. 1997; Peart 1979). Soil seed bank enables plant populations to maintain their genetic variability, withstand adverse periods, and persist through time (Baskin & Baskin 1978; Thompson & Grime 1979). Soil seed bank have both horizontal and vertical dimensions as a result of phase I and phase II dispersal (Chambers & MacMahon 1994; Guo et al. 1999; Simpson et al. 1989). Such distribution of seeds has a great impact on population growth and its structure (Chambers & MacMahon 1994). Seeds are present in high densities under plant canopies in arid habitats representing horizontal pattern of seed banks in soil (Guo et al. 1999). The present study was conducted to determine the pattern of seed dispersal of *Seriphidium quettense* and evaluate temporal and spatial status of its soil seed bank.

MATERIALS AND METHODS

Study site

The experiment was conducted in Chiltan National Park Hazarganji, Balochistan, Pakistan in an extended area of the park that was protected from livestock grazing since 1998. Climate of the area is Mediterranean type. Area receives rainfall mostly during the winter months. Occasionally rainfall occurs during the summer as well. Mean annual rainfall of over 19 years is 200 mm. Soil of the area is sandy-to-sandy loam. Dominant species of the site are *Seriphidium quettense, Cymbopogon jawarancusa, Chrysopogon aucheri* and annual grasses (Marwat et al. 1992).

Seed dispersal

Experiments were conducted for two-year to determine the pattern of seed dispersal in *S. quettense.* In Asteraceae (Compositae) the dispersing unit is a fruit, an achene or cypsela. However, the term seed is used in this study for the fruit dispersal. Fifty meters long transects were established during December 2002 and December 2003. Ten points were marked along the transect during each year and the nearest plant was selected on each point. Inflorescences of other plants within 3 meters radius were clipped to prevent confounding of the seeds. Fluorescent powder was applied to the selected plants prior to seed dispersal. Seed dispersal was observed at five days interval until the end of dispersal period. Distance of seed dispersal was measured from the edge of the base of the marked plants. Seeds were collected after measuring the distance. Percentage of dispersed seeds was determined in two microhabitats under parent plant canopy and open interspaces. The data were subjected to linear regression analysis between number of seeds dispersed and dispersal distance.

Soil seed bank

Temporal and spatial status of *S. quettense* seed bank in the soil was examined for two years from two depths (0–2 cm, 2–4 cm) and from two microhabitats (under canopy of adult individuals, and open interspaces). Samples were collected before and after fresh seed dispersal to assess temporal aspect of soil seed bank. Fifty meter long transects were established at each sampling date. Ten points were marked on transect lines. Five samples were collected under adult individuals and from open interspaces at 0–2 cm and 2–4 cm depths at each marked point by using 10 cm diameter soil core. First sampling before the seed dispersal period was done in mid November during 2002 and 2003. Second sampling was done in late February during 2003 and 2004. As seeds of *S. quettense* are 0.8 mm in size (Ghafoor 2002), 0.5 mm mesh sieve was used to remove gravel and unnecessary soil, to ensure maximum retention of seeds in the sample for their germination. The sub samples were pooled and filled in pots for observing seedling emergence. Pots were placed in open air

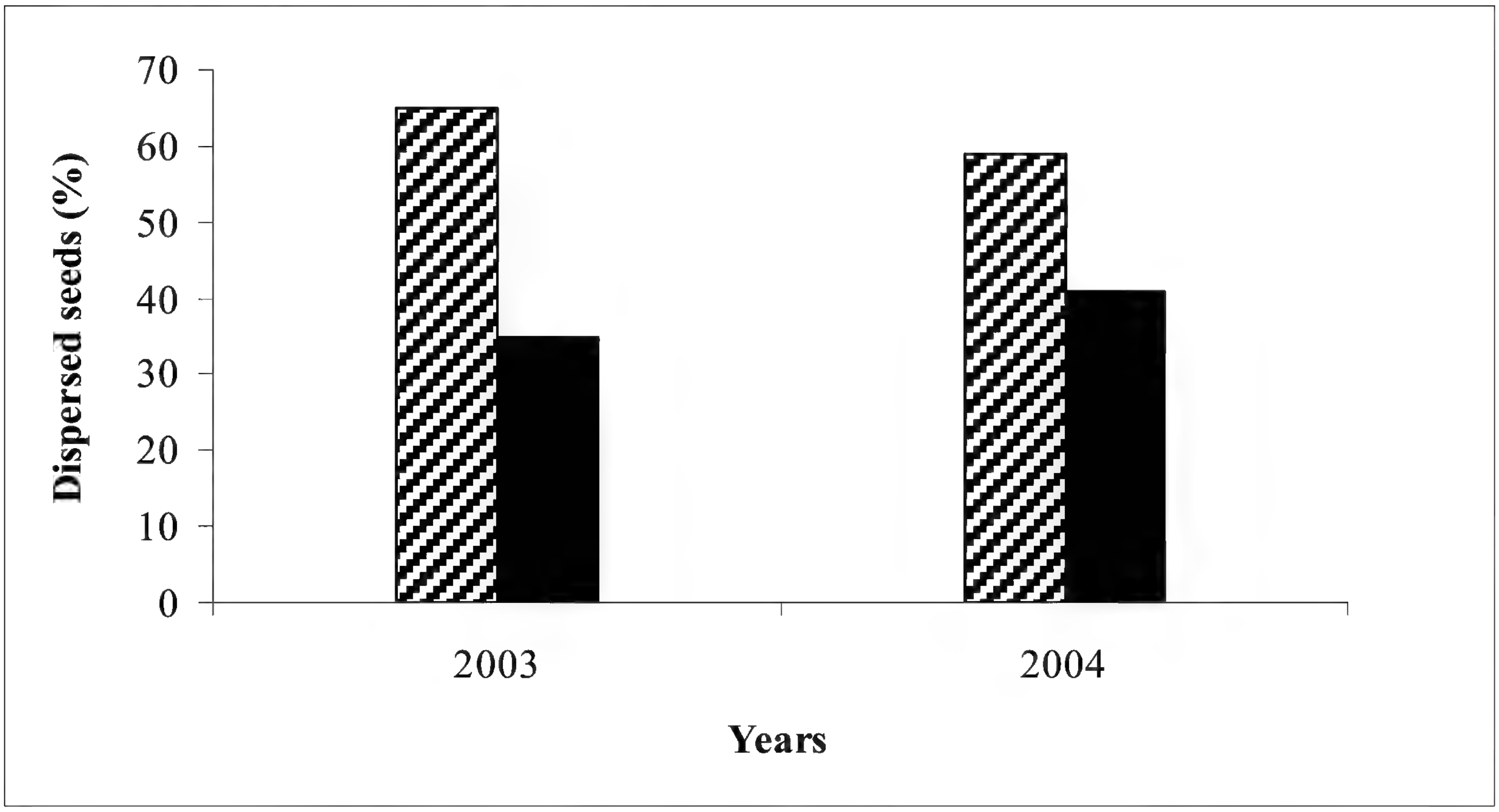

Fig. 1. Percentage of dispersed seeds (capitula) under parent plant canopies (▨) and in open interspaces (■) during 2003 and 2004

and watered regularly. The emerging seedlings were identified, counted and removed. Seedling emergence was observed for three months. First year samplings were germinated in mid March and the second year samplings in the last week of February.

RESULTS

Seed dispersal

Seed dispersal of *S. quettense* started from mid to late December and continued till late February. Primary dispersal agents were wind and water. Dispersal unit was a capitulum, most often without outermost whorl of phyllaries. There was generally one achene per capitulum but occasionally two to three achenes may also be present. Maximum dispersal distance was 130 cm and 210 cm for first and second year respectively. The mean dispersal distance from parent plants to ground surface was 23 to 40 cm for first and second year respectively. Seeds distributed in all directions around the plants. However, majority of seeds were found in northeast side according to wind direction. Majority of the seeds (59–65%) fell under canopy of parent plants (Fig. 1). There was a negative correlation between dispersal distance and number of the seeds (Fig. 2a, b). Number of the seeds decreased as the distance increased and created a negative exponential curve (Fig. 2a, b).

Soil seed bank

Seed densities of *S. quettense* varied with microhabitats and soil depths for each sampling date (Fig. 3a,b,c,d). High seed densities were found in the upper 0–2 cm soil layer than the lower 2–4 cm and under the adult individuals than in the open interspaces. In the first year sampling, microhabitats and depths were significant ($p<0.05$) for the second sampling while non-significant for the first sampling (Fig. 3a,b). In second year samplings, differences in numbers of seedlings between microhabitats were significant ($p<0.05$) for both samplings as a higher number of seeds were observed under canopy of adult individuals. Differences between soil depths were non-significant for both samplings (Fig. 3c,d). A high number of seeds were found in upper soil layer.

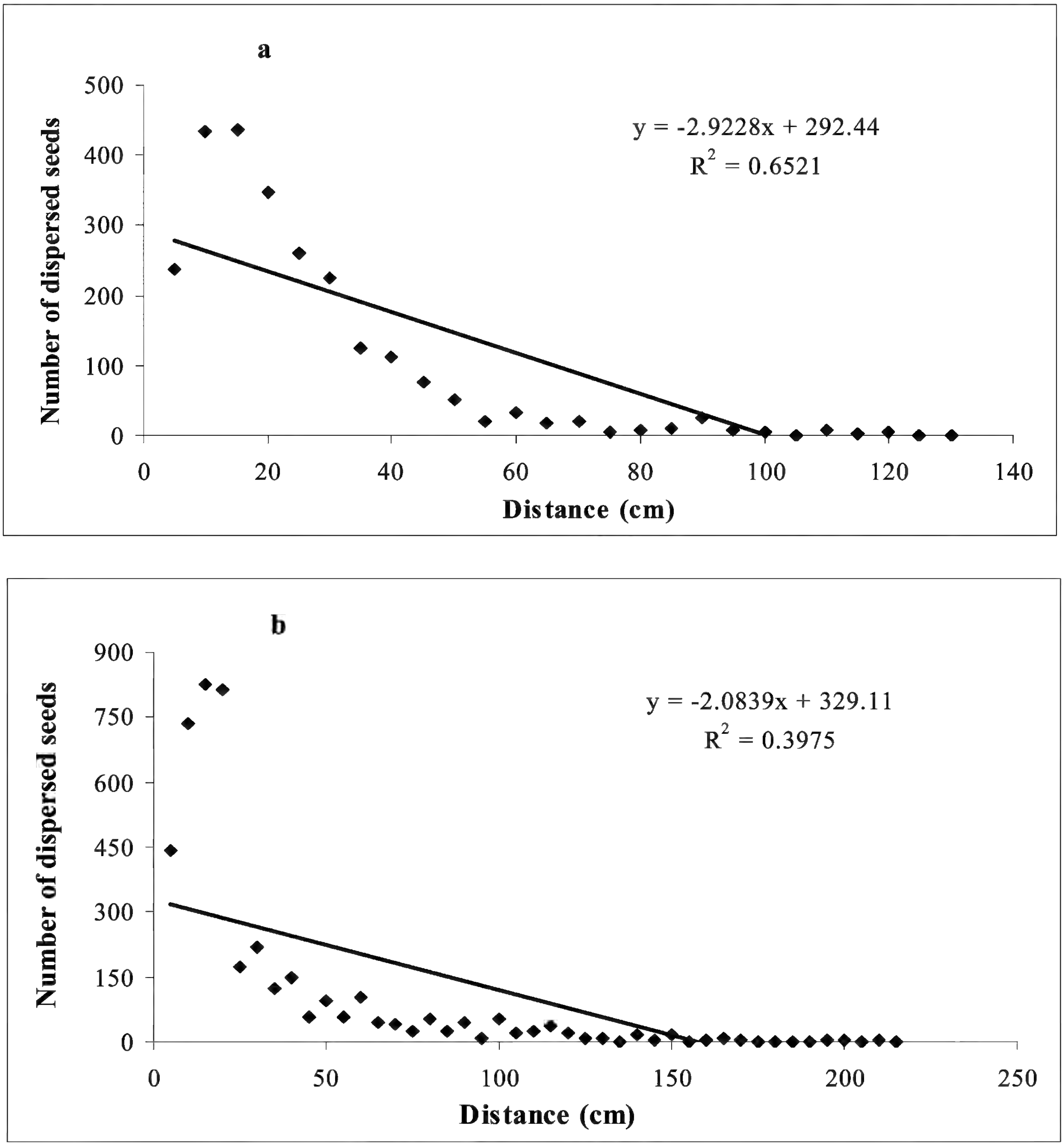

Fig. 2. Pattern of seed dispersal in *Seriphidium quettense* from parent plants to the ground surface during year 2003 (a) and 2004 (b). Lines are based on regression equations, where Y is number of dispersed seeds (capitula) and X is distance from parent plants.

DISCUSSION

Seriphidium quettense had a prolonged period of seed dispersal which started from early winter and lasted till early spring. Prolonged dispersal has also been reported for fringed sagebrush (Bai & Romo 1997). Although predation on *S. quettense* seeds is unknown, but prolonged dispersal is believed to be helpful in avoiding predation (Willson 1993). Longer periods of seed dispersal in *S. quettense* seems to be a tactic for contemporary seed germination as well as for the chances of seed burial in the soil (Davlaeminck et al. 2005; Mahmood et al. 2005; Olano et al. 2002). Though seeds of *S. quettense* are very light, dispersal was limited with a majority of seeds falling under the canopy of adult plants. Restricted dispersal of seeds around the

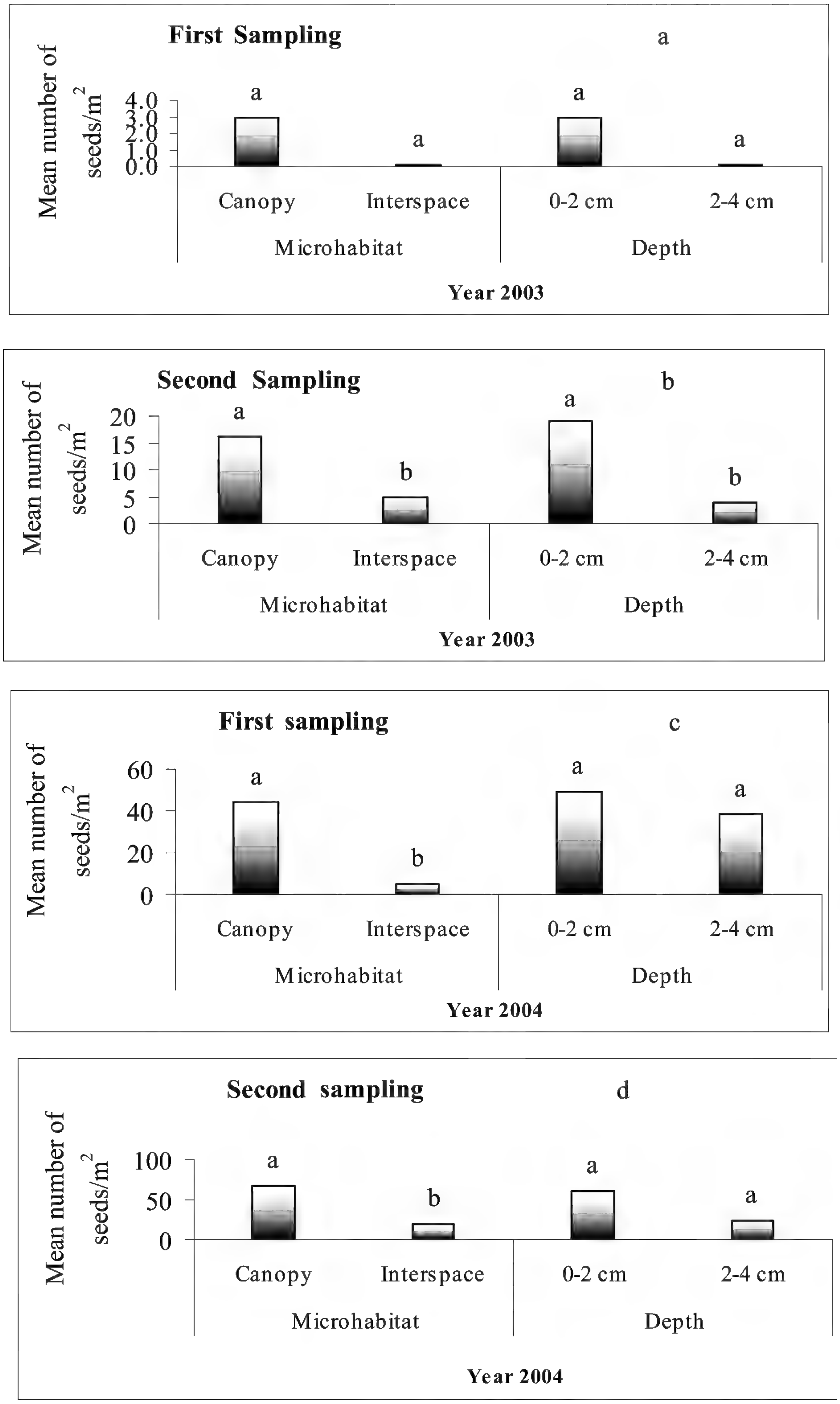

Fig. 3. Temporal and spatial pattern of soil seed bank. Means followed by the same letters are not significantly different at $P=0.05$.

parent plants signifies safe sites for seed germination (Davlaeminck et al. 2005; Mahmood et al. 2005). Characteristics like seed weight, size, shape, height of parent plants, and the nature of surrounding vegetation are important determinants when wind and gravity are the primary agents for seed dispersal (Willson 1993). The limited seed dispersal has also been reported for other species of *Artemisia* (Bai & Romo 1997; Bauer et al. 2002; Friedman & Orshan 1975) and has been attributed to low release height of the parent plants (Bauer et al. 2002). Phase II dispersal of seeds in horizontal and vertical direction may have greater influence on patterning of plants in ecosystems than their initial dispersal (Chambers & MacMahon 1994; Russel & Schupp 1998). There are greater chances of rain in the area during January and February that may help farther movement of the seeds and can greatly affect seed germination and seedling establishment.

Densities of emerged seedlings of *S. quettense* in pots ranged from 3 to 68 per m^2. Seed densities of fringed sagebrush in mixed prairie in Alberta have been reported as 75 to 183 per m^2 (Johnston et al. 1969). In second year, seedling densities were higher due to variation in sampling site and early placement of samples in the pots than the first year. Increasing temperature may hinder germination of these species (Bai & Romo 1994; Booth & Bai 1999). Roberts (1981) reported that use of seedling emergence techniques to quantify soil seed bank status may under estimate the soil seed bank density if germination requirements are not met. Soil seed bank of *S. quettense* showed variable spatial and temporal patterns across different samplings. Both increasing and decreasing trends have been reported for total number of seeds of *S. tridentatum* with distance from canopy center (Guo 1998). Canopies of *S. quettense* retained more seeds than open interspaces in all samplings. It may be attributed to the limited dispersal of the seeds and comparatively high quantity of litter under canopies as compared to bare interspaces (Russell & Schupp 1998).

Higher seed densities were found in upper soil layer (Guo et al. 1999). Small seeds are more prone to move downward in loose textured soils in arid environment as compared to larger ones (Chambers & MacMahon 1994). The period of seed dispersal of *S. quettense* immediately follows spring season. That can increase germination due to greater chances of rainfall during late winter or early spring.

Seriphidium quettense has a persistent soil seed bank and seedlings emerged from first samplings before the seed dispersal period. Our findings are in conformity with previous studies that small seeds and seeds of disturbed habitats generally form persistent soil seed bank (Bai et al. 1995; Bai & Romo 1997; Mahmood et al. 2005). Prolonged seed dispersal and persistent soil seed bank attributes of *S. quettense* may help their seeds to occupy safe sites as they develop over time.

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BOOK NOTICES

Bill Witt. 2006. **Orchids In Your Pocket: A Guide to the Native Orchids of Iowa.** (ISBN 1-58729-499-0, laminated fold-out guide). University of Iowa Press, 100 Kuhl House, Iowa City, IA 52242-1000, U.S.A. (**Orders:** www.uipress.uiowa.edu, 319-335-2000, 319-335-2055 fax, 1-800-621-2736). $9.95, 437 pp., 32 color photos, 4¼" × 9".

A plastic-laminated, fold-up pocket guide (9 x 4 inches) with color photos of thirty-one species of orchids plus two hybrids. Common and scientific names, habitat and distribution, height, phenology, and rarity status are given for each species. Eighteen of the species are listed as threatened, endangered, or of special concern.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

John Tullock. 2005. **Growing Hardy Orchids.** (ISBN 0-88192-715-5, hbk.). Timber Press Inc., The Haseltine Building, 133 SW Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, 503-227-2878, 503-227-3070 fax, 1-800-327-5680). $29.95, 244 pp., 100 color illustrations, 6" × 9".

"Part of the reason I first became interested in growing native orchids stemmed directly from their reputation for fussiness in cultivation. In no reference book could I find any encouragement for including native orchids in my wildflower garden; in fact, most of the books I consulted contained numerous exhortations to avoid even attempting to grow them. ... I developed my orchid growing techniques through direct observation of numerous orchid species in their natural settings, observations accumulated over thirty years of excursions up and down the [Tennessee] valley and into the mountains on either side of it. Assisted by the insights of other orchidists whose works appear in the bibliography, I now grow [in Knoxville] twelve North American orchid species and three exotic ones." Although there apparently is no explicit list of these species, the following are specifically mentioned in the text and photos as growing in his garden: *Bletilla striata*, *Cypripedium acaule*, *Dactylorhiza fuchsii*, *Goodyera pubescens*, *Platanthera ciliaris*, *Platanthera integrilabia*, *Platanthera flava*, *Platanthera peramoena*, *Platanthera psycodes*, *Spiranthes cernua* var. *odorata*, and *Tipularia discolor.*

The author is an ardent conservationist and notes the value of "bringing wild species into cultivation and developing effective techniques for their large-scale propagation" and that transplants of species in immediate threat of the "bulldozer" are a valuable way of conserving germ plasm. Among the appended resources is a list with addresses of orchid suppliers and organizations.

Chapters include: **1)** Native orchid conservation: One view; **2)** General principles of hardy orchid cultivation; **3)** Propagation of hardy orchids; **4)** Mycorrhizal associations and hardy orchids; **5)** Hardy orchids through the seasons; **6)** Bletilla: The ideal beginner's plant; **7)** A catalog of hardy and half-hardy orchids.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

Paul Martin Brown (Text) and Stan Folsom (Original Artwork). 2006. **Wild Orchids of the Prairies and Great Plains Region of North America.** (ISBN 0-8130-2975-9, flexibind). University Press of Florida, 15 Northwest 15th Street, Gainesville, FL 32611-2079, U.S.A. (**Orders:** www.upf.com, 352-392-1351, 352-392-7302 fax, 1-800-226-3822). $29.95, 376 pp., 316 color plates, 94 b/w illustrations, 81 maps, 6" × 9".

The beauty and compact taxonomy of North American orchids has stimulated production of a plethora of regional identification guides and accounts. This is a particularly fine one, plus it's relatively inexpensive and easily of size to be carried around in the field. Included are 21 genera, with 64 species, 9 varieties, and 8 hybrids, over a range from southern Saskatchewan and Manitoba south to the northeastern corner of New Mexico, the northern half of Texas, and the northwestern corner of Louisiana. The author notes that "recent work in volume 26 of *Flora of North America* (2002) has greatly fine-tuned the identification and distribution of these orchids."

The book is divided into four parts: (1) a brief discussion of prairies and orchids, an introduction to the format for Part 2, and keys to the genera, (2) treatments of the genera and species, (3) references and resources, and (4) orchid hunting. Two appendices give distribution by state for each species and a chart of flowering times. **Part 2** has keys to species within each genus and species descriptions, with detailed range maps, several color photos (and often line drawings) for each species showing habit and floral details, and comments from the author's personal experience on ecology, phenology, abundance, critical features of identification, and hybrids. Formally described color and growth forms are listed for each species. **Part 3** has a checklist for the region, provincial and state species lists, "some regional orchid statistics," rare, threatened, and endangered species, synonyms and misapplied names, recent literature references for new taxa, combinations, and additions, a commentary on use of Luer's 1975 compendium on orchids of the USA and Canada, and commentaries (with comparative photos) on distinctions in 8 cases of cryptic species, species pairs, and varietal pairs. **Part 4** give details suggestions on where to look for orchids in each of seven subregions.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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VASCULAR PLANT SPECIES/AREA RELATIONSHIPS (SPECIES RICHNESS) IN THE WEST GULF COASTAL PLAIN: A FIRST APPROXIMATION

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ABSTRACT

We surveyed the West Gulf Coastal Plain literature for information on vascular plant species/area relationships (species richness) and produced curves for small (micro-) areas (< 5 ha) and large (macro-) areas (> 50 ha). A brief preliminary comparison of species richness between the West Gulf Coastal Plain and the Atlantic and East Gulf Coastal Plain indicates that while some micro-scale areas may be richer in species in the East Gulf Coastal Plain, macro-scale areas have about the same richness in both areas.

RESUMEN

Se revisó la bibliografía sobre la llanura costera del West Gulf en busca de información sobre especies de plantas vasculares /relación con el área (riqueza de especies) y se hicieron curvas para micro-áreas (< 5 ha) y macro-áreas (> 50 ha). Una breve comparación preliminar de la riqueza de especies entre la llanura costera del West Gulf y la llanura costera del Golfo Atlántico y del Este indica que mientras algunas micro-áreas pueden ser mas ricas en especies en la llanura costera del East Gulf, las macro-áreas tienen aproximadamente la misma riqueza en ambas áreas.

INTRODUCTION

We have noted that many papers seeking to compare an area's species richness find few relevant studies with comparable information. For example, addressing the long-held belief that the Big Thicket is species rich, Diggs et al. (2006:169) ask: "How does [the Big Thicket] compare with other areas of similar size?" But, lacking "the needed comparative data," they were unable to answer the question. Being interested in species richness for some time and having collected considerable information on it for various communities and locations in the West Gulf Coastal Plain over the past two decades (MacRoberts & MacRoberts 1992b), we decided to survey the literature to see if we could locate enough data to draw a species/area curve for the West Gulf Coastal Plain.

Whittaker (1972) defined alpha, beta, and gamma diversity (richness). In this paper, we will be concerned with alpha diversity (within habitat or community, such as for a pitcher plant bog, prairie, or baygall) and gamma diversity (geographic scale diversity, such as for a county or state, which include many communities and habitats). We will not use Whittaker's terms in this paper but will speak only of species richness to cover both alpha and gamma diversity; all references to areas smaller than 5 ha in this paper indicate alpha diversity and all references to areas larger than 50 ha indicate gamma diversity.

METHODS/RESULTS

We surveyed the West Gulf Coastal Plain—eastern Texas, western Louisiana, southeastern Oklahoma, and southern Arkansas (Fig. 1)—literature for species richness information. Our criterion for accepting or rejecting a study was its thoroughness. This unfortunately left out most county/parish checklists done as Masters theses since few are thorough and virtually none are published. Nonetheless, we found data for both large and small areas including many community types (Peterson & Brown 1983; Matos & Rudolph 1985; MacRoberts & MacRoberts 1988,1990, 1991, 1992a, 1992b, 1993a, 1993b, 1993c, 1994, 1995a, 1995b, 1996a, 1996b, 1997, 1998a, 1998b, 2001, 2003, 2004a, 2004b, 2004c, 2005, 2006, in prep.; MacRoberts

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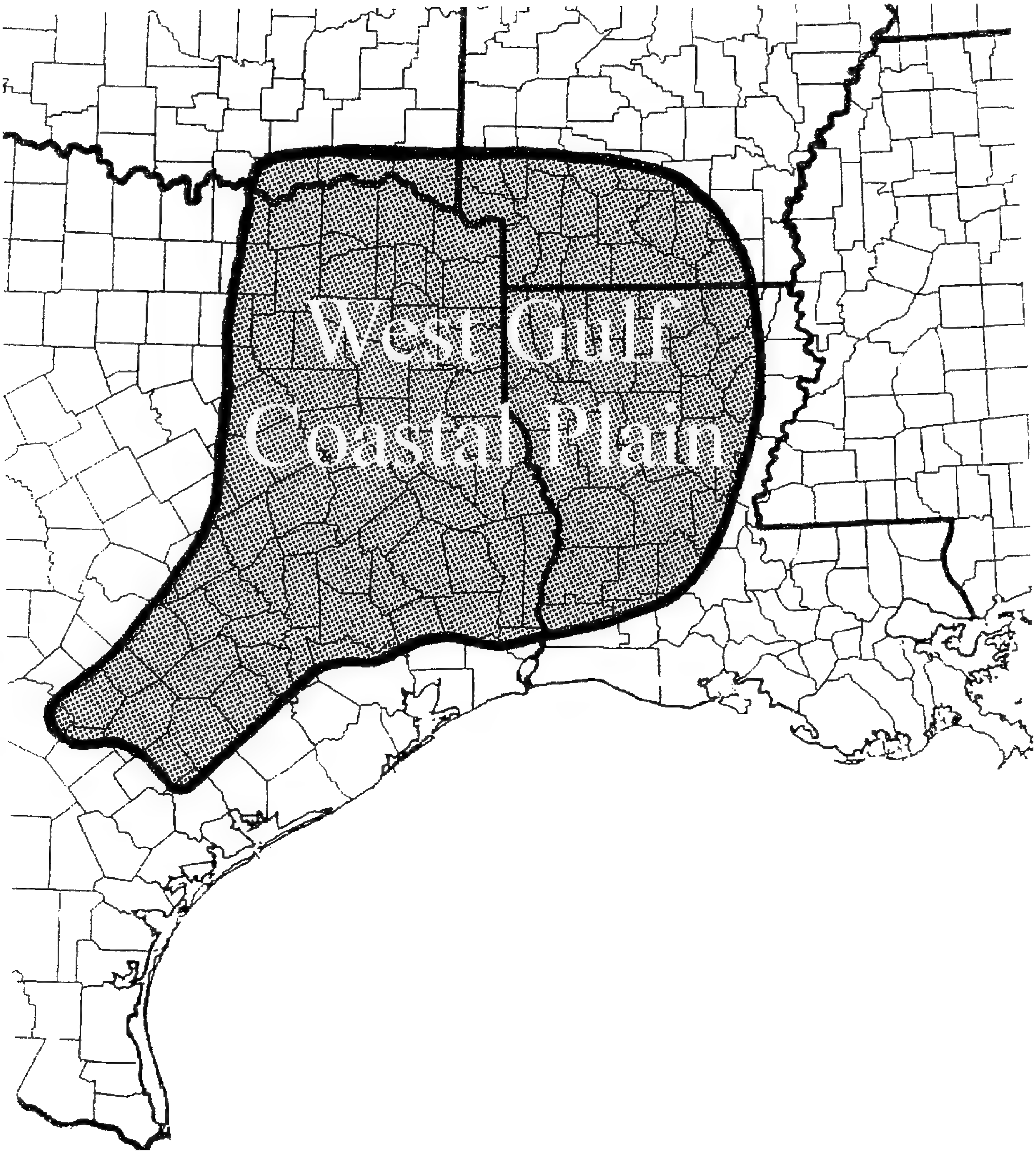

Fig. 1. Map showing extent of West Gulf Coastal Plain.

et al. 2002a, 2002b, 2002c, 2003, 2004; Thomas & Allen 1993–1998; Nesom & Brown 1998; Diggs et al. 1999, 2006; Neill 2000; Fleming et al. 2002; Neyland 2002; Singhurst et al. 2003; Brown et al. 2005, 2006; Philipps et al. in prep.; Thomas et al. in prep.) We plotted the data on a log/log scale. We did this separately for areas smaller than 5 ha and for areas larger than 50 ha. The results are shown in Figures 2 and 3.

DISCUSSION

There is wide variation in number of taxa reported for the same and for different sized areas in the West Gulf Coastal Plain. The reasons are many. Community differences account for some of the difference be-

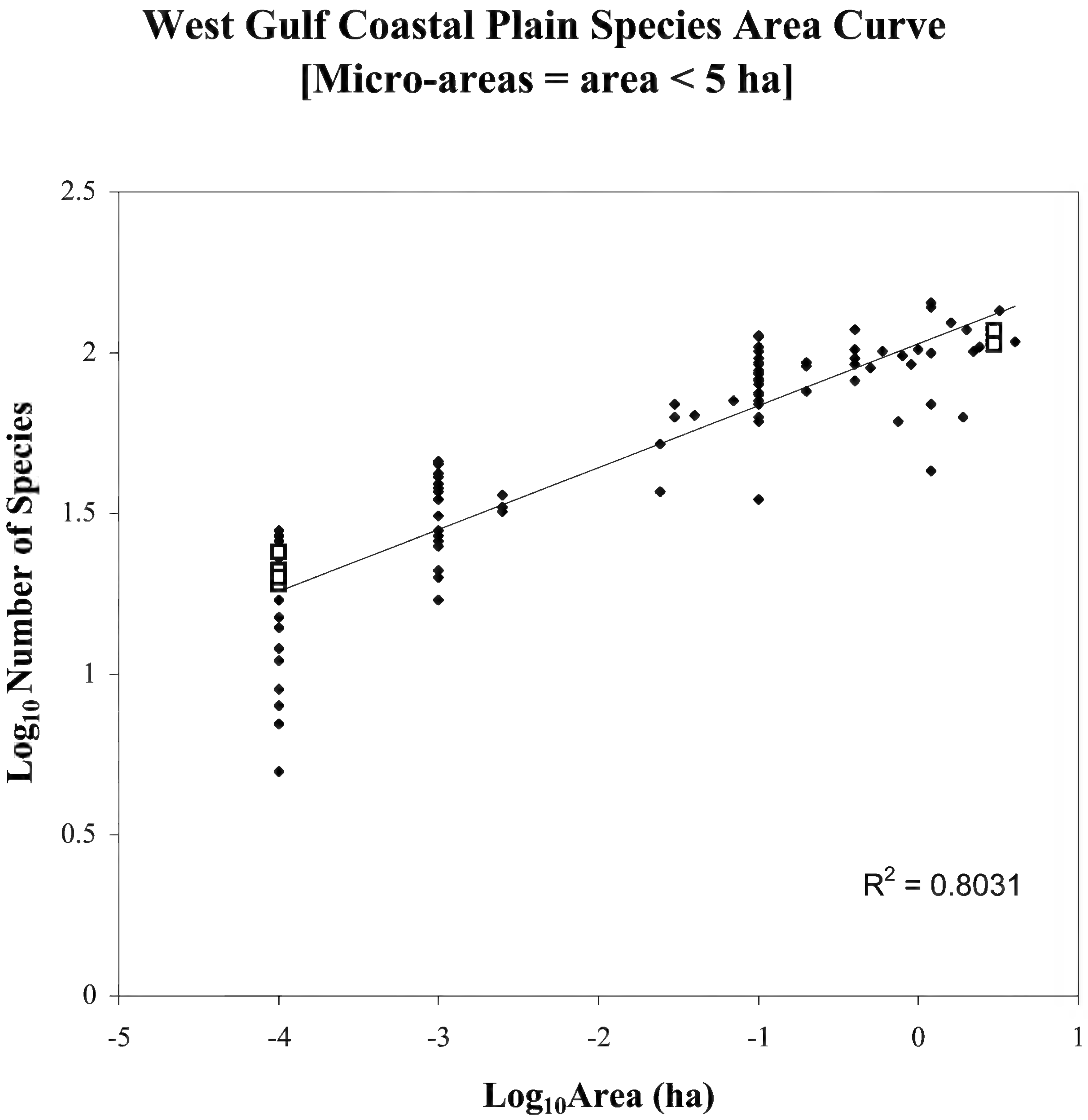

Fig. 2. West Gulf Coastal Plain species/area curve (Micro-areas = area <5 ha). Open boxes are Big Thicket sites.

cause different communities have different species numbers. For example, baygalls have fewer species per unit area than pitcher plant bogs (MacRoberts & MacRoberts 2001; MacRoberts et al. 2004). Thoroughness of collecting differs considerably. Some areas have been collected extensively for years, while others have not. For example, while Caddo Parish has been the subject of three checklists, few counties/parishes in the West Gulf Coastal Plain, notably in Texas, have been the subject of one (MacRoberts & MacRoberts 2006). Taxonomic preferences also affect numbers. Some investigators report species, subspecies, and varieties while others report only species (MacRoberts & MacRoberts 2006). Finally, inclusion criteria differ. Some investigators collect extensively in urban parks and lawns, transportation routes, and other highly disturbed ruderal areas and report many more non-natives than do others.

Nonetheless, allowing for these sources of variation and potential error, Figures 2 and 3 allow for general comparisons. For example, the question posed by Diggs et al. (2006) in our introductory remarks is now answerable. According to Diggs et al. (2006) the Big Thicket consists of 17,974 sq km and has 1826

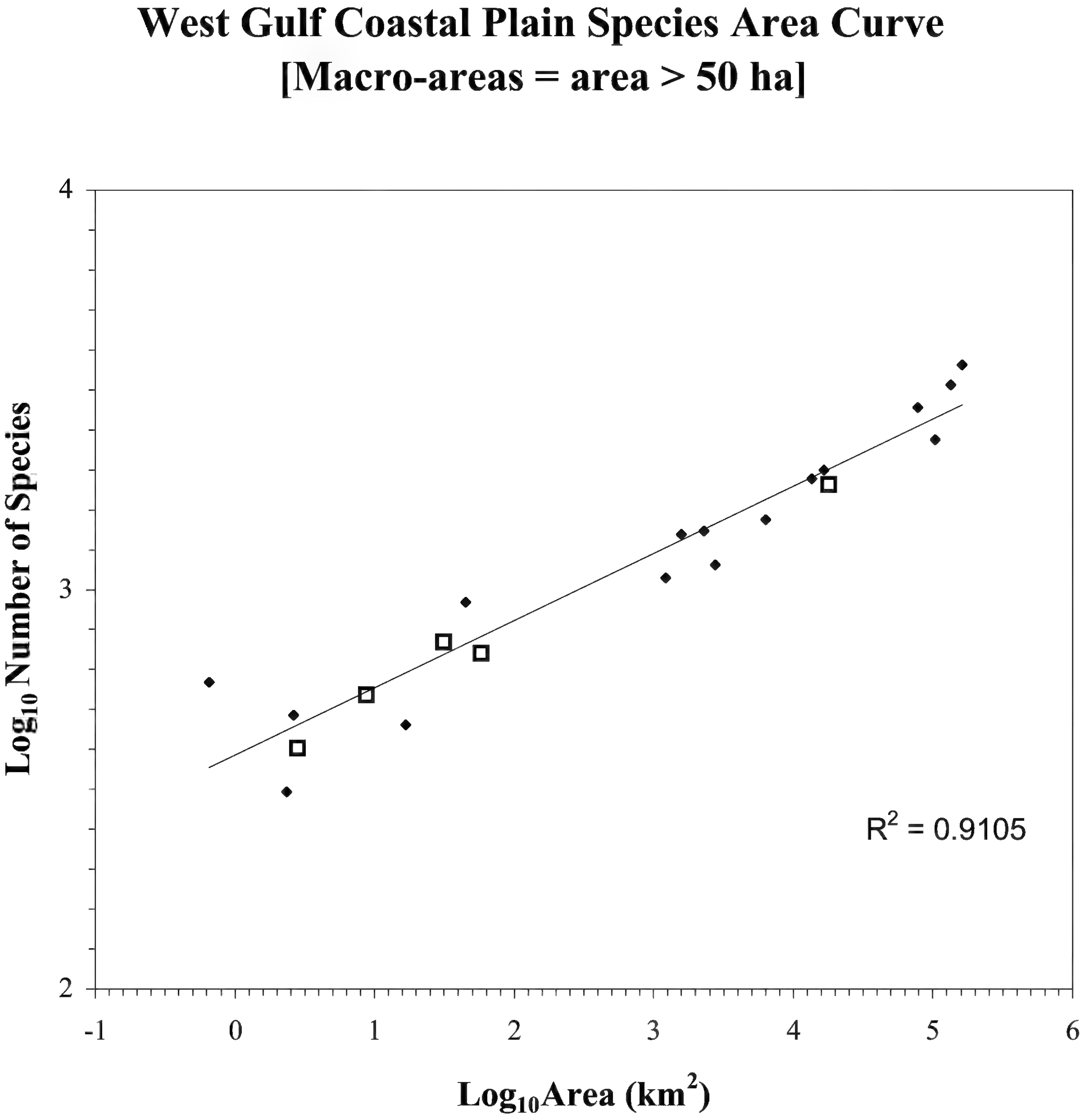

FIG. 3. West Gulf Coastal Plain species/area curve (Macro-areas = area > 50 ha). Open boxes are Big Thicket sites.

taxa. Located on the curve in Figure 3, the Big Thicket is therefore average. At micro-scale levels, although the data are scanty, the Big Thicket is typical: two 3.0 ha wetland pine savannas had 106 and 117 taxa, and four 0.0001 ha wetland pine savanna plots had 19, 20, 21, and 24 taxa (Fig. 2). At intermediate macro-scale levels: 2.84 sq km, 8.81 sq km, 31.5 sq km, and 58.1 sq km, the Big Thicket also appears to be unexceptional with 401, 544, 738, and 693 taxa respectively (Matos & Rudolph 1985; MacRoberts & MacRoberts 1998a; MacRoberts et al. 2002c; Brown et al. 2005, 2006)(Fig. 3).

While the aim of this paper is to develop species richness curves for the West Gulf Coastal Plain, it is almost impossible not to compare our figures with those farther east, since it has been suggested that the West Gulf Coastal Plain may not be as rich as the Atlantic and East Gulf Coastal Plain (Currie & Paquin 1987; Currie 1991). For example, Fort Bragg Military Reservation, North Carolina, consists of 738 sq. km and has an impressive 1206 taxa (Sorrie et al. 2006). Platt (1999) summarized some of the small area plots in frequently burned pine savannas in the Atlantic Coastal Plain: up to 30–40 species in 0.0001 ha plots, 70–90 species in 0.01 ha plots, and 100–150 species in 0.1 ha plots, making these the most species rich sites reported in North America (Walker & Peet 1983; Peet & Allard 1993; Brewer 1998).

However, state and county sized areas appear to be less spectacular: Florida, consisting of 170,305 sq km, has 3834 species of which 31% are exotics (Wunderlin 1998); the Florida panhandle, consisting of 38,628 sq km, has 2359 species of which 16% are exotics (Clewell 1985); Oktibbeh County, Mississippi, consisting of 1185 sq km, has 1148 species of which 15% are exotics (Leidolf et al. 2002); and Pike County, Alabama, consisting of 1759 sq km, has 1190 species of which 20% are exotics (Diamond 2003). Comparable areas in the West Gulf Coastal Plain appear to be as species rich. For example, east Texas, consisting of 162,134 sq km, has 3660 taxa (3402 species) of which 18% are exotic (Diggs et al. 2006); the Gus Engeling Wildlife Management Area in Anderson County, Texas, consisting of 45 sq km, has an impressive 930 taxa (Singhurst et al. 2003); the Walter B. Jacobs Memorial Nature Park, Caddo Parish, Louisiana, consisting of 65 ha, has a staggering 587 taxa (Thomas et al. in prep.); and Caddo Parish, Louisiana, consisting of 2,284 sq km, has an impressive 1405 species of which 17% are exotic (MacRoberts & MacRoberts 2006). At the micro-scale level, bogs, xeric sandylands, and upland longleaf pine savannas in the West Gulf Coastal Plain, while not reaching the higher numbers reported east of the Mississippi River, have been reported with up to 28 species in 0.0001 ha plots, 46 in 0.001 ha plots, and 113 in 0.1 ha plots (MacRoberts & MacRoberts 1993b, 2004c; MacRoberts et al. 2002b; Philipps et al. in prep).

These are preliminary comparisons. This paper is a first approximation at a West Gulf Coastal Plain species-area curve. It is based on a wide variety of sources, most of which were not prepared for the purpose of measuring species richness. Additionally, the data are relatively few. More information is needed on both micro- and macro-scale areas. Undoubtedly, further research, notably in frequently burned West Gulf Coastal Plain open habitats such as bogs, pine savannas, upland longleaf forest/savanna, xeric sandylands, and prairies, will alter these curves and make species-richness comparisons truly possible within the Gulf Coastal Plain and between the Gulf Coastal Plain and areas to the east, north, and west.

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We thank James H. Peck and Stephen P. McLaughlin for their helpful reviews.

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BOOK NOTICES

Elizabeth L. Horn. 1994. **Coastal Wildflowers of the Pacific Northwest.** (ISBN 0-87842-291-9, pbk.). Mountain Press Publishing Company, P.O. Box 2399, Missoula, MT 59806, U.S.A. (**Orders:** www.mountain-press.com, info@mtnpress.com, 406-728-1900, 406-728-1635 fax, 1-800-234-5308). $14.00, 179 pp., color photos, 1 map, 5½" × 8½".

This handy volume includes 164 species of the most common herbs and shrubs (no grasses, sedges, etc.) along the coast from Mendocino, California, to the northern tip of Vancouver Island, British Columbia, illustrated by 200 photos. The photos are grouped by family within each of five designated habitats—beaches and dunes; wetlands; cliffs and grasslands; brushlands; coastal forests. The text includes notes on ethnobotanical uses and personal observations on natural history. It's a nicely done, low-priced guide, the fourth printing (2002) of this 1993 volume, obviously continuing to be useful for students and visitors to the Pacific coast.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

Ronald J. Taylor and George W. Douglas. 1995. **Mountain Plants of the Pacific Northwest.** (ISBN 0-87842-314-1, pbk). Mountain Press Publishing Company, PO Box 2399, Missoula, MT 59806, U.S.A. (**Orders:** www.mountain-press.com, info@mtnpress.com, 406-728-1900, 406-728-1635 fax, 1-800-234-5308). $25.00, color photos, b/w line drawings, 6" × 9".

A field guide to Washington, western British Columbia, and southeastern Alaska, covering more than 450 species of "wildflowers, ferns, trees, and grasses." Subsequently published field guides for roughly the same region have covered many more species (Plants of Western Oregon, Washington & British Columbia -Kozloff 2005, 2500 species; Wildflowers of the Pacific Northwest -Turner & Gustafson 2006, 1200 species; see reviews in Sida 22(1); Plants of the Pacific Northwest Coast, Pojar & MacKinnon 2005, 794 species), but the coverage of the Taylor & Douglas book is excellent and representative, and the large, beautiful, and informative photos of Ron Taylor are worth having on any account.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

California Coastal Commission. 2005. **Experience the California Coast: A Guide to Beaches and Parks in Northern California.** (ISBN 0-520-24540-7, pbk). University of California Press, 2120 Berkeley Way, Berkeley, CA 94704-1012, U.S.A. (**Orders:** www.ucpress.edu, 1-800-777-4726, 1-800-999-1958 fax). $24.95, 320 pp., 315 color illustrations, 9 b/w photos, 1 line illustration, 47 maps, 6" × 9".

Excellent maps and photos for natural areas in Del Norte, Humboldt, Mendocino, Sonoma, and Marin counties. With this detailed guide and one of the excellent, recently published field guides to flowering plants, botanists studying northwestern California plants are set to go.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

Kristin Huisinga, Lori Makarick, Kate Watters. 2006. **River and Desert Plants of the Grand Canyon.** (ISBN 0-87842-523-3, pbk.). Mountain Press Publishing Company, P.O. Box 2399, Missoula, MT 59806, U.S.A. (**Orders:** www.mountain-press.com, info@mtnpress.com, 1-800-234-5308, 406-728-1900, 406-728-1635 fax). $22.00, 276 pp., 263 color photos, 80 line drawings, 5 color figures and maps, 6" × 9".

More than 300 low elevation species are illustrated by 310 excellent color photos and 92 line drawings. The species are arranged by family and genus within each of four categories: Ferns & fern allies, Grasses & grass-like plants, Trees, and Shrubs & forbs. Comments on natural history accompany each illustration. A brief introduction to Grand Canyon Ecology is up front, and a novel thumbnail ID guide is helpful: each of 5 pages shows 25 species, arranged by flower color. This is a great book, probably to become a huge seller, because it will be useful and accessible to students, naturalists at all levels, and even tangential tourists.

Asteraceae taxonomy is difficult: "*Cirsium mexicanum*" on p. 198 is *Carduus nutans*; "*Pseudognaphalium stramineum*" on p. 217 is *Pseudognaphalium luteoalbum*.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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DISTRIBUTION OF HANGING GARDEN VEGETATION ASSOCIATIONS ON THE COLORADO PLATEAU, USA

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ABSTRACT

Hanging gardens are island-like habitats dominated by mesophytic-hydrophytic plant communities, growing on seeps on the xeric canyon walls of the Colorado Plateau in the American West. We measured the abundance of species and physical microhabitat characteristics of 73 individual hanging gardens during the growing seasons of 1991–1993. Cluster analysis of a simplified Morisita community similarity index matrix produced four distinct clusters of herbaceous vegetation: *Adiantum capillus-veneris, Aquilegia micrantha, Calamagrostis scopulorum,* and *Cirsium rydbergii* Herbaceous Associations. These associations are based on species abundance and are floristically described via summary tables showing dominance, constancy, and presence of hanging-garden endemic species. Univariate comparisons of species richness, hanging garden size, and dominance show that the *A. capillus-veneris* and *A. micrantha* associations tend to be smaller, less species rich, and have higher dominance values than the *C. scopulorum* and *C. rydbergii* asssociations. Two associations were dominated by species endemic to hanging gardens: *Aquilegia micrantha* and *Cirsium rydbergii*. These four hanging garden associations contrast with previous local vegetation surveys which place all hanging garden communities into one vegetation type despite the lack of a common dominant or constant species.

RESUMEN

Los jardines colgantes son hábitats como islas dominados por comunidades de plantas mesófitas-hidrófitas, que crecen en las filtraciones de las paredes secas de los cañones de la Meseta de Colorado en el oeste de los Estados Unidos. Medimos la abundancia de especies y características físicas del microhábitat de 73 jardines colgantes individuales durante las épocas de crecimiento de 1991–1993. El cluster análisis de una matriz simplificada del índice de similitud de la comunidad de Morisita produjo cuatro grupos distintos de vegetación herbácea asociada: *Adiantum Capillus-veneris, Aquilegia micrantha, Calamagrostis scopulorum*, y *Cirsium rydbergii*. Estas asociaciones se basan en la abundancia de las especies y son descritos florísticamente en una tabla que muestra la dominancia, la constancia, y la presencia de las especies endémicas en los jardines colgantes. Las comparaciones univariantes de la riqueza de especies, el tamaño del jardín colgante y su dominancia muestran que las asociaciones de *A. capillus-veneris* y de *A. micrantha* tienden ser más pequeñas, menos ricas en especies, y tienen valores más altos en la dominancia que las asociaciones de *Calamagrostis scopulorum* y de *Cirsium rydbergii*. Dos asociaciones están dominadas por especies endémicas de los jardines colgantes: *Aquilegia micrantha* y *Cirsium rydbergii*. Estas cuatro asociaciones de jardines colgantes contrastan con los estudios locales previos de vegetación que colocan todas comunidades del jardines colgantes en un solo tipo de vegetación a pesar de la falta de una especie común, dominante o constante.

The lush plant growth of hanging gardens on canyon walls in the entrenched drainage system of the Colorado Plateau attracted the attention of early botanists and pioneers (Welsh & Toft 1981). Powell (1895), the first scientific explorer of the Colorado River canyon, noted the "oak glens," ferns and mosses on moistened sandstone, and rich vegetation associated with seeps "in marked contrast to the general appearance of naked rock" within what is now Glen Canyon NRA (Fig. 1). Many subsequent visitors have noted the island-like boundary between hanging gardens and their xeric canyon-wall surroundings (Woodbury 1933; Malanson & Kay 1980; Welsh 1989). The microclimate of the larger hanging gardens often contrasts sharply with the surrounding high desert: water is abundant, soils are moist, and canyon walls offer periodic shade (Malanson 1980; Welsh & Toft 1981). Hanging gardens are also relatively small, mostly less than one hectare, further contributing to the island-like effect, visually similar to the inselberg (granitic and gneissic rock outcrop) communities found in North and South America, Africa, and Australia (Barthlott & Porembski 2000). However, in contrast to the much better studied inselberg systems (Groger & Barthlett 1996; Porembski et

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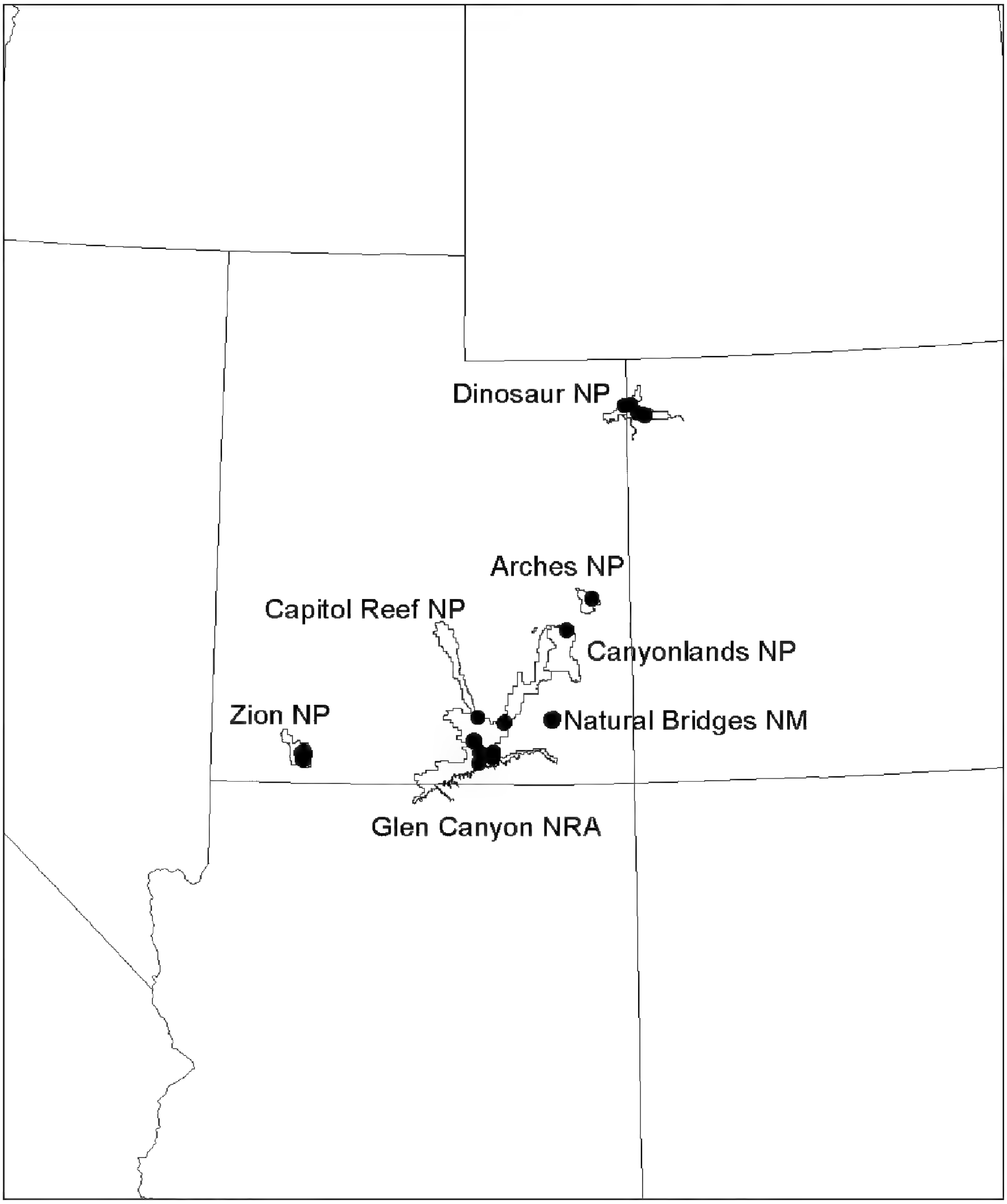

Fig. 1. Study areas and locations of hanging garden plant communities sampled on the Colorado Plateau during the summers of 1991–1993.

al. 1996; Sarthou & Villers 1998), hanging gardens are moist vegetation islands rather than xeric vegetation islands (Szarzynski 2000) embedded within bedrock expanses.

Hanging gardens are dominated by mesophytic and hydrophytic herbaceous vegetation (Malanson 1980; Welsh & Toft 1981; Welsh 1989) which develops at and downslope from ground-water seepage zones within the exposed aquifer along crossbedded sandstone canyon walls. Ground-water "sapping" erosion processes (Higgins 1984; Laity & Malin 1985; Baker 1990; Dunne 1990; May et al. 1995) produce the physical hanging garden habitat: perennially wet rock walls and/or wet, subirrigated colluvial soils (May et al. 1995). They are often located in wet theater-headed valleys formed "by weakening or removal of basal support as a result of enhanced weathering and erosion" by water seepage (Laity & Malin 1985, p. 203). These diffuse-discharge, seepage erosion areas are the result of ground water moving through highly transmissive aquifers, down the dip planes to where impermeable layers within or below an aquifer intersect a canyon wall, as well as along deep fractures within the aquifer (Laity & Malin 1985; Dunne 1990; May et al. 1995), and are distinctly different from point-source erosion processes caused by discharge at springs (Higgins 1984). Ground-water sapping processes provide both the raw material for colluvial soil development and water for subirrigation of vegetation growing on that habitat.

Floristic work has elucidated the flora associated with hanging garden habitats (Eastwood, 1896; Clover & Jotter 1944; Harrison et al. 1964; Welsh & Moore 1968; Welsh 1986a, b; Shultz et al. 1987; Welsh 1989), including several species endemic to hanging gardens (Harrison et al. 1964; Welsh 1989; Fowler et al. 1995; Welsh et al. 2003). Microhabitat affinities for several hanging garden plant species have also been described (Welsh & Toft 1981; Welsh 1989).

Woodbury (1933), Welsh and Toft (1981), and May et al. (1995) have proposed hanging garden classification systems based on microhabitats and geomorphology. Woodbury (1933) briefly described hanging garden seral associes in Zion NP as part of a park-wide vegetation classification monograph. Malanson (1980, 1982) and Malanson and Kay (1980) measured frequency of species occurrence, species richness, and calculated similarity indices to investigate the effects of flooding frequency, dispersal distance, plant dispersal types, and physical habitat characteristics on species assemblages in 29 small hanging gardens in Zion NP. These studies did not measure species abundance or take a phytosociological approach. In this study, we measured canopy coverage for each vascular plant species on 73 hanging gardens in a regional study, classified them into herbaceous associations, and examined the regional distribution of those associations.

STUDY AREA

The study area was located on the Colorado Plateau in Utah and Colorado (Fig. 1), a major portion of the known geographic range of hanging gardens. Field work was conducted on hanging gardens at seven National Park Service units during the summers of 1991–1993: Arches NP, Canyonlands NP, Capitol Reef NP, Dinosaur NP, Glen Canyon NRA, Natural Bridges NM, and Zion NP (Fig. 1). We selected most of the larger, known hanging gardens in each park unit and many smaller ones that we were able to locate. Hanging gardens that were too small to use the vegetation sampling methods described below were excluded from this study.

METHODS

We defined hanging garden habitats as predominately herbaceous vegetation growing on permanently wet soil and wet rock surfaces, originating from seeps on canyon walls in sandstone aquifers (Malanson & Kay 1980). Hanging gardens were delineated from the surrounding bedrock and xeric soils by the presence of wet rock surfaces and/or wet soils (May et al. 1995). The hanging garden boundary with a riparian community, when present, was defined by where colluvial soils stop and alluvial soils begin (May et al. 1995).

Each hanging garden was visually separated into the following microhabitats: seepline, wet wall, ledge, and wet colluvial soil to stratify vegetation sampling. Seeplines are drier, linear microhabitats that develop at fractures in the sandstone or, more often, at horizontal impervious bedding planes on canyon walls and at the back of small alcoves. Wet walls included inverted, vertical, or sloping rock surfaces below seeps that moisten the sandstone surface or have sufficient discharge to produce thin sheet flows of water with occasional drip points. Ledge microhabitats are of sufficient horizontal width to support strips of hydrophytic vegetation in depressions with wet, saturated soil. Wet colluvial soil microhabitats are complex in shape and composed of wet, subirrigated colluvial soils located downslope of seepage zones, sometimes within and/or below a larger alcove created by groundwater sapping. Since these soils develop directly from the weathering of sandstone, they are obviously very sandy and may be virtually saturated near seeps.

We collected data on the following physical parameters: length of major axis, aspect, elevation, map location, and geologic formation. Hanging garden size was calculated from major axis length and the mean of ten equally spaced widths taken during vegetation sampling.

Vegetation

On each hanging garden, the herbaceous, vascular plant vegetation stratum was systematically sampled (Cochran 1977; Krebs 1989) using 20 × 50 cm quadrats and six cover classes to estimate canopy cover for each species (Daubenmire 1959) in each microhabitat. Woody plants less than two m tall were included in the herbaceous stratum canopy estimates; the few occurrences of isolated trees were not included. The major axis of each microhabitat was divided into ten equal segments. Widths were measured beginning with a random starting point along the initial segment and at subsequent equal-segment lengths. A random point was chosen along each width to determine placement of the lower left corner of the sampling frame (20 cm side). Edge quadrats were proportionally weighted to include only the portion within the hanging garden. Total floristic composition (Daubenmire 1959, 1961), vascular plants only, was recorded during canopy cover sampling and during an additional visual search (approximately one hr) on each hanging garden. Voucher specimens for each species were collected. These were identified by B. E. Nelson, Herbarium Manager and R. L. Hartman, Curator of the Rocky Mountain Herbarium at the University of Wyoming and are deposited there and at the respective parks. Vascular plant nomenclature follows Flora of North America Editorial Committee (1993+) and Welsh et al. (2003) in that order of priority.

Floristics of each herbaceous association are described in summary stand tables by floristic criteria (Meuller-Dombois & Ellenberg 2002) and follow the definitions and analysis techniques of the U. S. National Vegetation Classification (ESA 2006). Diagnostic classes for this study were dominance determined by absolute canopy cover (Daubenmire 1959), constancy (frequency of occurrence)(Daubenmire 1952; Meuller-Dombois & Ellenberg 2002), and endemism.

Indices

Plant community diversity (heterogeneity) was measured as two separate components (Krebs 1989): species richness (McIntosh 1967) and dominance. Dominance in a community was determined by the proportion $d = N_{Max}/N_T$ (Berger & Parker 1970) where N_{Max} = number of individuals in the most abundant population and N_T = the total number of individuals in the community. Canopy coverage estimates were used as N_{Max}/N_T since both are proportional measures of species community importance.

Classification of hanging garden vegetation was based on cluster analysis of simplified Morisita (Horn 1966) community similarity indices for 73 hanging gardens calculated from species-level canopy coverage estimates of existing vegetation. An exception is the genus *Carex*. Our canopy coverage estimates for six species in this genus were combined since consistent, vegetative separation of species was not possible. These indices were placed in a community similarity matrix for cluster analysis in SYSTAT 9 (SYSTAT 1999a) using the complete linkage method (farthest neighbor) on maximum Euclidean distances between indices.

Statistics

Statistical analyses were performed with SYSTAT 9 (1999a). Plant species richness, species dominance, and hanging garden size data were analyzed by General Linear Model ANOVA. Dominance and hanging garden size were log transformed (SYSTAT 1999b) to achieve normal distributions prior to ANOVA tests. Homogeneity of variances was checked post hoc and Tukey HSD tests were used for pairwise comparisons of ANOVA results to detect significant differences between vegetation associations.

The statistical association between geologic formation and the putative herbaceous associations was described using the Pearson Chi-square goodness-of-fit test to detect the presence of an association (Loether & McTavish 1976; Wilkinson et al. 1996), and a proportional reduction in error measure (PRE), Goodman-Kruskal's lambda, to measure the strength of statistical association (Wilkinson et al. 1996). PRE statistics describe how much error is reduced in predicting the column variable when the row variable is known for association tables (Wilkinson et al. 1996).

RESULTS

Vegetation Classification

Species lists with abundance estimates for species are in Appendix I. Cluster analysis of the simplified

Morisita community similarity index (Krebs 1989) matrix classified the 73 hanging garden vascular plant communities into four associations plus one dissimilar cluster (Fig. 2): *Adiantum capillus-veneris, Aquilegia micrantha, Calamagrostis scopulorum,* and *Cirsium rybergii* Herbaceous Associations. Euclidian distance classification thresholds (Fig. 2) ranged from 1.03 for separating the *Cirsium rydbergii* Herbaceous Association from the dissimilar group to 1.31 for separating the *C. rydbergii* and the *Adiantum capillus-veneris* Herbaceous Associations. The dissimilar cluster (n=11) had hanging garden communities with little similarity within the cluster (mean similarity index of 0.069) and had no plant species consistently in common.

The distribution of the four herbaceous associations across the seven geologic formations was different than expected by chance alone (p=0.0098), the lambda statistic indicating a 25% improvement in being able to predict the herbaceous association when the geologic formation is known (Table 1). The *A. micrantha* and *C. scopulorum* Herbaceous Associations were widespread on the Colorado Plateau (Table 1). Both were found in five parks and five sandstone geologic formations, differing in only one park and one geologic formation; the *C. scopulorum* Herbaceous Association was found on the Humbug formation omitted from Table 1. The *C. rydbergii* Herbaceous Association was found only in the central part of the Colorado Plateau: two parks and three formations (Table 1). The *A. capillus-veneris* Herbaceous Association was found on the same geologic formation as the *C. rydbergii* Herbaceous Association but was more widespread (Table 1). The *A. capillus-veneris* and *C. rydbergii* Herbaceous Associations were notably absent from the Cedar Mesa and Weber formations, which were found only in our Natural Bridges NM and Dinosaur NP study sites respectively. However, there were significant, positive statistical associations between geologic formations and herbaceous associations (Table 1). The strongest ones being between the *A. micrantha* Herbaceous Association and the Weber formation and between the *C. rydbergii* Herbaceous Association and the Navajo formation.

***Adiantum capillus-veneris* Herbaceous Association**

Floristics of the *Adiantum capillus-veneris* Herbaceous Association are defined in Table 2. The dominant species in this association was *Adiantum capillus-veneris* which covered from 32–93% of the herbaceous canopy in the 11 hanging gardens classified here (Fig. 2). Pairwise simplified Morisita community similarity indices ranged from 0.48 to 0. 99. Both *A. capillus-veneris* and *Epipactis gigantea* had high constancy. *Adiantum capillus-veneris* was found in seepline and wet wall microhabitats, whereas *E. gigantea* was found in seepline microhabitats and on the upper portion of wet soil microhabitats next to vertical canyon walls with wetter seeplines. *Epipactis gigantea* and the Genus *Carex* also had high canopy cover on some hanging gardens. The vegetation was dominated by ferns, forbs, and graminoids (Table 2), but woody plants were occasionally present as isolated individuals or at the drier edges of the wet soil/rock habitats characteristic of hanging gardens.

Species diversity was relatively low in this association as shown by high dominance values, a measure of community evenness, as well as low species richness (Table 3). Dominance values were significantly higher than in *Calamagrostis scopulorum* and *Cirsium rydbergii* Herbaceous Associations (ANOVA F = 5.02, p = 0.0036; Tukey HSD p = 0.0167 and 0.044 respectively). Five species endemic to hanging gardens were found in this association (Table 2). The overall size of hanging gardens with this association was comparatively small (Table 3), significantly smaller than hanging gardens in the *Cirsium rybergii* and *Calamagrostis scopulorum* Herbaceous Associations (see below) (ANOVA F = 7.21, p = 0.0003; Tukey HSD p = 0.0003 and 0.0266 respectively).

***Aquilegia micrantha* Herbaceous Association**

The *Aquilegia micrantha* Herbaceous Association was dominated by the hanging garden endemic *A. micrantha*, a constant species with an average canopy cover of 29% (Table 4). *Aquilegia micrantha* predominately grew on wet colluvial soil microhabits. *Calamgrostis scopulorum* was also a constant species in this herbaceous association, but with less than 5% average cover. Pairwise simplified Morisita community similarity indices ranged from 0.28 to 1.00 for this association. With the exception of small *Pinus edulis* plants, which occurred in trace amounts of cover on 47% of these hanging gardens, woody plants rarely occurred (Table 4).

In addition to *A. micrantha*, four other hanging garden endemic species were found on these sites, but

Table 1. Percentage of hanging garden vegetation associations found on each of five geologic formations (row percentages). Pearson Chi Square ($X^2 = 34.8798$, $p = 0.0098$) and Goodman-Kruskal's lambda ($\lambda = 0.2564$ PRE) statistics indicate the existence and strength of statistical association respectively. Positive "+" and negative "-" indicate the statistical association between a geologic formation and a vegetation association. Cell Chi Square contributions are shown below cell percentages for each row followed by two letter park codes (shown in Fig. 2) to indicate geographic distribution. Observed geologic formations are Jurassic Entrada sandstone, Jurassic Navajo sandstone, Jurassic Navajo sandstone/Jurassic Kayenta formation contact zone, Permian Cedar Mesa sandstone, Pennsylvanian-Permian Weber sandstone. Vegetation associations are Adca, *Adiantum capillus-veneris*; Aqmi, *Aquilegia micrantha*; Casc, *Calamagrostis scopulorum*; Ciry, *Cirsium rydbergii*. N = 60, note that 2 geologic formations with only 1 hanging garden each were omitted from this table.

		Herbaceous Vegetation Association		
Geologic Formation	**Adca**	**Aqmi**	**Casc**	**Ciry**
	n = 11	n = 17	n = 19	n = 11
Entrada	29%	43%	0% -	29%
n = 7	0.4002	0.5211	2.4500	0.4002
	AR	AR	AR	
Navajo	35% +	6% -	18%	41% +
n = 17	2.6675	3.0243	1.4626	4.8386
	CR, GC, ZI	GC	GC, ZI	GC
Navajo/Kayenta	18%	18%	53%	12%
n = 17	0.0044	0.6852	1.5634	0.4001
	GC, ZI	CL, GC	CL, ZI	GC
Cedar Mesa	0%	50%	50%	0%
n = 8	1.4667	1.3255	0.5143	1.4667
		NB	NB	
Weber	0%	67% +	33%	0%
n = 9	1.6500	4.6676	0.0071	1.6500
		DI	DI	

at lower constancy (Table 4). This association was significantly less species rich than the *C. scopulorum* and *C. rydbergii* Herbaceous Associations (see below) (ANOVA F = 3.79, p = 0.015; Tukey HSD p = 0.0248 and 0.0372 respectively). Dominance values averaged 0.59, not significantly different than the other three associations (Table 3). Hanging gardens in this association were also significantly smaller in average size than hanging gardens classified in the *C. rydbergii* association (see below)(ANOVA F = 7.21, p = 0.0003; Tukey HSD p = 0.0009, Table 3).

***Calamagrostis scopulorum* Herbaceous Association**

Floristics of the *Calamagrostis scopulorum* Herbaceous Association are defined in Table 5. As the dominant species, *C. scopulorum* had an average cover of 31% and a range of 13–66% (Table 5). *Calamagrostis scopulorum* grew in larger clumps on wet colluvial soil microhabitats and as smaller patches on seepline and wet wall microhabitats. Several *Carex* species also occurred in these hanging gardens (Table 5). The hanging garden endemic *A. micrantha* was moderately constant and ranged up to 11% total cover. Simplified Moristia community similarity indices ranged from 0.27 to 0.99 among the 23 hanging gardens classified into this association.

Species diversity in this association was relatively high as shown by high species richness and low dominance (Table 3). This association was significantly richer than the *A. micrantha* Herbaceous Association (ANOVA F = 3.79, p = 0.0003; Tukey HSD p = 0.0248), and its dominance values were significantly lower than the *A. capillus-veneris* Herbaceous Association (ANOVA F = 5.02, p = 0.0036; Tukey HSD p = 0.0167). Three hanging garden endemic taxa were found on the 23 hanging gardens classified in this association (Table 5). The *C. scopulorum* Herbaceous Association tended to contain large hanging gardens (Table 3), significantly larger than hanging gardens in the *A. capillus-veneris* Herbaceous Association (ANOVA F = 7.21, p = 0.0003; Tukey HSD p = 0.027).

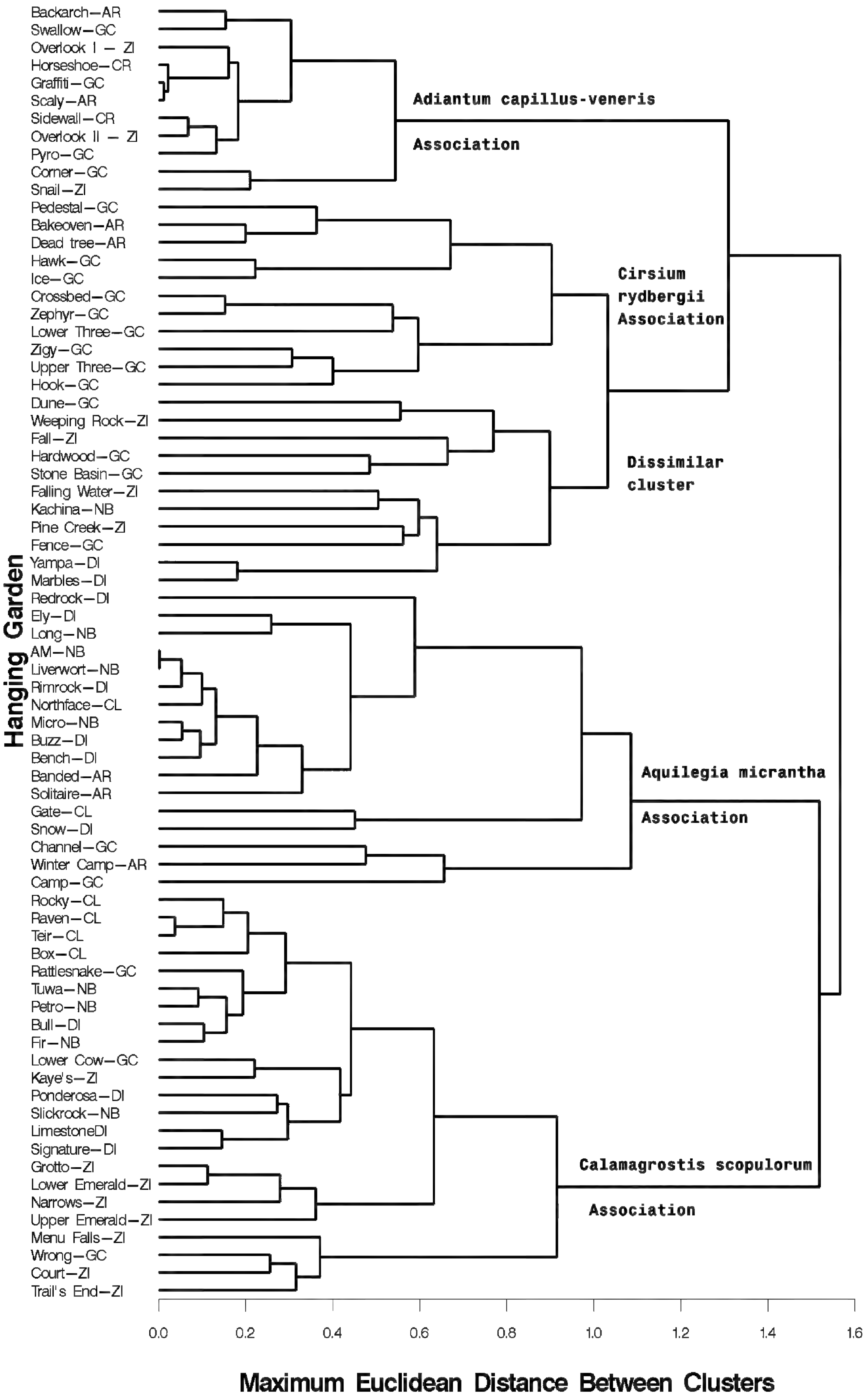

Fig. 2. Cluster tree showing four hanging garden herbaceous vegetation associations and a dissimilar cluster based on cluster analysis of simplified Moristia community similarity indices. Names refer to 73 individual hanging garden plant communities. Two letter codes following hanging garden names refer to individual parks: AR = Arches (NP); CL = Canyonlands (NP); GC = Glen Canyon (NRA); ZI = Zion (NP); CR = Capitol Reef (NP); NB = Natural Bridges (NM); DI = Dinosaur (NP).

Table 2. Stand table for the *Adiantum capillus-veneris* Herbaceous Association showing canopy cover, diagnostic classes, and constancy for all species with a constancy ≥0.40 and/or species endemic to hanging gardens. Constant species are defined as constancy ≥0.60, and "t" is defined as less than 0.5 % canopy cover. N = 11.

Species	Diagnostic class	Constancy	Average % cover	Minimum % cover	Maximum % cover
Adiantum capillus-veneris	dominant, constant	1.00	57	32	93
Epipactis gigantea	constant	0.82	2	0	16
Aquilegia micrantha	endemic	0.27	1	0	8
Cirsium rydbergii	endemic	0.36	2	0	8
Mimulus eastwoodiae	endemic	0.55	t	0	2
Primula specuicola	endemic	0.27	t	0	2
Zigadenus vaginatus	endemic	0.09	t	0	t
Carex sp.		0.45	3	0	18
Petrophytum caespitosum		0.45	t	0	2

Table 3. Mean values (± 1 SE) for hanging garden size, species richness, and dominance of four hanging garden herbaceous associations. Also shown are number of sites (N) and number of hanging garden endemic plants species found (HGE) in each association. Values followed by the same letter within each column do not differ at P<0.05 in Tukey's HSD *post hoc* tests.

Hanging garden vegetation association	Size m^2	Species Richness	Dominance	N	HGE
Adiantum capillus-veneris	68±20 ^{a}	14±2 ^{ab}	0.71±0.05 ^{a}	11	5
Aquilegia micrantha	167±45 ^{ab}	12±1 ^{a}	0.59±0.06 ^{ab}	17	5
Calamagrostis scopulorum	314±80 ^{bc}	18±2 ^{b}	0.48±0.04 ^{b}	23	3
Cirsium rydbergii	587±168 ^{c}	18±2 ^{b}	0.41±0.03 ^{b}	11	5

Table 4. Stand table for the *Aquilegia micrantha* Herbaceous Association showing canopy cover, diagnostic classes, and constancy for all species with a constancy ≥0.40 and/or species endemic to hanging gardens. Constant species are defined as constancy ≥0.60, and "t" is defined as less than 0.5 % canopy cover. N = 17.

Species	Diagnostic class	Constancy	Average % cover	Minimum % cover	Maximum % cover
Aquilegia micrantha	dominant, constant, endemic	1.00	29	9	54
Calamagrostis scopulorum	Constant	0.82	4	0	32
Cirsium rydbergii	Endemic	0.24	1	0	8
Mimulus eastwoodiae	Endemic	0.35	1	0	11
Primula specuicola	Endemic	0.24	t	0	2
Zigadenus vaginatus	Endemic	0.35	2	0	19
Carex sp.		0.41	2	0	10
Pinus edulis		0.47	t	0	t

Cirsium rydbergii Herbaceous Association

The hanging garden endemic *Cirsium rydbergii* dominated this association with an average of 23% canopy coverage (Table 6). These hanging gardens also had nine additional constant species (Table 6). Two of these were co-dominants, *A. capillus-veneris* and *Schyzacharium scoparium*, and three were endemic to hanging garden habitats: *A. micrantha* , *Mimulus eastwoodiae*, and *Primula specuicola*. One additional hanging garden endemic species was also found at low constancy in these hanging gardens: *Zigadenus vaginatus*. *Cirsium rydbergii* and *A. micrantha* were found throughout the wet colluvial soil microhabitat and *Z. vaginatus* was often

TABLE 5. Stand table for the *Calamagrostis scopulorum* Herbaceous Association showing canopy cover, diagnostic classes, and constancy for all species with a constancy ≥0.40 and/or species endemic to hanging gardens. Constant species are defined as constancy ≥0.60, and "t" is defined as less than 0.5 % canopy cover. N = 23.

	Diagnostic class	**Constancy**	**Average % cover**	**Minimum % cover**	**Maximum % cover**
Calamagrostis scopulorum	dominant	1.00	31	13	66
Carex sp.	constant	0.65	3	0	20
Aquilegia micrantha	endemic	0.43	2	0	11
Zigadenus vaginatus	endemic	0.22	1	0	14
Mimulus eastwoodiae	endemic	0.22	t	0	t
Adiantum capillus-veneris		0.57	4	0	30
Epipactis gigantea		0.48	1	0	16
Maianthemum stellatum		0.57	3	0	20
Toxicodendron rydbergii		0.48	t	0	11

TABLE 6. Stand table for the *Cirsium rydbergii* Herbaceous Association showing canopy cover, diagnostic classes, and constancy for all species with a constancy ≥0.40 and/or species endemic to hanging gardens. Constant species are defined as constancy ≥0.60, and "t" is defined as less than 0.5 % canopy cover. N = 11.

Species	**Diagnostic class**	**Constancy**	**Average % cover**	**Minimum % cover**	**Maximum % cover**
Cirsium rydbergii	dominant, constant, endemic	1.00	23	1	48
Adiantum capillus-veneris	co-dominant, constant	0.91	10	0	23
Schizachyrium scoparium	co-dominant, constant	0.64	15	0	50
Carex sp.	constant	0.91	7	0	19
Aquilegia micrantha	constant, endemic	0.82	3	0	14
Primula specuicola	constant, endemic	0.91	1	0	3
Mimulus eastwoodiae	constant, endemic	0.64	3	0	8
Calamagrostis scopulorum	constant	0.64	2	0	13
Petrophytum caespitosum	constant	0.64	2	0	12
Epipactis gigantea	constant	0.73	1	0	5
Zigadenus vaginatus	endemic	0.27	1	0	13
Castilleja linearifolia		0.45	t	0	2
Dichanthelium acuminatum		0.55	4	0	26

found in the upper portions of the wet colluvial soil microhabitat next to canyon walls. *Mimulus eastwoodiae* and *P. specuicola* were often attached directly to vertical or inverted, wet rock surfaces. Simplified Morisita community similarity indices ranged from 0.06 to 0.90 among the 11 hanging gardens in this association.

Species richness was relatively high (Table 3), significantly higher than in the *A. micrantha* Herbaceous Association (ANOVA F = 3.79 p = 0.015; Tukey HSD p = 0.0372. Dominance values were low (Table 3), significantly lower than in the *A. capillus-veneris* Herbaceous Association (ANOVA F = 5.02, p = 0.0036, Tukey HSD p = 0.0044). Similar to the *C. scopulorum* Herbaceous Association, this association occurred on large hanging gardens; the average size was significantly larger than in the *A. capillis-veneris* and *A. micrantha* Herbaceous Associations (ANOVA F = 7.21, p = 0.0003; Tukey HSD p = 0.0003 and 0.0009 respectively).

DISCUSSION

The *A. capillus-veneris* and *A. micrantha* Herbaceous Associations tend to grow on smaller hanging gardens that are less diverse; i.e., have low species richness and high dominance values (Table 3). The *A. capillus-veneris* Herbaceous Association is dominated by relatively dry seepline microhabitats and by rhizomatous stands of *A. capillus-veneris* which grow on and near narrow seeplines formed in the Navajo sandstone. The *A. micrantha* association is dominated by *A. micrantha* which grows on the less wet colluvial soil microhabitats, especially on Cedar Mesa and Weber sandstone formations. Note that these two geologic formations and the Entrada formation were found in only one park each and thus also act as surrogates for geography. In contrast, the hanging gardens with *C. scopulorum* and *C. rydbergii* Herbaceous Associations tended to be larger and, by implication, wetter: i.e., large wet colluvial soil microhabitats. They also tend to be more diverse: i.e., more species rich and low species dominance (Table 3).

The dissimilar cluster (Fig. 2) may represent a collection of unique plant communities which are not part of any herbaceous association. Alternatively, with further sampling on the Colorado Plateau, we may find that some of the hanging gardens within this cluster do represent undiscovered herbaceous associations. Further research is needed.

Neither Tuhy and MacMahon (1988) nor Romme et al. (1993) attempted to classify the vegetation of individual hanging gardens but rather placed all hanging gardens into one vegetation type. We found no species that all hanging gardens had in common (much less a common dominant) which precludes a single hanging garden herbaceous association. The alliance name on NatureServe (2006), Aquilegia micrantha saturated hanging garden herbaceous vegetation, would obviously work for the *A. micrantha* Herbaceous Association but not for the remaining three associations since neither *A. micrantha* nor any other species was constant or dominant across all four associations described in this paper (Tables 2, 4, 5, 6). Four separate alliances would seem to be necessary in spite of a common distinct habitat.

NatureServe (2006) also lists two hanging garden herbaceous associations inside our study area: *A. micrantha - M. eastwoodiae* and *A. micrantha - C. scopulorum* Herbaceous Vegetation, each association being named for its dominant species. *Aquilegia micrantha* and *C. scopulorum* are shown as characteristic species for both associations, but no data are shown for canopy coverage or constancy. In addition, no publications are cited that have this type of data and the link to VegBank (2006) indicates that no plot-observations are available, precluding further comparison. Woodbury's (1933) *fern-columbine* associes in Zion NP hanging gardens is habitat-based and seems to overlap the *A. capillus-veneris* and *C. scopulorum* Herbaceous Associations described in this paper.

Outside of Woodbury's (1933) study in Zion NP, there are no previously published studies that describe hanging garden associations. Most inselberg studies also classify vegetation by habitat (e.g., Burbanck & Platt 1964), but we found one with a phytosociological focus. Sarthou and Villiers (1998) conducted a regional vegetation study on three inselbergs in French Giana using relevé quadrats and tabular analysis. In spite of different techniques, their results were comparable to our study. They found six vegetation associations versus our four, and they found two French Gianan inselberg endemics versus our five hanging garden endemics. More interestingly, their most widespread vegetation association (with three subassociations) was dominated by *Pepinietum geyskesii*, a French Gianan inselberg endemic. In our study, two vegetation associations were dominated by hanging garden endemics: the *A. micrantha* and the *C. rydbergii* Herbaceous Associations (Tables 4 & 6). Both studies illustrate the concept of insular vegetation on continental islands at a regional scale. Our study also looked at the regional distribution of these four herbaceous associations and found that each has a unique distribution on the Colorado Plateau (Table 1).

APPENDIX 1

Vascular plant species lists and species richness (R) for each hanging garden sampled. Canopy coverage estimates (0-100%) are shown to the right of the scientific name for species which fell within community sampling quadrats with T indicating less than 0.5%; no estimates were made for taxa not falling within sampling quadrats: **ARCH** = Arches NP, **CANY** = Canyonlands NP, **CARE** = Capitol Reef NP, **DINO** = Dinosaur NM, **GLCA** = Glen Canyon NRA, **NABR** = Natural Bridges NM, **ZION** = Zion NP.

ARCH Backarch HG R = 24
Anacardiaceae
Toxicodendron rydbergii 7
Asteraceae
Cirsium rydbergii 7
Pseudognaphalium microcephalum T
Heterotheca villosa var. *minor* 1
Solidago velutina subsp. *sparsiflora*
Cyperaceae
Carex aurea 2
Euphorbiaceae
Euphorbia brachycera T

Fabiaceae
Dalea oligophylla 3
Fagaceae
Quercus turbinella T
Liliaceae
Zigadenus vaginatus T
Onagraceae
Oenothera longissima
Orchidaceae
Epipactis gigantea 2
Platantherera zothecina
Poaceae
Elymus canadensis T
Muhlenbergia andina 3
Dichanthelium acuminatum 1
Phragmites australis 2
Schizachyrium scoparium 1
Pteridaceae
Adiantum capillus-veneris 48
Primulaceae
Primula specuicola T
Ranunculaceae
Aquilegia micrantha 9
Rosaceae
Rosa sp.
Scrophulariaceae
Castilleja linariifolia
Mimulus eastwoodiae T

ARCH Bake-oven Wall HG R = 15
Asteraceae
Cirsium rydgbergii 1
Heterotheca villosa var. *minor* 3
Cyperaceae
Carex aurea 4
Euphorbiaceae
Euphorbia brachycera T
Fabaceae
Dalea oligophylla 1
Liliaceae
Zigadenus vaginatus T
Orchidaceae
Epipactis gigantea 3
Poaceae
Dichanthelium acuminatum 7
Schizachyrium scoparium 32
Pteridaceae
Adiantum capillus-veneris 23
Primulaceae
Primula specuicola 2
Ranunculaceae
Aquilegia micrantha 14
Clematis ligusticifolia T

Santalaceae
Comandra umbellata var. *pallida* 3
Scrophulariaceae
Mimulus eastwoodiae T

ARCH Scaly HG R = 8
Anacardiaceae
Rhus aromatica var. *simplicifolia*
Toxicodendron rydbergii 1
Asteraceae
Artemisia ludoviciana var. *ludoviciana*
Cyperaceae
Carex aurea 1
Orchidaceae
Platantherera zothecina T
Poaceae
Dichanthelium acuminatum
Pteridaceae
Adiantum capillus-veneris 72
Scrophulariaceae
Mimulus eastwoodiae 2

ARCH Banded HG R = 6
Pinaceae
Pinus edulis
Poaceae
Dichanthelium acuminatum
Pteridaceae
Adiantum capillus-veneris 6
Primulaceae
Primula specuicola
Ranunculaceae
Aquilegia micrantha 33
Scrophulariaceae
Mimulus eastwoodiae 11

ARCH Winter Camp HG R = 19
Anacardiaceae
Rhus aromatica var. *simplicifolia* T
Asteraceae
Cirsium rydbergii
Heterotheca villosa var. *minor* 16
Solidago velutina subsp. *sparsiflora*
Cyperaceae
Carex aurea 1
Euphorbiaceae
Euphorbia brachycera 2
Liliaceae
Zigadenus vaginatus 7
Oleaceae
Fraxinus anomala

Onagraceae
Oenothera longissima T
Orchidaceae
Epipactis gigantea 15
Poaceae
Dichanthelium acuminatum 1
Phragmites australis 9
Pteridaceae
Adiantum capillus-veneris 19
Pellaea breweri
Primulaceae
Primula specuicola 2
Ranunculaceae
Aquilegia micrantha 29
Santalaceae
Comandra umbellata var. *pallida* 2
Scrophulariaceae
Castilleja exilis
Mimulus eastwoodiae

ARCH Solitaire HG R = 16
Anacardiaceae
Rhus aromatica var. *simplicifolia* T
Toxicodendron rydbergii
Asteraceae
Cirsium rydbergii 1
Heterotheca villosa var. *minor* 2
Solidago velutina subsp. *sparsiflora* 1
Cyperaceae
Carex aurea 7
Euphorbiaceae
Euphorbia brachycera T
Liliaceae
Zigadenus vaginatus 19
Orchidaceae
Epipactis gigantea 5
Poaceae
Muhlenbergii thurberi 3
Dichanthelium acuminatum 1
Pteridaceae
Adiantum capillus-veneris 4
Pellaea glabella subsp. *simplex*
Primulaceae
Primula specuicola 2
Ranunculaceae
Aquilegia micrantha 38
Scrophulariaceae
Mimulus eastwoodiae 1

ARCH Dead Tree HG R = 18
Apocynaceae
Apocynum cannabinum
Asteraceae
Cirsium rydbergii 5
Heterotheca villosa var. *minor* 2
Cyperaceae
Carex aurea 4
Euphorbiaceae
Euphorbia brachycera T
Fagaceae
Quercus havardii
Juncaceae
Juncus ensifolius var. *montanus*
Liliaceae
Zigadenus vaginatus 1
Orchidaceae
Epipactis gigantea 5
Poaceae
Muhlenbergia andina 1
Dichanthelium acuminatum 8
Schizachyrium scoparium 19
Pteridaceae
Adiantum capillus-veneris 11
Primulaceae
Primula specuicola 3
Ranunculaceae
Aquilegia micrantha 8
Santalaceae
Comandra umbellata var. *pallida* 1
Scrophulariaceae
Castilleja exilis T
Mimulus eastwoodiae 8

CANY Box HG R = 17
Apocynaceae
Apocynum cannabinum 1
Asteraceae
Artemisia ludoviciana subsp. *ludoviciana*
Cirsium rydbergii 16
Packera multilobata
Cyperaceae
Carex aurea 2
Liliaceae
Maianthemum stellatum
Zigadenus vaginatus
Orchidaceae
Epipactis gigantea
Platantherera zothecina
Pinaceae
Pinus edulis

Poaceae
Calamagrostis scopulorum 66
Phragmites australis
Ranunculaceae
Aquilegia micrantha 10
Rhamnaceae
Rhamnus betulifolia
Rosaceae
Rosa sp.
Scrophulariaceae
Castilleja linariifolia
Mimulus eastwoodiae

CANY Northface HG R = 13
Asteraceae
Cirsium rydbergii 8
Betulaceae
Betula occidentalis
Cornaceae
Cornus sericea
Cyperaceae
Carex sp.
Fagaceae
Quercus gambelii
Liliaceae
Maianthemum stellatum
Zigadenus vaginatus
Orchidaceae
Platantherera zothecina
Poaceae
Calamagrostis scopulorum
Ranunculaceae
Aquilegia micrantha 54
Rosaceae
Amelanchier sp.
Rosa sp.
Scrophulariaceae
Mimulus eastwoodiae

CANY Raven HG R = 16
Anacardiaceae
Rhus aromatica var. *simplicifolia*
Toxicodendron rydbergii
Apocynaceae
Apocynum cannabinum T
Asteraceae
Cirsium arizonicum var. *bipinnatum*
Berberidaceae
Berberis fendleri 3
Cyperaceae
Carex aurea 10
Orchidaceae
Platantherera zothecina
Pinaceae
Pinus edulis T

Poaceae
Calamagrostis scopulorum 48
Ranunculaceae
Aquilegia micrantha 10
Rhamnaceae
Rhamnus betulifolia 3
Rosaceae
Holodiscus dumosus
Rosa sp.
Rubiaceae
Galium sp.
Scrophulariaceae
Castilleja linariifolia
Mimulus eastwoodiae

CANY Gate HG R = 12
Anacardiaceae
Toxicodendron rydbergii
Asteraceae
Cirsium arizonicum var. *bipinnatum* 2
Cyperaceae
Carex aurea 9
Orchidaceae
Platantherera zothecina
Pinaceae
Pinus edulis
Poaceae
Calamagrostis scopulorum 31
Muhlenbergia thurberi
Piptatherum micranthum
Ranunculaceae
Aquilegia micrantha 37
Rosaceae
Amelanchier sp.
Cercocarpus sp.
Rosa sp.

CANY Rocky HG R=7
Asteraceae
Cirsium arizonicum var. bipinnatum 8
Erigeron sparsifolius 1
Pinaceae
Pinus edulis
Poaceae
Calamagrostis scopulorum 21
Ranunculaceae
Aquilegia micrantha 6
Santalaceae
Comandra umbellata var. *pallida* 4
Scrophulariaceae
Mimulus eastwoodiae

CANY Tier HG R = 18
Agavaceae
Yucca sp. T
Anacardiaceae
Toxicodendron rydbergii 1
Apocynaceae
Apocynum cannabinum T
Asteraceae
Cirsium calareum 1
Cyperaceae
Carex aurea 9
Fagaceae
Quercus gambelii T
Liliaceae
Maianthemum stellatum 4
Orchidaceae
Epipactis gigantea 3
Platantherera zothecina T
Pinaceae
Pinus edulis
Poaceae
Calamagrostis scopulorum 49
Polemoniaceae
Gilia aggregata var. *maculata* 2
Ranunculaceae
Aquilegia micrantha 11
Rhamnaceae
Rhamnus betulifolia
Rosaceae
Rosa sp. 2
Santalaceae
Comandra umbellata var. *pallida* T
Scrophulariaceae
Castilleja linariifolia 1
Mimulus eastwoodiae T

CARE Sidewall HG R = 12
Anacardiaceae
Toxicodendron rydbergii 19
Asteraceae
Cirsium arizonicum var. bipinnatum 4
Heterotheca villosa var. minor
Sonchus sp.
Equisetaceae
Equisetum laevigatum 1
Oleaceae
Fraxinus anomala
Orchidaceae
Epipactis gigantea
Poaceae
Elymus canadensis T
Dichanthelium acuminatum 7

Pteridaceae
Adiantum capillus-veneris 56
Scrophulariaceae
Castilleja scabrida
Ulmaceae
Celtis reticulata 5

CARE Horseshoe HG R = 8
Apocynaceae
Apocynum cannabinum
Asteraceae
Brickellia longifolia var. *longifolia*
Orchidaceae
Epipactis gigantea T
Oleaceae
Fraxinus anomala
Poaceae
Elymus canadensis
Elymus trachycaulus
Pteridaceae
Adiantum capillus-veneris 95
Scrophulariaceae
Mimulus eastwoodiae T

DINO Ponderosa HG R = 17
Asteraceae
Cirsium ownbeyi 2
Erigeron nematopyllus
Heterotheca villosa var. *minor* T
Cupressaceae
Juniperus osteosperma
Hydrangiaceae
Fendlerella utahensis
Liliaceae
Zigadenus vaginatus 14
Pinaceae
Pinus edulis
Poaceae
Calamagrostis scopulorum 19
Muhlenbergia thurberi
Piptatherum micranthum
Poa fendleriana
Pteridaceae
Pellaea glabella subsp. *simplex*
Ranunculaceae
Aquilegia micrantha 1
Rosaceae
Amelanchier sp.
Petrophytum caespitosum
Rubiaceae
Galium sp.
Scrophulariaceae
Castilleja linariifolia

DINO Yampa HG R = 18

Asteraceae
Cirsium ownbeyi T
Erigeron nematophyllus 6
Heterotheca villosa var. *minor* 2
Packera multilobata
Taraxacum officinale
Caprifoliaceae
Symphoricarpos sp.
Hydrangiaceae
Fendlerella utahensis 9
Liliaceae
Zigadenus vaginatus 1
Linaceae
Linum lewisii
Poaceae
Calamagrostis scopulorum
Elymus repens 1
Hesperostipa comata var. *comata* 1
Pteridaceae
Pellaea glabella subsp. *simplex*
Ranunculaceae
Aquilegia micrantha 2
Rosaceae
Cercocarpus intricatus 7
Holodiscus dumosus T
Petrophytum caespitosum 7
Scrophulariaceae
Castilleja linariifolia T

DINO Bull HG R = 16

Aceraceae
Acer negundo 2
Anacardiaceae
Rhus aromatica var. *trilobata* 1
Toxicodendron rydbergii 2
Asteraceae
Achillea millefolium T
Taraxacum officinale
Betulaceae
Betula occidentalis
Caprifoliaceae
Symphoricarpos sp. 2
Cornaceae
Cornus sericea
Liliaceae
Maianthemum stellatum 7
Orchidaceae
Platantherera zothecina 7
Pinaceae
Pseudotsuga menziesii
Poaceae
Calamagrostis scopulorum 36
Primulaceae
Dodecatheon pulchellum var. *pulchellum*
Ranunculaceae
Clematis ligusticifolia
Rubiaceae
Galium sp.
Salicaceae
Salix sp.

DINO Snow HG R = 8

Anacardiaceae
Rhus aromatica var. *trilobata* 2
Cupressaceae
Juniperus osteosperma
Loasaceae
Mentzelia multicaulis 2
Orchidaceae
Epipactis gigantea 19
Pinaceae
Pinus ponderosa
Poaceae
Calamagrostis scopulorum 19
Primulaceae
Dodecatheon pulchellum var. *pulchellum* 12
Ranunculaceae
Aquilegia micrantha 15

DINO Bench HG R = 17

Asteraceae
Achillea millefolium
Ericameria nauseosa
Cirsium ownbeyi 2
Erigeron nematophyllus
Heterotheca villosa var. *minor*
Cupressaceae
Juniperus osteosperma
Cyperaceae
Carex aurea 2
Ephedraceae
Ephedra viridis
Hydrangiaceae
Fendlerella utahensis 1
Liliaceae
Zigadenus vaginatus 7
Pinaceae
Pinus edulis
Poaceae
Calamagrostis scopulorum
Elymus elymoides var. *brevifolius*
Polypodiaceae
Pellaea glabella subsp. *simplex*
Ranunculaceae
Aquilegia micrantha 35
Rosaceae
Cercocaarpus intricatus T
Salicaceae
Populus deltoides subsp. *wislizenii*

DINO Rimrock HG R = 9

Asteraceae
Erigeron nematophyllus
Heterotheca villosa var. *minor*
Liliaceae
Zigadenus vaginatus 2
Pinaceae
Pinus edulis
Poaceae
Calamagrostis scopulorum
Ranunculaceae
Aquilegia micrantha 19
Rosaceae
Cercocarpus intricatus
Petrophytum caespitosum
Scrophulariaceae
Castilleja lineariifolia

DINO Signature HG R = 19

Asteraceae
Ericameria nauseosa
Cirsium ownbeyi 4
Heterotheca villosa var. *minor*
Brassicaceae
Lepidium montanum var. *jonesii*
Cyperaceae
Carex aurea 2
Euphorbiaceae
Euphorbia brachycera
Liliaceae
Zigadenus vaginatus 2
Orchidaceae
Epipactis gigantea 16
Poaceae
Calamagrostis scopulorum 37
Muhlenbergia thurberi
Dichanthelium acuminatum T
Pteridaceae
Adiantum capillus-veneris T
Pellaea glabella subsp. *simplex*
Primulaceae
Dodecatheon pulchellum var. *pulchellum*
Ranunculaceae
Aquilegia micrantha 3
Clematis ligusticifolia 34
Rosaceae
Cercocarpus intricatus
Petrophytum caespitosum
Scrophulariaceae
Castilleja linariifolia

DINO Marbles HG R = 16

Asteraceae
Erigeron nematophyllus 18
Heterotheca villosa var. *minor* 2
Xanthisma grindelioides T
Taraxacum officinale T
Berberidaceae
Berberis repens
Boraginaceae
Cryptantha sp. 1
Caprifoliaceae
Symphoricarpos sp. 1
Hydrangiaceae
Fendlerella utahensis 2
Pinaceae
Pinus edulis T
Poaceae
Achnatherum hymenoides T
Pteridaceae
Pellaea glabella subsp. *simplex*
Ranunculaceae
Aquilegia micrantha 1
Rosaceae
Cercocarpus intricatus 8
Holodiscus dumosus 3
Petrophytum caespitosum 5
Scrophulariaceae
Castilleja sp. T

DINO Buzz HG R = 7

Asteraceae
Artemisia ludoviciana subsp. *ludoviciana* 6
Cyperaceae
Carex aurea 1
Fabaceae
Melilotus officinalis
Poaceae
Agrostis stolonifera 6
Calamagrostis scopulorum 2
Primulaceae
Dodecatheon pulchellum var. *pulchellum* 2
Ranunculaceae
Aquilegia micrantha 37

DINO Redrock HG R = 18
Asteraceae
Toxicodendron rydbergii
Artemisia ludoviciana subsp. *ludoviciana* 2
Heterotheca villosa var. *minor* 4
Taraxacum officinale 4
Brassicaceae
Lepidium latifolium 15
Cyperaceae
Carex aurea 5
Fabaceae
Melilotus albus
Melilotus officinalis
Liliaceae
Maianthemum stellatum
Orchidaceae
Platantherera zothecina 11
Poaceae
Agrostis stolonifera
Calamagrostis scopulorum 2
Muhlenbergia andina
Poa pratensis 2
Ranunculaceae
Aquilegia micrantha 18
Clematis ligusticifolia
Rosaceae
Petrophytum caespitosum 7
Ulmaceae
Celtis reticulata 4

DINO Limestone HG R = 29
Apocynaceae
Apocynum cannabinum
Asclepiadaceae
Asclepias speciosa
Asteraceae
Artemisia ludoviciana subsp. *ludoviciana* 2
Ericameria nauseosa
Cirsium ownbeyi 15
Tragopogon dubius T
Brassicaceae
Lepidium montanum var. *jonesii*
Cyperaceae
Carex parryanna 2
Carex aquatilis var. *aquatilis*
Carex aurea
Equisetaceae
Equisetum laevigatum 1
Fabaceae
Melilotus officinalis T
Juncaceae
Juncus ensifolius var. *montanus*
Lamiaceae
Mentha arvensis 2
Liliaceae
Maianthemum stellatum T
Onagraceae
Epilobium sp.
Oenothera caespitosa T
Poaceae
Calamagrostis scopulorum 28
Elymus trachycaulus 1
Glyceria striata T
Koeleria macrantha
Phragmites australis 8
Poa pratensis
Pseudoroegneria spicata
Polygonaceae
Erigonum corymbosum var. *corymbosum*
Ranunculaceae
Aquilegia micrantha 1
Clematis ligusticifolia 12
Rosaceae
Rosa woodsii 6
Violaceae
Viola sp.

DINO Ely HG R = 17
Asteraceae
Crepis runcinata var. *glauca*
Erigeron nematophyllus
Betulaceae
Betula occidentalis
Euphorbiaceae
Euphorbia brachycera T
Hydrangiaceae
Fendlerella utahensis
Loasaceae
Mentzelia sp. 3
Pinaceae
Pinus edulis
Poaceae
Calamagrostis scopulorum 4
Muhlenbergia thurberi 1
Achnatherum hymenoides 1
Pteridaceae
Pellaea glabella subsp. *simplex* 4
Primulaceae
Dodecatheon pulchellum var. *pulchellum* 1
Ranunculaceae
Aquilegia micrantha 13
Rosaceae
Cercocarpus intricatus
Petrophytum caespitosum 7
Santalaceae
Comandra umbellata var. *pallida* 2
Scrophulariaceae
Castilleja linariifolia

GLCA Camp HG R = 19
Apocynaceae
Apocynum cannabinum 3
Asteraceae
Artemisia ludoviciana subsp. *mexicana*
Brickellia longifolia var. *longifolia* T
Taraxacum officinale
Berberidaceae
Berberis repens
Betulaceae
Ostrya knowltonii
Cyperaceae
Carex aurea 10
Fabaceae
Cercis occidentalis var. *orbiculata* 3
Fagaceae
Quercus gambelii
Orchidaceae
Platantherera zothecina 1
Poaceae
Calamagrostis scopulorum 4
Polypogon interruptus
Polypogon viridis
Pteridaceae
Adiantum capillus-veneris 15
Ranunculaceae
Aquilegia micrantha 9
Clematis ligusticifolia
Rhamnaceae
Rhamnus betulifolia
Rosaceae
Rubus neomexicanus 3
Scrophulariaceae
Mimulus eastwoodiae 3

GLCA Channel HG R = 11
Anacardiaceae
Toxicodendron rydbergii T
Asteraceae
Cirsium rydbergii 1
Cyperaceae
Carex sp. T
Fagaceae
Quercus gambelii 2
Poaceae
Calamagrostis scopulorum 6
Pteridaceae
Adiantum capillus-veneris 7
Primulaceae
Primula specuicola 1
Ranunculaceae
Aquilegia micrantha 18
Rosaceae
Petrophytum caespitosum 5
Scrophulariaceae
Mimulus eastwoodiae 1
Vitaceae
Parthenocissus vitacea 2

GLCA Corner HG R = 13
Agavaceae
Yucca sp. T
Anacardiaceae
Rhus aromatica var. *simplicifolia*
Asteraceae
Artemisia ludoviciana subsp. *ludoviciana*
Cirsium rydbergii 2
Cyperaceae
Carex aurea
Fagaceae
Quercus gambelii
Orchidaceae
Epipactis gigantea
Poaceae
Calamagrostis scopulorum 14
Pteridaceae
Adiantum capillus-veneris 54
Rosaceae
Petrophytum caespitosum
Scrophulariaceae
Mimulus eastwoodiae
Ulmaceae
Celtis reticulata
Vitaceae
Parthenocissus vitacea 4

GLCA Crossbed HG R = 23
Agavaceae
Yucca sp. 1
Anacardiaceae
Rhus aromatica var. *simplicifolia*
Asteraceae
Brickellia longifolia var. *longifolia* 1
Cirsium rydbergii 11
Erigeron sparsifolius
Tetraneuris ivesiana
Gutierrezia sarothrae T
Solidago velutina subsp. *sparsiflora* 2
Cyperaceae
Carex curatorum 3

Loasaceae
Mentzelia cronquistii
Oleaceae
Fraxinus anomala
Orchidaceae
Epipactis gigantea
Poaceae
Andropogon glomeratus var. *scabriglumis*
Calamagrostis scopulorum 2
Dichanthelium acuminatum
Schizachyrium scoparium 26
Polygonaceae
Eriogonum corymbosum var. *corymbosum* T
Pteridaceae
Adiantum capillus-veneris 2
Primulaceae
Primula specuicola 1
Rhamnaceae
Rhamnus betulifolia
Rosaceae
Petrophytum caespitosum 12
Scrophulariaceae
Castilleja linariifolia
Ulmaceae
Celtis reticulata

GLCA Dune HG R = 20
Agavaceae
Yucca sp. 7
Anacardiaceae
Rhus aromatica var. *simplicifolia* 3
Asteraceae
Symphotrichum chilense T
Cirsium rydbergii 9
Solidago velutina subsp. *sparsiflora* 2
Cyperaceae
Carex sp. 19
Oleaceae
Fraxinus anomala
Orchidaceae
Epipactis gigantea
Poaceae
Andropogon glomeratus var. *scabriglumis* 1
Bromus tectorum T
Calamagrostis scopulorum 7
Muhlenbergia andina T
Dichanthelium acuminatum
Pteridaceae
Adiantum capillus-veneris 6
Primulaceae
Primula specuicola 1
Rhamnaceae
Rhamnus betulifolia 9
Rosaceae
Petrophytum caespitosum 4
Salicaceae
Salix ligulifolia 8
Scrophulariaceae
Castilleja linariifolia 1
Ulmaceae
Celtis reticulata

GLCA Fence HG R = 19
Anacardiaceae
Rhus aromatica var. *trilobata*
Toxicodendron rydbergii 1
Asteraceae
Cirsium sp. T
Heterotheca villosa var. *minor* 2
Solidago canadensis
Solidago velutina subsp. *sparsiflora* 1
Campanulaceae
Lobelia cardinalis subsp. *graminea*
Cyperaceae
Carex sp. 9
Fagaceae
Quercus gambelii
Liliaceae
Zigadenus vaginatus T
Oleaceae
Fraxinus sp. 2
Orchidaceae
Epipactis gigantea
Poaceae
Andropogon glomeratus var. *scabriglumis* 69
Dichanthelium acuminatum
Phragmites australis
Polemoniaceae
Gilia aggregata var. *maculata* 2
Pteridaceae
Adiantum capillus-veneris 4
Primulaceae
Primula specuicola
Rosaceae
Petrophytum caespitosum

GLCA Graffiti HG R = 8
Asteraceae
Brickellia longifolia var. *longifolia*
Orchidaceae
Epipactis gigantea 5
Poaceae
Muhlenbergia sp. T
Pteridaceae
Adiantum capillus-veneris 93
Ranunculaceae
Aquilegia micrantha
Rhamnaceae
Rhamnus betulifolia
Rosaceae
Petrophytum caespitosum
Ulmaceae
Celtis reticulata

GLCA Hardwood HG R = 29
Anacardiaceae
Rhus aromatica var. *simplicifolia* 1
Asteraceae
Baccharis emoryi 7
Cirsium rydbergii
Erigeron sparsifolius
Brassicaceae
Thelypodium integrifolium
Cyperaceae
Carex aurea
Cladium californicum 6
Fabaceae
Cercis occidentalis var. *orbiculata*
Fagaceae
Quercus gambelii 3
Juncaceae
Juncus arcticus 13
Oleaceae
Forestiera pubescens 6
Orchidaceae
Epipactis gigantea
Poaceae
Calamagrostis scopulorum 3
Elymus canadensis T
Muhlenbergia andina
Dichanthelium acuminatum-T
Panicum virgatum 7
Phragmites australis
Schizachyrium scoparium T
Sphenopholis obtusata
Pteridaceae
Adiantum capillus-veneris 9
Primulaceae
Primula specuicola 1
Ranunculaceae
Clematis ligusticifolia 1
Rhamnaceae
Rhamnus betulifolia 1
Rosaceae
Petrophytum caespitosum 1
Scrophulariaceae
Castilleja linariifolia
Mimulus eastwoodiae T
Ulmaceae
Celtis reticulata
Vitaceae
Parthenocissus vitacea 3

GLCA Hawk HG R = 12
Asteraceae
Brickellia longifolia var. *longifolia*
Cirsium rydbergii 36
Cyperaceae
Carex aurea 4
Fagaceae
Quercus gambelii T
Poaceae
Calamagrostis scopulorum 1
Muhlenbergia andina
Polypogon viridis T
Pteridaceae
Adiantum capillus-veneris 20
Primulaceae
Primula specuicola T
Ranunculaceae
Aquilegia micrantha T
Rosaceae
Petrophytum caespitosum
Scrophulariaceae
Mimulus eastwoodiae 1

GLCA Hook HG R = 28
Asteraceae
Artemisia ludoviciana subsp. *ludoviciana* 4
Herrickia glauca var. *glauca* 4
Brickellia longifolia var. *longifolia*
Cirsium rydbergii 49
Solidago sp.
Sonchus asper
Cyperaceae 6
Carex aurea
Carex curatorum
Equisetaceae
Equisetum hyemale 2
Equisetum laevigatum
Fagaceae
Quercus gambelii 2
Juncaceae
Juncus arcticus 9
Liliaceae
Maianthemum stellatum 5
Orchidaceae
Epipactis gigantea T

Poaceae
Agrostis exarata
Andropogon glomeratus var. *scabriglumis* T
Bromus tectorum T
Calamagrostis scopulorum T
Elymus canadensis 4
Muhlenbergia andina 2
Muhlenbergia thurberi
Dichanthelium acuminatum T
Phragmites australis 2
Sphenopholis obtusata
Pteridaceae
Adiantum capillus-veneris 2
Primulaceae
Primula specuicola
Ranunculaceae
Aquilegia micrantha
Scrophulariaceae
Mimulus eastwoodiae

GLCA Ice HG R = 17
Anacardiaceae
Toxicodendron rydbergii
Asteraceae
Aster sp.
Artemisia ludoviciana subsp. *ludoviciana*
Brickellia longifolia var. *longifolia*
Cirsium rydbergii 29
Cyperaceae 19
Carex lanuginosa
Equisetaceae
Equisetum sp.
Oleaceae
Fraxinus anomala
Orchidaceae
Platantherera zothecina
Poaceae
Calamagrostis scopulorum T
Pteridaceae
Adiantum capillus-veneris 22
Primulaceae
Primula specuicola
Ranunculaceae
Aquilegia micrantha 3
Rosaceae
Petrophytum caespitosum
Scrophulariaceae
Castilleja linariifolia
Scrophulariaceae
Mimulus eastwoodiae
Vitaceae
Parthenocissus vitacea 7

GLCA Lower Cow HG R = 12
Anacardiaceae
Toxicodendron rydbergii 1
Asteraceae
Cirsium rydbergii
Solidago velutina subsp. *sparsiflora* 1
Campanulaceae
Lobelia cardinalis subsp. *graminea* 1
Cyperaceae
Carex curatorum 14
Fagaceae
Quercus gambelii T
Orchidaceae
Epipactis gigantea T
Poaceae
Calamagrostis scopulorum 19
Phragmites australis
Pteridaceae
Adiantum capillus-veneris 4
Primulaceae
Primula specuicola 10
Ranunculaceae
Clematis ligusticifolia 2

GLCA Lower Three Garden R = 8
Asteraceae
Cirsium rydbergii 21
Cyperaceae 8
Carex aurea
Carex curatorum
Poaceae
Dichanthelium acuminatum 26
Muhlenbergia sp. 2
Primulaceae
Primula specuicola 3
Rosaceae
Petrophytum caespitosum 10
Scrophulariaceae
Castilleja linariifolia 2

GLCA Pedestal HG R = 14
Agavaceae
Yucca sp. 4
Asteraceae
Cirsium rydbergii 7
Heterotheca villosa var. *minor* T
Cyperaceae 14
Carex aurea
Carex curatorum
Juncaceae
Juncus arcticus T
Onagraceae
Oenothera longissima 1
Orchidaceae
Epipactis gigantea T
Poaceae
Calamagrostis scopulorum T
Schizachyrium scoparium 32
Pteridaceae
Adiantum capillus-veneris 17
Ranunculaceae
Aquilegia micrantha 1
Clematis ligusticifolia 1
Rhamnaceae
Rhamnus betulifolia 1

GLCA Pyro HG R = 22
Asteraceae
Artemisia ludoviciana subsp. *albula* 2
Brickellia longifolia var. *longifolia* T
Cirsium rydbergii 8
Conyza canadensis
Pseudognaphalium luteoalbum
Sonchus arvensis
Sonchus asper
Cyperaceae
Carex aurea 9
Scirpus sp.
Fabaceae
Cercis occidentalis var. *orbiculata*
Fagaceae
Quercus gambelii
Orchidaceae
Epipactis gigantea T
Poaceae
Bromus rubens
Elymus canadensis T
Muhlenbergia andina
Dichanthelium acuminatum 1
Polypogon monspeliensis
Pteridaceae
Adiantum capillus-veneris 68
Primulaceae
Primula specuicola
Scrophulariaceae
Mimulus eastwoodiae
Tamaricaceae
Tamarix ramosissima
Typhaceae
Typha sp. 6

GLCA Rattlesnake HG R = 20
Asteraceae
Brickellia longifolia var. *longifolia* T
Cirsium rydbergii T
Solidago sp. 6
Cyperaceae
Carex aurea 1
Fagaceae
Quercus gambelii 1
Juncaceae
Juncus ensifolius var. montanus
Liliaceae
Maianthemum stellatum 4
Oleaceae
Forestiera pubescens T
Fraxinus anomala
Orchidaceae
Epipactis gigantea 3
Platantherera zothecina T
Poaceae
Agrostis exarata
Calamagrostis scopulorum 56
Elymus canadensis T
Pteridaceae
Adiantum capillus-veneris 7
Ranunculaceae
Aquilegia micrantha 3
Rhamnaceae
Rhamnus betulifolia
Rosaceae
Petrophytum caespitosum
Scrophulariaceae
Mimulus eastwoodiae T
Vitaceae
Parthenocissus vitacea 4

GLCA Stone Basin HG R = 15
Anacardiaceae
Toxicodendron rydbergii 1
Apocynaceae
Apocynum cannabinum 11
Asteraceae
Conyza canadensis T
Pseudognaphalium sp. 2
Solidago sp. 4
Campanulaceae
Lobelia cardinalis subsp. *graminea*
Cyperaceae
Carex sp. 4
Poaceae
Andropogon glomeratus var. *scabriglumis*

Bouteloua curtipendula var. *caespitosa*
Calamagrostis scopulorum T
Elymus canadensis 3
Dichanthelium acuminatum 14
Pteridaceae
Adiantum capillus-veneris 4
Scrophulariaceae
Castilleja linariifolia
Vitaceae
Parthenocissus vitacea 10

GLCA Swallow HG R = 11
Asteraceae
Cirsium rydbergii
Sonchus sp. T
Cyperaceae
Carex aurea 18
Orchidaceae
Platantherera zothecina 3
Poaceae
Calamagrostis scopulorum T
Pteridaceae
Adiantum capillus-veneris 42
Primulaceae
Primula specuicola 2
Ranunculaceae
Aquilegia micrantha 6
Clematis ligusticifolia
Rosaceae
Rubus neomexicanus
Scrophulariaceae
Mimulus eastwoodiae

GLCA Upper Three HG R = 16
Asclepiadaceae
Asclepias latifolia
Asteraceae
Solidago velutina subsp. *sparsiflora*
Cirsium rydbergii 40
Cyperaceae
Carex aurea 15
Fabaceae
Cercis occidentalis var. *orbiculata*
Fagaceae
Quercus gambelii 1
Orchidaceae
Epipactis gigantea 1
Poaceae
Calamagrostis scopulorum 13
Muhlenbergia sp. 1
Dichanthelium acuminatum
Schizachyrium scoparium[1] 5
Pteridaceae
Adiantum capillus-veneris 1
Primulaceae
Primula specuicola T
Rosaceae
Petrophytum caespitosum
Scrophulariaceae
Castilleja linariifolia
Mimulus eastwoodiae T

GLCA Wrong HG R = 10
Anacardiaceae
Toxicodendron rydbergii 11
Apocynaceae
Apocynum cannabinum
Asteraceae
Artemisia ludoviciana subsp. *mexicana* T
Solidago velutina subsp. *sparsiflora*
Fagaceae
Quercus gambelii 1
Poaceae
Andropogon glomeratus var. *scabriglumis* 25
Calamagrostis scopulorum 28
Dichanthelium acuminatum 2
Polemoniaceae
Gilia aggregata var. *maculata*
Pteridaceae
Adiantum capillus-veneris 30

GLCA Zephyr HG R = 17
Agavaceae
Yucca sp. 12
Anacardiaceae
Rhus aromatica var. *simplicifolia* 2
Asteraceae
Cirsium rydbergii 31
Cyperaceae
Carex curatorum 4
Fagaceae
Quercus gambelii
Orchidaceae
Epipactis gigantea T
Poaceae
Andropogon glomeratus var. *scabriglumis*
Muhlenbergia sp. T
Schizachyrium scoparium 50
Primulaceae
Primula specuicola T
Pteridaceae
Adiantum capillus-veneris 2
Ranunculaceae
Aquilegia micrantha 2
Rhamnaceae
Rhamnus betulifolia 2
Rosaceae
Petrophytum caespitosum 2
Scrophulariaceae
Castilleja linariifolia 2
Ulmaceae
Celtis reticulata
Urticaceae
Parietaria pennsylvanica T

GLCA Zigy HG R = 30
Agavaceae
Yucca toftiae
Apocynaceae
Apocynum cannabinum T
Asteraceae
Artemisia ludoviciana subsp. *ludoviciana*
Cirsium rydbergii 21
Conyza canadensis
Sonchus asper
Cyperaceae 3
Carex aurea
Carex curatorum
Eleocharis rostellata 12
Scirpus sp.
Fabaceae
Oxytropis sp.
Liliaceae
Zigadenus vaginatus 13
Onagraceae
Oenothera longissima
Orchidaceae
Epipactis gigantea T
Poaceae
Agrostis exarata
Bromus tectorum
Calamagrostis scopulorum 6
Muhlenbergia asperifolia
Muhlenbergia thurberi
Dichanthelium acuminatum
Phragmites australis T
Schizachyrium scoparium 10
Pteridaceae
Adiantum capillus-veneris 1
Primulaceae
Primula specuicola T
Ranunculaceae
Aquilegia micrantha 1
Clematis ligusticifolia
Rosaceae
Petrophytum caespitosum
Rosa woodsii
Scrophulariaceae
Mimulus eastwoodiae
Typhaceae
Typha sp.

NABR AM HG R= 5
Pinaceae
Pinus edulis T
Poaceae
Calamagrostis scopulorum
Ranunculaceae
Aquilegia micrantha 27
Rhamnaceae
Rhamnus betulifolia
Rosaceae
Cercocarpus montanus

NABR Fir HG R=11
Asteraceae
Cirsium undulatum
Heterotheca villosa var. *minor*
Gentianaceae
Swertia radiata 2
Hydrophyllaceae
Phacelia sp.
Liliaceae
Zigadenus vaginatus 6
Pinaceae
Abies bifolia
Poaceae
Calamagrostis scopulorum 29
Poa fendleriana
Rosaceae
Amelanchier sp. 2
Holodiscus dumosus 2
Rubiaceae
Galium multiflorum var. *coloradoense*

NABR Kachina HG R = 19
Apiaceae
Aletes macdougalii subsp. *breviradiatus* 2
Asteraceae
Cirsium undulatum 5
Cirsium sp.
Erigeron kachinensis 5
Heterotheca villosa var. *minor* T
Celastraceae
Pachystima myrsinites T
Cyperaceae
Carex aurea T
Ephedraceae
Ephedra viridis 12
Gentianaceae
Swertia radiata T
Juncaceae
Juncus arcticus T

Liliaceae
Zigadenus vaginatus 19
Orchidaceae
Epipactis gigantea T
Pinaceae
Pinus edulis
Poaceae
Calamagrostis scopulorum 4
Muhlenbergia thurberi 5
Ranunculaceae
Aquilegia micrantha T
Clematis ligusticifolia
Rhamnaceae
Rhamnus betulifolia 4
Rubiaceae
Galium multiflorum var. *coloradoense*
Santalaceae
Comandra umbellata var. *pallida* 1

NABR Liverwort HG R = 9
Brassicaceae
Lepidium montanum var. *jonesii* T
Lesquerella rectipes
Cupressaceae
Juniperus osteosperma
Elaeagnaceae
Shepherdia rotundifolia
Pinaceae
Pinus edulis T
Poaceae
Calamagrostis scopulorum
Pteridaceae
Cheilanthes feei
Ranunculaceae
Aquilegia micrantha 49
Rosaceae
Petrophytum caespitosum

NABR Long HG R = 10
Berberidaceae
Berberis repens
Gentianaceae
Swertia radiata
Asteraceae
Erigeron kachinensis
Liliaceae
Zigadenus vaginatus
Pinaceae
Pinus edulis
Poaceae
Calamagrostis scopulorum 4
Ranunculaceae
Aquilegia micrantha 14
Rhamnaceae
Rhamnus betulifolia
Rosaceae
Cercocarpus montanus
Rubiaceae
Galium multiflorum var. *coloradoense*

NABR Micro HG R = 4
Asteraceae
Cirsium sp. 3
Erigeron kachinensis 6
Poaceae
Calamagrostis scopulorum 3
Ranunculaceae
Aquilegia micrantha 48

NABR Petro HG R = 9
Asteraceae
Cirsium undulatum 11
Erigeron kachinensis 7
Heterotheca villosa var. *minor* T
Cyperaceae
Carex aurea 11
Gentianaceae
Swertia radiata
Orchidaceae
Platantherera sp. 1
Poaceae
Calamagrostis scopulorum 35
Pteridaceae
Adiantum capillus-veneris T
Ranunculaceae
Aquilegia micrantha T

NABR Slickrock HG R = 14
Asteraceae
Cirsium sp. 13
Cirsium arizonicum var. *bipinnatum*
Cirsium undulatum
Heterotheca villosa var. *minor*
Cyperaceae
Carex aurea 2
Fagaceae
Quercus gambelii
Gentianaceae
Swertia radiata
Juncaceae
Juncus arcticus 12
Liliaceae
Zigadenus vaginatus T
Orchidaceae
Platantherera sp.
Pinaceae
Pinus edulis 2
Poaceae
Bromus tectorum
Calamagrostis scopulorum 18
Muhlenbergia thurberi
Rubiaceae
Galium multiflorum var. *coloradoense* 5

NABR Tuwa HG R = 10
Apiaceae
Aletes macdougalii subsp. *breviradiatus*
Asteraceae
Cirsium undulatum 5
Cyperaceae
Carex aurea 8
Gentianaceae
Swertia radiata 4
Juncaceae
Juncus arcticus
Pinaceae
Pinus edulis T
Poaceae
Calamagrostis scopulorum 40
Muhlenbergia thurberi 3
Ranunculaceae
Aquilegia micrantha 2
Rhamnaceae
Rhamnus betulifolia

ZION Canyon Overlook I HG R = 14
Aceraceae
Acer negundo var. *violaceum*
Asteraceae
Brickellia californica 2
Ageratina herbacea
Perityle tenella T
Stephanomeria pauciflora
Fagaceae
Quercus turbinella T
Orchidaceae
Epipactis gigantea 16
Poaceae
Muhlenbergia thurberi 5
Poa fendleriana
Pteridaceae
Adiantum capillus-veneris 34
Rosaceae
Holodiscus dumosus
Petrophytum caespitosum T
Saxifragaceae
Heuchera rubescens
Scrophulariaceae
Castilleja sp.

ZION Canyon Overlook II HG R = 26
Asteraceae
Artemisia ludoviciana subsp. *albula* 3
Brickellia californica
Brickellia grandiflora 6
Erigeron sionis T
Heterotheca villosa var. minor 1
Perityle tenella
Solidago velutina subsp. *sparsiflora*
Sonchus asper
Stephanomeria pauciflora 1
Taraxacum officinale T
Celastraceae
Pachystima myrsinites 1
Fagaceae
Quercus turbinella
Onagraceae
Oenothera sp.
Zauschneria latifolia 2
Orchidaceae
Epipactis gigantea 1
Poaceae
Bromus ciliatus
Bromus tectorum 1
Muhlenbergia thurberi T
Poa fendleriana 1
Poa pratensis
Pteridaceae
Adiantum capillus-veneris 33
Rosaceae
Cercocarpus intricatus
Petrophytum caespitosum 2
Salicaceae
Populus fremontii 3
Salix gooddingii
Scrophulariaceae
Castilleja scabrida var. *scabrida*

ZION Court of the Patriarchs HG R = 20
Aceraceae
Acer negundo var. *negundo* T
Agavaceae
Yucca utahensis
Asteraceae
Artemisia ludoviciana subsp. *ludoviciana*
Perityle tenella
Solidago missouriensis
Sonchus asper
Cyperaceae
Carex aurea 5

Equisetaceae
Equisetum laevigatum 5
Liliaceae
Maianthemum stellatum 2
Oleaceae
Fraxinus velutina
Orchidaceae
Epipactis gigantea
Poaceae
Agrostis exarata
Calamagrostis scopulorum 13
Muhlenbergia sp. 14
Poa pratensis 5
Pteridaceae
Adiantum capillus-veneris 13
Rosaceae
Petrophytum caespitosum
Rubiaceae
Galium trifidum
Saxifragaceae
Parnassia palustris var. *montanensis*
Scrophulariaceae
Mimulus cardinalis

ZION Fall HG R = 14

Araliaceae
Aralia racemosa subsp. *bicrenata*
Asteraceae
Erigeron sionis
Taraxacum officinale
Brassicaceae
Nasturtium officinale
Juncaceae
Juncus ensifolius var. *montanus* T
Liliaceae
Maianthemum stellatum 6
Orchidaceae
Epipactis gigantea
Poaceae
Agrostis exarata
Pteridaceae
Adiantum capillus-veneris 40
Primulaceae
Dodecatheon pulchellum var. *zionense* 32
Ranunculaceae
Aquilegia chrysantha 2
Aquilegia formosa var. *formosa*
Rosaceae
Petrophytum caespitosum
Scrophulariaceae
Mimulus cardinalis

ZION Falling Water HG R = 21

Aceraceae
Acer negundo var. *violaceum*
Anacardiaceae
Toxicodendron rydbergii
Araliaceae
Aralia racemosa ssp. *bicrenata*
Asteraceae
Symphotrichum lanceolatum var. *hesperium* 30
Brickellia longifolia var. *longifolia*
Cirsium sp.
Chrysothamnus scopulorum
Sphaeromeria ruthiae
Cyperaceae
Carex aurea 1
Hydrangiaceae
Jamesia americana var. *zionis*
Liliaceae
Maianthemum stellatum
Oleaceae
Fraxinus velutina
Poaceae
Bromus ciliatus
Calamagrostis scopulorum 10
Pteridaceae
Adiantum capillus-veneris 2
Ranunculaceae
Aquilegia chrysantha 22
Clematis ligusticifolia
Rosaceae
Petrophytum caespitosum
Rubiaceae
Galium triflorum
Scrophulariaceae
Mimulus cardinalis
Violaceae
Viola sp. T

ZION Grotto HG R = 28

Aceraceae
Acer negundo var. *violaceum*
Anacardiaceae
Toxicodendron rydbergii
Araliaceae
Aralia racemosa subsp. *bicrenata* 2
Asteraceae
Artemisia ludoviciana
Symphotrichum lanceolatum var. *hesperium*
Brickellia longifolia var. *longifolia*
Cirsium neomexicanum
Berberidaceae
Berberis repens T
Brassicaceae
Erysimum capitatum
Caprifoliaceae
Symphoricarpos sp.
Celastraceae
Pachystima myrsinites
Hydrangiaceae
Jamesia americana var. *zionis*
Liliaceae
Maianthemum stellatum 2
Poaceae
Bromus ciliatus
Calamagrostis scopulorum 33
Pteridaceae
Adiantum capillus-veneris 1
Adiantum aleuticum
Primulaceae
Dodecatheon pulchellum var. *zionense* 19
Ranunculaceae
Aquilegia chrysantha 4
Aquilegia formosa var. *formosa*
Rosaceae
Amelanchier alnifolia
Cercocarpus intricatus
Holodiscus dumosus
Petrophytum caespitosum
Rubiaceae
Galium triflorum T
Saxifragaceae
Heuchera rubescens
Scrophulariaceae
Mimulus cardinalis 6
Violaceae
Viola nephrophylla 2

ZION Kaye's HG R = 30

Anacardiaceae
Toxicodendron rydbergii 1
Asteraceae
Artemisia ludoviciana subsp. *ludoviciana* T
Cirsium arizonicum
Taraxacum officinale T
Cyperaceae 19
Carex aurea
Carex curatorum
Equisetaceae
Equisetum hyemale
Fagaceae
Quercus turbinella
Hydrophyllaceae
Phacelia heterophylla
Juncaceae
Juncus ensifolius var. *montanus* T
Liliaceae
Maianthemum stellatum T
Oleaceae
Fraxinus velutina
Orchidaceae
Epipactis gigantea
Poaceae
Agrostis exarata
Calamagrostis scopulorum 40
Muhlenbergia andina 1
Dichanthelium acuminatum 2
Phragmites australis 1
Poa pratensis 2
Danthonia californica T
Pteridaceae
Adiantum capillus-veneris 3
Ranunculaceae
Aquilegia chrysantha 2
Aquilegia formosa var. *formosa*
Clematis ligusticifolia
Rosaceae
Petrophytum caespitosum
Rubiaceae
Galium trifidum
Saxifragaceae
Heuchera rubescens
Parnassia palustris var. *montanensis*
Scrophulariaceae
Mimulus cardinalis T
Violaceae
Viola sp. 1

ZION Lower Emerald HG R = 12

Anacardiaceae
Toxicodendron rydbergii
Asteraceae
Herrickia glauca var. *glauca* 1
Cyperaceae
Carex aurea
Liliaceae
Maianthemum stellatum 3
Orchidaceae
Epipactis gigantea 1
Poaceae
Agrostis exarata 5
Calamagrostis scopulorum 33

Pteridaceae
Adiantum capillus-veneris 1
Primulaceae
Dodecatheon pulchellum var. *zionense* 25
Ranunculaceae
Aquilegia chrysantha T
Scrophulariaceae
Mimulus cardinalis
Vitaceae
Vitis arizonica

ZION Menu Falls HG R = 23
Aceraceae
Acer negundo var. *negundo*
Anacardiaceae
Toxicodendron rydbergii
Apocynaceae
Apocynum cannabinum
Asteraceae
Baccharis salicina
Cirsium arizonicum
Sonchus asper
Cyperaceae T
Carex aurea
Carex curatorum
Equisetaceae
Equisetum laevigatum
Fagaceae
Quercus turbinella
Liliaceae
Maianthemum stellatum
Oleaceae
Fraxinus velutina
Poaceae
Agrostis exarata
Bromus diandrus
Calamagrostis scopulorum 13
Polypogon viridis
Muhlenbergia sp. 6
Pteridaceae
Adiantum capillus-veneris 16
Ranunculaceae
Aquilegia chrysantha 9
Aquilegia formosa var. *formosa*
Clematis ligusticifolia
Rosaceae
Petrophytum caespitosum
Scrophulariaceae
Mimulus cardinalis 15

ZION Narrows Trail HG R = 26
Aceraceae
Acer negundo var. *negundo* 4
Anacardiaceae
Toxicodendron rydbergii T
Asteraceae
Artemisia ludoviciana subsp. *ludoviciana*
Brickellia longifolia var. *longifolia*
Cirsium neomexicanum
Cirsium wheeleri
Sonchus asper
Berberidaceae
Berberis repens
Cannabaceae
Humulus lupulus var. *neomexicanus*
Cyperaceae
Carex aurea T
Liliaceae
Maianthemum stellatum 19
Orchidaceae
Epipactis gigantea
Poaceae
Bromus ciliatus
Bromus diandrus
Calamagrostis scopulorum 26
Elymus glaucus
Muhlenbergia andina
Achnatherum hymenoides
Pteridaceae
Adiantum capillus-veneris 8
Primulaceae
Dodecatheon pulchellum var. *zionense* 13
Ranunculaceae
Aquilegia chrysantha 1
Aquilegia formosa var. *formosa*
Clematis ligusticifolia T
Rosaceae
Petrophytum caespitosum
Scrophulariaceae
Mimulus cardinalis T
Vitaceae
Vitis arizonica 3

ZION Pine Creek HG R = 6
Asteraceae
Herrickia glauca var. *glauca* 8
Solidago velutina subsp. *sparsiflora*
Poaceae
Calamagrostis scopulorum
Poa fendleriana
Pteridaceae
Adiantum capillus-veneris
Primulaceae
Dodecatheon pulchellum var. *zionense* 6

ZION Snail HG R = 13
Anacardiaceae
Toxicodendron rydbergii
Asteraceae
Herrickia glauca var. *glauca*
Liliaceae
Maianthemum stellatum T
Oleaceae
Fraxinus velutina
Orchidaceae
Epipactis gigantea
Poaceae
Bromus ciliatus
Calamagrostis scopulorum 15
Polypogon viridis
Pteridaceae
Adiantum capillus-veneris 32
Ranunculaceae
Aquilegia chrysantha 1
Rosaceae
Petrophytum caespitosum
Rubiaceae
Galium aparine var. *echinospermum*
Scrophulariaceae
Mimulus cardinalis

ZION Trail's End HG R = 13
Asteraceae
Cirsium arizonicum var. *arizonicum*
Sonchus arvensis
Sonchus asper
Berberidaceae
Berberis repens 1
Liliaceae
Maianthemum stellatum 3
Orchidaceae
Epipactis gigantea
Poaceae
Bromus diandrus
Calamagrostis scopulorum 15
Pteridaceae
Adiantum capillus-veneris 19
Primulaceae
Dodecatheon pulchellum var. *zionense* 12
Ranunculaceae
Aquilegia chrysantha
Scrophulariaceae
Mimulus cardinalis
Vitaceae
Vitis arizonica

ZION Upper Emerald HG R = 33
Anacardiaceae
Toxicodendron rydbergii 2
Apiaceae
Angelica pinnata T
Apocynaceae
Apocynum cannabinum 3
Asclepiadaceae
Asclepias hallii
Asclepias speciosa
Asteraceae
Artemisia ludoviciana subsp. *ludoviciana*
Cirsium sp. T
Brickellia grandiflora
Sonchus arvensis
Sonchus asper
Berberidaceae
Berberis repens
Cyperaceae 3
Carex aurea
Carex curatorum
Equisetaceae
Equisetum arvense
Liliaceae
Maianthemum stellatum 20
Oleaceae
Fraxinus velutina 1
Onagraceae
Oenothera longissima
Orchidaceae
Epipactis gigantea T
Poaceae
Bromus tectorum
Calamagrostis scopulorum 20
Elymus canadensis 3
Muhlenbergia andina 1
Poa pratensis
Pteridaceae
Adiantum capillus-veneris
Primulaceae
Dodecatheon pulchellum var. *zionense* 20
Ranunculaceae
Aquilegia chrysantha T
Aquilegia formosa var. *formosa*
Rosaceae
Petrophytum caespitosum
Saxifragaceae
Heuchera rubescens
Scrophulariaceae
Mimulus cardinalis

Mimulus guttatus
Violaceae
Viola sp. 3
Vitaceae
Vitis arizonica

ZION Weeping Rock HG
$\underline{R} = 28$

Apocynaceae
Apocynum cannabinum 1
Asteraceae
Artemisia ludoviciana subsp. *ludoviciana* 1
Cirsium arizonicum var. arizonicum
Berberidaceae
Berberis repens
Cyperaceae 7
Carex aurea
Carex curatorum
Fagaceae
Quercus gambelii
Quercus turbinella
Liliaceae
Maianthemum stellatum 7
Linaceae
Linum lewisii
Oleaceae
Fraxinus velutina
Poaceae
Bromus diandrus T
Calamagrostis scopulorum 18
Muhlenbergia thurberi
Panicum sp.
Phragmites australis 2
Polypogon interruptus 8
Pteridaceae
Adiantum capillus-veneris 7
Primulaceae
Dodecatheon pulchellum var. *zionense* 2
Ranunculaceae
Aquilegia chrysantha 7
Aquilegia formosa var. *formosa*
Clematis ligusticifolia
Rosaceae
Petrophytum caespitosum 1
Rubiaceae
Galium multiflorum var. *multiflorum*
Scrophulariaceae
Mimulus cardinalis 30
Tamaricaceae
Tamarix ramosissima
Ulmaceae
Celtis reticulata
Violaceae
Viola sp. T

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[1]**possibly** *Andropogon glomeratus*; **vegetative sample**

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BOOK NOTICES

RAY F. EVERT WITH CONTRIBUTIONS BY SUSAN E. EICHHORN. 2006. **Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function, and Development, 3rd Edition.** (ISBN 978-0-471-73843-5, hbk). John Wiley & Sons Inc., One Wiley Drive, Somerset, NJ 08875, U.S.A. (**Orders:** www.wiley.com, 877-762-2974, 1-800-597-3299 fax). $159.95, 624 pp., b/w photos, line drawings, 8¼" × 11¼".

This is a complete redo of Esau's second edition, which is hardly recognizable except for the general organization of the chapters. The last few chapters of edition 2 (Stem, Leaf, Root, Flower, Fruit, Seed) are gone, having been integrated into earlier discussion or in part probably relegated to treatments of plant "morphology." The format is modern and easily readable—with excellent illustrations. "A major goal of this book is to provide a firm foundation in the meristems, cells, and tissues of the plant body, while at the same time noting some of the many advances being made in our understanding of their function and development through molecular research. ... [It has been] planned primarily for advanced students in various branches of plant science, for researchers (from molecular to whole plant), and for teachers of plant anatomy."

General References include: **1)** Structure and Development of the Plant Body—An Overview. **2)** The Protoplast: Plasma Membrane, Nucleus, and Cytoplasmic Organelles. **3)** The Protoplast: Endomembrane System, Secretory Pathways, Cytoskeleton, and Stored Compounds. **4)** Cell Wall. **5)** Meristems and Differentiation. **6)** Apical Meristems. **7)** Parenchyma and Collenchyma. **8)** Sclerenchyma. **9)** Epidermis. **10)** Xylem: Cell Types and Developmental Aspects. **11)** Xylem: Secondary Xylem and Variations in Wood Structure. **12)** Vascular Cambium. **13)** Phloem: Cell Types and Developmental Aspects. **14)** Phloem: Secondary Phloem and Variations in Its Structure. **15)** Periderm. **16)** External Secretory Structures. **17)** Internal Secretory Structures. Addendum: other pertinent references not cited in the text. Glossary; Author Index; Subject Index.

It's remarkable to see a new text for plant anatomy, as several recent publications have risen and relatively quickly gone out of press. But in addition to Esau's classics and Evert's revision, those below are apparently now available.

Dickison, W.C. 2000. *Integrative plant anatomy.* Harcourt/Academic Press. (hardback)

Fahn, A. 1990. *Plant Anatomy* (ed. 4). (587 pages) Pergamon Press, Oxford. (used paperback on Amazon)

Mauseth, J.D. 1988. *Plant Anatomy.* (560 pages). Benjamin/Cummings. Menlo Park, California. (paperback on Amazon.com)

—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

DAVID AND SHIRLEY BASSETT. 2007. **Delphiniums.** (ISBN 978-0-88192-800-6, hbk.). Timber Press Inc., The Haseltine Building, 133 SW Second Avenue, Suite 450, Portland, OR 97204-3527, U.S.A. (**Orders:** www.timberpress.com, 503-227-2878, 503-227-3070 fax, 1-800-327-5680). $29.95, 160 pp., 80 color photos, 7½" × 9¾".

This is a beautifully done book about delphiniums (*Delphinium*) and larkspurs (*Consolida*), mostly from the perspective of their use as garden plants. *Delphinium* includes about 300 species (mostly perennial) primarily in the northern Hemisphere; *Consolida* includes about 40 species (mostly annual). The inherent native diversity along with several hundred years of intensive cultivation have provided a huge diversity in flower form and color (purple, blue, red, pink, white, yellow) and plant habit.

The book is divided into two parts: **1)** Knowing Delphiniums (Introducing D; A survey of wild D; D in cultivation; Breeding D). **2)** Growing Delphiniums (D in the Garden; Cultivation of D; D propagation; Growing D in containers; Pests and diseases; Hybridizing D; Growing species).—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

PETER GOLDBLATT AND DALE E. JOHNSON (eds.). 2006. **Index to Plant Chromosome Numbers: 2001-2003.** (ISBN 978-1-930723-54-2, pbk.). Missouri Botanical Garden Press, P.O. Box 299, Saint Louis, MO 63166-0299, U.S.A. (**Orders:** www.mbgpress.org, orders@mbgpress.org, 314-577-9547, 314-577-9594 fax). $40.00, 242 pp., 7" × 10".

The latest summary in this invaluable series of chromosome counts of naturally occurring and cultivated plants, taken from publications throughout the world. Counts for this volume were extracted from 238 serials. Reviewers are from the Missouri Botanical Garden, University of North Carolina, Hiroshima University, Komarov Botanical Institute, Royal Botanic Gardens (Kew), and the University of Istanbul. "Chromosome counts for bryophytes and vascular plants published in the IPCN (from 1975 onward) may be accessed through the Missouri Botanical Garden's w^{3}TROPICOS at the Garden's website, *www.mobot.org.*" The counts from 2001-2003 had not been posted to the online index, as of 15 June, 2007.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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THE VASCULAR FLORA OF THE HANCOCK BIOLOGICAL STATION, MURRAY STATE UNIVERSITY, CALLOWAY COUNTY, KENTUCKY

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ABSTRACT

The vascular flora of the Hancock Biological Station, Murray State University, was surveyed throughout the growing seasons of 1998–1999 and during June 2000, 2001, 2002, and 2006. The 37.5-ha tract lies 23 km from Murray, Kentucky, in northeastern Calloway County contiguous to Kenlake State Resort Park to the north and adjoins the Kentucky Lake shoreline to the east. The study site is situated within the Jackson Purchase of western Kentucky. Vegetation is predominately upland dry and dry-mesic oak-hickory forest. Burned warm-season grassland, early to mid-successional areas, culturally-disturbed areas, and wetland areas are other diverse habitats. Vascular plants consist of 573 specific and infraspecific taxa in 334 genera from 121 families. A total of 469 are native and 104 are exotic species. Of the exotics, 47 are Kentucky invasive pest plant species. Taxonomic representations are one Lycopodiophyta, one Equisetophyta, eight Polypodiophyta, four Pinophyta, and 559 Magnoliophyta.

Key Words: Hancock Biological Station, vascular flora, habitats, oak-hickory forest, field station; invasive exotics, Kentucky Lake

RESUMEN

La flora vascular del Centro Biológico Hancock de la Universidad Estatal de Murray se estudió durante las temporadas de crecimiento de 1998–1999 y durante junio de 2000, 2001, 2002, y 2006. El terreno de 37,5 hectáreas está ubicado a 23 kilómetros de Murray, Kentucky en la parte noreste del condado de Calloway contiguo al centro recreativo Kenlake State Resort Park hacia el norte y junto a la ribera del lago Kentucky hacia el este. El terreno que se ha investigado está situado dentro del Jackson Purchase del oeste de Kentucky. La vegetación que predomina es el bosque seco-húmedo de roble-nogal americano de las tierras altas. Paraderas quemadas en la estación templada, áreas de sucesión temprana o mediana, áreas afectadas por cultivos y áreas húmedas son otros de los hábitats. Las plantas vasculares son 573 grupos taxonómicos específicos e infraespecíficos de 334 géneros de 121 familias. Un total de 469 son nativas y 104 son especies exóticas. De las exóticas, 47 son especies de plantas invasoras en Kentucky. Representaciones taxonómicas son una Lycopodiophyta, una Equisetophyta, ocho Polypodiophyta, cuatro Pinophyta y 559 Magnoliophyta.

INTRODUCTION

Hancock Biological Station (HBS), a 37.5-hectare tract of upland Oak-Hickory Forest adjacent to Kentucky Lake, is the biological field station of Murray State University, Murray, Kentucky (Fig. 1). HBS is a member of the Organization of Biological Field Stations, a consortium of 220 biological field stations in North America (OBFS 2006) and a member of the Association of Ecosystems Research Centers. HBS was founded in 1966 through the efforts of Hunter M. Hancock, former Murray State University professor and chair of the Department of Biological Sciences (White 2002). Since 1972, HBS has served as a year-round facility for aquatic and terrestrial biology research and service programs, and it has presented students with opportunities for field classes, independent research, and faculty-directed undergraduate and graduate research (White 2002).

In the early 1980s, HBS and the Land Between the Lakes (LBL) were designated as an Experimental Ecological Reserve by the National Science Foundation and the Institute of Ecology. As an Experimental Ecological Reserve, HBS and LBL serve as an important natural system for long-term ecological research (White 2002). HBS currently serves as the primary field research facility for the Center for Reservoir Research (CRR) established in 1987 by the Commonwealth of Kentucky. Among the CRR's goals is the improvement in knowledge needed to manage, protect, and preserve the environmental quality of reservoir resources. The CRR has become nationally recognized in basic and applied aquatic research and education by providing facilities and a permanent research technical staff (White 2002).

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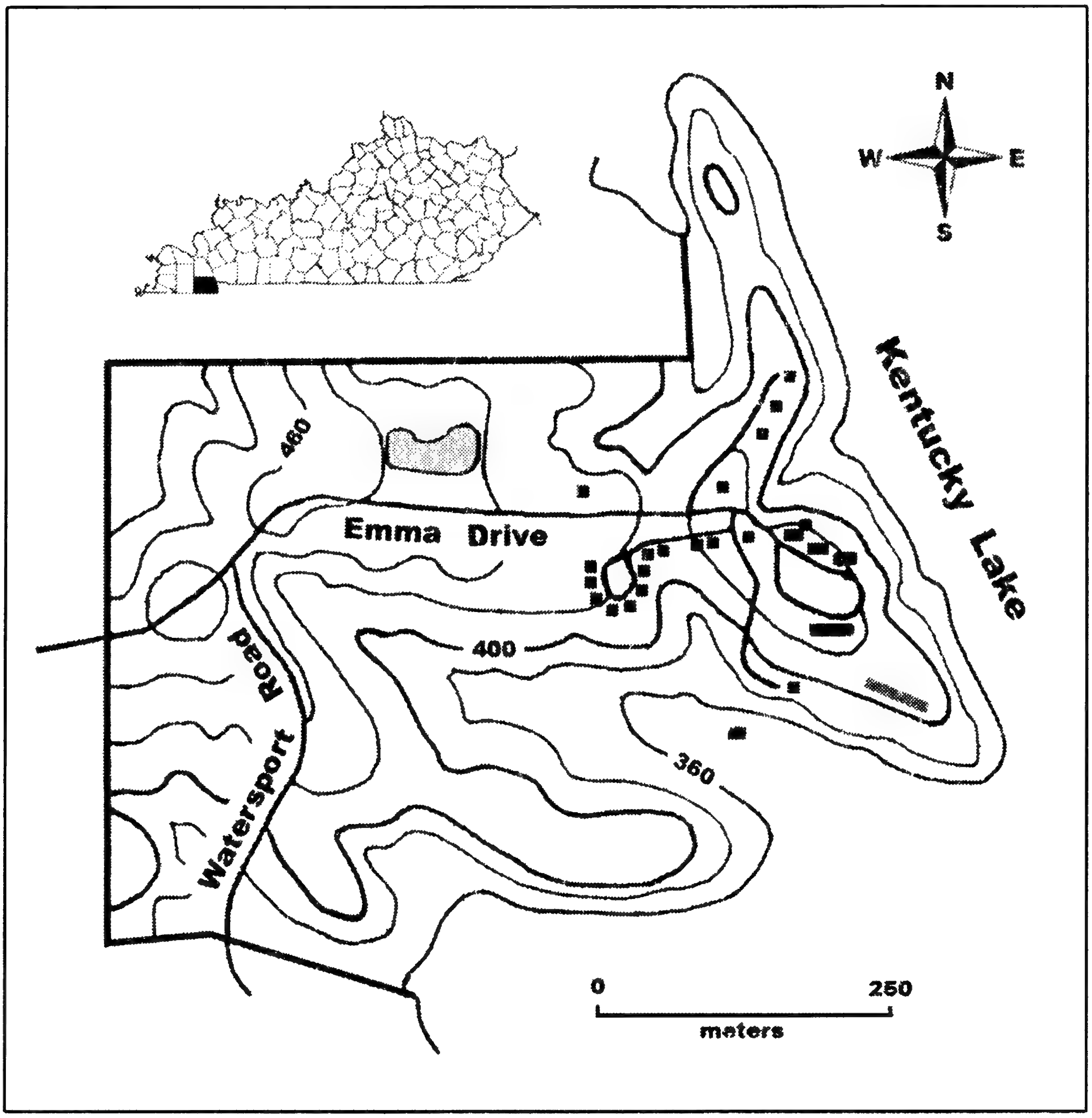

Fig. 1. Hancock Biological Station, Calloway County, Kentucky, on Kentucky Lake. Adapted from the Rushing Creek Quadrangle, 7.5 minute topographic series, 1950, United States Geological Survey, Washington, D.C., and Mid-America Remote Sensing Center (2003a).

To further serve education, in the mid-1980s the Ecological Consortium of Mid-America (ECOMA) was formed among several colleges and universities. The purposes of ECOMA were to utilize the HBS facilities, the LBL resources, and the Kentucky Lake-Barkley Lake complex in undergraduate and graduate teaching, to facilitate service programs, and to serve as a base of operation for field trips and research throughout the year (White 2002).

The Hancock Biological Station was one of five major collection sites for a master's thesis of the vascular flora of Calloway County by Woods (1983). After additional collections were added to the Murray State University Herbarium, the vascular flora of Calloway County was published by Woods and Fuller (1988). To do a thorough floristic survey of just HBS, the objectives of the current descriptive study were to 1) document the HBS vascular flora with voucher specimens, 2) depict the physical site, 3) describe the plant habitats, and 4) present a complete annotated list of the vascular plants with origins, habitats, and relative abundance values.

THE STUDY SITE

History and Facilities

Hancock Biological Station lies between latitudes 36°44’24” and 36°44’00” N and between longitudes 88°07’30” and 88°06’52”W within the 7.5-minute series Rushing Creek Quadrangle (Fig. 1). Prior to the 1920s, the oak-hickory forests west of the Tennessee River were completely harvested with much of the wood used as fuel for the iron furnaces in the LBL region. Through the 1940s, a large floodplain existed on the west bank of the Tennessee River in front of the present station, and most of the terrain in the uplands was pastures, cultivated fields, or scattered woodlands. The completion of Kentucky Dam on the Tennessee River in 1944 formed Kentucky Lake and impounded much of the upland terrain. In the past 80 years, the present vegetation has evolved from a combination of secondary forest succession and human activities that have limited natural habitats at HBS through the creation of Kentucky Lake .

In 1966, the original station grounds consisted of 16.2 ha of abandoned fields, pastures, and oak-hickory forest stands to the south of Kenlake State Resort Park. An agreement in the late 1960s between Murray State University and the Tennessee Valley Authority (TVA) provided an additional 13.3 ha of land from the 114 m TVA boundary upward. In 1988, Kenlake State Resort Park transferred an additional 8.0 ha to HBS (White 2002). The total HBS tract is currently estimated at 37.5 ha.

HBS facilities currently consist of 26 buildings. Facilities include the main laboratory and classroom building, glasshouse/mesocosm building, a resource building, boat house, bath house, 15 student cabins, four faculty cabins, maintenance shop, and well house, as well as a picnic area and wastewater wetland complex (Fig. 2). The station is reached at the end of the asphalt-paved Emma Drive that leads to Lancaster Road, KY 497, and then to KY 94. Watersport Road leads from the Pacer Point Recreation Area, passes through the western portion of the HBS property, and connects with Emma Drive. Elevation at HBS ranges from 107.9 m at the Kentucky Lake shoreline to the 114.3 m Tennessee Valley Authority boundary to a 143 m ridge crest just west of the junction of Emma Drive and Watersport Road (Fig. 1).

Physiography

HBS is located in the Jackson Purchase or the Mississippi Embayment Section of the East Gulf Coastal Plain based on Fenneman (1938). Keys et al. (1995) classified the area west of the Tennessee River (the Kentucky Lake impoundment) as belonging to the Deep Loess Hills and Bluffs Subsection of the Upper Gulf Coastal Plain Section of the Eastern Broadleaf Forest Province. Woods et al. (2002) designated the hilly terrain west of Kentucky Lake as a part of the Western Highland Rim extending eastward through the Tennessee River and Cumberland River Valleys.

Geology

The geology at the study site includes alluvium, loess, and cherty limestone bedrock of the Quaternary, Cretaceous, and Mississippian Carboniferous Series (Seeland and Wilshire 1965; Fig. 3). The exposed flattened ridges and rolling hills are covered with unstratified, clayey, silty loess from the Quaternary Pleistocene that covers continental sand and gravel deposits. Sand, gravel, and clay of the Upper Cretaceous McNairy Formation are found in the southwestern corner of HBS. In a small area by Kentucky Lake, gravel, clay, and clayey silts of the Upper Cretaceous Tuscaloosa Formation overlie Mississippian bedrock. Thick-bedded cherty limestone of the Mississippian Warsaw Limestone Formation is in the extreme northwestern part of the boundary. The largest amount of bedrock at HBS is composed of cherty, fine-grained limestone of the Mississippian Fort Payne Formation. The Fort Payne System bedrock is exposed along the steep cliff line at Kentucky Lake. Quaternary Pleistocene and Recent alluvium comprised of silt, sand, and stratified cherty gravel is found in three lowland valley coves adjacent to Kentucky Lake (Fig. 3).

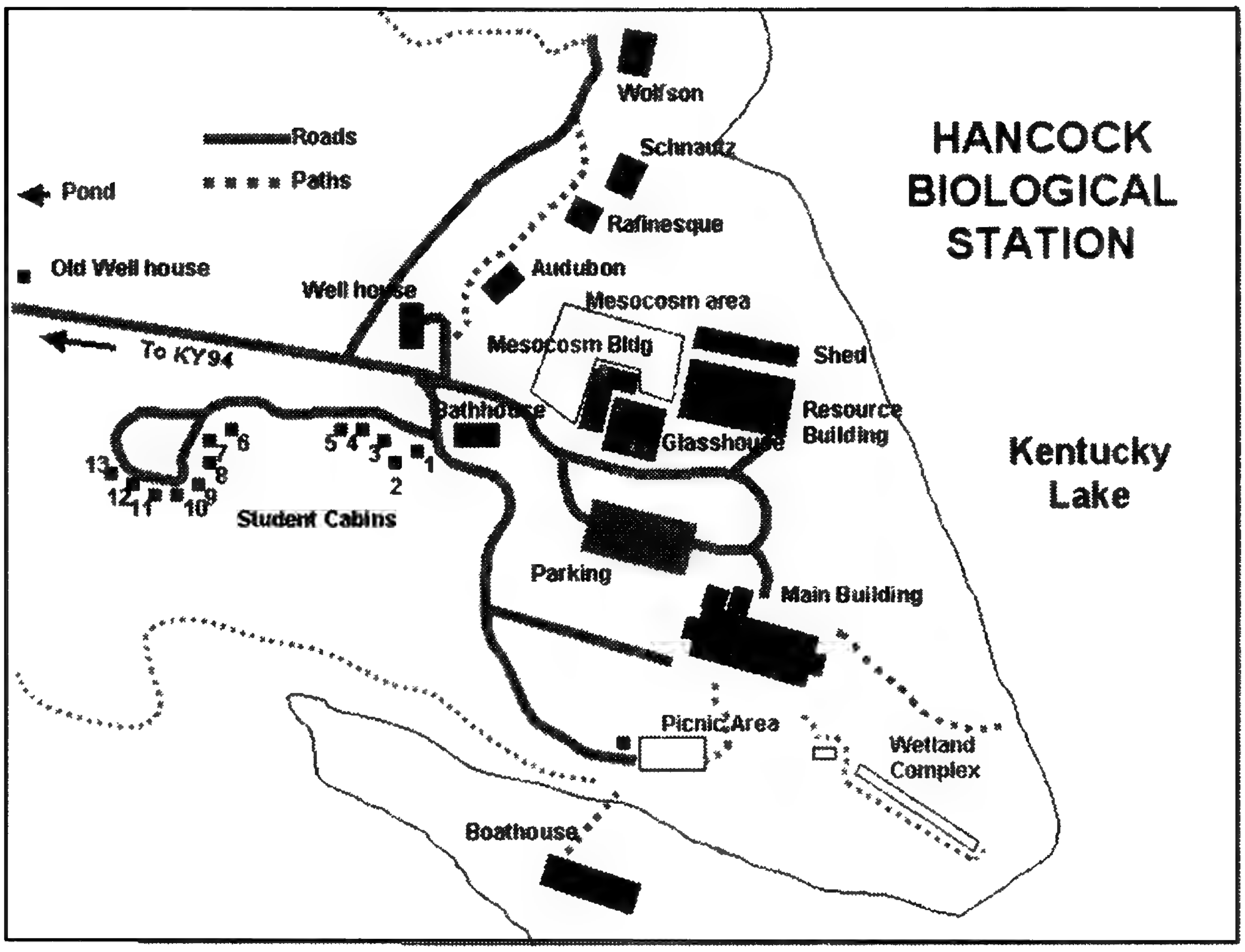

Fig. 2. The physical site facilities of the Hancock Biological Station, directly from http://www.mursuky.edu/hbs (Murray State University 2006). (Map not to scale). See Figure 1 for facilities location on the property

Soils

The principal soil association of HBS and vicinity is the Bodine-Brandon Association (Humphrey et al. 1973; Fig. 4). This soil association predominates on steep to sloping, well-drained to excessively drained, silty cherty uplands. Bodine series are acid to strongly acid (4.5–5.0 pH), well-drained or excessively drained residual cherty limestone soils from the Warsaw Limestone and Fort Payne Formations. These soils are located on 12–60 percent upper to middle slopes and side slopes leading to the Kentucky Lake shoreline. Bodine topsoils are brown cherty silt loams to 13 cm and subsoils are yellowish-brown, cherty silty loams from 15–57 cm, and yellowish-red, very cherty, silty clay loams from 58–157 cm deep. The Brandon series occupy 6–30 percent rolling upper elevation side slopes and flattened ridges at HBS (Fig. 4). These soils are acid to strongly acid (4.5–5.5 pH), well-drained, and are developed in 0.6–1.2 m of loess. Brandon topsoils consist of brown silty loams to 24 cm deep, subsoils of yellowish-red silty clay loams from 25–69 cm, and Coastal Plain gravelly brown loams from 71–127 cm in depth (Humphrey et al. 1973).

A thin band of Saffell series lies between Bodine and Brandon soils on a ridge with 6–12 percent slopes in the west central portion of HBS. Saffell topsoils are acid to strongly acid (4.5–5.5 pH), well–drained, yellowish-brown, very gravelly silt loams 25 cm deep. The subsoils are yellowish-red gravelly loams from 26–88 cm and very gravelly brown sandy loams from 90–150 cm. The Ochlockonee series lies on the 0–4 percent sloping alluvial valley floodplain in the southernmost part of the study site near Pacer Point Recreation Area. Ochlockonee topsoils are strongly acid (5.1–5.5 pH), well-drained, brown silt loams to 18 cm. Subsoils are

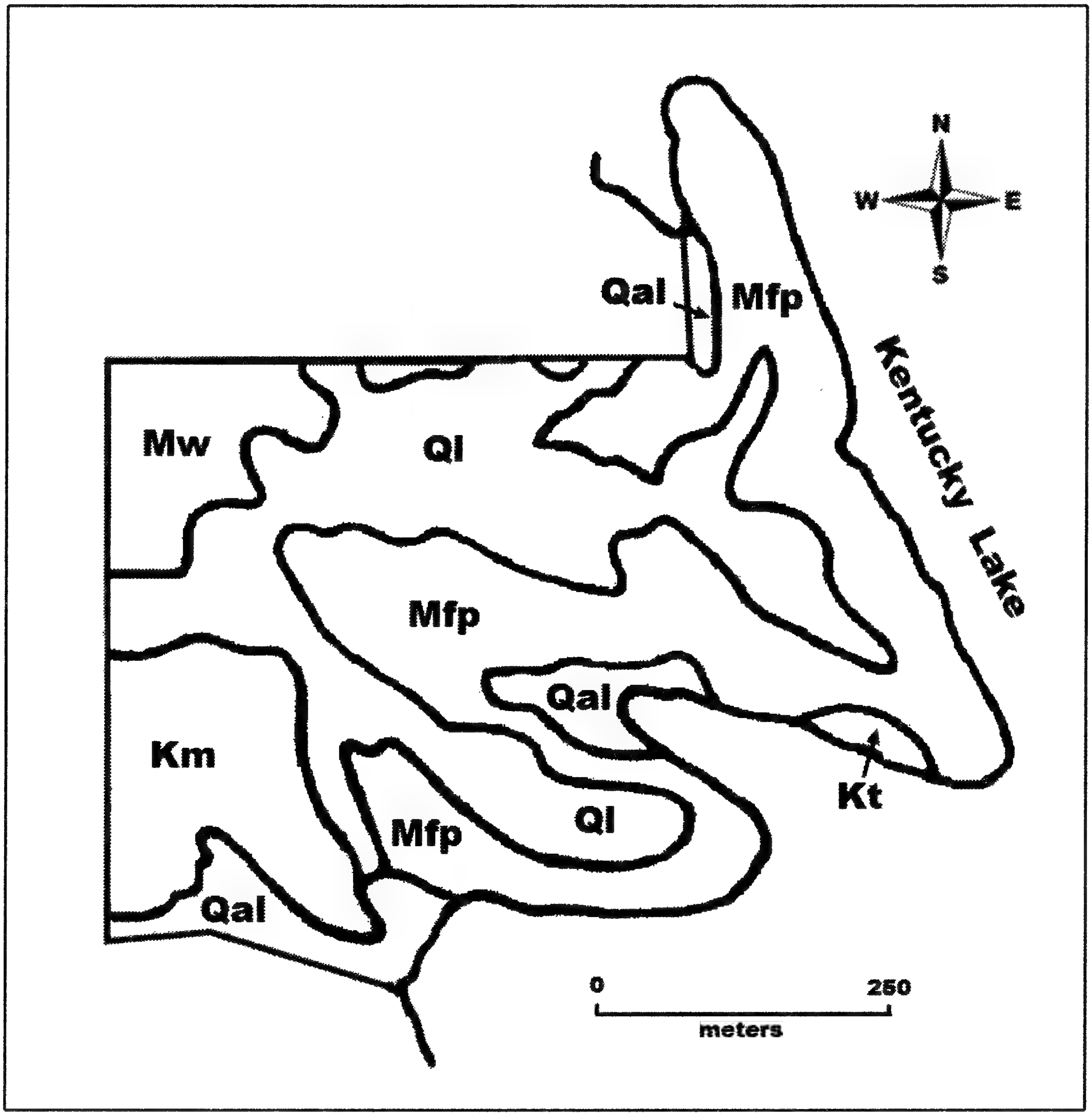

Fig. 3. Geology of the Hancock Biological Station. Modified from Seeland, D.A. and H.G. Wilshire (1965) and Mid-America Remote Sensing Center (2003b). Geology code: Qal = Quaternary alluvium; Ql = Quaternary loess; Km = Upper Cretaceous McNairy Formation; Kt = Upper Cretaceous Tuscalossa Formation; Mw = Mississippian Warsaw Limestone; Mfp = Mississippian Fort Payne Formation.

brown sandy loams from 18–89 cm and gravelly sandy loams from 90–127 cm in depth (Humphrey et al. 1973).

Vegetation

The forest vegetation in the Jackson Purchase is predominantly Oak-Hickory Forest (Küchler 1964; Bryant and Held 2001; Woods et al. 2002). Braun (1950) included the Jackson Purchase (Mississippi Embayment Section) in her Western Mesophytic Forest Region based on the mixed mesophytic vegetation composition of the western loess bluffs. Braun (1950) noted that she would have placed the vegetation in her Oak-Hickory Forest Region except for these western loess bluffs. The forest vegetation of Hancock Biological Station is currently a mixture of dry oak-hickory forest and dry-mesic oak-hickory forest (Fig. 5).

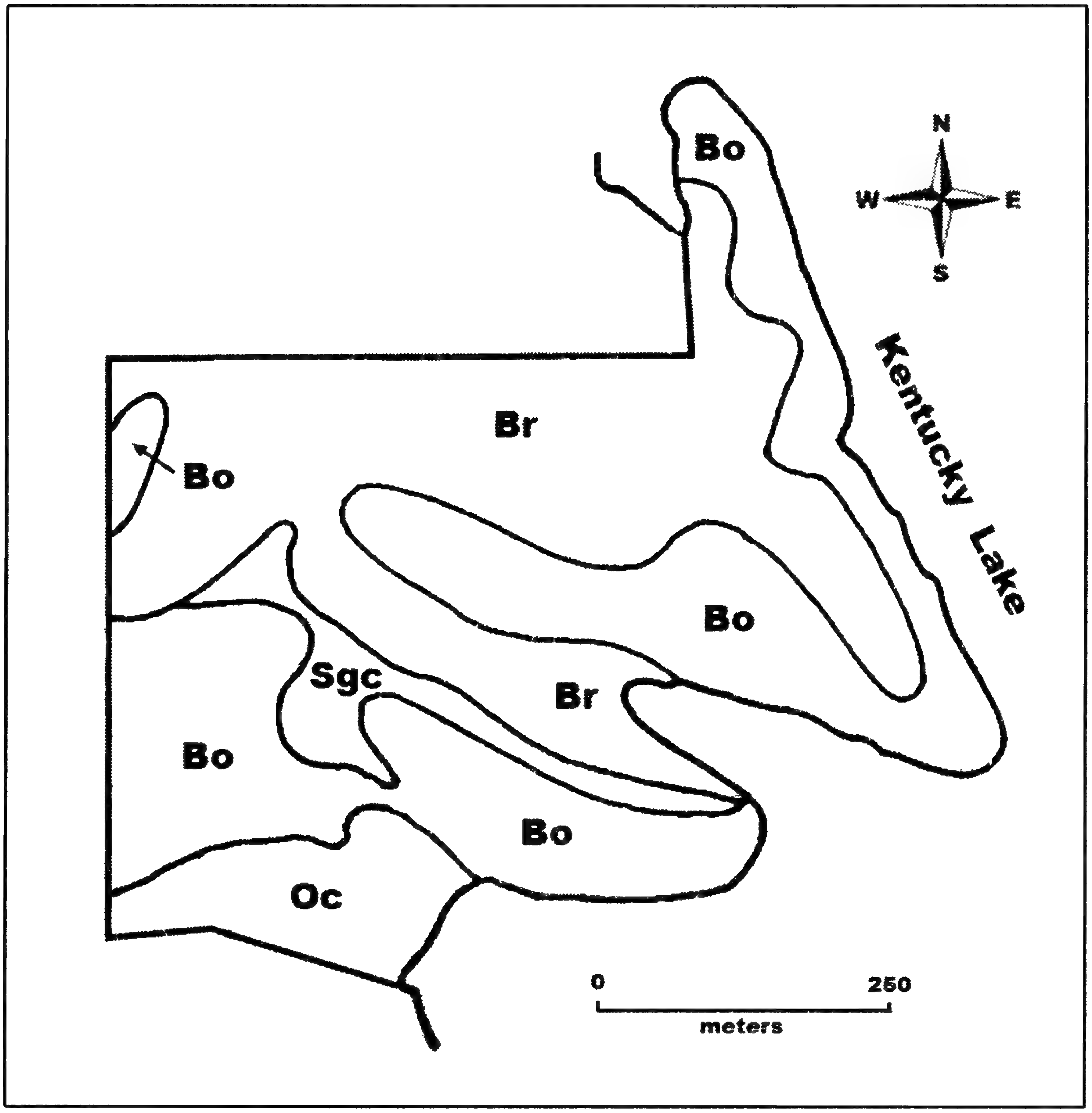

Fig. 4. Soils of the Hancock Biological Station. Modified from Humphrey et al. (1973) and Mid-America Remote Sensing Center (2003c). Soil code: Bo = Bodine cherty silt loams, 12–60% slopes; Br = Brandon silt loam, 6–30% slopes; Oc = Ochlockonee gravelly loams, 0–4% slopes; Sgc = Saffell very gravelly silt loams, 6–12% slopes.

Climate

Climate of the Jackson Purchase is a humid temperate continental type characterized by warm to hot summers and cool to moderately cold winters. Climatic data (1971–2000) are from the United States Department of Agriculture, Forest Service Weather Station at Golden Pond, 13 km east-northeast from HBS. The mean annual temperature is 14.9° C. January is the coldest month at 1.2° C, and July is the warmest month at 26.0° C. The length of the growing season averages 209 days from the median first frost on October 27 to the median last freeze on April 6. Mean annual precipitation is 127 cm and is fairly well distributed throughout the year. August is the driest month at 8.1 cm of precipitation and December is the wettest at 12.9 cm. The mean annual snowfall in January, February, and March is 10.8 cm (Kentucky Climate Center 2006).

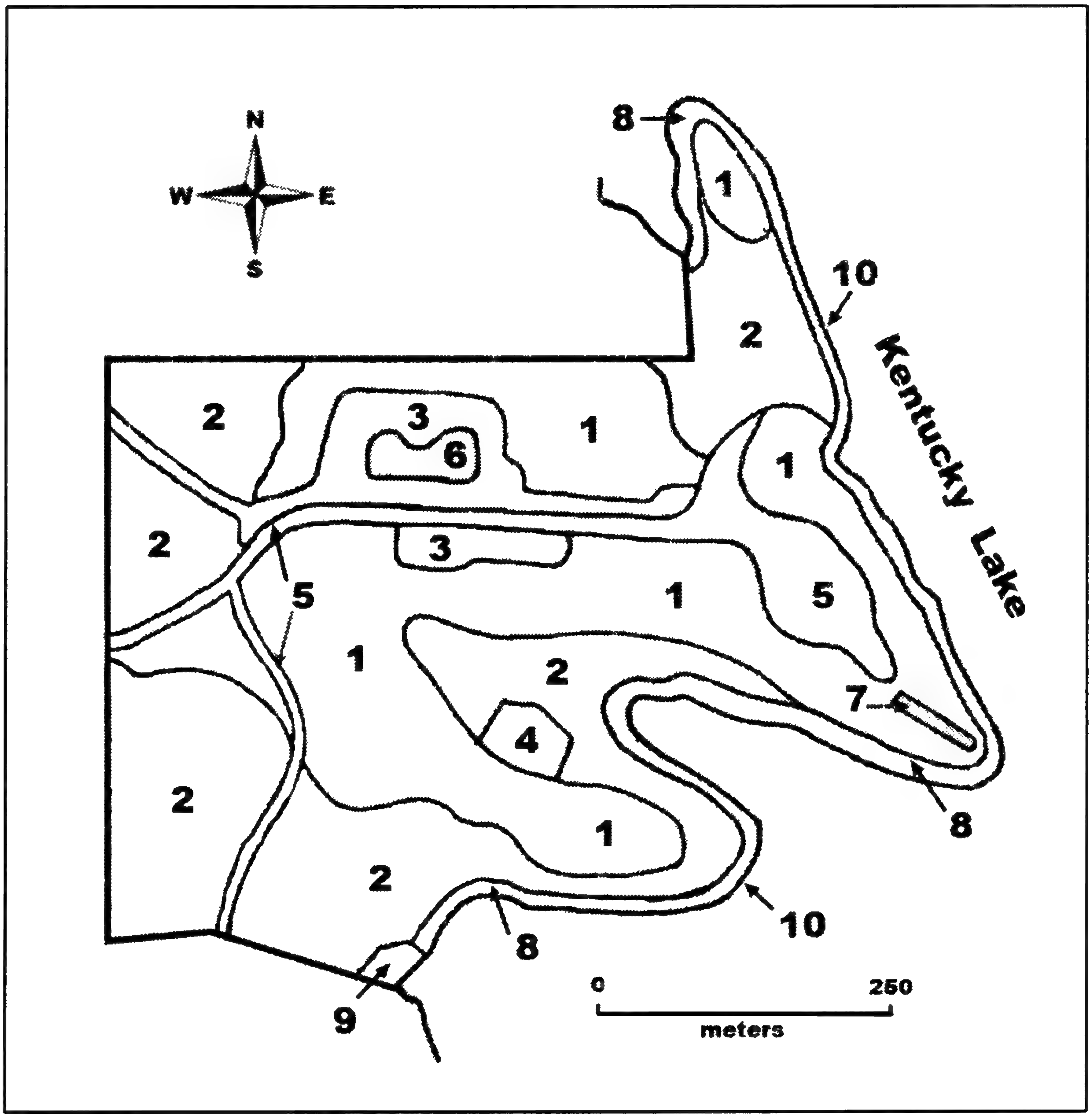

Fig. 5. Habitats of the Hancock Biological Station. Habitat code: 1 = dry oak-hickory forest, 2 = dry-mesic oak-hickory forest, 3 = upland early and mid-successional areas, 4 = burned old-field warm season grassland, 5 = culturally disturbed areas, 6 = pond and roadside ditches, 7 = wetland complex, 8 = riparian forest, 9 = emergent marsh and wetland meadow, 10 = seasonal dewatered shoreline.

METHODS

A floristic survey was conducted during the growing seasons from March–November 1998 and 1999 with additional collections in June 2000, 2001, 2002, and 2006. Vascular plants were identified using Mohlenbrock (1986), Gleason and Cronquist (1991), and Jones (2005). Arrangement of families and nomenclature follows Jones (2005). Vernacular names are derived from a combination of Jones (2005) and USDA, NRCS (2006). Plants were collected in duplicate with the master set deposited into the Berea College Herbarium (BEREA) and the second set placed in the herbarium of Hancock Biological Station, a part of the Murray State University Herbarium (MUR). Plant habitats were delineated through field reconnaissance and field collections in conjunction with topographic-moisture features, soil type, underlying geology, vegetation (dominant and associated species of the canopy, subcanopy, shrub, and herbaceous layers), and anthropogenic disturbances.

A relative abundance value is assigned each taxon inclusive throughout all HBS habitats. Relative abundance categories modified from Thompson and Poindexter (2006) are Rare—1 to 4 individuals or colonies, Scarce—5 to 10 individuals or colonies, Infrequent—11 to 30 individuals or colonies, Occasional—31 to 100 individuals, Frequent—101 to 1000 individuals or colonies, and Abundant—1000s of individuals or colonies.

RESULTS AND DISCUSSION

Taxonomic Summary

The annotated list from the boundaries of HBS includes 573 specific and infraspecific taxa in 334 genera from 121 families (Table 1). Taxonomic representation is one Lycopodiophyta, one Equisetophyta, eight Polypodiophyta, four Pinophyta, and 559 Magnoliophyta (411 Magnoliopsida and 148 Liliopsida). A total of 104 (18.2 %) were exotic taxa (Table 1). Thirty species, native or exotic, were deliberately planted on the study site. The largest families in species richness are Asteraceae (72), Poaceae (68), Fabaceae (41), Cyperaceae (36), Lamiaceae (21), Rosaceae (17), and Scrophulariaceae (16). The largest genera are *Carex* (20), *Quercus* (11), *Dichanthelium* (10), *Juncus* (8), *Lespedeza* (8), *Polygonum* (8), and *Hypericum* (7). One hundred-five are woody plants (64 trees, 22 shrubs, and 19 vines), and 468 are herbaceous plants (148 annuals, 17 biennials, and 303 perennials).

Woods (1983) listed 912 species, 428 genera, and 119 families from his M.S. thesis on the vascular flora of Calloway County. After more collections, Woods and Fuller (1988) increased the number to 1018 species, 462 genera, and 129 families. In this study at HBS, 573 specific and infraspecific taxa account for 56.3% of the total Calloway County flora based on Woods and Fuller (1988). This number also comprises 22.0% of the 2600 known vascular plant species of Kentucky based on Jones (2005).

Thirty-nine new Calloway County records were documented in the present study from a search of MUR, the vascular plant atlas of Campbell et al. (2006), and the distribution maps from the USDA, NRCS (2006). *Trepocarpus aethusae*, occasional in relative abundance along the Kentucky Lake shoreline, was state-listed "Threatened" in 2000 (KSNPC 2000) and state-listed "Special concern" in 2005 (KSNPC 2006). *Aphanes microcarpa*, an exotic European annual, was first documented in Kentucky from Madison County (Abbott et al. 2001). The collection from HBS is the second county recorded for Kentucky.

Invasive Exotic Species

In Kentucky, 94 invasive exotic plants belong to the "severe threat" (29 species), "significant threat" (33 species), and "lesser threat" (32 species) classifications (Kentucky Exotic Pest Plant Council 2000). The 104 naturalized species at Hancock Biological Station have a definite impact upon the native flora, vegetation, and habitats. Forty-seven (45.2%) of the 104 exotics are invasive pest plants. Twenty-nine species (27.9%) belong to the "severe threat" (14 species) and "significant threat" (15 species) categories. Several of these invasive exotics have become naturalized on the Hancock premises thorough deliberate plantings.

The most notable "severe threat" exotics affecting HBS native vegetation are the abundant and widespread *Festuca arundinacea*, *Lespedeza cuneata*, *Lonicera japonica*, and *Microstegium vimineum*. Among other "severe threat" taxa are *Coronilla varia*, *Elaeagnus umbellata*, *Ligustrum sinense*, *Rosa multiflora*, *Sorghum halepense*, and *Stellaria media*. "Significant threat" exotics include *Daucus carota*, *Eleusine indica*, *Glechoma hederacea*, *Hedera helix*, *Lespedeza stipulacea*, *L. striata*, *Poa pratensis*, *Polygonum caespitosum*, *P. persicaria*, *Seteria faberi*, and *Vinca minor*. The 104 exotic species will continue to have deleterious effects of displacing and replacing native species, disrupting nutrient cycles, and changing the pattern of plant succession.

Plant Habitats

Hancock Biological Station is delineated into 10 habitats: five terrestrial and five wetland. Terrestrial habitats are dry oak-hickory forest, dry-mesic oak-hickory forest, upland early and mid-successional areas, burned old field warm-season grassland, and culturally disturbed areas (Fig. 5). The dry oak-hickory and dry-mesic

Table 1. Taxonomic distribution of vascular plants at the Hancock Biological Station, Kentucky.

Division	**Families**	**Genera**	**Species**	**Native**	**Exotic**	**Percent Species Composition**
Equisetophyta	1	1	1	1	0	0.17
Lycopodiophyta	1	1	1	1	0	0.17
Polypodiophyta	4	7	8	8	0	1.40
Pinophyta	3	3	4	4	0	0.70
Magnoliophyta	101	322	559	455	104	97.56
Magnoliopsida	87	248	411	337	74	71.73
Liliopsida	15	74	148	118	30	25.83
Totals:	121	334	573	469	104	100.00

oak-hickory forests are representative of the two types of oak-hickory forest in the Jackson Purchase Area described by Bryant and Held (2001).

The five wetland areas are pond and roadside ditches, wetland complex, riparian forest, emergent marsh and wetland meadow, and seasonally dewatered shoreline (Fig. 5). Transitional ecotones tend to exist between adjacent terrestrial and terrestrial, terrestrial and wetland, and wetland and wetland habitats. These 10 plant habitats are described and characteristic species or indicator species within each habitat are listed.

Dry oak-hickory forest.—The woody vegetation of open dry flat to rolling topography on southern and western trending upper slopes, ridge tops, and higher elevations is characterized by dry oak-hickory forest (Fig. 3). Forest soils include Bodine cherty silt loams covered by Quaternary loess and some areas of Brandon silt loams. *Quercus stellata*, *Q. marilandica*, *Q. falcata*, and *Carya glabra* are canopy indicator trees. Other important overstory trees include *Acer rubrum*, *Carya tomentosa*, *Nyssa sylvatica*, *Q. velutina*, and *Ulmus alata*. The understory layer is somewhat scrubby and sparse. Among the shrubs and small trees are *Amelanchier arborea*, *Vaccinium arboreum*, *V. stamineum*, and *Viburnum rufidulum*. A single clump of the hemiparasitic shrub, *Phoradendron leucarpum*, was observed in one *Carya glabra*. Woody vines include *Parthenocissus quinquefolia*, *Smilax bona-nox*, *S. glauca*, *Toxicodendron radicans*, and *Vitis aestivalis*.

Several native herbaceous perennials are found beneath the dry oak-hickory forest. Characteristic perennial herbs include *Antennaria plantaginifolia*, *Asplenium platyneuron*, *Aureolaria flava*, *Carex muehlenbergii*, *Comandra umbellata*, *Coreopsis major*, *Cunila origanoides*, *Danthonia spicata*, *Dichanthelium acuminatum*, *D. boscii*, *D. laxiflorum*, *Euphorbia corollata*, *Galium circaezans*, *Houstonia canadensis*, *Hypoxis hirsuta*, *Lechea tenuifolia*, *Orbexilum pedunculatum*, *Porteranthus stipulatus*, *Pteridium aquilinum* var. *latiusculum*, *Sericocarpus linifolius*, *Scutellaria parvula*, *Symphyotrichum patens*, *Tephrosia virginiana*, and *Viola pedata*. In certain exposed areas, fruticose lichens (*Cladina* spp. and *Cladonia* spp.) and cushiony mosses are abundant.

Dry-mesic oak-hickory forest.—These forest stands occur on more mesic, steeper northern, western and eastern trending middle to upper side slopes of shallow valleys and valley coves, and adjoin the Kentucky Lake shoreline (Fig. 5). Forest soils are Brandon silt loams from the Warsaw Limestone and the Fort Payne Formations. Topographic-moisture conditions, slope aspect, and soil types are extremely important in the transitional mosaic of dry-mesic oak-hickory forest to dry oak-hickory forest relative to species composition. A considerable intergradation of woody and herbaceous species exists between these two oak-hickory forest types. *Quercus alba* is the dominant canopy tree. Other indicator canopy trees of dry-mesic oak-hickory forest include *Quercus rubra*, *Q. velutina*, *Carya ovata*, *C. tomentosa*, *Acer rubrum*, *Fraxinus americana*, *Nyssa sylvatica*, *Prunus serotina*, and *Ulmus rubra*. *Diospyros virginiana*, *Juniperus virginiana*, *Morus rubra*, *Sassafras albidum*, and *Ulmus alata* are scattered in the stand. Subcanopy trees are *Cercis canadensis* and *Cornus florida*. Characteristic woody vines and shrubs are *Aralia spinosa*, *Asimina triloba*, *Parthenocissus quinquefolia*, *Rosa carolina*, *Smilax bona-nox*, *S. glauca*, *Staphylea trifolia*, *Toxicodendron radicans*, *Vaccinium stamineum*, *Vitis aestivalis*, and *V. rotundifolia*.

Many perennial herbs are especially evident during spring and summer. Characteristic herbs include *Anemonella thalictroides*, *Brachyelytrum erectum*, *Bromus pubescens*, *Desmodium nudiflorum*, *Dioscorea villosa*, *Galium triflorum*, *Luzula bulbosa*, *Scutellaria elliptica*, *Spigelia marilandica*, and *Viola palmata*. Other perennials of more mesic, shaded side slopes and valley bottoms are *Carex albicians*, *C. blanda*, *C. digitalis*, *Dentaria laciniata*, *Iris cristata*, *Maianthemum racemosum*, *Podophyllum peltatum*, *Polygonatum biflorum*, *Polystichum acrostichoides*, *Solidago caesia*, and *Uvularia sessilifolia*. Representative herbs of the three alluvial valley coves adjoining the riparian forest include *Boehmeria cylindrica*, *Carex grayi*, *C. typhina*, *Chasmanthium latifolium*, *Elymus virginicus*, *Iris virginica*, *Phegopteris hexagonoptera*, *Phryma leptostachya*, *Pilea pumila*, *Polygonum virginianum*, and the abundant "severe threat" *Microstegium vimineum*.

Upland early and mid-successional areas.—Most of the area in early and mid-successional stages have developed from a large abandoned pasture of native grasses, forbs, and dry woodland species. Shade intolerant, successional woody species are prevalent in the old pasture and the other disturbed habitats that include dry and dry-mesic oak-hickory forest edges, a narrow power line corridor-cut bordering Emma Drive, and a small 25 year old planted loblolly pine stand (Fig. 5). If succession continues without significant disturbance, these areas will progress toward an oak-dominated forest with a hickory component. Invading trees present are *Acer rubrum*, *Albizia julibrissin*, *Diospyros virginiana*, *Juniperus virginiana*, *Nyssa sylvatica*, *Sassafras albidum*, and *Ulmus alata*. The undergrowth is variable and ranges from sparse to densely vegetated areas. Characteristic successional shrubs include *Rhus copallina*, *R. glabra*, *Rosa setigera*, *Rubus argutus*, *R. flagellaris*, and *Symphoricarpos orbiculatus*. The ubiquitous woody vines are abundant *Lonicera japonica*, *Toxicodendron radicans*, and *Vitis rotundifolia*.

A combination of annuals, biennials, and perennials in the summer and fall aspects are present in the successional areas including several from the Asteraceae, Fabaceae, and Poaceae. Several tall grass prairie species are persisting in the old pasture. Characteristic species in these successional areas are *Ambrosia artemisiifolia*, *Andropogon virginicus*, *Daucus carota*, *Dichanthelium polyanthes*, *Diodia teres*, *Festuca arundinacea*, *Erigeron annuus*, *Eupatorium serotinum*, *Galium pilosum*, *Lespedeza cuneata*, *L. intermedia*, *L. procumbens*, *Monarda fistulosa*, *Pyncnanthemum tenuifolium*, *Potentilla simplex*, *Schizachyrium scoparium*, *Setaria parviflora*, *Solidago canadensis*, *Symphyotrichum dumosum*, *S. pilosum*, *Verbesina helianthoides*, and *Vernonia missurica*.

Burned old field warm season grassland.—This open dry habitat has several tall grass prairie species and forbs; but, it never was a part of the Midwestern Tall Grass Prairie Region. The habitat (1450 m^2) was initially derived from an abandoned field with upland dry forest soils, and it is now completely enclosed by dry and dry-mesic oak-hickory forest (Fig. 5). The habitat is representative of the warm season grassland barrens described for Land Between the Lakes by Martin and Taylor (2002). HBS personnel prescribed-burn the site every 1–2 years to preserve a non-forested or grassland habitat and to enhance the persisting warm season prairie elements. Secondary successional woody invaders suppressed by fire in the old field are *Acer rubrum*, *Diospyros virginiana*, *Juniperus virginiana*, *Liquidambar styraciflua*, *Liriodendron tulipifera*, *Nyssa sylvatica*, *Rhus copallina*, *R. glabra*, *Rubus argutus*, *Smilax bona-nox*, and *S. glauca*.

Species composition in this fire-maintained habitat is similar to the warm season grassland of the Elk and Bison Prairie of Land Between the Lakes National Recreation Area (Thompson and Poindexter 2006). Indicator species present are *Andropogon ternarius*, *Asclepias tuberosa*, *Carex hirsutella*, *Ceanothus americanus*, *Coreopsis major*, *Crotalaria sagittalis*, *Hypericum denticulatum*, *Euphorbia corollata*, *Linum medium* var. *texanum*, *Lobelia puberula*, *Parthenium integrifolium*, *Polygala sanguinea*, *P. ambigua*, *Pycnanthemum tenuifolium*, *Oenothera fruticosa*, *Rudbeckia hirta*, *Scleria pauciflora*, *S. triglomerata*, *Schizachyrium scoparium*, *Sorghastrum nutans*, *Stylosanthes biflora*, and *Tripsacum dactyloides*.

Culturally disturbed areas.—Anthropogenic-influenced habitats include the mowed irregular-shaped station yard, the mowed Emma Drive road shoulder, the Boy Scout trail, faculty cabins' trail, the ruderal graveled area around the glasshouse/mesocosm and the gravel roads to student cabins, Wolfson House, and boat house (Figs. 2, 5). Many exotic and native annuals and perennials have become established in these disturbed grassy and gravelly areas. The preeminent taxon is the "severe threat" *Festuca arundinacea*. Other characteristic species include *Bromus commutatus*, *Cardamine hirsuta*, *Cerastium glomeratum*, *Cynodon dactylon*, *Dactylis glomerata*, *Dichanthelium laxiflorum*, *Digitaria sanguinalis*, *Eleusine indica*, *Gamochaeta purpurea*, *Juncus tenuis*, *Lespedeza cuneata*, *L. stipulacea*, *L. striata*, *Medicago lupulina*, *Oxalis stricta*, *Plantago lanceolata*, *P. rugelii*, *Poa pratensis*, *Stellaria media*, *Taraxacum officinale*, *Trifolium dubium*, *T. repens*, and *Veronica arvensis*.

Pond and roadside ditches.—In 2000, Hancock Pond (1300 m^2) was created within an old successional pasture 20 m from the HBS entrance gateway and 25 m north of Emma Drive (Fig. 5). The borrowed soil was used as fill for the glasshouse/mesocosm (Fig. 2). The pond readily filled with water and hydrosere succession has progressed rapidly for the last six years. Invading emergent species include *Cyperus pseudovegetus*, *Eleocharis ovata*, *Hypericum mutilum*, *Juncus acuminatus*, *J. brachycarpus*, *J. diffusissiimus*, *J. effusus* var. *solutus*, *Ludwigia alternifolia*, *Scirpus cyperinus*, and *Typha latifolia*. *Salix nigra* is currently the only woody volunteer. The roadside ditches along Emma Drive and Watersport Road have a few wetland plants established including *Carex lurida*, *Eleocharis ovata*, *Juncus biflorus*, *J. effusus* var. *solutus*, *Ludwigia alternifolia*, *Salix nigra*, *Scirpus cyperinus*, and *Typha latifolia*. These wetland plants from the ditches undoubtedly provide a viable seed source for hydrosere pond succession.

Wetland complex.—An artificial-designed gravel-covered wetland (5 m by 40 m or 200 m^2) was built in 1990 for the station wastewater (Fig. 5). This wetland complex was initially planted with several native wetland species, and other native and exotic wetland species have volunteered. Established wetland species include *Boehmeria cylindrica*, *Carex crinita*, *C. frankii*, *C. lupulina*, *C. vulpinoidea*, *Diodia virginiana*, *Equisetum hyemale*, *Impatiens capensis*, *Hemerocallis fulva*, *Iris virginica*, *I. pseudoacorus*, *Justicia americana*, *Leersia oryzoides*, *Onoclea sensibilis*, *Pontederia cordata*, *Polygonum sagittatum*, *Schoenoplectus tabernaemontani*, *Scirpus atrovirens*, *S. cyperinus*, *Thalia dealbata*, and *Typha latifolia*.

Riparian forest.—Riparian forest is scattered along the Kentucky Lake shoreline. It abuts dry-mesic oak hickory forest borders including three low relief, mesic valley bottoms or coves at Pacer Point cove, boat dock cove, and the north peninsula cove (Fig. 5). The Kentucky Lake shoreline is composed of Fort Payne cherty limestone gravel, sand, and silt. Shoreline habitats are annually flooded during the winter and spring months. Riparian indicator trees are *Acer negundo*, *A. saccharinum*, *Betula nigra*, *Liquidambar styraciflua*, *Platanus occidentalis*, and *Salix nigra* with a few *Populus deltoides*, *Taxodium distichum*, two *Quercus lyrata*, and one *Nyssa aquatica*. At the edge of alluvial valley coves and the gravelly shoreline, *Alnus serrulata*, *Amorpha fruticosa*, *Cephalanthus occidentalis*, *Cornus amomum*, *Ilex decidua*, and *Styrax americana* are characteristic shrub-swamp species. Entangled woody vines on trees and shrubs consist of *Bignonia capreolata*, *Brunnichia ovata*, *Campsis radicans*, *Smilax rotundifolia*, *Toxicodendron radicans*, *Vitis palmata*, *V. rotundifolia*, and *Wisteria frutescens*. Characteristic herbs of the riparian forest include many from the dry-mesic oak-hickory forest valley coves and the seasonally dewatered shoreline gravel, sand, and mudflats.

Emergent marsh and wetland meadow.—With nearly level relief and saturated soils, a seasonally flooded emergent marsh intermixed with a sedge-grass wetland meadow has developed between HBS Pacer Point cove and Pacer Point Recreation Area (Fig. 5). Riparian shrubs and trees are typically missing. A combination of emergent marsh and meadow species include *Alternanthera philoxeroides*, *Ammannia coccinea*, *Carex frankii*, *C. lupulina*, *C. tribuloides*, *Cyperus strigosus*, *Eleocharis acicularis*, *Fimbristylis autumnalis*, *Hibiscus laevis*, *Hypericum mutilum*, *Juncus effusus* var. *solutus*, *Justicia americana*, *Leersia oryzoides*, *Lindernia dubia*, *Lycopus virginicus*, *Mimulus alatus*, *Panicum rigidulum*, *Phyla lanceolata*, *Polygonum sagittatum*, *Rotala ramosior*, and *Rhynchospora corniculata*.

Seasonal dewatered shoreline.—The Kentucky Lake shoreline habitat ranges from steep cherty limestone erosion areas several meters high connecting to oak-hickory forest, to a nearly level or slightly level band of seasonally dewatered gravel, sand, silt, and clay mudflats. The sparsely vegetated shoreline is most prominent in the fall when the water level of Kentucky Lake is lowered to 107.9 m (winter pool) and then disappears when the lake is raised to 109.4 m in spring (summer pool). Among the many native and exotic characteristic annuals are *Acalypha virginica*, *Amaranthus rudis*, *A. tuberculatus*, *Bidens frondosa*, *B. vulgata*, *Diodia virginiana*, *Echinochloa crusgalli*, *Eclipta alba*, *Euphorbia maculata*, *E. nutans*, *Ipomoea lacunosa*, *Myosurus minimus*, *Panicum dichotomiflorum*, *Polygonum caespitosum* var. *longisetum*, *P. persicaria*, *P. pennsylvanicum*, and *Sida spinosa*.

ANNOTATED LIST OF PLANTS

The annotated list of the vascular flora is arranged alphabetically by family, genus, and species in the Pteridophyta, Pinophyta, and Magnoliophyta (Magnoliopsida and Liliopsida). Nomenclature follows Jones (2005). An asterisk (*) preceding a scientific name indicates an exotic or non-indigenous taxon. A double asterisk (**) indicates an invasive exotic plant for Kentucky from the Kentucky Exotic Pest Plant Council (2000). A dagger (†) represents a planted native or exotic taxon at HBS. A diesis or double dagger (‡) indicates a new Calloway County distribution record. After the scientific name, plant habitat(s) are given in a numbered code: **1**=dry oak-hickory forest, **2**=dry-mesic oak-hickory forest, **3**=upland early and mid-successional areas, **4**=burned old field warm season grassland, **5**=culturally disturbed areas, **6**=pond and roadside ditches, **7**=wetland complex, **8**=riparian forest, **9**=emergent marsh and wetland meadow, and **10**=seasonal dewatered shoreline. Relative abundance values, Rare (**R**), Scarce (**S**), Infrequent (**I**), Occasional (**O**), Frequent (**F**), and Abundant (**A**), follow habitat(s). An italicized representative voucher number by the author or other collector ends the entry for each species.

EQUISETOPHYTA

Equisetaceae

†*Equisetum hyemale* L. var. *affine* (Engelm.) Calder & R.L. Taylor, Common scouring-rush, 7; I; *98-87*

LYCOPODIOPHYTA

Lycopodiaceae

Lycopodium digitatum Dill., Southern ground cedar, 3; R; *99-318*

POLYPODIOPHYTA

Aspleniaceae

Asplenium platyneuron (L.) B.S.P., Ebony spleenwort, 1; I; *98-98*

Dennstaedtiaceae

Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underw., Western bracken fern, 1, 2; O; *99-237*

Dryopteridaceae

†*Onoclea sensibilis* L., Sensitive fern, 7; O; *02-213*
Polystichum acrostichoides (Michx.) Schott, Christmas fern, 2; O; *99-227*
Woodsia obtusa (Spreng.) Torr., Bluntlobe cliff fern, 2; I; *98-190*

Ophioglossaceae

Botrychium dissectum Spreng., Cutleaf grape fern, 2; I; *98-718*
Botrychium virginianum (L.) Sw., Rattlesnake fern, 2; I; *06-230*

Thelypteridaceae

Phegopteris hexagonoptera (Michx.) Fee, Broad-beech fern, 2; S; *06-251*

PINOPHYTA

Cupressaceae

Juniperus virginiana L., Eastern redcedar, 1, 2, 3; O; *98-101*
Taxodium distichum (L.) Rich., Bald cypress, 8; S; *98-406*

Pinaceae

†*Pinus taeda* L., Loblolly pine, 3; O; *00-157*
†*Pinus virginiana* Mill., Virginia pine, 5; R; *99-423*

MAGNOLIOPHYTA—MAGNOLIOPSIDA

Acanthaceae

Justicia americana (L.) Vahl, American water-willow, 7, 9; A; *99-309*
Ruellia caroliniensis (J.F. Gmel.) Steud., Carolina wild petunia, 2, 3; O; *98-71*

Aceraceae

‡*Acer barbatum* Michx., Southern sugar maple, 2; I; *02-226*
Acer negundo L., Box-elder, 7, 8; O; *98-110*
Acer rubrum L. var. *rubrum*, Red maple, 1, 2, 3, 4; A; *99-29*
Acer saccharinum L., Silver maple, 8; O; *99-02*

Amaranthaceae

**Alternanthera philoxeroides* (Mart.) Griseb., Alligator-weed, 9, 10; A; *01-241*
**Amaranthus rudis* J.D. Sauer, Water-hemp, 10; O; *99-451*
**Amaranthus retroflexus* L., Redroot amaranth, 10; S; *99-449*
Amaranthus tuberculatus (Moq.) J.D. Sauer, Roughfruit amaranth, 10; I; *Fuller 3000*

Anacardiaceae

Rhus copallina L., Winged sumac, 1, 3, 4; F; *98-324*
Rhus glabra L., Smooth sumac, 3, 4; O; *98-111*
Toxicodendron radicans (L.) Kuntze, Eastern Poison Ivy, 1, 2, 3, 5, 8; A; *02-209*

Annonaceae

Asimina triloba (L.) Dunal, Pawpaw, 2; O; *98-415*

Apiaceae

Angelica venenosa (Greenway) Fernald, Hairy angelica, 4; R; *98-426*
Chaerophyllum tainturieri Hook., Hairyfruit chervil, 3, 5; F; *99-110*
Cicuta maculata L., Spotted water hemlock, 9, 10; I.; *98-440*
***Daucus carota* L., Queen Anne's lace, 3, 5; F; *06-247*
Eryngium prostratum Nutt., Creeping eryngo, 5; I; *98-366*
Sanicula canadensis L., Canadian snakeroot, 2; O; *99-274*
‡**Torilis arvensis* (Huds.) Link, Spreading hedge-parsley, 5; S; *98-383*
Trepocarpus aethusae Nutt. ex DC., White nymph, 2, 8; O; *01-209*

Apocynaceae
Amsonia tabernaemontana Walter, Eastern bluestar, 3; R; _99-308_
Apocynum cannabinum L., Indian-hemp, 3, 5; I; _98-01_
†**_Vinca minor_ L., Common periwinkle, 5; O; _01-214_

Aquifoliaceae
Ilex decidua Walter, Deciduous holly, 2; R; _02-236_

Araliaceae
Aralia spinosa L., Hercules-club, 2; O; _06-225_
†**_Hedera helix_ L., English ivy, 5; I; _98-56_

Aristolochiaceae
Aristolochia serpentaria L., Virginia snakeroot, 2; R; _99-338_

Asclepiadiaceae
Ampelamus albidus (Nutt.) Britton, Honeyvine, 2, 3; S; _98-567_
Asclepias amplexicaulis Sm., Clasping milkweed, 4; R; _99-232_
Asclepias perennis Walter, Aquatic milkweed, 8, 9; S; _99-386_
Asclepias syriaca L., Common milkweed, 1, 3; S; _98-168_
Asclepias tuberosa L., Butterfly milkweed, 3, 4; I; _01-178_
Asclepias variegata L., Redring milkweed, 2; I, S; _98-44_
‡_Matelea gonocarpos_ (Walter) Shinners, Angularfruit milkvine, 3; R; _98-134_

Asteraceae
*_Achillea millefolium_ L., Common yarrow, 3, 4; I; _00-166_
Ageratina altissima (L.) R.M. King & H.E. Rob., White snakeroot, 2; I; _01-607_
Ambrosia artemisiifolia L., Annual ragweed, 3, 5; F; _01-150_
Ambrosia trifida L., Giant ragweed, 3; O; _98-431_
Antennaria plantaginifolia (L.) Richardson, Plantain pussytoes, 1; O; _99-28_
Bidens aristosa (Michx.) Britton, Bearded beggar-tick, 6; S; _99-435_
Bidens bipinnata L., Spanish needles, 5; S; _Woods 818_
Bidens frondosa L., Devil's beggar-tick, 9, 10; F; _01-601_
Bidens vulgata Greene, Big devil's beggar-tick, 9; I; _01-608_
Boltonia asteroides (L.) L'Her. var. _recognita_ (Fernald & Griscom) Cronquist, White doll's daisy, 3; I; _98-690_
**_Chrysanthemum leucanthemum_ L., Ox-eye daisy, 3, 5; I; _99-82_
**_Cichorium intybus_ L., Chicory, 5; S; _98-384_
Cirsium discolor (Muhl. ex Willd.) Spreng., Field thistle, 3; I; _98-570_
‡*_Cirsium vulgare_ (Savi) Ten., Bull thistle, 3; R; _98-583_
Conoclinium coelestinum L., Blue mistflower, 9; I; _01-634_
Conyza canadensis (L.) Cronquist, Horseweed, 5; O; _99-442_
‡_Coreopsis auriculata_ L., Lobed tickseed, 2; R; _98-395_
†_Coreopsis lanceolata_ L., Lanceleaf tickseed, 3; I; _99-179_
Coreopsis major Walter, Greater tickseed, 1, 4; O; _01-120_
Coreopsis tinctoria Nutt. var. _tinctoria_, Golden tickseed, 3, 5; S; _01-222_
Coreopsis tripteris L., Tall tickseed, 1, 2; I; _98-552_
†*_Cosmos bipinnatus_ Cav., Garden cosmos, 3; S; _01-360_
*_Eclipta prostrata_ (L.) L., False daisy, 9, 10; S; _98-662_
Elephantopus carolinianus Raeusch., Carolina elephant's-foot, 2; I; _98-707_
Erechtites hieraciifolia (L.) Raf. ex DC., American burnweed, 5; I; _01-614_
Erigeron annuus (L.) Pers., Annual fleabane, 3, 4, 5; F; _01-105_
Erigeron philadelphicus L., Philadelphia fleabane, 5; I; _06-227_
Erigeron strigosus Muhl ex Willd., Prairie fleabane, 2, 4; F; _00-160_
Eupatorium fistulosum Barratt, Trumpetweed, 3, 4; O; _98-550_
Eupatorium perfoliatum L., Common boneset, 3, 9; O; _99-419_
Eupatorium serotinum Michx., Lateflowering thoroughwort, 6, 9; O; _01-603_
Eupatorium sessilifolium L., Upland boneset, 2; S; _98-587_
Euthamia graminifolia (L.) Nutt. ex Cass., Flat-top goldenrod, 3, 6; I; _99-411_
Gamochaeta purpurea (L.) Cabrera, Spoonleaf purple everlasting, 2, 5; F; _02-204_
Helenium flexuosum Raf., Purplehead sneezeweed, 6; S; _98-594_
Helianthus angustifolius L., Swamp sunflower, 3; I; _01-625_
Helianthus divaricatus L., Woodland sunflower, 2, 3; I; _98-405_
Helianthus hirsutus Raf., Hairy sunflower, 1; O; _99-412_
Helianthus microcephalus Torr. & A. Gray, Small woodland sunflower, 2, 3; O; _98-548_
Hieracium gronovii L., Beaked hawkweed, 1; O; _98-623_
Krigia biflora (Walter) S.F. Blake, Twoflower dwarf-dandelion, 2, 3; O; _99-51_
Krigia caespitosa (Raf.) K.L. Chambers, Weedy dwarf-dandelion, 5; O; _06-229_
Krigia dandelion (L.) Nutt., Potato dwarf-dandelion, 1; I; _99-60_
Lactuca canadensis L., Canada lettuce, 3; O; _98-347_
Lactuca floridana (L.) Gaertn., Woodland lettuce, 2, 3; I; _98-545_
*_Lactuca serriola_ L., Prickly lettuce, 3; S; _99-312_
Liatris squarrosa (L.) Michx., Plains blazing-star, 1, 3; I; _99-520_
Liatris squarrulosa Michx., Southern blazing-star, 1, 3; O; _99-42/_
‡_Matricaria discoidea_ DC., Disc mayweed, 3; R; _99-244_
Mikania scandens (L.) Willd., Climbing hempvine, 8; R; _98-686_
Packera glabella (Poir.) C. Jeffrey, Yellowtop, 10; F; _99-03_
Parthenium integrifolium L., Wild quinine, 1, 4; O; _01-121_
Pluchea camphorata (L.) DC., Marsh fleabane, 8; R; _99-460_
Pseudognaphalium obtusifolium (L.) Hilliard & B.L. Burtt., Fragrant cudweed, 3; I; _98-639_
Pyrrhopappus carolinianus (Walter) DC., Carolina desert-chicory, 3, 5; I; _99-283_
Rudbeckia hirta L., Black-eyed susan, 3, 4; O; _98-67_
Sericocarpus linifolius (L.) B.S.P., Narrowleaf white-topped aster, 1,3, 4; O; _01-245_
Solidago caesia L., Axillary goldenrod, 2; O; _98-706_
Solidago canadensis L., Canada goldenrod, 3, 4; F; _01-610_
Solidago juncea Aiton, Early goldenrod, 3; F; _99-328_
Solidago nemoralis Aiton, Gray goldenrod, 3; O; _98-643_
Solidago odora Aiton, Anise-scented goldenrod, 4; I; _01-612_
Solidago speciosa Nutt. var. _erecta_ (Pursh) McMillan, Showy goldenrod, 1; O; _01-622_
*_Sonchus asper_ (L.) Hill, Spiny sow-thistle, 5; R; _98-456_
Symphyotrichum dumosum (L.) G.L. Nesom, Longstalk aster, 3, 4; F; _01-619_

Symphyotrichum lateriflorum (L.) A. Love & D. Love, Calico aster, 2, 3; I; *01-617*
‡*Symphyotrichum ontarione* (Wiegand) G.L. Nesom, Bottomland aster, 10; O; *01-611*
Symphyotrichum patens (Aiton) G.L. Nesom var. *patens*, Clasping aster, 1; O; *01-633*
Symphyotrichum pilosum (Willd.) G.L. Nesom, Hairy white old-field aster, 3; F; *01-615*
**Taraxacum officinale* G.H. Weber ex Wiggers, Common dandelion, 5; F; *99-12*
Verbesina helianthoides Michx., Ozark wingstem sunflower, 3; O; *00-163*
Vernonia missurica Raf., Missouri ironweed, 3; O; *01-604*
Xanthium strumarium L., Rough cocklebur, 10; F; *98-657*

Balsaminaceae

Impatiens capensis Meerb., Orange jewelweed, 7, 8, 9, 10; A; *98-432*

Berberidaceae

Podophyllum peltatum L., May-apple, 2; O; *99-20*

Betulaceae

Alnus serrulata (Aiton) Willd., Hazel alder, 8; O; *99-445*
Betula nigra L., River birch, 8; O; *99-242*
Corylus americana Walter, American hazelnut, 2; S; *98-224*
‡*Ostrya virginiana* (Mill.) K. Koch, Hop-hornbeam, 3; I; *01-224*

Bignoniaceae

Bignonia capreolata L., Cross-vine, 8; F; *98-163*
Campsis radicans (L.) Seem. ex Bureau, Trumpet-creeper, 8, 10; O; *01-204*

Boraginaceae

Cynoglossum virginianum L.,Wild comfrey, 2; R; *02-234*
Myosotis macrosperma Engelm., Largeseed forget-me-not, 3; I; *99-183*

Brassicaceae

**Arabidopsis thaliana* (L.) Heynh, Mouse-ear cress, 5; O; *99-73*
**Capsella bursa-pastoris* (L.) Medik., Shepherd's purse, 5; R; *99-41*
**Cardamine hirsuta* L., Hairy bittercress, 5, 10; A; *99-16*
Cardamine parviflora L., Dryland bittercress, 2; I; *99-98*
Cardamine pensylvanica Muhl. ex Willd., Pennsylvania bittercress, 10; I; *99-05*
Dentaria laciniata Muhl. ex Willd., Cutleaf toothwort, 2; I; *99-18*
Draba brachycarpa Nutt. ex Torr. & A. Gray, Shortfruit whitlow-grass, 5; I; *99-33*
**Draba verna* L., Whitlow-grass, 5; F; *99-13*
Lepidium virginicum L., Wild peppergrass, 5; I; *00-167*
Rorippa sessiliflora (Nutt.) Hitchc., Marsh yellowcress, 9; O; *99-45*
**Sisymbrium officinale* (L.) Scop., Hedge-mustard, 5; S; *99-175*

Callitrichaceae

‡*Callitriche terrestris* Raf., Terrestrial water starwort, 5; S; *Poindexter 06-133*

Campanulaceae

Campanulastrum americanum (L.) Small, American bellflower, 2; R; *98-325*
Lobelia inflata L., Indian tobacco, 5, 10; I; *99-336*
Lobelia puberula Michx., Downy lobelia, 3, 4; O; *01-621*
Lobelia spicata Lam., Spiked lobelia, 3; R; *Hunter & Austin 1807*
Triodanis perfoliata (L.) Nieuwl. var. *biflora* (Ruiz & Pav.) Bradley, Venus' looking glass, 1, 5; I; *98-69*
Triodanis perfoliata (L.) Nieuwl. var. *perfoliata*, Venus' looking glass, 5; F; *00-165*

Caprifoliaceae

***Lonicera japonica* Thunb., Japanese honeysuckle, 2, 4, 5, 8; A; *98-03*
Sambucus canadensis L., Common elderberry, 2; 8; I; *01-164*
Symphoricarpos orbiculatus Moench, Coralberry, 2, 3; O; *98-375*
Viburnum rufidulum Raf., Rusty blackhaw, 1, 2; I; *99-111*

Caryophyllaceae

***Arenaria serpyllifolia* L., Thymeleaf sandwort, 5; F; *01-101*
**Cerastium brachypetalum* Desportes ex Pers., Gray mouse-ear chickweed, 5; R; *99-104*
**Cerastium glomeratum* Thuill., Clammy mouse-ear chickweed, 5; F; *99-56*
‡*Cerastium nutans* Raf., Nodding mouse-ear chickweed, 5; S; *99-52*
**Cerastium vulgatum* L., Common mouse-ear chickweed, 5; O; *98-66*
***Dianthus armeria* L., Deptford pink, 5; I; *00-151*
Silene antirrhina L., Sleepy catchfly, 5; S; *99-138*
Silene stellata (L.) W.T. Aiton, Starry campion, 2; S; *98-414*
Silene virginica L., Fire pink, 2; I; *99-22*
***Stellaria media* (L.) Vill., Common chickweed, 5; F; *99-53*

Chenopodiaceae

***Chenopodium album* L., Lamb's-quarters, 10; S; *01-168*

Cistaceae

Lechea mucronata Raf., Hairy pinweed, 1; S; *98-511*
‡*Lechea tenuifolia* Michx., Narrowleaf pinweed, 1; F; *01-218*

Clusiaceae

Hypericum denticulatum Walter, Coppery St. John's-wort, 1, 3, 4; O; *99-332*
Hypericum drummondii (Grev. & Hook.) Torr. & A. Gray, Nits-and-lice, 1; R; 98 493
Hypericum hypericoides (L.) Crantz subsp. *hypericoides*, St. Andrew's-cross, 2; O; *01-184*
Hypericum mutilum L., Marsh St. John's-wort, 6, 9; O; *99-390*
‡*Hypericum prolificum* L., Shrubby St. John's-wort, 2; S; *99-314*
Hypericum punctatum Lam., Dotted St. John's-wort, 2, 3, 4; O; *01 199*
Hypericum stragulum W.P. Adams & N. Robson, St. Andrew's-cross, 1, 3, 4; O; *98-409*

Convolvulaceae

**Calystegia sepium* (L.) R. Br. var. *sepium*, Hedge bindweed, 8; I; *99-379*

**Ipomoea hederacea* Jacq., Ivyleaf morning-glory, 10; R; *99-439*

Ipomoea lacunosa L., White morning-glory, 10; F; *98-665*

Cornaceae

Cornus amomum Mill., Silky dogwood, 8; I; *01-117*

Cornus florida L., Flowering dogwood, 2, 3, 5; O; *99-26*

Cucurbitaceae

‡*Melothria pendula* L., Creeping cucumber, 5; R; *98-604*

Sicyos angulatus L., Bur cucumber, 2, 8; S; *01-643*

Cuscutaceae

Cuscuta pentagona Engelm., Field dodder, 5; O; *99-302*

Ebenaceae

Diospyros virginiana L., Persimmon, 2, 3, 8; F; *98-130*

Elaeagnaceae

†***Elaeagnus umbellata* Thunb., Autumn-olive, 5; S; *99-32*

Ericaceae

Vaccinium arboreum Marshall, Sparkleberry, 1; F; *00-156*

Vaccinium stamineum L., Deerberry, 1, 2; O; *01-216*

Euphorbiaceae

Acalypha rhomboidea Raf., Rhomboic copperleaf, 5, 10; I; *99-463*

Acalypha virginica L., Virginia copperleaf, 5, 10; F; *98-561*

Croton capitatus Michx., Woolly croton, 5; R; *98-621*

Croton glandulosus L. var. *septentrionalis* (L.) Muell.-Arg., Toothleaf croton, 3; I; *98-711*

Croton monanthogynus Michx., Prairie-tea, 5; O; *98-370*

Euphorbia corollata L., Flowering spurge, 1, 3, 4; O; *98-356*

Euphorbia maculata L., Spotted sandmat, 5; 10; F; *99-431*

Euphorbia nutans Lag., Eyebane spurge, 5, 10; O; *98-684*

Phyllanthus caroliniensis Walter, Carolina leaf-flower, 10; R; *99-443*

Fabaceae

***Albizia julibrissin* Durazz., Mimosa, 3, 5; O; *01-165*

Amorpha fruticosa L., False indigo, 8; S; *99-224*

Cercis canadensis L., Eastern redbud, 2, 3, 5; O; *99-31*

Chamaecrista fasciculata (Michx.) Greene, Partridge-pea, 3, 4; O; *98-596*

Chamaecrista nicitans (L.) Moench., Sensitive-pea, 3, 4; I; *98-584*

Clitoria mariana L., Butterfly pea, 2, 3; I; *00-321*

***Coronilla varia* L., Crown-vetch, 5; O; *01-128*

Crotalaria sagittalis L., Weedy rattlebox, 4; R; *99-325*

‡*Desmodium glabellum* (Michx.) DC., Smooth tick-trefoil, 3, 5; O; *98-692*

‡*Desmodium glutinosum* (Muhl. ex Willd.) A. Wood, Clustered tick-trefoil, 2; S; *98-398*

Desmodium marilandicum (L.) DC., Maryland tick-trefoil, 2, 3; I; *98-588*

Desmodium nudiflorum (L.) DC., Naked tick-trefoil, 2; O; *99-320*

Desmodium paniculatum (L.) DC., Panicled tick-trefoil, 3; O; *98-651*

Desmodium rotundifolium DC., Roundleaf tick-trefoil, 1; S; *98-571*

‡*Dioclea multiflora* (Torr. & A. Gray) C. Mohr, Cluster-pea, 1; S; *98-303*

Galactia volubilis (L.) Britton, Hairy milk-pea, 3; O; *99-326*

Gleditsia triacanthos L., Honey locust, 2; R; *98-326*

***Lespedeza cuneata* (Dum.-Cours.) G. Don, Sericea lespedeza, 3, 5; A; *01-635*

Lespedeza hirta (L.) Hornem., Hairy lespedeza, 1; O; *01-618*

Lespedeza intermedia (S. Wats.) Britton, Wand lespedeza, 1, 3; O; *98-703*

Lespedeza procumbens Michx., Downy trailing lespedeza, 3; F; *98-699*

Lespedeza repens (L.) Barton, Smooth trailing lespedeza, 3; O; *99-202*

***Lespedeza stipulacea* Maxim., Korean clover, 3, 5; A; *98-379*

‡***Lespedeza striata* (Thunb.) Hook. & Arn., Japanese clover, 3, 5; A; *01-636*

Lespedeza virginica (L.) Britton, Virginia lespedeza, 3; I; *98-626*

†**Lotus corniculatus* L., Birdsfoot-trefoil, 3; R; *01-203*

***Medicago lupulina* L., Black medic, 5, 10; F; *06-246*

***Melilotus alba* Medik., White sweet-clover, 3; 5; I; *01-221*

***Melilotus officinalis* (L.) Lam., Yellow sweet-clover, 5; R; *06-248*

Orbexilum pedunculatum (Mill.) Rydb., Sampson's snakeroot, 1; O; *98-18*

Robinia pseudoacacia L., Black locust, 2; O; *99-91*

Strophostyles umbellata (Muhl. ex Willd.) Britton, Perennial woolly-bean, 3; S; *98-595*

Stylosanthes biflora (L.) B.S.P., Pencil-flower, 3, 4; O; *99-234*

Tephrosia virginiana (L.) Pers., Virginia goat's-rue, 1; O; *01-124*

**Trifolium campestre* Schreb., Pinnate hop-clover, 5; S; *98-46*

‡**Trifolium dubium* Sibth., Little hop-clover, 5; A; *01-102*

†**Trifolium pratense* L., Red clover, 3, 5; O; *02-237*

**Trifolium repens* L., White clover, 5; A; *01-139*

**Vicia sativa* L., Common vetch, 5; S; *99-215*

**Vicia villosa* Roth var. *varia* (Host) Corb., Winter vetch, 3; R; *01-253*

Wisteria frutescens (L.) Poir., American wisteria, 8; O; *98-412*

Fagaceae

Fagus grandifolia Ehrh., American beech, 2; S; 99-290

Quercus alba L., White oak, 1, 2; A; 98-540

Quercus coccinea Muenchh., Scarlet oak, 1, 2; R; 98-369

Quercus falcata Michx., Southern red oak, 1, 2; F; 98-564

Quercus imbricaria Michx., Shingle oak, 2; I; 98-449

Quercus lyrata Walter, Overcup oak, 8; R; 99-424

Quercus marilandica Muenchh., Blackjack oak, 1; F; 99-200

‡*Quercus muhlenbergii* Engelm., Chinkapin oak, 2; R; 98-41

Quercus rubra L., Northern red oak, 2; F; 98-345

†*Quercus shumardii* Buckley, Shumard oak, 5; R; 98-603

Quercus stellata Wangenh., Post oak, 1, 2; A; 98-123

Quercus velutina Lam., Black oak, 1, 2, 3; A; 02-231

Gentianaceae

Sabatia angularis (L.) Pursh, Rose marsh-pink, 3, 6; I; 99-324

Geraniaceae

Geranium carolinianum L., Carolina crane's-bill, 3, 5; O; *99-116*

Haloragaceae
‡**Myriophyllum spicatum* L., European water-milfoil, 9; I; *Fuller 3004*

Hamamelidaceae
Liquidambar styraciflua L., Sweetgum, 2, 4, 8; O; *98-192*

Hippocastanaceae
†*Aesculus pavia* Aiton, Red buckeye, 2; R; *99-334*

Hydrangeaceae
Hydrangea cinerea Small, Wild hydrangea, 2; I; *01-207*

Juglandaceae
‡*Carya cordiformis* (Wangenh.) K. Koch, Bitternut hickory, 2; R; *99-218*
Carya glabra (P. Mill.) Sweet, Pignut hickory, 1, 2; A; *02-223*
Carya ovata (P. Mill.) K. Koch, Shagbark hickory, 2, 3; A; *98-231*
‡*Carya pallida* (Ashe) Engl. & Graebn., Pale hickory, 2; S; *98-197*
Carya tomentosa (Poir.) Nutt., Mockernut hickory, 2, 3; A; *02-230*

Lamiaceae
***Glechoma hederacea* L., Ground-ivy, 5; O; *01-255*
Cunila origanoides (L.) Britton, Maryland dittany, 1; O; *98-717*
Hedeoma pulegioides (L.) Pers., American false pennyroyal, 2; R; *Woods 819*
***Lamium amplexicaule* L., Henbit, 5; I; *99-11*
**Lamium purpureum* L., Purple dead-nettle, 5; O; *99-14*
Lycopus virginicus L., Virginia water-horehound, 9; S; *98-682*
†***Mentha* × *piperita* L., Peppermint, 7; R; *00-322*
Monarda fistulosa L. subsp. *mollis* (L.) Benth., Wild bergamot, 3; 4; I; *01-170*
**Perilla frutescens* (L.) Britton, Beefsteak plant, 10; R; *98-710*
Prunella vulgaris L. var. *lanceolata* (W. Barton) Fernald, Self-heal, 3, 5; O; *98-64*
Pycnanthemum pycnanthemoides (Leavenw.) Fernald, Southern mountain mint, 3, 4; I; *01-623*
Pycnanthemum tenuifolium Schrad., Slender mountain mint, 3, 4; O; *99-285*
‡*Pycnanthemum virginianum* (L.) Durand & A.B. Jackson, Virginia mountain mint, 3; S; *98-519*
Salvia lyrata L., Wild sage, 2, 5; O; *99-151*
Scutellaria elliptica Muhl., Hairy skullcap, 2; O; *00-158*
Scutellaria incana Biehler, Downy skullcap, 2; I; *98-294*
Scutellaria integrifolia L., Largeflower skullcap, 2; I; *99-167*
Scutellaria ovata Hill, Heartleaf skullcap, 2; R; *98-93*
Scutellaria parvula Michx., Little skullcap, 1; I; *99-87*
Stachys tenuifolia Willd., Smooth hedge-nettle, 6; R; *00-320*
Teucrium canadense L., Canada germander, 10; R; *98-208*

Lauraceae
Sassafras albidum (Nutt.) Nees, Sassafras, 1, 2, 3, 4; O; *98-223*

Linaceae
Linum medium (Planch.) Britton var. *texanum* (Planch.) Fernald, Common yellow flax, 3, 4; O; *06-239*

Loganiaceae
Spigelia marilandica L., Indian-pink, 2; I; *01-112*

Lythraceae
Ammannia coccinea Rottb., Valley redstem, 9; S; *98-659*
Rotala ramosior (L.) Koehne, Tooth-cup, 9, 10; A; *99-383*

Magnoliaceae
Liriodendron tulipifera L., Tuliptree, 2, 3; S; *98-293*
†*Magnolia grandiflora* L., Southern magnolia, 5; R; *06-224*

Malvaceae
Hibiscus laevis All., Smooth rose-mallow, 9, 10; O; *99-387*
**Sida spinosa* L., Prickly sida, 10; S; *98-539*

Melastomataceae
Rhexia virginica L., Wingstem meadow-beauty, 8; R; *Woods 821*

Menispermaceae
Cocculus carolinus (L.) DC., Carolina coralbeads, 2; I; *98-496*

Molluginaceae
**Mollugo verticillata* L., Carpetweed, 5, 10; O; *01-162*

Monotropaceae
‡*Monotropa hypopithys* L., Pine-sap, 2; R; *98-217*

Moraceae
Maclura pomifera (Raf.) C.K. Schneid., Osage-orange, 3; R; *01-169*
Morus rubra L., Red mulberry, 2, 3; O; *98-195*

Nyssaceae
Nyssa aquatica L., Swamp tupelo, 8; R; *02-151*
Nyssa sylvatica Marshall, Blackgum, 2, 3, 4; A; *01-119*

Oleaceae
Fraxinus americana L., White ash, 2, 3; I; *98-382*
Fraxinus pennsylvanica Marshall, Green ash, 8; R; *98-357*
†***Ligustrum sinense* Lour., Chinese privet, 5; R; *99-393*

Onagraceae
Ludwigia alternifolia L., Square-pod water-primrose, 6, 9; O; *98-516*
Ludwigia decurrens Walter, Wingstem water-primrose, 9; R; *99-381*
Oenothera biennis L., Common evening-primrose, 3, 5; O; *01-630*
Oenothera fruticosa L. subsp. *fruticosa*, Common sundrops, 4; I; *99-188*
Oenothera speciosa Nutt., White evening-primrose, 3; R; *98-02*

Oxalidaceae
Oxalis stricta L., Common yellow wood-sorrel, 5; S; *01-108*
Oxalis violacea L., Violet wood-sorrel, 1, 2; I; *99-80*

Passifloraceae
Passiflora incarnata L., Maypop passion-flower, 2, 3; R; *00-325*
Passiflora lutea L. var. *glabriflora* Fernald, Yellow passion-flower, 2; S; *98-373*

Phrymaceae
Phyrma leptostachya L., Lopseed, 2; I; *98-279*

Phytolaccaceae
Phytolacca americana L., American pokeweed, 5; I; *01-113*

Plantaginaceae
Plantago aristata Michx., Bracted plantain, 5; I; *01-223*
**Plantago lanceolata* L., English plantain, 5; F; *98-74*
Plantago rugelii Decne., Rugel's plantain, 5; F; *98-180*
Plantago virginica L., Hoary plantain, 3, 5; O; *99-126*

Platanaceae
Platanus occidentalis L., American sycamore, 7, 8; O; *98-201*

Polemoniaceae
Phlox divaricata L., Forest phlox, 2; O; *99-23*
†*Phlox paniculata* L., Summer phlox, 5; R; *99-321*

Polygalaceae
Polygala ambigua Nutt., Loose milkwort, 4; I; *98-404*
Polygala sanguinea L., Blood milkwort, 4; S; *98-124*

Polygonaceae
Brunnichia ovata (Walter) Shinners, Buckwheat vine, 8; O; *99-377*
Polygonum amphibium L. var. *emersum* Michx., Water smartweed, 9; I; *98-652*
**Polygonum aviculare* L., Knotweed, 5, 10; O; *99-462*
***Polygonum caespitosum* Blume var. *longisetum* (Bruijn) Steward, Asiatic smartweed, 5, 10; F; *01-638*
Polygonum hydropiperoides Michx., False water-pepper, 9; O; *99-438*
Polygonum pensylvanicum L., Pennsylvania smartweed, 10; I; *98-664*
***Polygonum persicaria* L., Spotted lady's thumb, 5, 10; O; *01-187*
Polygonum sagittatum L., Arrowleaf tearthumb, 7, 9; O; *99-447*
Polygonum virginianum L., Jumpseed, 2; I; *98-568*
***Rumex acetosella* L., Sheep sorrel, 5; F; *98-77*
**Rumex crispus* L., Curly dock, 5; I; *98-83*
**Rumex obtusifolius* L., Bitter dock, 5; I; *98-446*

Portulacaceae
Claytonia virginica L., Spring-beauty, 5; O; *99-38*

Primulaceae
Lysimachia ciliata L., Fringed loosestrife, 2; S; *99-254*
Lysimachia lanceolata Walter, Lanceleaf loosestrife, 2; R; *Hunter and Austin 1806*

Ranunculaceae
Anemone virginiana L., Tall anemone, 2; I; *98-102*
Anemonella thalictroides (L.) Spach., Rue-anemone, 2; O; *99-21*
Clematis virginiana L., Virgin's-bower, 2; I; *98-447*
Myosurus minimus L., Mouse-tail, 10; R; *99-49*
Ranunculus abortivus L., Smooth smallflower crowfoot, 5; O; *99-08*
‡*Ranunculus micranthus* (A. Gray) Nutt. ex Torr. & A. Gray, Hairy smallflower crowfoot, 5; I; *99-59*
‡***Ranunculus parviflorus* L., Stickseed buttercup, 5; R; *99-61*
Ranunculus recurvatus Poir., Hooked buttercup, 2; I; *99-150*
**Ranunculus sardous* Crantz., Hairy buttercup, 5; O; *99-61*

Rhamnaceae
Ceanothus americanus L., New Jersey tea, 1, 4; I; *98-149*

Rosaceae
Agrimonia rostellata Wallr., Beaked agrimonia, 2; I; *98-549*
Amelanchier arborea (F. Michx.) Fernald, Downy serviceberry, 1, 2; F; *99-25*
‡**Aphanes microcarpa* (Boiss. & Reut.) Rothm., Slender parsley piert, 5; S; *Poindexter 06-152*
Crataegus mollis (Torr. & A. Gray) Schelle, Downy hawthorn, 1; R; *99-278*
Fragaria virginiana Duchesne, Wild strawberry, 3; I; *99-140*
Geum canadense Jacq., White avens, 2; O; *98-209*
Porteranthus stipulatus (Muhl. ex Willd.) Britton, Indian-physic, 1; F; *01-100*
Potentilla simplex Michx., Old-field cinquefoil, 3, 4; F; *99-79*
Prunus americana Marshall, American plum, 1; R; *02-218*
Prunus angustifolia Marshall, Chickasaw plum, 1; I; *00-164*
Prunus serotina Ehrh., Wild black cherry, 2, 3; F; *99-99*
Rosa carolina L., Pasture rose, 1, 3; O; *98-560*
***Rosa multiflora* Thunb., Multiflora rose, 3, 4; S; *01-176*
Rosa setigera Michx., Prairie rose, 3; I; *01-192*
Rubus allegheniensis Porter, Common blackberry, 3; I; *98-244*
Rubus argutus Link, Southern blackberry, 3, 4; F; *98-169*
Rubus flagellaris Willd., Northern dewberry, 3, 4; F; *99-229*

Rubiaceae
Cephalanthus occidentalis L., Buttonbush, 8; O; *01-206*
Diodia teres Walter, Rough buttonweed, 3; F; *01-246*
Diodia virginiana L., Virginia buttonweed, 7, 9, 10; F; *99-346*
Galium aparine L., Cleavers, 3, 5; O; *99-119*
Galium circaezans Michx., Forest bedstraw, 1; O; *02-217*
***Galium pedemontanum* (Bellardi) All., Piedmont bedstraw, 5; S; *98-78*
Galium pilosum Aiton, Hairy bedstraw, 1, 3; O; *99-316*
Galium tinctorium L., Swamp bedstraw, 9; I; *98-133*
Galium triflorum Michx., Fragrant bedstraw, 2; O; *98-425*
Houstonia caerulea L., Spring bluets, 5; F; *99-50*
Houstonia canadensis Willd. ex Roem. & Schult., Canada bluets, 1; O; *99-135*
Houstonia pusilla Schoepf, Small bluets, 5; O; *99-57*
‡**Sherardia arvensis* L., Field-madder, 5; R; *Poindexter 06-142*

Salicaceae
Populus deltoides W. Bartram ex Marshall, Eastern cottonwood, 8; S; *98-327*
Salix humilis Marshall, Upland willow, 3; I; *99-415*
Salix nigra Marshall, Black willow, 6, 8; O; *99-239*

Santalaceae
Comandra umbellata (L.) Nutt. subsp. *umbellata*, Bastard toadflax, 1; I; *99-139*

Sapindaceae
**Cardiospermum halicacabum* L., Balloon-vine, 10; R; *Fuller 3006*

Saururaceae
Saururus cernuus L., Lizard's-tail, 9; I.; *99-344*

Saxifragaceae
Heuchera americana L., American alumroot, 2; S; *98-13*

Scrophulariaceae

Agalinis tenuifolia (Vahl) Raf., Common false foxglove, 3; I; *01-616*
Aureolaria flava (L.) Farw., Smooth foxglove, 1; S; 98-615
Aureolaria pedicularia (L.) Raf. var. *pectinata* (Nutt.) Gleason, Annual foxglove, 1;O; *01-624*
‡*Leucospora multifida* (Michx.) Nutt., Cleftleaf Conobea, 5; O; *99-361*
Lindernia dubia (L.) Pennell var. *anagallidea* (Michx.) Cooperr., False pimpernel, 9, 10; O; *99-437*
Lindernia dubia (L.) Pennell var. *dubia*, False pimpernel, 9, 10; I; *99-389*
Mecardonia acuminata (Walter) Small, Axilflower, 10; R; *98-653*
Mimulus alatus Aiton, Sharpwing monkey-flower, 9; I; *98-515*
Mimulus ringens L., Alleghany monkey-flower, 7; R; *98-494*
Penstemon digitalis Nutt. ex Sims, Foxglove beardtongue, 1; I; *99-134*
Penstemon pallidus Small, Eastern white beardtongue, 3; S; *01-116*
**Verbascum blattaria* L., Moth mullein, 3; R; *00-168*
**Verbascum thapsus* L., Common mullein, 3; R; *98-146*
**Veronica arvensis* L., Corn speedwell, 5; F; *98-55*
Veronica peregrina L. subsp. *peregrina*, Purslane speedwell, 5; O; *99-48*
Veronicastrum virginicum (L.) Farw., Culver's root, 1; R; *99-418*

Simaroubaceae

***Ailanthus altissima* (Miller) Swingle, Tree-of-heaven, 2; R; *01-231*

Solanaceae

Physalis pubescens L., Downy ground-cherry, 10; I; *99-426*
Solanum carolinense L., Bull-nettle, 3, 5; S; *98-339*
Solanum ptycanthum Dunal ex DC., Black nightshade, 5; R; *99-396*

Staphyleaceae

Staphylea trifolia L., Bladdernut, 2; R; *98-266*

Styracaceae

Styrax americanus Lam., American snowbell, 8; I; *99-343*

Ulmaceae

Celtis occidentalis L., Common hackberry, 2; I; *02-211*
Ulmus alata Michx., Winged elm, 1, 2, 3, 4; F; *98-151*
Ulmus americana L., American elm, 2; O; *98-220*
Ulmus rubra Muhl., Red elm, 1, 3; F; *98-164*

Urticaceae

Boehmeria cylindrica (L.) Sw., False nettle, 2, 7, 8; F; *98-292*
Pilea pumila (L.) A. Gray, Clearweed, 2; O; *98-441*

Valerianaceae

Valerianella radiata (L.) Dufr., Beaded corn-salad, 3; O; *99-74*

Verbenaceae

Phyla lanceolata (Michx.) Greene, Frogfruit, 7, 9; O; *01-240*
Verbena simplex Lehm., Narrowleaf vervain, 3; S; *98-50*
Verbena urticifolia L., White vervain, 6, 9; I; *98-436*

Violaceae

Viola palmata L., Threelobe wood violet, 2; O; *99-65*
Viola pedata L., Bird'sfoot violet, 1; I; *99-78*
Viola rafinesquii Greene, Field pansy, 3, 5; O; *99-36*
Viola sororia Willd., Common blue violet, 5; F; *99-09*

Viscaceae

Phoradendron leucarpum (Raf.) Reveal & M.C. Johnst., American mistletoe, 1; R; *06-757*

Vitaceae

Ampelopsis cordata Michx., Raccoon-grape, 2; S; 99-*364*
Parthenocissus quinquefolia (L.) Planch., Virginia-creeper, 1, 2; A; *01-208*
Vitis aestivalis Michx., Summer grape, 1, 2; F; *98-118*
‡*Vitis palmata* Vahl, Red grape, 8; R; *01-217*
Vitis rotundifolia Michx., Muscadine grape, 1, 2, 8; A; *01-114*

MAGNOLIOPHYTA—LILIOPSIDA

Agavaceae

Manfreda virginica (L.) Salisb. ex Rose, False aloe, 1; R; *98-344*
†*Yucca filamentosa* L., Spanish-bayonet, 5; R; *02-224*

Alliaceae

Allium canadense L., Wild onion, 3; O; *99-240*
**Allium vineale* L., Field garlic, 3; I; *02-207*

Amaryllidaceae

†**Narcissus pseudonarcissus* L., Daffodil, 2; I; *99-17*

Araceae

Arisaema dracontium (L.) Schott, Green-dragon, 2; R; *01-226*

Commelinaceae

***Commelina communis* L., Asiatic dayflower, 5; O; 06-231
**Commelina diffusa* Burm. f., Creeping dayflower, 10; I; *98-671*
Commelina virginica L., Virginia dayflower, 8; O; *98-669*

Convallariaceae

Maianthemum racemosum (L.) Link var. *racemosum*, False Solomon's-seal, 2; I; *98-09*
Polygonatum biflorum (Walter) Elliott, Smooth Solomon's-seal, 2; S; *99-272*

Cyperaceae

‡*Carex albicans* Willd. var. *albicans*, Whitetinge sedge, 2; O; *99-159*
Carex blanda Dewey, Eastern wood sedge, 2; O; *99-162*
Carex caroliniana Schwein, Carolina sedge, 2; R; *99-123*
Carex cephalophora Muhl. ex Willd., Oval-leaf sedge, 5; I; *99-120*
†*Carex crinita* Lam. var. *crinita*, Fringed sedge, 7; O; *99-149*
Carex debilis Michx. var. *debilis*, White-edge sedge, 2; O; *99-158*
Carex digitalis Willd. var. *macropoda* Fernald, Slender wood sedge, 2; O; *99-163*
‡*Carex frankii* Kunth, Frank's sedge, 9; S; *98-271*
Carex glaucodea Tuck., Blue sedge, 9; S; *98-19*
Carex grayi J. Carey, Gray's sedge, 2; I; *06-222*
Carex hirsutella Mack., Hairy green sedge, 3, 4; F; *01-134*
Carex laxiflora Lam. var. *laxiflora*, Broad looseflower sedge, 2; I; *99-153*
†*Carex lupulina* Muhl. ex Willd., Hop sedge, 7, 9; O; *01-233*
Carex lurida Wahlenb., Yellow green sedge, 6; S; *99-213*

Carex muehlenbergii Schkuhr ex Willd., Muhlenberg's sedge, 1; F; *01-130*
Carex nigromarginata Schwein., Blackedge sedge, 2; R; 99-96
Carex retroflexa Muhl. ex Willd., Reflexed sedge, 2; O; *99-161*
Carex tribuloides Wahlenb., Blunt broom sedge, 9; S; *01-215*
Carex typhina Michx., Cattail sedge, 2, 9; S; *01-232*
Carex vulpinoidea Michx., Fox sedge, 7; S; *98-75*
Cyperus echinatus (L.) A. Wood, Globe flatsedge, 3, 6; S; *01-236*
Cyperus esculentus L., Yellow nutsedge, 9; S; *99-444*
Cyperus pseudovegetus Steud., Marsh nutsedge, 6, 9; S; *01-238*
Cyperus squarrosus L., Bearded nutsedge, 8, 10; A; *99-436*
Cyperus strigosus L., Strawcolor nutsedge, 6, 9; I; *01-234*
‡*Eleocharis acicularis* (L.) Roem. & Schult., Needle spikerush, 10; A; *99-455*
Eleocharis ovata (Roth) Roem. & Schult., Blunt ovate spikerush, 6; I; *98-444*
Fimbristylis autumnalis (L.) Roem. & Schult., Slender fimbry, 9; A; *99-380*
Isolepis carinata Hook. & Arn. ex Torr., Keeled bulrush, 6; S; *Poindexter 06-161*
‡*Kyllinga gracillima* Miq., Pasture spikesedge, 5; I; *Poindexter 06-162*
Rhynchospora corniculata (Lam.) A. Gray, Shortbristle horned beakrush, 9; I; *99-376*
†*Schoenoplectus tabernaemontani* (K.C. Gmel.) Palla, Softstem bulrush, 7; S; *98-522*
†*Scirpus atrovirens* Willd., Green bulrush, 7; I; *99-214*
Scirpus cyperinus (L.) Kunth, Woolgrass, 6, 9; O; *98-554*
Scleria pauciflora Mulh. ex Willd., Fewflower nutrush, 4; O; *99-235*
Scleria triglomerata Michx., Whip nutrush, 4; O; *98-137*

Dioscoreaceae

‡***Dioscorea oppositifolia* L., Chinese yam, 7; R; *99-250*
Dioscorea villosa L., Wild yam, 2; O; *01-220*

Hemerocallidaceae

†***Hemerocallis fulva* (L.) L., Orange day-lily, 5, 7; O; *99-258*

Hydrocharitaceae

Najas guadalupensis (Sprengel) Magnus, Southern water-nymph, 9; A; *99-457*

Hypoxidaceae

Hypoxis hirsuta (L.) Coville, Yellow star-grass, 1; I; *99-77*

Iridaceae

Iris cristata Soland. ex Aiton, Dwarf crested iris, 2; O; *99-69*
†**Iris pseudoacorus* L., Yellow flag, 7; S; *99-147*
†*Iris virginica* L., Southern blue flag, 7, 8; O; *99-148*
Sisyrinchium angustifolium Mill., Narrowleaf blue-eyed-grass, 3; O; *99 84*

Juncaceae

Juncus acuminatus Michx., Taperpoint rush, 6; I; *98-143*
Juncus biflorus Elliott, Bog rush, 3, 6; O; *01-225*
Juncus brachycarpus Engelm., Whiteroot rush, 6; I; *98-256*
Juncus diffusissiimus Buckley, Slimpod rush, 6; S; *99-287*
Juncus effusus L. var. *solutus*. Fern. & Wieg., Soft rush, 6, 9; O; *02-202*
Juncus marginatus Rostk., Grassleaf rush, 6; I; *98-153*
‡*Juncus nodatus* Coville, Stout rush, 6; S; *Poindexter 06-140*
Juncus tenuis Willd., Slender path rush, 3, 5; A; *99-245*
Luzula bulbosa (A. Wood) Rydb., Bulbous woodrush, 1, 2; F; *99-86*

Marantaceae

†*Thalia dealbata* Fraser ex Roscoe, Powdery alligator-flag, 7; S; *98-716*

Melanthiaceae

Chamaelirium luteum (L.) A. Gray, Devil's-bit, 2; R; *99-208*

Orchidaceae

Spiranthes cernua (L.) Rich., Nodding labies'-tresses, 3; R; *98-641*
Spiranthes lacera (Raf.) Raf. var. *gracilis* (Bigelow) Luer, Slender ladies'-tresses, 5; R; *98-611*
Spiranthes vernalis Engelm. & A. Gray, Spring ladies'-tresses, 6; R; *98-212*
Tipularia discolor (Pursh) Nutt., Crane-fly orchid, 2; S; *98-526*

Poaceae

**Agrostis gigantea* Roth., Redtop, 6, 7; O; *00-326*
**Agrostis stolonifera* L., Creeping bent grass, 3; I; *99-133*
Alopecurus carolinianus Walter, Carolina foxtail, 2; R; *99-47*
Andropogon ternarius Michx., Splitbeard bluestem, 3, 4; O; *01-626*
Andropogon virginicus L., Broom-sedge, 3, 4; F; *01-637*
Aristida dichotoma Michx., Churchmouse threee-awn, 3; F; *01-642*
Aristida longespica Poir., Slimspike three-awn, 3; O; *01-640*
Brachyelytrum erectum (Schreb.) P. Beauv., Bearded shorthusk, 2; O; *98-181*
**Bromus commutatus* Schrad., Hairy chess, 3, 5; O; *00-159*
Bromus pubescens Muhl., Woodland brome, 2; O; *99-219*
Chasmanthium latifolium (Michx.) H.O. Yates, Wood oats, 2; F; *99-378*
**Cynodon dactylon* (L.) Pers., Bermuda grass, 5; A; *98-352*
**Dactylis glomerata* L., Orchard grass, 3, 5; O; *02-200*
Danthonia spicata (L.) P. Beauv., Poverty oat grass, 1; A; *01-111*
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark subsp. *fasciculatum* (Torr.) Freckmann & Delong, Hairy panic grass, 1, 3; A; *01-138*
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark subsp *lindheimerii* (Nash) Freckmann & Delong, Hairy panic grass, 1, 3; I; *01-201*
Dichanthelium boscii (Poir.) Gould & C.A. Clark, Bosc's panicum, 1, 2; F; *02-215*
Dichanthelium clandestinum (L.) Gould, Deer-tongue panicum, 2, 6; O; *98-430*
Dichanthelium commutatum (Schult.) Gould, Variable panic grass, 1, 3; F; *99-145*
Dichanthelium depauperatum (Muhl.) Gould, Starved panic grass, 1; O; *01-133*
Dichanthelium dichotomum (L.) Gould, Forking panic grass, 2; F; *98-17*

Dichanthelium laxiflorum (Lam.) Gould, Looseflower panic grass, 1, 5; A; _98-23_
Dichanthelium polyanthes (Schult.) Mohlenb., Manyflower panic grass, 2; O; _01-115_
Dichanthelium villossimum (Nash) Freckmann subsp. _villosissimum_, Longhair panic grass, 3; S; _99-203_
*_Digitaria ischaemum_ (Schreb.) Schreb. ex Muhl., Smooth crab grass, 5, 10; I; _98-668_
*_Digitaria sanguinalis_ (L.) Scop., Hairy crab grass, 5, 10; F; _99-448_
**_Echinochloa crus-galli_ (L.) P. Beauv., Common barnyard grass, 6, 10; F; _99-446_
**_Eleusine indica_ (L.) Gaertn., Yardgrass, 5; O; _98-300_
Elymus glabriflorus (Vasey) Bush, Smooth wildrye, 3; O; _99-275_
Elymus virginicus L. var. _virginicus_, Virginia wildrye, 2; O; _01-205_
‡**_Eragrostis cilianensis_ (All.) Vignolo ex Janch.,Tufted love grass, 5; R; _98-605_
Eragrostis hypnoides (Lam.) B.S.P., Teal love grass, 10; O; _98-666_
‡_Eragrostis pectinacea_ (Michx.) Nees, Tufted love grass, 5; O; _01-250_
Eragrostis spectabilis (Pursh) Steud., Purple love grass,3, 4; O; _98-593_
**_Festuca arundinacea_ Schreb., Tall fescue, 3, 5, 6; A; _99-172_
**_Holcus lanatus_ L., Velvet grass, 3, 6; S; _02-229_
Hordeum pusillum Nutt., Little barley, 5; O; 06-234
Leersia oryzoides (L.) Sw., Rice cut grass, 7, 9; F; _98-655_
Leersia virginica Willd., Virginia cut grass, 2; O; _98-598_
†**_Lolium perenne_ L. var. _aristatum_ Willd., Perennial rye grass, 3; I; 06-245
Melica mutica Walter, Twoflower melic grass, 2; S; 06-238
**_Microstegium vimineum_ (Trin.) A. Camas, Nepalese eulalia, 2; A; _01-631_
Muhlenbergia schreberi J.F. Gmel., Nimblewill, 5; F; _98-693_
Muhlenbergia sobolifera (Muhl.) Trin., Rock muhly, 2; I; _98-492_
Panicum anceps Michx., Beaked panic grass, 6, 9; F; _99-382_
Panicum dichotomiflorum Michx. subsp. _dichotomiflorum_, Fall panicum, 10; O; _98-679_
Panicum rigidulum Bosc ex Nees, Redtop panicum, 9; F; _99-384_
*_Paspalum dilatatum_ Poir., Dallis grass, 5; S; _00-327_
Paspalum floridanum Michx., Florida paspalum, 9; I; _98-715_
Paspalum laeve Michx., Smooth beadgrass, 5; F; _01-186_
*_Phleum pratense_ L., Timothy, 3, 5; I; _02-220_
**_Poa annua_ L., Annual bluegrass, 5; F; 06-226
**_Poa compressa_ L., Canada bluegrass, 5; O; _01-172_
**_Poa pratensis_ L., Kentucky bluegrass, 5; A; _02-216_
Poa sylvestris A. Gray, Woodland bluegrass, 2; I; _00-328_
Saccharum alopecuroides (L.) Nutt., Silver plume grass, 2, 3; I; _01-632_
Schizachyrium scoparium (Michx.) Nash, Little bluestem, 3, 4; A; _01-641_
**_Setaria faberi_ R.A. Herrm., Nodding foxtail, 5; I; _01-188_
Setaria parviflora (Poir.) Kerguelen, Knotroot foxtail, 3, 4; F; _98-597_
*_Setaria pumila_ (Poir.) Roem. & Schult., Yellow foxtail, 5; I; _99-362_
Sorghastrum nutans (L.) Nash, Indian grass, 3, 4; F; _98-642_
**_Sorghum halepense_ (L.) Pers., Johnson grass, 3; O; _01-194_
Sphenopholis nitida (Biehler) Scribn., Shiny wedge grass, 2; O; _99-102_
Tridens flavus (L.) Hitchc., Purpletop, 3, 4, 5; F; _01-639_
Tripsacum dactyloides (L.) L., Eastern gama-grass, 4; O; _98-97_
†*_Triticum aestivum_ L., Wheat, 3; R; _01-135_
Urochloa platyphylla (Nash) R.D. Webster, Signal grass, 3; R; _01-605_
Vulpia octoflora (Walter) Rydb., Common six-weeks fescue, 2; A; _01-110_

Ponteridiaceae

†_Pontederia cordata_ L., Pickerel-weed, 7; R; _98-86_

Potamogetonaceae

‡_Potamogeton pusillus_ L., Slender pondweed, 6; F; _99-422_

Smilacaceae

Smilax bona-nox L., Catbrier, 2, 3, 4; O; _98-117_
Smilax glauca Walter, Glaucous greenbrier, 2, 3, 4; F; _98-239_
Smilax hispida Raf., Bristly greenbrier, 2; R; _99-223_
Smilax herbacea L. var. _pulverulenta_ (Michx.) A. Gray, Carrion-flower, 2; R; _99-370_
Smilax rotundifolia L., Common greenbrier, 2, 3, 4; F; _99-273_

Typhaceae

Typha latifolia L., Common cat-tail, 6, 7; F; _01-252_

Uvulariaceae

Uvularia sessilifolia L., Sessileleaf bellwort, 2; O; _01-229_

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CHECKLIST OF THE VASCULAR PLANTS OF CRAWFORD COUNTY, PENNSYLVANIA

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ABSTRACT

Crawford County has been botanized since the early 1800s; however, a checklist of the county's vascular flora has not previously been compiled. A search of herbaria augmented by targeted fieldwork has resulted in a list of 1168 taxa of native and naturalized plants comprising 485 genera and 134 families. The five families, with the largest number of species, are Asteraceae, Poaceae, Cyperaceae, Rosaceae, and Liliaceae. *Carex*, *Potamogeton*, *Polygonum*, *Salix*, and *Rubus*, are the five largest genera. There are approximately 208 non-native species that have been introduced mainly from Europe and Eurasia. This checklist recognizes 10 species of Lycophytes, 46 species of Pteridophytes, 7 species of Gymnosperms and 1105 species of Angiosperms. Ninety-seven species have global or state ranking.

RESUMEN

El Condado de Crawford, se localiza en el estado de Pennsylvania. Este condado es considerado una de las áreas más diversas del estado, sin embargo hasta ahora no ha sido completado un catálogo. Este catálogo contiene familias, géneros, y taxa específicos que están ordenados alfabéticamente en los grupos de plantas vasculares tales como Pteridofitas, Gimnospermas y Angiospermas. Esta lista incluye los nombres de especies nativas y naturalizadas conocidas que ocurren en el Condado de Crawford. Se encontraron un total de al menos 134 familias, 485 géneros, y 1168 especies. Las cinco familias mayores, por el número de especies, fueron Asteraceae, Poaceae, Cyperaceae, Rosaceae y Liliaceae. Los seis géneros mayores, por el número de especies, fueron *Carex*, *Potamogeton*, *Polygonum*, *Salix* y *Rubus*.

INTRODUCTION

Even though Pennsylvania lacks checklists for most of its counties, the vascular flora known thus far is quite diverse. Rhoads and Klein (1993) reported 3318 taxa of vascular plants for the state, including 2076 native and 1242 introduced. Approximately 25 of Pennsylvania's 67 counties have floras completed, but some are unpublished theses and surveys and therefore unavailable to the public. The exact number of genera and species in the flora of Crawford County was not previously known because a checklist had never been compiled. Such checklists provide baseline information that can be used to monitor environmental changes and guide conservation decisions.

Site Description

Crawford County is located in the northwestern corner of Pennsylvania, adjacent to Ohio (Fig. 1). It is bordered by the counties of Erie to the north, Warren to the east, Venango to the southeast, and Mercer to south. Named for Colonel William Crawford on March 12, 1800, the county contains approximately 2,690 sq. km. Crawford County receives total annual precipitation of approximately 97 cm in its southwestern region and 112 cm in its northwestern region; 55% of this precipitation usually falls between April and September. Average season snowfall is 178 cm in the southwestern area, 230 to 240 cm in the central area, and more than 300 cm in the northeastern area. The last frost of the season is usually around May 15th and the first frost of the season around October 6th. The length of the growing season, from the last killing

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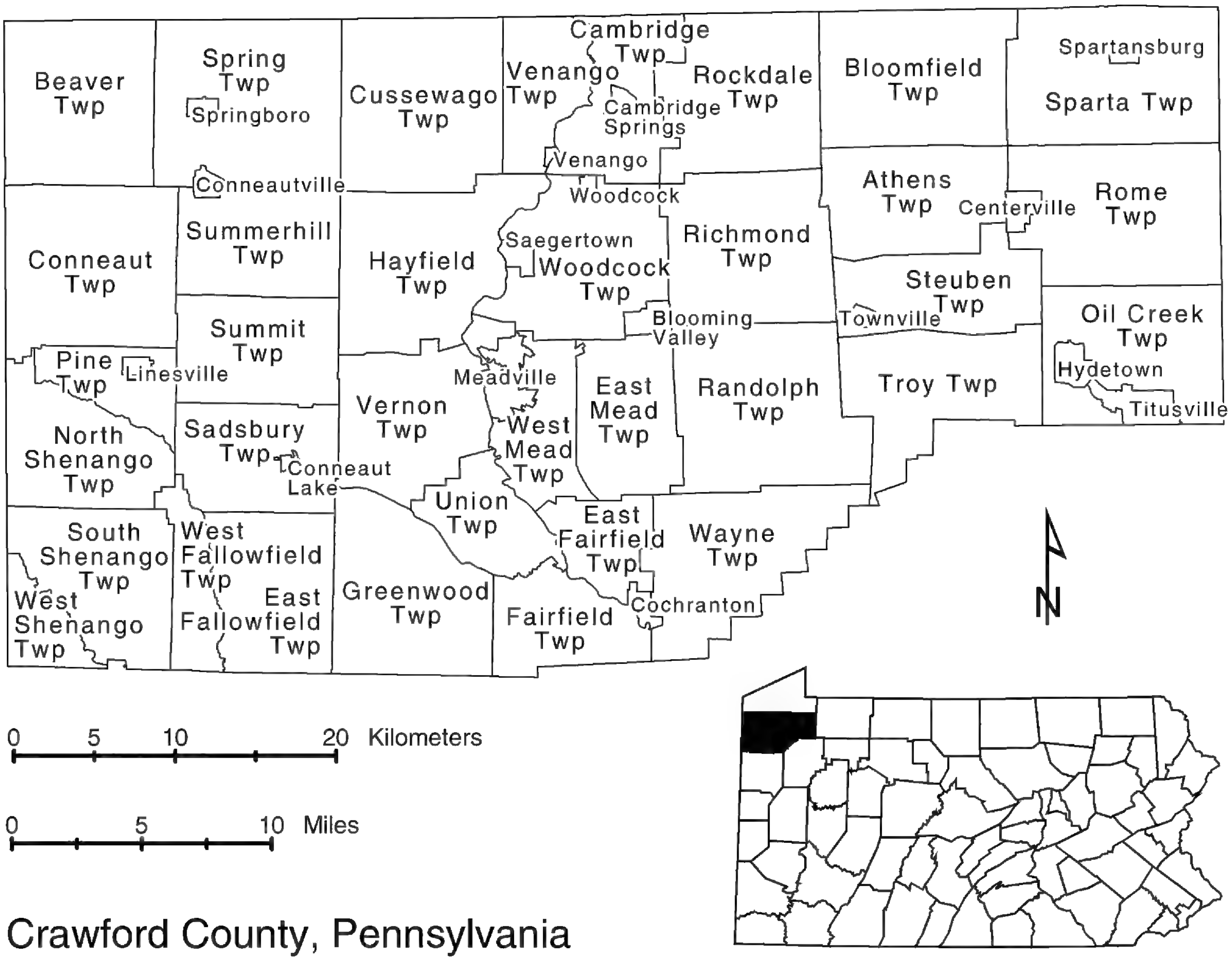

Fig. 1 **Top: Crawford County, Pennsylvania and townships.**

frost in spring to the first killing frost in autumn, ranges from 145 to 150 days in the southwestern region to 130 to 135 days in the northeastern region (USDA 1979).

The soils of the county consist mainly of the following 7 series, covering at least 1,963 sq. km., or 75%, of Crawford County: Venango, Cambridge, Frenchtown, Holly, Red Hook, Sheffield, and Alden.

The Venango Series consists of nearly level upland flats, to knobs and side slopes of valleys that make up about 29% of the county. These soils are weathered glacial till that contain sandstone, siltstone, and shale. They have very slow permeability and a moderate available water capacity. Most areas are cleared and used for crops or pasture or are idle.

The Cambridge Series consists of nearly level areas to upland knobs, side slopes of valleys, and crests of slopes that make up about 13% of the county. These soils are weathered from glacial till that contains sandstone, siltstone, and shale. They have slow permeability and a moderate available water capacity. Most of the area is used for crops or pasture, but some land is wooded or idle.

The Frenchtown Series consists of nearly level and gently sloping areas that make up about 12% of the county. These soils are weathered from glacial till that contains sandstone, shale, and some crystalline rocks. They have slow permeability and a moderate available water capacity. Most of the area is wooded but some areas are idle or used for crops or pasture land.

The Holly Series consists of nearly level soils that are on floodplains of major stream valleys that make up about 9% of the county. These soils are weathered from recent stream deposits. They have moderate slow permeability and a moderate to high available water capacity. Most of the area is used for pasture land but some areas are woodland or idle or used for crops.

The Red Hook Series consists of nearly level to gently sloping soils on terraces in stream valleys that make up about 4% of the county. These soils are weathered from glacial outwash. They have moderate permeability and a moderate to high available water capacity. Most of the areas are used for woodland, pasture, or crops or are idle.

The Sheffield Series consists of poorly drained, nearly level soils that make up about 4% of the county. These soils are weathered from glacial till that contains sandstone, shale, and some limestone. They have very slow permeability and a moderate available water capacity. Most areas are woodlands but some contain crops, pasture, or are idle.

The Alden Series consists of nearly level soils with slight depressions that make up about 4% of the county. These soils are weathered from glacial till and local alluvium. They have low permeability and high available water capacity. Most of the areas are woodlands, but pasture and idle lands are also present.

Crawford County is part of the Northwestern Glaciated Plateau section of the Appalachian Plateau Province. The Northwestern Glaciated Plateau section consists of broad, rounded uplands cut by long, linear valleys. The uplands are transected by flat-floored, narrow to wide valleys and are separated from adjacent uplands by steep slopes on one or both sides of the valley. The valleys are oriented northwest-southeast and are linear with the valley floors often containing wetlands. Elevation ranges from 900 to 2,200 feet (USDA 1979).

Crawford County contain stands of old growth, timber that has been logged very little or never. Old growth makes up less than 5% of the forests remaining in the United States and contains unique trees that make a significant contribution to forest biodiversity. One site is the Tryon-Weber Woods, which has 40 acres of rare hardwood old growth, containing American beech and sugar maples. This type of forest is the only remaining stand in Pennsylvania. During early settlement, most of Pennsylvania was covered with Eastern hemlock, white pine, and mixed hardwoods. From then until the early 1900s forests were logged and as the forests were clear-cut, fast growing species quickly regenerated. The forest structure since then has shifted to mixed hardwoods.

The effects of herbivory on individual species and isolated populations have been documented for Crawford County; region wide effects on the flora are evident but not well documented. Over time, selective browsing by densely populated deer can result in reduced species richness and altered species composition, with dominance by a few non-preferred and browsing-resilient species. Unpalatable and browsing-resilient species become abundant and can interfere with the reestablishment of preferred and less browsing-resilient species. Overall, heavy browsing by deer in woody plant communities can change the trajectory of forest vegetation development. Whether these changes for Crawford County are permanent is a matter of scientific debate and will most likely be determined in due time and with additional studies.

Crawford County contains several major watersheds, which contain large wetland areas. Several major watersheds include the Shenango River Watershed, French Creek Watershed, Oil Creek Watershed and the Conneaut Creek Watershed.

The Crawford County area of the Shenango Creek Watershed comprises 120,700 acres. The tributaries of Shenango Creek in Crawford County include Paden Creek, Linesville Creek and Crooked Creek. The watershed includes a major impoundment, Pymatuning Lake, which is the largest man-made reservoir in Pennsylvania. Pymatuning Lake drains into the Shenango system from two outlets. The first is Crooked Creek in Crawford County, which flows southward through the Pymatuning Marsh and the second is the Shenango River, which flows southward out of the western lobe of the lake between South and West Shenango Townships. Two other features within the Crawford County portion of the Shenango River Watershed are Crystal Lake and Dollar Lake. Both Crystal and Dollar Lakes are glacial kettle lakes formed during the last Ice Age.

The French Creek Watershed encompasses 1270 sq. mi. in area; with approximately 41% of Crawford

County lying therein. Wetlands, such as marshes, swamps, and fens are all found within the French Creek watershed. Conneaut Marsh is an example of a wetland that works to control flooding, filter excess nutrients in the water and provide habitats to several aquatic species. French Creek contains major waterways and many smaller streams. The area within the watershed has much overland flow, which picks up pollutants. Consequently one of the major threats to the French Creek watershed is non-point source pollution. However, to date it has been characterized as having very good to excellent water quality. The watershed is hailed as one of the most ecologically diverse systems in Pennsylvania.

The Oil Creek Watershed is located in the eastern part of Crawford County. Oil Creek flows mainly within Venango, Crawford and Warren Counties and is approximately 340 sq. mi. Crawford County comprises 167 sq. mi. of the watershed with dramatic topography of forested hillsides and clean clear streams.

The Conneaut Creek Watershed flows northward into Lake Erie near Conneaut, Ohio. The watershed takes in approximately 96 sq. mi. Some streams include Main Branch, Middle Branch, and East Branch of Conneaut Creek and Stone Run. Conneaut Creek Watershed is located in Beaver, Spring, Conneaut, Summerhill and Summit Townships in Crawford County.

History

Initially the Seneca Indians dominated the region. The French arrived in 1748 and formed a short portage between Presque Isle and Le Boeuf until 1758. Europeans did not settle the land again until 1788, when a small party came out from Northumberland County and began to build an establishment where Meadville now stands.

On March 12th of 1800 the Allegheny Legislature passed an act separating Crawford, Mercer, Venango, Warren, and Erie counties from the territory of Allegheny County. Crawford County was named in honor of Col. William Crawford, a staunch defender of the white settlers against Indian attacks.

French Creek, which flows from north to south, was the chief route for shipping local lumber to Pittsburgh. The only other means of transportation was horse and wagon. In 1826 Major Douglass made surveys for the development of a canal crossing to link the north to the south; this was the first constructed transportation route in the county. The canal, called the Feeder Canal, was approximately 22 miles long. It was completed in 1834, and canal boats began operating between Bemustown Dam and Conneaut Lake.

Before the 1800s there were no roads at all. Until the Erie and Waterford Turnpike Company was chartered in 1805, the settlers would just make their way through the woods. The Meadville-Waterford-Erie Turnpike was constructed between 1806 and 1809 and used for thirty-five years until it became the Susquehanna and Waterford Turnpike. By 1820 this road extended from Waterford to Bellefonte in Centre County and by 1824 to Philadelphia. The Turnpike was used from 1824 until it was abandoned in 1845. The Mercer and Meadville Turnpike was completed in 1821 and is still known to county residents as the Mercer Pike. In 1859 Col. E.L. Drake successfully drilled a well that produced oil in eastern Crawford County. This development brought prosperity and railroads to Titusville.

The lack of adequate shipping facilities had hindered the development of local manufacturing as well as the marketing of local produce outside the county. The completion of Atlantic and Great Western Railways of Pennsylvania (now the Erie Railroad) to Meadville in 1862 stimulated economic growth. In 1913 Col. Lewis Walker purchased a small enterprise, first called the Automatic Hook and Eye Company and later Talon, Inc., which eventually made Meadville the zipper capital of the world. Railroad construction boomed from 1860 to 1866. By 1871 tracks ran from Bloomfield, Steuben, Troy, and Oil Creek to Titusville and became part of the Buffalo, New York, and Philadelphia Line. Today Crawford County has more miles of railroad than any county in Pennsylvania.

Industry developed gradually, and today most boroughs have manufacturing enterprises that provide substantial employment. The five principal industries are agriculture, gas and oil production, textiles and textile products, and metals and metal products, and allied products. Today about 40% of Crawford County is farmed, 46% is used for commercial woodland, and the rest is being developed for urban use or recreation. Dairying is the primary farming; Crawford is one of Pennsylvania's top 10 milk-producing counties.

Principal crops are corn, wheat, oats, and hay. Lumber, pulpwood, maple syrup, and Christmas trees from the woodland areas also generate income. Besides agricultural and industry, a thriving resort business attracts thousands of summer visitors to the recreational facilities of Conneaut Lake, Pymatuning Reservoir, Cambridge Springs, and Canadohta Lake (Bates 1885).

In 1800 the county population was approximately 2,345; according to the census of 2000, Crawford County has 90,366 residents (USDA (1979, 2000)).

Major Collectors

Collecting in Crawford County for the Carnegie Museum Herbarium began in the early 1800s and has continued to the present. Most of the collectors have been members of the Botanical Society of Western Pennsylvania and the staff of the Section of Botany at Carnegie Museum.

Botanists who have made significant contributions to the knowledge of the Crawford County are: J.K. Bissell, J.A. Isaac, L. Speedy, R.C. Leberman, S.P. Grund and O.E. Jennings.

METHODS

This checklist was compiled by searching the herbaria of the Carnegie Museum of Natural History (CM) and the Cleveland Museum of Natural History (CLM) for Crawford County specimens. In addition, fieldwork was conducted targeting underrepresented areas of the county. Most of the collections were made during the last two years, but several specimens date back as far as 1881 and 1882. The majority of the specimens are deposited at the Carnegie Museum of Natural History (CM). Herbarium collection information was obtained from the Morris Arboretum (MOAR) and the Cleveland Museum of Natural History (CLM) for 189 samples. Other herbaria that were examined for specimens include the Academy of Natural Sciences of Philadelphia. Rhoads and Block (2000) was the primary source for plant identification. For generic and species names, we have generally followed the Synthesis of North American Flora (Kartesz 1999). Authorities are abbreviated for the majority of taxa according to Brummitt and Powell (1992).

RESULTS AND DISCUSSION

This list includes the names of all native and naturalized species known to occur in Crawford County. It includes a total of 134 families, 485 genera, and 1168 species. The five families with the largest number of species, are Asteraceae, Poaceae, Cyperaceae, Rosaceae, and Liliaceae. *Carex*, *Potamogeton*, *Polygonum*, *Salix* and *Rubus*, are the largest genera. This checklist recognizes 10 species of Lycophytes, 46 species of Pteridophytes, 7 species of Gymnosperms and 1105 species of Angiosperms. There are approximately 208 non-native species that have been introduced mainly from Europe and Eurasia. Ninety-seven species have global or state ranking.

Of the 97 plants that have global or state ranking only three taxa have a global ranking of G3 or vulnerable status (*Potamogeton hillii*, *Poa paludigena*, and *Platanthera leucophaea*). The remaining 94 plants are either a G4 or G5 status, indicating an apparently secure or secure condition globally.

The genus *Potamogeton* is in the family Potamogetonaceae. *Potamogeton hillii* is one of the smaller linear-leaved pondweeds and can be difficult to recognize. This herbaceous perennial is totally submerged except for the flowering spike. The leaves range from 1.5-2.0 mm wide and are bristle-tipped, and 3-veined. The flowers are arranged in very short, few flowered spikes which are nearly globose. It occurs in cold, clear, slow-moving water in streams, ponds, and beaver ponds with a muddy substrate.

Poa is part of the grass family (Poaceae). Most members of this genus are very similar and require microscopic identification of the flower parts to identify. *Poa paludigena* is a perennial with culms forming loose clumps. Culm internodes are terete with leaf-sheaths scaberulous. Leaf blades are erect and 0.3-2 mm wide. The inflorescence is a panicle, with branches in pairs. Spikelets are comprised of 2-5 fertile florets and are oblong and laterally compressed. Florets are slightly woolly. It typically grows in moist, open areas such as meadows or moist woods and can be found among sphagnum or other mosses. This species can be easily overlooked or misidentified due to its similarity to closely related species.

Platanthera is a member of the Orchid family. The specific epithet leucophaea refers to the off-white color of the flowers. This species forms a cluster of fleshy thickened roots at the base. The 2-5 leaves are lanceolate with the bases sheathing the stem. The inflorescence is a raceme of 5-20 flowers, creamy-white and strongly fragrant at dusk. The basal petal, the labellum, is tripartite and fringed. It is found almost exclusively in moist prairies or open sphagnum bogs. Currently it is found in less than sixty sites in the U.S., many with only a few individuals.

There are four taxa in the Crawford County flora that are listed by the Pennsylvania Department of Agriculture (2004) as noxious weeds: *Cirsium arvense* (canadian thistle), *Cirsium vulgare* (bull or spear thistle), *Lythrum salicaria* (purple loosestrife), and *Rosa multiflora* (multiflora rosa). Other species considered invasive in our native ecosystems are *Acer platanoides* (Norway maple), *Lonicera japonica* (Japanese honeysuckle), *Phragmites australis* (Common reed), *Polygonum cuspidatum* (Japanese knotweed), *Elaeagnus umbellata* (Autumn olive), *Lonicera morrowii* (Morrow's honeysuckle), and *Lonicera tatarica* (Tatarian honeysuckle) (DCNR 2000).

While this checklist is probably not all-inclusive of every species in Crawford County, it is the most comprehensive list presently available.

ANNOTATED CHECKLIST OF THE SPECIES OF CRAWFORD COUNTY, PENSYLVANIA

Taxa are listed according to the following format: taxon name, author(s), {(year) collector and number} **global: state ranking** [*Synonyms*] and non-native source. We follow the state (**S**) and global (**G**) ranking systems developed by The Nature Conservancy (1996 version). The global numbers are designated from **1** (critically imperiled) to **5** (secure). Other notations include **SH,** which denotes historical occurrence, and **SR,** which indicates reported without persuasive documentation. Synonyms are included for names not in common usage in the state or regional manuals. In cases where there was more than one specimen present in the collection, recent collections of current known collectors for the western Pennsylvania region were cited.

Families, genera, and specific and infraspecific taxa are arranged alphabetically within vascular plant groups Angiosperms, Gymnosperms, Lycophytes, and Pteridophytes.

ANGIOSPERMS

Acanthaceae

Justicia americana (L.) Vahl, 1988 J.K. Bissell et al. 88:101

Aceraceae

Acer negundo L., 1997 R.C. Leberman. s.n.
Acer nigrum Michx. f., 1922 O.E. Jennings. s.n.
Acer pensylvanicum L., 2003 R Coxe and M. Bradburn s.n.
Acer platanoides L., 1997 R.C. Leberman s.n. Europe
Acer rubrum L. var. *rubrum*, 2005 L. Speedy LSB329
Acer rubrum L. var. *trilobum* Torr. & A. Gray ex K. Koch, 1952 L.K. Henry and W.E. Buker s.n.
Acer saccharinum L., 2003 S. Ernst et al. 71
Acer saccharum Marsh. var. *saccharum,* 1955 L.K. Henry s.n.
Acer spicatum Lam., 1932 W.R. Van Dersal 1866

Acoraceae

Acorus americanus (Raf.) Raf., 2002 J.K. Bissell 2002:134 G5:S1
Acorus calamus L., 1999 J.K. Bissell and B. Danielson 1999:194 Europe

Alismataceae

Alisma subcordatum Raf., 2003 J.K. Bissell 2003:148
Sagittaria latifolia Willd., 2004 S.P.Grund and L. Miller 3487
Sagittaria rigida Pursh, 2001 J.K. Bissell 2001:149

Amaranthaceae

Amaranthus albus L., 1918 E.M. Gress s.n.
Amaranthus blitum L., 2005 R. Thompson 05-504 Tropical America
Amaranthus hybridus L., 1947 H.A. Wahl 4076
Amaranthus retroflexus L., 1948 S. Tisherman s.n. Tropical America

Anacardiaceae

Rhus glabra L., 2004 J.A. Isaac 17601
Rhus typhina L., 1997 R.C. Leberman s.n.
Toxicodendron radicans (L.) Kuntze, 1997 J.A. Isaac 9878
Toxicodendron vernix (L.) Kuntze, 2005 L. Speedy LSB1565

Annonaceae

Asimina triloba (L.) Dunal, 1955 D.L. Pearth s.n.

Apiaceae

Angelica atropurpurea L., 1928 J.A. Murray s.n.
Angelica triquinata Michx., 1980 C.E. Jenkins et al. 2777
Angelica venenosa (Greenway) Fern, 1901 J.A. Shafer s.n.
Chaerophyllum procumbens (L.) Crantz, 2004 S.P. Grund and L.Miller 3534
Cicuta bulbifera L., 2005 L. Speedy, M. Bowers and M. Fodse LSB1608
Cicuta maculata L., 2000 J.A. Isaac and C.F. Chuey 13168

Conium maculatum L., 1980 F.Q. Jenkins and C.E. Jenkins 2836 Europe
Cryptotaenia canadensis (L.) DC., 2004 J.A. Isaac 17468
Daucus carota L., 2000 J.A. Isaac and C.F. Chuey 13170 Eurasia
Erigenia bulbosa (Michx.) Nutt, 2004 J.K. Bissell 2004:006 G5:S2
Heracleum maximum Bartr., 2000 J.A. Isaac and C.F. Chuey 13167
Hydrocotyle americana L., 2004 J.K. Bissell 2004:114
Osmorhiza claytonii (Michx.) C.B. Clarke, 1972 W.E. Buker s.n.
Osmorhiza longistylis (Torr.) DC., 1972 W.E. Buker s.n.
Pastinaca sativa L., 1968 R.C. Leberman s.n. Eurasia
Sanicula canadensis L. var. *canadensis,* 2004 J.A. Isaac 17678
Sanicula marilandica L., 1989 J.K. Bissell and B. Danielson 1989:112
Sanicula odorata (Raf.) K.M. Pryer & L.R. Phillippe, 1984 J.K. Bissell 84:120
Sium suave Walt., 2005 L. Speedy LSB1557
Taenidia integerrima (L.) Drude, 1972 W.E. Buker s.n.
Thaspium barbinode (Michx.) Nutt, 1997 R.C. Leberman s.n.
Zizia aurea (L.) W.D.J. Koch, 1962 W.E. Buker s.n.

Apocynaceae

Apocynum androsaemifolium L., 1997 R.C. Leberman s.n.
Apocynum cannabinum L., 2005 L. Speedy 761
Vinca minor L., 1919 H.W. Mossman s.n. Europe

Aquifoliaceae

Ilex montana Torr. & A. Gray ex Gray, 1975 R.C. Leberman s.n.
Ilex verticillata (L.) A. Gray, 2005 L. Speedy LSB1091
Nemopanthus mucronatus (L.) Loes., 2004 J.A. Isaac 17593

Araceae

Arisaema dracontium (L.) Schott, 1995 R.C Leberman. s.n.
Arisaema triphyllum (L.) Schott ssp. *stewardsonii* (Britt.) Huttleston, 1994 J.D Wagner et al. 114
Arisaema triphyllum (L.) Schott spp. *triphyllum,* 2004 S.P. Grund and. L. Miller 3642
Arisaema triphyllum (L.) Schott ssp. *pusillum* (Peck) Huttleston, 1914 C.A. Darling s.n.
Calla palustris L., 2004 J.A. Isaac18474
Peltandra virginica (L.) Schott, 2005 L. Speedy, M. Bowers, and M. Fodse LSB1607
Symplocarpus foetidus (L.) Salisb. ex Nutt., 2005 L. Speedy LSB337

Araliaceae

Aralia hispida Vent., 1962 L.K. Henry s.n.
Aralia nudicaulis L., 1996 R.C. Leberman s.n.
Aralia racemosa L., 1996 R.C. Leberman s.n.
Aralia spinosa L., 2005 R. Thomspson 05-858
Panax quinquefolium L., 1962 R.C. Lebermans.n.
Panax trifolius L., 2005 L. Speedy LSB349

Aristolochiaceae

Asarum canadense L., 1972 W.E. Buker s.n.

Asclepiadaceae

Asclepias exaltata L., 1981 R.C. Leberman s.n.
Asclepias incarnata L. ssp. *incarnata,* 2005 L. Speedy, J. Bissell, M. Bowers and T.Pearson LSB1583
Asclepias syriaca L., 2004 J.A. Isaac 17609

Asteraceae

Achillea millefolium L., 2004 J.A Isaac and. R. Coxe 17590 Eurasia
Ageratina altissima (L.) King & H.E. Robins. var. *altissima,* 1998 R. Leberman s.n.
Ambrosia artemisiifolia L. var. *elatior* (L.) Descourtils, 1928 J.A. Murray s.n.
Ambrosia trifida L. var. *trifida,* 1928 J.A. Murray s.n.
Anaphalis margaritacea (L.) Benth., 1968 W.E. Buker s.n.
Antennaria howellii Greene ssp. *neodioica* (Greene) Bayer, 1950 L.K. Henry and W.E. Buker s.n.
Antennaria neglecta Greene, 1984 A.W. Cusick 23365
Antennaria parlinii Fern. ssp. *parlinii* Fern., 1971 W.E. Buker s.n.
Anthemis arvensis L., 1980 R.C. Leberman s.n. Europe
Anthemis cotula L., 2004 J.A. Isaac 17602 Europe
Arctium lappa L., 2000 J.A. Isaac and C.F. Chuey 13172 Eurasia
Arctium minus Bernh., 1970 W.E. Buker s.n. Eurasia
Artemisia vulgaris L., 1969 W.E. Buker s.n. Eurasia
Bellis perennis L., 2004 S.P. Grund and L. Miller 3588 Europe
Bidens cernua L., 1991 R.C. Leberman s.n.
Bidens connata Muhl. ex Willd., 2005 L. Speedy, J. Bissell, M. Bowers and T. Pearson LSB1558
Bidens coronata (L.) Britt., 2004 J.A. Isaac 18456
Bidens discoidea (Torr. & A. Gray) Britt., 2003 J.K. Bissell 2003:172 G5:S3
Bidens frondosa L., 1969 W.E. Buker s.n.
Bidens laevis (L.) B.S.P., 1868 Thomas C. Porter s.n. G5:S3
Bidens tripartita L., 2004 J.A .Isaac et al. 17722
Bidens vulgata Greene, 1944 O.E. Jennings s.n.
Centaurea biebersteinii DC., 2003 S. Ernst 32 Exotic
Cichorium intybus L., 1928 J.A. Murray s.n. Europe
Cirsium arvense (L.) Scop., 1980 C.E. Jenkins and F.Q. Jenkins 2883 Eurasia
Cirsium muticum Michx., 1987 J.K. Bissell and B. Danielson 1987:269
Cirsium pumilum (Nutt.) Spreng., 1928 J.A. Murray s.n.
Cirsium vulgare (Savi) Ten., 1969 W.E. Buker s.n. Eurasia
Conyza canadensis (L.) Cronq. var. *canadensis,* 1997 W.E. Tomon W.E. s.n.
Coreopsis tripteris L., 1994 K. Marsh et al. s.n.
Crepis capillaris (L.) Wallr., 2004 J.A. Isaac and R. Coxe 17589 Europe
Doellingeria infirma (Michx.) Greene, 2005 L. Speedy et al. 1569 s.n. [*Aster infirmus* Michx.]
Doellingeria umbellata (P. Mill.) Nees var. *umbellata,* 2004 S.P. Grund and L. Miller 3668
Erechtites hieraciifolia (L.) Raf. ex DC. var. *hieraciifolia,* 1992 K. Marsh et al. s.n.
Erigeron annuus (L.) Pers., 2004 J.A. Isaac 17699
Erigeron philadelphicus L. var. *philadelphicus,* 1972 W.E. Buker s.n.
Erigeron pulchellus Michx. var. *pulchellus,* 1982 W.E. Buker and T.J. Grisez s.n.
Erigeron strigosus Muhl. ex Willd. var. *strigosus,* 1928 J.A. Murray s.n.

Eupatorium altissimum L., 1998 K. Marsh s.n.
Eupatorium fistulosum Barratt, 1984 J.K. Bissell 1984:119
Eupatorium maculatum L. var. *maculatum,* 2005 L. Speedy, J. Bissell, M. Bowers and T.Pearson LSB1566
Eupatorium perfoliatum L. var. *perfoliatum,* 2005 L. Speedy and L. Armstrong LSB1598
Eurybia chlorolepis (Burgess) Nesom, 1997 J.D. Wagner and G. Podniesinski 1780 [*Aster chlorolepis* Burgess]
Eurybia macrophylla (L.) Cass, 1991 R.C. Leberman s.n.
Eurybia schreberi (Nees) Nees, 1997 J.K. Bissell et al. 1997:182 [*Aster schreberi* Nees]
Euthamia graminifolia (L.) Greene var. *graminifolia*, 2004 S.P. Grund and L. Miller 3601
Galinsoga quadriradiata Cav., 1994 K. Marsh and G. Marsh s.n. Central & South America
Gamochaeta purpurea (L.) Cabrera, 1901 J.A. Shafer s.n.
Gnaphalium uliginosum L., 1962 L.K. Henry. s.n. Europe
Hasteola suaveolens (L.) Pojark., 1998 J.K. Bissell 1998:074
Helenium autumnale L., 1951 L.K. Henry and W.E. Buker s.n.
Helenium flexuosum Raf., 2006 S.P. Grund 4137
Helianthus microcephalus Torr. & Gray, G.W. Clinton s.n. G5:S3
Helianthus tuberosus L., 1970 W.E. Buker s.n.
Heliopsis helianthoides (L.) Sweet, var. *helianthoides,* 1983 R.C. Leberman s.n.
Hieracium aurantiacum L., 2004 J.A. Isaac 17489 Europe
Hieracium caespitosum Dumort., 2004 J.A. Isaac 17460 Europe
Hieracium gronovii L., 1965 D.L. Pearth s.n.
Hieracium paniculatum L., 1887 B.H. Patterson s.n.
Hieracium pilosella L. var. *pilosella,* 2004 J.A. Isaac 17487 Europe
Hieracium scabrum Michx. var. *scabrum,* 1928 J.A. Murray s.n.
Hieracium venosum L., 1996 R.C. Leberman s.n.
Hypochaeris radicata L., 1980 R.C. Leberman s.n. Eurasia
Inula helenium L., 2004 J.A. Isaac 17686 Europe
Krigia biflora (Walt.) Blake var. *biflora,* 2004 J.A. Isaac 17481
Lactuca biennis (Moench) Fern., 1951 L.K. Henry and W.E. Buker s.n.
Lactuca canadensis L., 1959 L.K. Henry and F.H. Beer s.n.
Lactuca floridana (L.) Gaertn. var. *floridana,* 1970 W.E. Buker s.n.
Lactuca saligna L., 1970 W.E. Buker s.n. Europe
Lactuca sativa L., 2003 S. Ernst 117 Exotic
Leucanthemum vulgare Lam., 2004 J.A. Isaac and R. Coxe 17585 Exotic
Matricaria discoidea DC., 2004 J.A. Isaac 17453 Exotic
Megalodonta beckii (Torr. ex Spreng.), Greene 2003 S. Ernst et al. 102 G4G5:S1
Packera aurea (L.) A. & D. Löve, 2005 L. Speedy LSB346 [*Senecio aureus* L.]
Packera obovata (Muhl. ex Willd.) W.A. Weber & A. Löve, 1971 W.E. Buker s.n. [*Senecio obovatus* Muhl.ex Willd.]
Petasites hybridus (L.) P.G. Gaertn., B. Mey. & Scherb., 1968 M. Bayliss s.n. Europe
Prenanthes alba L., 1994 K. Marsh et al. s.n.
Prenanthes altissima L., 2005 R. Thompson 05-1041
Pseudognaphalium macounii (Greene) Kartesz, 2002 J.A. Isaac 15721
Pseudognaphalium obtusifolium (L.) Hilliard & Burtt ssp. *obtusifolium,* 1997 T.J. Tomon s.n.
Rudbeckia hirta L. var. *hirta*, 1980 C.E. Jenkins 2851
Rudbeckia hirta L. var. *pulcherrima* Farw., 1952 L.K. Henry and F.H. Beer s.n.
Rudbeckia laciniata L. var. *laciniata,* 2004 J.A. Isaac 18457
Sericocarpus asteroides (L.) B.S.P., 1928 J.A. Murray s.n.
Silphium perfoliatum L. var. *perfoliatum,* 1994 K. Marsh et al. s.n.
Solidago altissima L., 1997 J. Long s.n.
Solidago bicolor L., 1970 W.E. Buker s.n.
Solidago caesia L., 1970 W.E. Buker s.n.
Solidago canadensis L. var. *canadensis,* 2005 L. Speedy LSB1571
Solidago flexicaulis L., 1969 W.E. Buker s.n.
Solidago gigantea Ait., 2005 L. Speedy LSB1119
Solidago juncea Ait., 1959 L.K. Henry and F.H. Beer s.n.
Solidago nemoralis Ait., 1991 R.C. Leberman s.n.
Solidago patula Muhl. ex Willd. var. *patula,* 2004 J.A. Isaac 18440
Solidago rugosa P. Mill var. *aspera* (Ait.) Cronq., 1949 O.E. Jennings and C.M. Boardman s.n.
Solidago rugosa P. Mill var. *rugosa,* 2005 L. Speedy LSB1559
Solidago uliginosa Nutt. var. *uliginosa,* 1914 J. Bright s.n. G4G5:S3
Solidago uliginosa Nutt. var. *linoides* (Torr. & A. Gray) Fern., 1940 J. Wurdack Jr. s.n. G4G5:SH
Sonchus arvensis L. ssp. *arvensis,* 2004 J.A. Isaac 17706 Europe
Sonchus arvensis L. ssp. *uliginosus* (Bieb.) Nyman, 1968 W.E. Buker s.n. Europe
Sonchus asper (L.) Hill, 2005 R. Thompson 05-1094 Europe
Symphyotrichum boreale (Torr. & A.Gray) A. & D. Löve, 1993 J.K. Bissell and B. Danielson 1993:182 G5:S1
Symphyotrichum lanceolatum (Willd.) Nesom ssp. *lanceolatum,* 2002 J.A. Isaac 15713 [*Aster lanceolatus* Willd. ssp. *lanceolatus* var. *lanceolatus*]
Symphyotrichum lateriflorum (L.) A. & D. Löve var. *lateriflorum,* 2004 J.A. Isaac 18478 [*Aster lateriflorus* (L.) Britton]
Symphyotrichum lowrieanum (Porter) Nesom, 1994 K. Marsh et al. s.n.
Symphyotrichum novae-angliae (L.) Nesom, 2004 J.A. Isaac 18477 [*Aster novae-angliae* L.]
Symphyotrichum pilosum (Willd.) Nesom var. *pilosum,* 2004 J.A. Isaac 18479 [*Aster pilosus* Willd.]
Symphyotrichum pilosum (Willd.) Nesom var. *pringlei* (Gray) Nesom, 1971 W.E. Buker s.n.
Symphyotrichum praealtus (Poir.) Nesom var. *praealtus,* 1997 J.K. Bissell et al. 1997:077 G5:S3
Symphyotrichum prenanthoides (Muhl. ex Willd.) Nesom, 2004 J.A. Isaac 18461 [*Aster prenanthoides* Muhl. ex Willd.]
Symphyotrichum puniceum (L.) A. & D. Löve var. *puniceum,* 2005 L. Speedy LSB1617 [*Aster puniceus* L.]
Symphyotrichum urophyllum (Lindl.) Nesom, 1971 W.E. Buker s.n.

Symphyotrichum × *longulum* (Sheldon) Nesom [boreale × puniceum], 1993 J.K. Bissell and B. Danielson 1993:188
Tanacetum vulgare L., 1935 A.G. Dickey s.n. Europe
Taraxacum officinale G. Weber ex Wiggers ssp. *officinale,* 1997 J. Long s.n. Eurasia
Tragopogon dubius Scop., 2004 J.A. Isaac and R. Coxe 17576 Europe
Tragopogon porrifolius L., 1947 W.E. Bukers.n. Europe
Tragopogon pratensis L., 2004 J.A. Isaac 17716 Europe
Triadenum fraseri (Spach) Gleason, 1994 J.D. Wagner 664
Triadenum virginicum (L.) Raf., 2005 L. Speedy LSB1623
Tussilago farfara L., 2004 J.A. Isaac 17317 Eurasia
Verbesina alternifolia (L.) Britt. ex Kearney, 1946 N. Russell NR-2804
Vernonia gigantea (Walt.) Trel., 1997 J.A. Isaac 9872

Balsaminaceae

Impatiens capensis Meerb., 2005 L. Speedy LSB1114
Impatiens pallida Nutt., 1940 R.W. Little s.n.

Berberidaceae

Berberis thunbergii DC., 2005 R. Thompson 05-1051 Japan
Berberis vulgaris L., 2004 J.A. Isaac 18463 Europe
Caulophyllum thalictroides (L.) Michx., 2004 J.A. Isaac 17357
Podophyllum peltatum L., 1934 O.E. Jennings s.n.

Betulaceae

Alnus incana (L.) Moench ssp. *rugosa* (Du Roi) Clausen, 2005 L. Speedy, M. Bowers and M. Fodse LSB1618
Alnus serrulata (Ait.) Willd., 2005 L. Speedy, M. Bowers and M. Fodse LSB1609
Betula alleghaniensis Britt. var. *alleghaniensis,* 2005 L. Speedy LSB341
Betula alleghaniensis Britt. var. *macrolepis* (Fern.) Brayshaw, 1930 O.E. Jennings s.n.
Betula lenta L., 1950 L.K. Henry and W.E. Buker s.n.
Betula pendula Roth, 1952 L.K. Henry and F.H. Beer s.n. Eurasia
Betula populifolia Marsh., 1997 R.C. Leberman s.n.
Corylus americana Walt., 1998 R.C. Leberman s.n.
Ostrya virginiana (P. Mill.) K. Koch var. *virginiana,* 1997 R.C. Leberman s.n.

Boraginaceae

Cynoglossum officinale L., 1915 O.E. Jennings and G.K. Jennings s.n. Eurasia
Cynoglossum virginianum L. var. *virginianum,* 1925 O.E. Jennings s.n.
Echium vulgare L., 2004 J.A. Isaac and R. Coxe 17575 Europe
Hackelia virginiana (L.) I.M. Johnst., 2005 R. Thompson 05-776
Lappula squarrosa (Retz.) Dumort., 1914 J. Bright s.n. Eurasia
Myosotis laxa Lehm., 2004 S.P. Grund and L. Miller 3488
Myosotis scorpioides L., 2005 L. Speedy LSB741 Europe
Symphytum officinale L., 1928 J.A. Murray s.n. Eurasia

Brassicaceae

Alliaria petiolata (Bieb.) Cavara & Grande, 2005 R. Thompson 05-653 Europe
Arabidopsis thaliana (L.) Heynh., 2004 J.A. Isaac 17454 Europe
Arabis glabra (L.) Bernh., 1905 O.E. Jennings s.n.
Arabis lyrata L., 1930 W.R. VanDersal s.n.
Armoracia rusticana P.G. Gaertn., B. Mey. & Scherb., 1909 O.E. Jennings s.n. Eurasia
Barbarea vulgaris Ait. f., 2005 L. Speedy LSB325 Eurasia
Brassica juncea (L.) Czern., 1971 R.C. Leberman s.n. Eurasia
Brassica nigra (L.) W.D.J. Koch, 2004 J.A. Isaac 17713 Eurasia
Brassica rapa L. var. *rapa,* 1949 L.K. Henry s.n. Europe
Capsella bursa-pastoris (L.) Medik., 2004 J.A. Isaac 17352 Eurasia
Cardamine angustata O.E. Shulz, 1989 J.K. Bissell et al. 89:021
Cardamine bulbosa (Schreb. ex Muhl.) B.S.P., 2005 L. Speedy LSB3360
Cardamine concatenata (Michx.) Sw., 2004 J.A. Isaac 17337
Cardamine diphylla (Michx.) Wood, 2005 L. Speedy LSB351
Cardamine douglassii Britt., 2005 L. Speedy LSB330
Cardamine pensylvanica Muhl. ex Willd., 2005 L. Speedy LSB305
Cardamine pratensis L. var. *pratensis,* 1994 J.K. Bissell et al. 1994:044 G5T5:S1
Cardamine rotundifolia Michx., 1993 J.K. Bissell et al. 93:148
Draba verna L., 1958 W.E. Buker s.n. Europe
Erysimum cheiranthoides L., 1909 O.E. Jennings s.n. Eurasia
Erysimum inconspicuum (S. Watson) MacMill.ill. var. *inconspicuum,* 1951 L.K. Henry s.n.
Hesperis matronalis L., 2004 S.P. Grund and L. Miller 3632 Europe
Lepidium campestre (L.) Ait. F., 1982 R.C. Leberman s.n. Eurasia
Lepidium virginicum L. var. *virginicum,* 1981 W.E. Buker s.n.
Raphanus raphanistrum L., 1949 L.K. Henry s.n. Mediterranean
Raphanus sativus L., 1914 J. Bright s.n. Mediterranean
Rorippa nasturtium-aquaticum (L.) Hayek, 2005 L. Speedy LSB743
Rorippa palustris (L.) Bess. ssp. *fernaldiana* (Butters & Abbe) Jonsell, 1995 R.C. Leberman s.n.
Rorippa palustris (L.) Bess. ssp. *hispida* (Desv.) Jonsell, 1901 J.A. Shafer s.n.
Rorippa sylvestris (L.) Bess., 1995 R.C. Leberman s.n. Europe
Sisymbrium altissimum L., 1960 W.E. Buker s.n. Eurasia
Sisymbrium officinale (L.) Scop., 1901 J.A. Shafer s.n. Europe
Thlaspi arvense L., 1930 O.E. Jennings s.n. Europe

Cabombaceae

Brasenia schreberi J.F. Gmel., 2004 L. Miller and S.P. Grund 22
Cabomba caroliniana Gray var. *caroliniana,* 2003 S. Ernst et al. 68

Caesalpiniaceae

Senna hebecarpa (Fern.) Irwin & Barneby, 1947 H.A. Wahl 4184

Callitrichaceae

Callitriche heterophylla Pursh ssp. *heterophylla,* 1991 J.K. Bissell et al. 1991:058
Callitriche palustris L., 1988 J.K. Bissell et al. 88:130

Campanulaceae

Campanula aparinoides Pursh, 1988 J.K. Bissell et al. 1988:135
Campanula rapunculoides L., 1970 W.E. Buker s.n. Eurasia
Campanulastrum americana (L.) Small., 2002 J.K. Bissell and B. Danielson 2002:156 [*Cyanococcus fascatus* Small]
Lobelia cardinalis L., 1988 J.K. Bissell et al. 1988:135
Lobelia inflata L., 1959 L.K. Henry and F.H. Beer s.n.
Lobelia siphilitica L. var. *siphilitica,* 2004 J.A. Isaac 18460
Lobelia spicata Lam. var. *spicata,* 1922 O.E. Jennings s.n.

Capparaceae

Polanisia dodecandra (L.) DC. ssp. *dodecandra,* 1950 W.E. Buker s.n.

Caprifoliaceae

Diervilla lonicera P. Mill, 1997 R.C. Leberman s.n.
Lonicera canadensis Bartr. ex Marsh., 1997 J.D. Wagner and G. Podniesinski 1776
Lonicera dioica L., 2004 S.P. Grund and L. Miller 3573
Lonicera morrowii Gray, 2004 S.P. Grund and L. Miller 3616 Japan
Lonicera oblongifolia (Goldie) Hook., 1993 J.K. Bissell and B. Danielson 1993:119 G4:S1
Lonicera tatarica L., 1980 C.E. Jenkins and F.Q. Jenkins 2873 Eurasia
Lonicera villosa (Michx.) J.A. Schultes, 1994 J.D. Wagner 905 G5:S1
Sambucus nigra L. ssp. *canadensis* (L.) R. Bolli, 2005 L. Speedy LSB736
Sambucus racemosa L. var. *racemosa,* 1995 R.C. Leberman s.n.
Triosteum perfoliatum L., 1940 O.E. Jennings s.n.
Viburnum acerifolium L., 2004 J.A. Isaac 17461
Viburnum lentago L., 2005 L. Speedy LSB1129
Viburnum nudum L. var. *cassinoides* (L.) Torr. & A. Gray, 2004 J.A. Isaac 18437 G5:S1
Viburnum opulus L. var. *americanum* Ait., 2004 J.A. Isaac 17503 [*Viburnum opulus* L. ssp. *trilobum* (Marsh.) Clausen] G5T5:S3S4
Viburnum opulus L. var. *opulus,* 2004 J.A. Isaac 17599 Eurasia
Viburnum rafinesquianum J.A. Schultes, 1980 C.E. Jenkins and F.Q. Jenkins 2862
Viburnum recognitum Fern., 1994 J.D. Wagner et al. 93

Caryophyllaceae

Agrostemma githago L., 1922 O.E. Jennings s.n. Europe
Arenaria serpyllifolia L., 2004 J.A. Isaac and R. Coxe 17586 Europe
Cerastium fontanum Baumg., 1904 O.E. Jennings s.n. Eurasia
Cerastium glomeratum Thuill., 2000 A.W. Cusick 35372 Eurasia
Cerastium nutans Raf. var. *nutans,* 2004 J.A. Isaac 17709
Dianthus armeria L., 2004 J.A. Isaac and R. Coxe 17583 Europe
Dianthus barbatus L., 1954 W.E. Buker s.n. Eurasia
Moehringia lateriflora (L.) Fenzl, 1993 J.K. Bissell et al. 1993:151
Myosoton aquaticum (L.) Moench, 2004 J.A. Isaac and R. Coxe 17571 Europe
Paronychia canadensis (L.) Wood, 1914 C.A. Darling s.n.
Saponaria officinalis L., 1994 K. Marsh et al. s.n. Europe
Silene antirrhina L., 1951 L.K. Henry and W.E. Buker s.n.
Silene dioica (L.) Clairv., 1970 R.C. Leberman s.n. Europe
Silene latifolia Poir. ssp. *alba* (P. Mill.) Greuter & Burdet, 1972 W.E. Buker s.n. Europe
Silene noctiflora L., J.A. Murray s.n. Europe
Silene vulgaris (Moench) Garcke, 1980 R.C. Leberman s.n. Europe
Stellaria corei Shinners, 1932 W.R. VanDersal 1923
Stellaria graminea L., 2004 J.A. Isaac 17697 Europe
Stellaria longifolia Muhl. ex Willd. var. *longifolia,* 1994 J.D. Wagner 902
Stellaria media (L.) Vill. var. *media,* 1919 H.W. Mossman s.n. Europe
Vaccaria hispanica (P. Mill.) Rauschert, 1868 T.C. Porter s.n. Europe

Celastraceae

Celastrus scandens L., 1973 R.C. Leberman s.n.
Euonymus alata (Thunb.) Sieb., 2005 R. Thompson 05-519 China & Japan
Euonymus obovata Nutt., 2001 J.A. Isaac and C.F. Chuey 13648

Ceratophyllaceae

Ceratophyllum demersum L., 2004 S.P. Grund and L. Miller 3579
Ceratophyllum echinatum Gray, 2002 J.K. Bissell 2002:128
Ceratophyllum muricatum Cham., 1984 J.K. Bissell 1984:119

Chenopodiaceae

Atriplex prostrata Bouchér ex DC., 1887 B.H. Patterson s.n.
Chenopodium album L. var. *album,* 1966 L.K. Henry s.n.
Chenopodium berlandieri Moq. var. *bushianum* (Aellen) Cronq., 1947 H.A. Wahl 4073
Chenopodium botrys L., 1941 W.C. Grimm s.n. Europe
Chenopodium capitatum (L.) Ambrosi, 1909 O.E. Jennings s.n. G5:SH
Chenopodium simplex (Torr.) Raf., 1923 E.M. Gress s.n.

Clusiaceae

Hypericum ascyron L., 1998 R. Leberman s.n.
Hypericum ellipticum Hook., 1868 Thomas C. Porter s.n.
Hypericum mutilum L., 1997 J.A. Isaac 9870
Hypericum perforatum L., 2004 S.P. Grund and L. Miller 3516 Europe
Hypericum prolificum L., 2005 L. Speedy LSB1120.
Hypericum punctatum Lam., 2004 S.P. Grund and L. Miller 3626

Commelinaceae

Tradescantia virginiana L., 1914 C.A. Darling s.n.

Convolvulaceae

Calystegia sepium (L.) R. Br. ssp. *angulata* Brummitt, 2005 L. Speedy, J. Bissell, M. Bowers and T. Pearson
Calystegia sepium (L.) R. Br ssp.*erratica* Brummitt, 1950 L.K. Henry and W.E. Buker s.n.

Cornaceae

Cornus alternifolia L. f., 1998 R. Leberman s.n.

Cornus amomum P. Mill, 2005 L. Speedy LSB720
Cornus canadensis L., 1988 J.K. Bissell and B. Danielson 1988:035
Cornus florida L., 1988 J.K. Bissell 1988:034
Cornus obliqua Raf., 2005 L. Speedy LSB1128
Cornus racemosa Lam., 2005 L. Speedy LSB1127
Cornus sericea L. ssp. *sericea,* 2005 L. Speedy, M. Bowers and M. Fodse LSB1613

Crassulaceae

Sedum acre L., 1995 R.C. Leberman s.n. Eurasia
Sedum ternatum Michx., 1932 W.R. Van Dersal 1940

Cucurbitaceae

Echinocystis lobata (Michx.) Torr. & A. Gray, 1991 R.C. Leberman s.n.
Sicyos angulatus L., 1997 J. Long s.n.

Cuscutaceae

Cuscuta cephalanthi Engelm., 1988 J.K. Bissell et al. 88:232 G5:SU
Cuscuta gronovii Willd. ex J.A. Schultes, 2005 J.K. Bissell 2005:131
Cuscuta obtusiflora Kunth, 1988 J.K. Bissell and B. Danielson 1988:271
Cuscuta polygonorum Engelm., 1988 J.K. Bissell et al. 88:271 G5:SU

Cyperaceae

Bulbostylis capillaris (L.) Kunth ex C.B. Clarke ssp. *capillaris,* 1988 J.K. Bissell et al. 88:270
Carex aestivalis M.A. Curtis ex Gray, 1907 O.E. Jennings s.n.
Carex alata Torr., 2003 J.K. Bissell 2003:082 G5:S2
Carex albicans Willd. ex Spreng. var. *albicans,* 1930 O.E. Jennings s.n.
Carex albursina Sheldon, 2004 J.A. Isaac 17464
Carex amphibola Steud., 2004 J.A. Isaac 17450
Carex annectens (Bickn.) Bickn., 2004 S.P. Grund and L. Miller 3498
Carex appalachica J. Webber & P.W. Ball, 2005 L. Speedy 1134
Carex arctata Boott ex Hook., 1984 J.K. Bissell 84:103
Carex atlantica Bailey var. *atlantica,* 1991 J.K. Bissell and B. Danielson 1991:071
Carex atlantica Bailey ssp. *capillacea* (Bailey) Reznicek, 1997 J.K. Bissell and G. Buckley 1997:102
Carex baileyi Britt., 1980 R.C. Leberman s.n.
Carex bebbii Olney ex Fern., 1988 J.K. Bissell et al. 88:076 G5:S1
Carex blanda Dewey, 2004 J.A. Isaac and R. Coxe 17572
Carex bromoides Schkuhr ex Willd., 2004 J.A. Isaac 17540
Carex brunnescens (Pers.) Poir, 1991 J.K. Bissell and B. Danielson 1991:070
Carex bushii Mack., 1997 R.C. Leberman s.n.
Carex buxbaumii Wahlenb., 2004 J.A. Isaac and M. Fiely 17668 G5:S3
Carex canescens L. var. *canescens,* 2004 J.A. Isaac 17475
Carex canescens L. var. *disjuncta* (Fern.) Toivonen, 1952 W.E. Buker s.n.
Carex caroliniana Schwein., 2000 J.K. Bissell and B. Danielson 2000:038
Carex cephalophora Muhl. ex Willd., 1980 R.C. Leberman s.n.
Carex communis Bailey, 1991 J.K. Bissell and B. Danielson 1991:070
Carex comosa Boott, 2005 L. Speedy and L. Armstron LSB1594
Carex crinita Lam. var. *crinita,* 2005 L. Speedy 742
Carex cristatella Britt., 2004 J.A. Isaac 17694
Carex cryptolepis Mack., 1993 J.K. Bissell and B. Danielson 1993:092 G4:S1
Carex debilis Michx. var. *pubera* Gray, 1886 B.H. Patterson s.n.
Carex debilis Michx. var. *rudgei* Bailey, 2004 J.A. Isaac 17441
Carex diandra Schrank, 2004 J.A. Isaac 17534 G5:S2
Carex digitalis Willd. var. *digitalis,* 2004 J.A. Isaac 17465
Carex disperma Dewey, 2004 J.K. Bissell 2004:193 G5:S3
Carex echinata Murr. ssp. *echinata,* 1993 J.A. Isaac 4761
Carex flava L., 2004 J.A. Isaac 17674 G5:S2
Carex folliculata L., 2004 J.K. Bissell 2004:121
Carex gracilescens Steud., 1985 J.K. Bissell 85:55
Carex gracillima Schwein., 2005 L. Speedy LSB1121
Carex granularis Muhl. ex Willd., 1994 J.D. Wagner and J.K. Bissell 352
Carex grayi Carey, 2004 J.A. Isaac 17532
Carex gynandra Schwein., 2004 S.P. Grund and L. Miller 3664
Carex hirsutella Mack., 1952 L.K. Henry and W.E. Buker s.n.
Carex hystericina Muhl. ex Willd., 2004 S.P. Grund and L. Miller 3607
Carex interior Bailey, 2004 J.A. Isaac 17672
Carex intumescens Rudge, 2005 L. Speedy 1132
Carex lacustris Willd., 2004 S.P. Grund and L. Miller 3556
Carex laevivaginata (Kükenth.) Mack., 1988 J.K. Bissell and B. Danielson 1988:035
Carex lasiocarpa Ehrh. var. *americana* Fern., 1994 J.D. Wagner and J.K. Bissell 392 G5:S3
Carex laxiculmis Schwein. var. *laxiculmis,* 2004 J.A. Isaac 17436
Carex laxiflora Lam., 1908 O.E. Jennings s.n.
Carex leptalea Wahlenb. ssp. *leptalea,* 2004 J.A. Isaac 17538
Carex leptonervia (Fern.) Fern, 2004 J.A. Isaac 17434
Carex lupulina Muhl. ex Willd., 2005 L. Speedy 739
Carex lurida Wahlenb., 2005 L. Speedy 1103
Carex mitchelliana M.A. Curtis, 2004 J.A. Isaac 17600 G3G4:S1
Carex normalis Mack., 1922 J. Bright s.n.
Carex novae-angliae Schwein., 1992 J.K. Bissell and B. Danielson 92:063
Carex oligocarpa Schkuhr ex Willd., 1929 J. Bright 1766
Carex ormostachya Wieg., 1985 J.K. Bissell 85:052 G4:S2
Carex pallescens L., 1997 S.P. Grund and J.A. Isaac 1873
Carex pedunculata Muhl. ex Willd., 1989 J.K. Bissell et al. 1989:021
Carex pensylvanica Lam., 2004 J.A. Isaac 17455
Carex plantaginea Lam., 2004 J.A. Isaac 17495
Carex platyphylla Carey, 1980 R.C. Leberman s.n.
Carex prairea Dewey ex Wood, 2004 J.K. Bissell 2004:085 G5?:S2
Carex prasina Wahlenb., 2001 J.A. Isaac 13638

Carex projecta Mack., 2004 S.P. Grund and L. Miller 3554
Carex pseudocyperus L., 2004 J.A. Isaac 17669 G5:S1
Carex radiata (Wahlenb.) Small, 2004 J.A. Isaac 17448
Carex rosea Schkuhr ex Willd., 2004 S.P. Grund and L. Miller 3553
Carex sartwellii Dewey, 1947 O.E. Jennings s.n. G4G5:SX
Carex scabrata Schwein., 2001 J.A. Isaac 13639
Carex scoparia Schkuhr ex Willd. var. *scoparia,* 2004 S.P. Grund and L. Miller 3608
Carex seorsa Howe, 2004 J.A. Isaac 17471
Carex sparganioides Muhl. ex Willd., 1929 O.E. Jennings s.n.
Carex squarrosa L., 1942 C.E. Wood 2209
Carex stipata Muhl. ex Willd. var. *maxima* Chapman, 1906 O.E. Jennings s.n.
Carex stipata Muhl. ex Willd. var. *stipata,* 2004 J.A. Isaac 17440
Carex straminea Willd. ex Schkuhr, 1991 J.K. Bissell et al. 1991:061
Carex stricta Lam., 2004 S.P. Grund and L. Miller 3555
Carex swanii (Fern.) Mack., 2005 L. Speedy 1087
Carex tenera Dewey, 1991 J.K. Bissell et al. 91:061
Carex torta Boott ex Tuck., 2004 J.A. Isaac 17426
Carex tribuloides Wahlenb., 1993 J.K. Bissell and B. Danielson 1993:090
Carex trichocarpa Muhl ex Willd., 1994 J.K. Bissell et al. 94:068
Carex trisperma Dewey, 2004 J.A. Isaac 17539
Carex tuckermanii Dewey, 2002 J.K. Bissell 2002:161
Carex typhina Michx., 1998 J.K. Bissell 1998:101 G5:S2
Carex utriculata Boott, 1993 J.K. Bissell et al. 93:093
Carex vesicaria L. var. *monile* (Tuck.) Fern., 1952 L.K. Henry and F.H. Beer s.n.
Carex virescens Muhl. ex Willd., 1930 H.E. Stone s.n.
Carex vulpinoidea Michx., 2004 L. Miller and S.P. Grund 44
Cladium mariscoides (Muhl.) Torr., 1994 J.D. Wagner and L.L. Smith 653 G5:S2
Cyperus bipartitus Torr., 2004 S.P. Grund and L. Miller 3614
Cyperus erythrorhizos Muhl., 2004 J.A. Isaac and J. Wagner 18542
Cyperus esculentus L., 1901 J.A. Shafer s.n. Exotic
Cyperus houghtonii Torr., 1941 W.C. Grimm s.n. G4?:S1
Cyperus odoratus L., 2001 J.K. Bissell 2001:150
Cyperus strigosus L., 2004 S.P. Grund and L. Miller 3598
Dulichium arundinaceum (L.) Britt., 2005 L. Speedy LSB1105
Eleocharis acicularis (L.) Roemer & J.A. Schultes, 2004 S.P. Grund and L. Miller 3499
Eleocharis compressa Sull., 1993 J.K. Bissell and B. Danielson 93:92 G4:S1
Eleocharis elliptica Kunth, 1994 J.D. Wagner and J.K. Bissell 399 G5:S2
Eleocharis erythropoda Steud., 1988 J.K. Bissell et al. 88:035
Eleocharis intermedia J.A. Schultes, 1992 J.K. Bissell and B. Danielson 92:130 G5:S2
Eleocharis obtusa (Willd.) J.A. Schultes var. *obtusa,* 2005 J.K. Bissell 2005:074
Eleocharis ovata (Roth) Roemer & J.A. Schultes, 2004 J.A. Isaac 17696
Eleocharis palustris (L.) Roemer & J.A. Schultes, 1995 R.C. Leberman s.n.
Eriophorum virginicum L., 2004 J.A. Isaac 18471
Eriophorum viridicarinatum (Engelm.) Fern., 1994 J.D. Wagner and J.K. Bissell 358 G5:S2
Rhynchospora alba (L.) Vahl, 1994 J.D. Wagner 662
Schoenoplectus acutus (Muhl. ex Bigelow) A. & D. Löve var. *acutus,* 1988 J.K. Bissell et al. 1988:129 G5:G2
Schoenoplectus pungens (Vahl) Palla, Verh.K.K., 1974 R. Fulton s.n.1974 R. Fulton s.n.
Schoenoplectus fluviatilis (Torr.) M.T. Strong, 1997 J.A. Isaac 9880 G5:S3
Schoenoplectus tabernaemontani (K.C. Gmel.) Palla, 2004 L. Miller and S.P. Grund 27
Scirpus atrocinctus Fern., 1984 J.K. Bissell 84:119
Scirpus atrovirens Willd., 2004 S.P. Grund and L. Miller 3670
Scirpus cyperinus (L.) Kunth, 2005 L. Speedy LSB1107
Scirpus georgianus R.M. Harper, 2004 S.P. Grund and L. Miller 3519
Scirpus hattorianus Makino, 2004 J.A. Isaac 17695
Scirpus lineatus Michx., 1972 R.C. Leberman s.n.
Scirpus microcarpus J. & K. Presl, 1993 J.K. Bissell and S. Lor 1993:206
Scirpus pendulus Muhl., 2004 J.A. Isaac 17704
Scirpus polyphyllus Vahl, 2005 L. Speedy LSB1112

Dioscoreaceae

Dioscorea villosa L., 1904 O.E. Jennings s.n.

Droseraceae

Drosera rotundifolia L. var. *rotundifolia,* 1994 J.D. Wagner and L.L. Smith 652

Elaeagnaceae

Elaeagnus umbellata Thunb., 1991 R.S. Fox s.n. Asia
Shepherdia canadensis (L.) Nutt., 1992 J.K. Bissell and B. Danielson 92:064 G5:S1

Ericaceae

Arctostaphylos uva-ursi (L.) Spreng,. 1930 W.R. Van Dersal 1327 G5:SX
Chamaedaphne calyculata (L.) Moench, 1991 R.C. Leberman s.n.
Epigaea repens L., 2004 J.A. Isaac 17325
Gaultheria procumbens L., 1990 J.K. Bissell and B. Danielson 1990:197
Gaylussacia baccata (Wangenh.) K. Koch, 2004 J.A. Isaac 17611
Lyonia ligustrina (L.) DC. var. *ligustrina,* 1884 F.T. Aschman s.n.
Rhododendron maximum L., 1962 L.K. Henry s.n.
Rhododendron periclymenoides (Michx.) Shinners, 1942 O.E. Jennings s.n.
Rhododendron prinophyllum (Small) Millais, 1927 O.E. Jennings et al. s.n.
Vaccinium corymbosum L., 2005 L. Speedy LSB302
Vaccinium fuscatum Ait., 1983 R.C. Leberman s.n. [*Cyanococcus atrococcus* (Gray) Small]
Vaccinium macrocarpon Ait., 1999 J.K. Bissell 1999:073
Vaccinium myrtilloides Michx., 2004 J.A. Isaac 18436

Vaccinium pallidum Ait., 2004 J.A. Isaac 17463
Vaccinium stamineum L., 2004 J.A. Isaac 17457

Eriocaulaceae
Eriocaulon aquaticum (Hill) Druce, 1933 W.R. Van Dersal s.n.

Euphorbiaceae
Acalypha rhomboidea Raf., 1970 W.E. Buker s.n.
Chamaesyce maculata (L.) Small, 1964 W.E. Buker s.n.
Chamaesyce nutans (Lag.) Small, 1964 W.E. Buker s.n.
Euphorbia corollata L., 1901 J.A. Shafer s.n.
Euphorbia cyparissias L., 1933 O.E. Jennings s.n. Eurasia

Fabaceae
Amphicarpaea bracteata (L.) Fern. var. *bracteata,* 1984 J.K. Bissell 1984:120
Amphicarpaea bracteata (L.) Fern. var. *comosa* (L.) Fern, 1939 O.E. Jennings s.n.
Apios americana Medik., 2004 S.P. Grund and L. Miller 3604
Baptisia tinctoria (L.) R. Br. ex Ait. f., 1968 R.C. Leberman s.n.
Chamaecrista fasciculata (Michx.) Greene var.*fasciculata,* 1994 K. Marsh et al. s.n.
Desmodium canadense (L.) DC., 1968 W.E. Buker s.n.
Desmodium glutinosum (Muhl. ex Willd.) Wood, 2004 J.A. Isaac 17682
Desmodium marilandicum (L.) DC., 1994 K. Marsh et al. s.n.
Desmodium nudiflorum (L.) DC., 1907 J.A. Shafer s.n.
Desmodium paniculatum (L.) DC. var. *paniculatum,* 1973 R.C. Leberman s.n.
Desmodium perplexum Schub., 1994 K. Marsh et al. s.n.
Desmodium rotundifolium DC., 1907 J.A. Shafer s.n.
Gleditsia triacanthos L., 1909 O.E. Jennings s.n.
Lathyrus japonicus Willd. var. *maritimus* (L.) Kartesz & Gandhi, 1914 J. Bright s.n. G5:S2
Lathyrus ochroleucus Hook., 1901 J.A. Shafer s.n. G4G5:S1
Lespedeza frutescens (L.) Hornem., 1994 K. Marsh et al. s.n.
Lespedeza hirta (L.) Hornem. var. *hirta,* 1994 K. Marsh et al. s.n.
Lotus corniculatus L., 1980 F.Q. Jenkins and C.E. Jenkins 2820 Europe
Lupinus perennis L. ssp. *perennis,* 1930 W.R. VanDersal 1271 G5:S3
Medicago lupulina L., 2004 J.A. Isaac 17707 Eurasia
Medicago sativa L. ssp. *sativa,* 2004 J.A. Isaac 17691 Eurasia
Melilotus officinalis (L.) Lam., 1922 O.E. Jennings s.n. Eurasia
Strophostyles helvola (L.) Elliott, 1933 O.E. Jennings s.n.
Trifolium aureum Pollich, 1952 L.K. Henry and W.E. Buker s.n. Eurasia
Trifolium campestre Schreb., 1914 C.A. Darling s.n. Europe
Trifolium dubium Sibth., 2005 R. Thompson 05-650 Europe
Trifolium hybridum L., 1914 C.A. Darling s.n. Eurasia
Trifolium pratense L., 1938 O.E. Jennings s.n. Europe
Trifolium repens L., 1904 O.E. Jennings s.n. Europe
Vicia sativa L. ssp. *nigra* (L.) Ehrh., 1928 J.A. Murray s.n. Europe
Vicia tetrasperm (L.) Schreb., 2005 R. Thompson 05-600 Eurasia
Vicia villosa Roth. ssp. *villosa,* 1972 W.E. Buker s.n. Europe

Fagaceae
Castanea dentata (Marsh.) Borkh., 2004 J.A. Isaac 18419
Fagus grandifolia Ehrh., 1997 R.C. Leberman s.n.
Quercus alba L., 1996 R.C. Leberman s.n.
Quercus bicolor Willd., 1909 O.E. Jennings s.n.
Quercus coccinea Muenchh. var. *coccinea,* 1963 P.B. Monk s.n.
Quercus imbricaria Michx., 1997 R.C. Leberman s.n.
Quercus macrocarpa Michx. var. *macrocarpa,* 1919 O.E. Jennings and J.C. Fettermann s.n.
Quercus palustris Muenchh., 1997 R.C. Leberman s.n.
Quercus prinus L., 1996 R.C. Leberman s.n.
Quercus rubra L. var. *rubra,* 2005 L. Speedy LSB1080-2
Quercus shumardii Buckl., 2006 J.K. Bissell 2006:007 G5:S1
Quercus velutina Lam., 2003 S. Ernst 28

Fumariaceae
Corydalis flavula (Raf.) DC., 1932 W.R. Van Dersal 1921

Gentianaceae
Bartonia virginica (L.) B.S.P., 1996 S. Grund 1741
Centaurium pulchellum (Sw.) Druce, 2004 J.A. Isaac 18406 Europe
Gentiana clausa Raf., 1988 J.K. Bissell and B. Danielson 1990:197

Geraniaceae
Geranium maculatum L., 2005 L. Speedy LSB755

Haloragaceae
Myriophyllum sibiricum Kom., 2003 J.K. Bissell 2003:091 G5: S1
Myriophyllum spicatum L., 2004 L. Miller and S.P. Grund 18 Eurasia
Myriophyllum verticillatum L., 2001 J.K. Bissell 2001:148 G5:S1
Proserpinaca palustris L. var. *crebra* Fern. & Grisc., 1993 J.A. Isaac 4762

Hamamelidaceae
Hamamelis virginiana L., 1997 R.C. Leberman s.n.

Hippocastanaceae
Aesculus glabra Willd. var. *glabra,* 1997 R.C. Leberman s.n.

Hydrocharitaceae
Elodea canadensis Michx., 2004 S.P. Grund and L. Miller 3586
Elodea nuttallii (Planch.) St. John, 1923 O.E. Jennings s.n.
Vallisneria americana Michx., 2004 S.P. Grund and L. Miller 3587

Hydrophyllaceae
Hydrophyllum virginianum L., 1960 L.K. Henry s.n.

Iridaceae
Iris pseudacorus L., 2004 J.A. Isaac and J. Wagner 18543 Europe
Iris versicolor L., 2004 L. Miller and S.P. Grund 39
Sisyrinchium angustifolium P. Mill., 2004 J.A. Isaac 17483

Juglandaceae
Carya cordiformis (Wangenh.) K. Koch, 1997 R.C. Leberman s.n.
Carya glabra (P. Mill.) Sweet, 1996 R.C. Leberman s.n.
Carya laciniosa (Michx. f.) G. Don, 1997 J.K. Bissell et al. 1997:183 G5:S3

Carya ovalis (Wangenh.) Sarg., 1915 O.E. Jennings and G.K. Jennings s.n.
Carya ovata (P. Mill.) K. Koch, 1907 O.E. Jennings s.n.
Carya × laneyi Sarg. [cordiformis × ovata], 1938 O.E. Jennings s.n.
Juglans cinerea L., 1924 O.E. Jennings s.n.
Juglans nigra L., 1963 P. Monk s.n.

Juncaceae

Juncus acuminatus Michx., 1997 J.K. Bissell and B. Gordon 1997:155
Juncus articulatus L., 2004 L. Miller and S.P. Grund 47
Juncus bufonius L. var. *bufonius,* 2004 J.A. Isaac 17710
Juncus canadensis J. Gay ex Laharpe, 2004 J.A. Isaac 18470
Juncus dudleyi Wieg., 1997 J.A. Isaac 9859
Juncus effusus L. var. *pylaei* (Laharpe) Fern. & Wieg, 2004 S.P. Grund and L. Miller 3495
Juncus effusus L. var. *solutus* Fern. & Wieg., 2005 L. Speedy LSB31106
Juncus marginatus Rostk., 1973 R.C. Leberman s.n.
Juncus nodosus L., 1996 S. Grund et al. 1750
Juncus subcaudatus (Engelm.) Coville & Blake var. *subcaudatus,* 1932 W.R. Van Dersal 51
Juncus tenuis Willd., 2004 L. Miller and S.P. Grund 48
Luzula acuminata Raf. var. *acuminata,* 2005 L. Speedy LSB344
Luzula echinata (Small) F.J. Herm., 1981 R.C. Leberman s.n.
Luzula multiflora (Ehrh.) Lej. ssp. *multiflora,* 2005 L. Speedy LSB301

Lamiaceae

Agastache scrophulariifolia (Willd.) Kuntze, 1947 H.A. Wahl 4082A
Blephilia ciliata (L.) Benth., 1909 B.H. Patterson s.n.
Clinopodium vulgare L., 2005 L. Speedy LSB757
Collinsonia canadensis L., 1904 O.E. Jennings s.n.
Galeopsis tetrahit L. var. *tetrahit,* 2004 J.A. Isaac 18420 Eurasia
Glechoma hederacea L., 1932 R. Van Dersal 1922 Eurasia
Hedeoma pulegioides (L.) Pers., 1955 D.L. Pearth s.n.
Lamium amplexicaule L., 1887 B.H. Patterson s.n. Eurasia
Leonurus cardiaca L. ssp. *cardiaca,* 1973 R.C. Leberman s.n. Asia
Lycopus americanus Muhl. ex W. Bart., 2004 S.P. Grund and L. Miller 3589
Lycopus uniflorus Michx. var. *uniflorus,* 2005 L. Speedy and L. Armstrong LSB1099
Lycopus virginicus L., 1904 O.E. Jennings s.n.
Mentha arvensis L., 1984 J.K. Bissell 1984:105
Mentha spicata L., 1901 J.A. Shafer s.n. Europe
Mentha × piperita L. (pro sp.) [aquatica × spicata], 1984 J.K. Bissell 84:119 Eurasia
Mentha × villosa Huds. (pro sp.) [spicata × suaveolens], 2005 R. Thompson 05-869 Eurasia
Monarda clinopodia L., 1998 R. Leberman s.n.
Monarda didyma L., 1966 L.K. Henry and W.E. Buker s.n.
Monarda fistulosa L. var. *fistulosa,* 1994 K. Marsh et al. s.n.
Monarda fistulosa L. var. *mollis* (L.) Benth., 1975 R.C. Leberman s.n.
Monarda media Willd., 1996 J.K. Bissell et al. 1996:091
Nepeta cataria L., 1901 J.A. Shafer s.n. Europe
Prunella vulgaris L. ssp. *lanceolata* (W. Bart.) Hultén, 2004 S.P. Grund and L. Miller 3515
Pycnanthemum incanum (L.) Michx. var. *incanum,* 1901 J.A. Shafer s.n.
Scutellaria galericulata L., 2005 L. Speedy LSB1102
Scutellaria lateriflora L. var. *lateriflora,* 2004 J.A. Isaac 18415
Stachys tenuifolia Willd., 1973 R.C. Leberman s.n.
Teucrium canadense L. var. *canadense,* 1998 R. Leberman s.n.
Teucrium canadense L. var. *occidentale* (Gray) McClintock & Epling, 1932 W.R. Van Dersal 1806
Trichostema dichotomum L., 1901 J.A. Shafer s.n.

Lauraceae

Lindera benzoin (L.) Blume var. *benzoin,* 2005 L. Speedy LSB334
Sassafras albidum (Nutt.) Nees, 1997 R.C. Leberman s.n.

Lemnaceae

Lemna minor L., 2005 L. Speedy LSB731
Lemna trisulca L., 1997 J.K. Bissell and B.W. Danielson 1997:067
Lemna turionifera Landolt, 1951 O.E. Jennings s.n. G5:SU
Spirodela polyrhiza (L.) Schleid., 2004 L. Miller and S.P. Grund 34
Wolffia borealis (Engelm. ex Hegelm.) Landolt ex Landolt & Wildi, 1951 O.E. Jennings s.n.
Wolffia brasiliensis Wedd., 2004 J.A. Isaac and J. Wagner 18546
Wolffia columbiana Karst., 1986 J.K. Bissell et al. 1986:285
Wolffiella gladiata (Hegelm.) Hegelm., 1997 J.K. Bissell and B. Danielson 1997:067 G5:S2

Lentibulariaceae

Utricularia gibba L., 1988 J.K. Bissell and B. Danielson 1988:265
Utricularia intermedia Hayne, 2004 J.A. Isaac 17675 G5:S2
Utricularia macrorhiza Le Conte, 2004 S.P. Grund and L. Miller 3609
Utricularia minor L., 2004 J.K. Bissell and B. Danielson 2004:208

Liliaceae

Allium canadense L. var. *canadensis,* 1950 L.K. Henry and W.E. Buker s.n.
Allium tricoccum Ait., 2004 J.A. Isaac 17683
Asparagus officinalis L., 1957 W.E. Buker s.n. Europe
Chamaelirium luteum (L.) Gray, 1900 D. Bard s.n.
Clintonia borealis (Ait.) Raf., 2004 J.A. Isaac 17421
Clintonia umbellulata (Michx.) Morong, 1981 R.C. Leberman s.n.
Erythronium albidum Nutt., 2001 J.K. Bissell 2001:006 G5:S3
Erythronium americanum Ker-Gawl ssp. *americanum,* 2004 J.A. Isaac 17315
Hemerocallis fulva (L.) L., 1914 C.A. Darling s.n. Asia
Hyacinthoides nonscripta (L.) Chouard ex Rothm., 1998 G. Shaffer s.n. Exotic
Hypoxis hirsuta (L.) Coville, 1889 J. Whitesides s.n.
Leucojum aestivum L. ssp. *aestivum,* 1998 C. Stelter s.n. Exotic

Lilium canadense L. ssp. *editorum* (Fern.) Wherry, 1997 R.C. Leberman s.n.
Lilium philadelphicum L. var. *philadelphicum,* 1882 J. Whitesides s.n.
Lilium superbum L., 1998 R. Leberman s.n.
Maianthemum canadense Desf., 2005 L. Speedy LSB1086
Maianthemum racemosum (L.) Link spp. *racemosum,* 1997 R.C. Leberman s.n.
Maianthemum stellatum (L.) Link, 1919 O.E. Jennings s.n.
Maianthemum trifolium (L.) Sloboda, 1937 O.E. Jennings s.n.
Medeola virginiana L., 1981 R.C. Leberman s.n.
Polygonatum biflorum (Walt.) Ell. var. *commutatum* (J.A. & J.H.), 1997 R.C. Leberman s.n.
Polygonatum pubescens (Willd.) Pursh, 2004 J.A. Isaac 17435
Prosartes lanuginosa (Michx.) D. Don, 1981 R.C. Leberman s.n. [*Disporum lanuginosa* (Michx.) Nichols.]
Stenanthium gramineum (Ker-Gawl.) Morong var. *gramineum* ca, 1890 J.E. Whiteside s.n. G4G5:S1S2
Streptopus lanceolatus (Ait.) Reveal var. *roseus* (Michx.) Reveal, 1985 J.K. Bissell and M. Hoberecht 1985:048
Trillium erectum L., 2004 J.A. Isaac 17335
Trillium flexipes Raf., 1941 O.E. Jennings s.n. G5:S2
Trillium grandiflorum (Michx.) Salisb., 2004 J.A. Isaac 17339
Trillium undulatum Willd., 1971 R.C. Leberman s.n.
Uvularia grandiflora Sm., 1974 G. Williamson 94
Uvularia perfoliata L., 1919 O.E. Jennings s.n.
Uvularia sessilifolia L., 1981 R.C. Leberman s.n.
Veratrum viride Ait., 2005 L. Speedy LSB752

Limnanthaceae
Floerkea proserpinacoides Willd., 2005 L. Speedy LSB347

Linaceae
Linum striatum Walt., 1992 J.K. Bissell et al. 92:170
Linum usitatissimum L., 1901 J.A. Shafer s.n. Europe

Lythraceae
Decodon verticillatus (L.) Elliott, 2005 L. Speedy LSB1109
Lythrum salicaria L., 2005 L. Speedy LSB727 Europe

Magnoliaceae
Liriodendron tulipifera L., 1917 C.A. Darling s.n.
Magnolia acuminata (L.) L., 1997 R.C. Leberman s.n.

Malvaceae
Abutilon theophrasti Medik., 1994 K. Marsh and G. Marsh s.n. Asia
Malva moschata L., 2004 J.A. Isaac et al. 17723 Europe
Malva neglecta Wallr., 1948 D.H. Krouse s.n. Eurasia & N. Africa

Menispermaceae
Menispermum canadense L., 1914 C.A. Darling s.n.

Menyanthaceae
Menyanthes trifoliata L., 1994 J.D. Wagner and J.K. Bissell 393

Moraceae
Morus alba L., 1997 R.C. Leberman s.n. Asia

Myricaceae
Morella pensylvanica (Mirb.) Kartesz, 1994 J.D. Wagner and J.K. Bissell 404

Najadaceae
Najas flexilis (Willd.) Rostk. & Schmidt, 2004 S.P. Grund and L. Miller 3576
Najas gracillima (A. Braun ex Engelm.) Magnus, 2004 S.P. Grund and L. Miller 3581
Najas guadalupensis (Spreng.) Magnus ssp. *guadalupensis,* 2004 S.P. Grund and L. Miller 3584
Najas minor All., 2004 S.P. Grund and L. Miller 3637 Exotic

Nelumbonaceae
Nelumbo lutea Willd., 1992 J.K. Bissell 1992:109

Nymphaeaceae
Nuphar lutea (L.) Sm ssp. *advena* (Ait.) Kartesz & Gandhi, 2003 S. Ernst 116
Nuphar lutea (L.) Sm ssp. *variegata* (Dur.) E.O. Beal, 2004 J.K. Bissell 2004:111
Nymphaea odorata Ait. ssp. *odorata,* 2004 L. Miller and S.P. Grund 26
Nymphaea odorata Ait. ssp. *tuberosus* (Paine) Wiersma & Hellquist, 1923 O.E. Jennings s.n.

Nyssaceae
Nyssa sylvatica Marsh., 2004 J.A. Isaac 17545

Oleaceae
Fraxinus americana L., 2004 S.P. Grund and L. Miller 3540
Fraxinus nigra Marsh., 2004 S.P. Grund and L. Miller 3535
Fraxinus pennsylvanica Marsh., 2001 J.A. Isaac 13668
Fraxinus profunda (Bush) Bush, 2003 R. Coxe and M. Bradburn s.n. G4:S1
Ligustrum obtusifolium Sieb. & Zucc., 1998 K. Marsh s.n. Japan

Onagraceae
Chamerion angustifolium (L.) Holub ssp. *circumvagum* (Mosquin) Kartesz, 1967 W.E. Buker s.n.
Circaea alpina L. ssp. *alpina,* 1972 R.C. Leberman s.n.
Circaea lutetiana L. ssp. *canadensis* (L.) Asch. & Magnus, 2004 S.P. Grund 3552
Epilobium ciliatum Raf. ssp. *ciliatum,* 1928 J.A. Murray s.n.
Epilobium coloratum Biehler, 2005 L. Speedy and L. Armstrong LSB1593
Epilobium hirsutum L., 1994 K. Marsh and G. Marsh s.n. Europe
Epilobium leptophyllum Raf., 1994 J.D. Wagner 678
Epilobium strictum Muhl. ex Spreng., 2004 J.A. Isaac 18426 G5?:S3
Ludwigia palustris (L.) Elliott., 2005 J.K. Bissell 2005:074
Oenothera biennis L., 1964 W.E. Buker s.n.
Oenothera fruticosa L. ssp. *glauca* (Michx.) Straley, J.A. Murray s.n.
Oenothera nutans Atk. & Bartlett, Curtis 39
Oenothera perennis L., 1981 R.C. Leberman s.n.

Orchidaceae
Arethusa bulbosa L., 1905 O.E. Jennings s.n. G4:S1
Calopogon tuberosus (L.) B.S.P. var. *tuberosus,* 1994 J.D. Wagner and J.K. Bissell 390
Corallorhiza maculata (Raf.) Raf. var. *maculata,* 1998 R. Leberman s.n.

Corallorhiza maculata (Raf.) Raf. var. *occidentalis* (Lindl.) Ames, 1881 C.W. C. s.n.
Corallorhiza trifida Chatel., 2004 J.A. Isaac 17417
Cypripedium acaule Ait., 1962 L.K. Henry s.n.
Cypripedium parviflorum Salisb. var. *pubescens* (Willd.) Knight, 1969 W.E. Buker and W.C. Buker s.n. G5:S1
Cypripedium reginae Walt., 1962 L.K. Henry s.n. G4:S2
Epipactis helleborine (L.) Crantz, 1998 R. Leberman s.n. Europe
Galearis spectabilis (L.) Raf., 1949 L.K. Henry s.n.
Goodyera pubescens (Willd.) R. Br. ex Ait. f., 2004 J.A. Isaac 17443
Isotria verticillata Raf., 1997 R.C. Leberman s.n.
Liparis loeselii (L.) L.C. Rich., 1969 W.E. Buker s.n.
Malaxis brachypoda (Gray) Fern., 1968 W.E. Buker s.n. G4Q:S1
Platanthera clavellata (Michx.) Luer., 2005 L. Speedy LSB1085
Platanthera dilatata (Pursh) Lindl. ex Beck var. *dilatata,* 1994 J.S. Shriver and C. Smith 216 G5:S1
Platanthera flava (L.) Lindl. var. *herbiola* (R. Br. ex Ait. f.) Luer,, 1975 R.C. Leberman s.n.
Platanthera grandiflora (Bigelow) Lindl., 1922 J. Bright s.n.
Platanthera huronensis (Nutt.) Lindl., 1965 J. Stull and D. Stull s.n.
Platanthera hyperborea (L.) Lindl. var. *hyperborean,* 1997 J.A. Isaac 9881 G5:S1
Platanthera lacera (Michx.) G. Don, 1980 R.C. Leberman s.n.
Platanthera leucophaea (Nutt.) Lindl., 1881 C.W. C. s.n. G3:SX
Platanthera macrophylla (Goldie) P.M. Brown, 1962 R.C. Leberman s.n.
Platanthera orbiculata (Pursh) Lindl., 1982 R.C. Leberman s.n.
Platanthera psycodes (L.) Lindl., 1962 L.K. Henry s.n.
Pogonia ophioglossoides (L.) Ker-Gawl., 1994 J.D. Wagner and J.K. Bissell 391
Spiranthes cernua (L.) L.C. Rich., 2002 J.K. Bissell 2002:176
Spiranthes lucida (H.H. Eat) Ames, 1982 W.E. Buker s.n. G5:S3
Spiranthes ochroleuca (Rydb.) Rydb., 1970 R.C. Leberman s.n.
Spiranthes romanzoffiana Cham., 1995 J.S. Shriver and C. Smith 423 G5:S1

Orobanchaceae
Conopholis americana (L.) Wallr. F., 2004 J.A. Isaac 17456
Epifagus virginiana (L.) W. Bart., 2005 L. Speedy, M. Bowers and M. Fodse LSB1605

Oxalidaceae
Oxalis dillenii Jacq., 1904 O.E. Jennings s.n.
Oxalis montana Raf., 1985 J.K. Bissell and M. Hoberecht 1985:048
Oxalis stricta L., 1905 O.E. Jennings s.n.

Papaveraceae
Chelidonium majus L. var. *majus,* 2004 J.A. Isaac 17355 Europe

Phrymaceae
Phryma leptostachya L., 1901 J.A. Shafer s.n.

Phytolaccaceae
Phytolacca americana L. var. *americana,* 1969 W.E. Buker s.n.

Plantaginaceae
Plantago aristata Michx., 1904 O.E. Jennings s.n.
Plantago lanceolata L., 2004 J.A. Isaac 17711 Europe
Plantago major L., 1901 J.A. Shafer s.n.
Plantago rugelii Dcne., 1901 J.A. Shafer s.n.

Platanaceae
Platanus occidentalis L., 1928 J.A. Murray s.n.

Poaceae
Agrostis gigantea Roth, 2004 J.A. Isaac 17703 Europe
Agrostis perennans (Walt.) Tuck., 1907 O.E. Jennings s.n.
Agrostis scabra Willd., 2003 J.K. Bissell 1999:073
Agrostis stolonifera L., 2004 J.A. Isaac et al. 17666
Alopecurus aequalis Sobol. var. *aequalis,* 2001 J.A. Isaac and C.F. Chuey 13659 G5:S3
Andropogon gerardii Vitman, 2002 J.A. Isaac 15714
Andropogon virginicus L. var. *virginicus,* 2002 J.A. Isaac 15717
Anthoxanthum odoratum L. spp. *odoratum,* 2004 J.A. Isaac 17350 Eurasia
Arrhenatherum elatius (L.) P. Beauv. ex J. & C. Presl var. *elatius,* 1952 W.E. Buker s.n. Europe
Bouteloua curtipendula (Michx.) Torr. var. *curtipendula,* 2002 J.A. Isaac 15715 G5:S2
Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths, 2002 J.A. Isaac 15723
Brachyelytrum erectum (Schreb. ex Spreng.) Beauv., 1984 J.K. Bissell 1984:103
Bromus ciliatus L. var. *ciliatus,* 1992 J.K. Bissell et al. 1992:102
Bromus inermis Leyss. ssp. *inermis,* 2004 J.A. Isaac 17715 Europe
Bromus japonicus Thunb. ex Murr., 2004 J.A. Isaac and R. Coxe 17577 Eurasia
Bromus latiglumis (Shear) A.S. Hitchc., 1994 K. Marsh et al. s.n.
Bromus racemosus L., 2004 J.A. Isaac 17692 Europe
Bromus secalinus L., 1968 W.E. Buker s.n. Europe
Bromus tectorum L., 1922 O.E. Jennings s.n. Europe
Cinna arundinacea L., 2005 L. Speedy LSB1110
Cinna latifolia (Trev. ex Goepp.) Griseb., 1998 J.K. Bissell 1998:104
Dactylis glomerata L. ssp. *glomerata,* 1980 R.C. Leberman s.n. Europe
Danthonia compressa Austin ex Peck, 1984 J.K. Bissell 1984:103
Danthonia spicata (L.) Beauv. ex Roem. & J.A. Schultes, 1882 J. Whitesides s.n.
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *fasciculatum* (Torr.) Freckm ann, 2005 J.K. Bissell 2005:074
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *lindheimeri* (Nash) Gould & C.A. Clark, 1933 O.E. Jennings s.n.
Dichanthelium clandestinum (L.) Gould, 1981 R.C. Leberman s.n.
Dichanthelium dichotomum (L.) Gould var. *dichotomun,* 1901 J.A. Shafer s.n.
Dichanthelium latifolium (L.) Gould & C.A. Clark, 1993 J.K. Bissell et al. 1993:065

Dichanthelium linearifolium (Scribn.ex Nash) Gould, 1922 J. Bright s.n.
Dichanthelium sabulorum (Lam.) Gould & C.A. Clark var. *thinium* (A.S. Hitchc. & Chase) Gould & C.A. Clark, 2002 J.A. Isaac 15712
Dichanthelium sphaerocarpon (Elliott) Gould var. *sphaerocarpon,* 1922 J. Bright s.n.
Digitaria ischaemum (Schreb.) Schreb. ex Muhl., 2002 J.A. Isaac 15718 Eurasia
Digitaria sanguinalis (L.) Scop., 1881 J. Whitesides s.n.
Echinochloa crus-galli (L.) Beauv., 1984 D.W. Vogler and C.W. Bier 6-4 Eurasia
Echinochloa muricata (Beauv.) Fern. var. *muricata,* 2005 J.K. Bissell 2005:074 Exotic
Eleusine indica (L.) Gaertn., 1882 J. Whitesides s.n. Old World Tropics
Elymus hystrix L. var. *hystrix,* 2005 L. Speedy LSB754
Elymus repens (L.) Gould, 2004 J.A. Isaac 17693 Exotic
Elymus riparius Wieg., 1994 K. Marsh et al. s.n.
Elymus villosus Muhl. ex Willd., 1882 J. Whitesides s.n.
Elymus virginicus L. var. *virginicus,* 1997 J.A. Isaac 9876
Eragrostis cilianensis (All.) Vign. ex Janchen, 1964 W.E. Buker s.n. Europe
Eragrostis hypnoides (Lam.) B.S.P., 2005 J.K. Bissell and B. Danielson 2005:074
Eragrostis pectinacea (Michx.) Nees ex Steud. var. *pectinacea,* 1952 H.A. Wahl 13813
Eragrostis spectabilis (Pursh) Steud., 1994 K. Marsh et al. s.n.
Festuca subverticillata (Pers.) Alexeev, 1922 J. Bright s.n.
Glyceria acutiflora Torr., 1992 J.K. Bissell et al. 92:108
Glyceria canadensis (Michx.) Trin., 2005 L. Speedy and L. Armstrong LSB1599
Glyceria grandis S. Watson var. *grandis,* 1932 W.R. Van Dersal s.n.
Glyceria laxa (Scribn.) Scribn., 1909 B.H. Patterson s.n.
Glyceria melicaria (Michx.) F.T. Hubb., 2005 L. Speedy LSB1116
Glyceria septentrionalis A.S. Hitchc., 2004 S.P. Grund and L. Miller 3520
Glyceria striata (Lam.) A.S. Hitchc., 2005 L. Speedy LSB1098
Holcus lanatus L., 2004 J.A. Isaac 17714 Europe
Hordeum vulgare L., 1916 C.A. Darling s.n. Eurasia
Leersia oryzoides (L.) Sw., 2004 S.P. Grund and L. Miller 3669
Leersia virginica Willd., 2004 J.A. Isaac 18408
Lolium perenne L. spp. *multiflorum* (Lam.) Husnot, 2004 J.A. Isaac 17605 Europe
Lolium perenne L. ssp. *perenne,* 1949 Edgar T. Wherry s.n. Europe
Lolium pratense (Huds.) S.J. Darbysh., 1994 J.D. Wagner and J.K. Bissell 363 Europe
Milium effusum L. var. *cisatlanticum* Fern., 2004 J.A. Isaac 17544
Muhlenbergia frondosa (Poir.) Fern, 2002 J.A. Isaac 15726
Muhlenbergia glomerata (Willd.) Trin., 1994 J.D. Wagner 661
Muhlenbergia mexicana (L.) Trin., 1994 J.D. Wagner 695
Muhlenbergia schreberi J.F. Gmel., 1946 W.E. Buker s.n.
Muhlenbergia sobolifera (Muhl. ex Willd.) Trin., 1887 J. Whitesides s.n.
Muhlenbergia sylvatica Torr. ex Gray, 1997 J.A. Isaac 9856
Oryzopsis asperifolia Michx., 1980 A.W. Cusick and B. Andreas 19922
Panicum capillare L., 1964 W.E. Buker s.n.
Panicum dichotomiflorum Michx. var. *dichotomiflorum,* 2002 J.A. Isaac 15725
Panicum gattingeri Nash, 1998 J.K. Bissell 1998:159
Panicum rigidulum Bosc ex Nees var. *elongatum* (Pursh) Lelong, 1988 J.K. Bissell and B. Danielson 1988:273
Panicum virgatum L. var. *virgatum,* 2002 J.A. Isaac 15722
Pennisetum glaucum (L.) R. Br., 2002 J.A. Isaac 15711 Exotic
Phalaris arundinacea L., 2005 L. Speedy LSB737 v
Phleum pratense L., 2004 J.A. Isaac 17604 Europe
Phragmites australis (Cav.) Trin. ex Steud. ssp. *americana,* 2005 L. Speedy et al. 1579 s.n.
Poa alsodes Gray, 2004 J.A. Isaac 17449
Poa annua L., 2004 J.A. Isaac 17452 Eurasia
Poa compressa L., 2004 J.A. Isaac 17708 Europe
Poa paludigena Fern. & Wieg., 2002 J.K. Bissell 2002:061 G3: S3
Poa palustris L., 1952 L.K. Henry and W.E. Buker s.n.
Poa pratensis L., 1952 L.K. Henry and W.E. Buker s.n. Europe
Poa saltuensis Fern. & Wieg., 1994 J.K. Bissell et al. 94:106
Poa trivialis L., 1991 J.K. Bissell et al. 1991:059 Europe
Schizachne purpurascens (Torr.) Swallen, 1925 S.S. Dickey s.n.
Setaria faberi Herrm., 1997 J.A. Isaac 9851 Asia
Setaria parviflora (Poir.) Kerguélen, 1994 K. Marsh et al. s.n.
Setaria pumila (Poir.) Roemer & J.A. Schultes, 1949 Edgar T. Wherry s.n. Europe
Sorghastrum nutans (L.) Nash, 2002 J.A. Isaac 15716
Spartina pectinata Bosc ex Link, 1933 O.E. Jennings s.n.
Sphenopholis intermedia (Rydb.) Rydb., 1993 J.K. Bissell et al. 93:102
Sphenopholis pensylvanica (L.) A.S. Hitchc., 1994 J.D. Wagner and J.K. Bissell 354
Sporobolus compositus (Poir.) Merr. var. *compositus,* 1996 S. Grund 1747
Sporobolus cryptandrus (Torr.) Gray, 2002 J.A. Isaac 15724
Sporobolus vaginiflorus (Torr. ex Gray) Wood var. *vaginiflorus,* 1949 O.E. Jennings and C.M. Boardman s.n.
Torreyochloa pallida (Torr.) Church var. *pallida,* 2001 J.A. Isaac 13661
Tridens flavus (L.) A.S. Hitchc. var. *flavus,* 1994 K. Marsh et al. s.n.
Triticum aestivum L., 1916 C.A. Darling s.n. Eurasia

Podostemaceae

Podostemum ceratophyllum Michx., 1997 J.K. Bissell

Polemoniaceae

Collomia linearis Nutt., 1914 J. Bright s.n.
Phlox divaricata L. ssp. *divaricata,* 1971 W.E. Buker s.n.
Phlox maculata L. ssp. *maculata,* 1935 A.G. Dickey s.n.
Phlox paniculata L., 2004 S.P. Grund and L. Miller 3618
Phlox stolonifera Sims, 2004 J.A. Isaac 17356
Polemonium reptans L. var. *reptans,* 2005 L. Speedy LSB759

Polygalaceae

Polygala polygama Walt., 2006 J.K. Bissell 2006:190 G5:S1
Polygala sanguinea L., 1970 R.C. Leberman s.n.
Polygala verticillata L. var. *verticillata,* 1901 J.A. Shafer s.n.

Polygonaceae

Fagopyrum esculentum Moench, 1993 J.A. Isaac 4896 Asia
Polygonum amphibium L. var. *emersum* Michx., 2004 J.A. Isaac 18427
Polygonum amphibium L. var. *stipulaceum* Coleman, 1999 J.K. Bissell 1999:073
Polygonum arifolium L., 2005 L. Speedy LSB1113
Polygonum aviculare L., 2004 J.A. Isaac 17717 Europe
Polygonum caespitosum Blume, 1997 J. Long s.n. Asia
Polygonum cilinode Michx., 1993 J.K. Bissell and B. Danielson 1993:105
Polygonum convolvulus L. var. *convolvulus,* 1914 C.A. Darling s.n. Europe
Polygonum cuspidatum Sieb. & Zucc., 1997 J. Long s.n. Japan
Polygonum hydropiper L., 2004 J.A. Isaac 18422 Europe
Polygonum hydropiperoides Michx., 2004 J.A. Isaac and J. Wagner 18540
Polygonum lapathifolium L., 1988 J.K. Bissell and B. Danielson 1988:299
Polygonum pensylvanicum L., 2005 J.K. Bissell 2005:074
Polygonum persicaria L., 2004 J.A. Isaac 17712 Europe
Polygonum punctatum Elliott var. *confertiflorum* (Meisn.) Fassett, 1904 O.E. Jennings s.n.
Polygonum punctatum Elliott var. *punctatum,* 1996 S. Grund 1748
Polygonum robustius (Small) Fern., 2003 J.K. Bissell and J. Bish 2003:125
Polygonum sagittatum L., 2005 L. Speedy LSB1101
Polygonum scandens L., 1994 K. Marsh and G. Marsh s.n. Exotic
Polygonum setaceum Baldwin, 2005 L. Speedy et al. 1580 G5T4:S2
Polygonum virginianum L., 2005 L. Speedy LSB1136
Rumex acetosella L., 2004 J.A. Isaac 17444 Europe
Rumex altissimus Wood, 1930 H.E. Stone s.n.
Rumex crispus L. ssp. *crispus,* 1952 L.K. Henry and F.H. Beer s.n. Europe
Rumex obtusifolius L., 2004 S.P. Grund and L. Miller 3518 Europe
Rumex orbiculatus Gray var. *orbiculatus,* 1988 J.K. Bissell et al. 1988:135
Rumex verticillatus L., 1995 R.C. Leberman s.n.

Pontederiaceae

Heteranthera dubia (Jacq.) MacM., 2003 J.K. Bissell 2003:074
Pontederia cordata L., 2004 S.P. Grund and L. Miller 3592

Portulacaceae

Claytonia caroliniana Michx. var. *caroliniana,* 2005 L. Speedy LSB332 2005
Claytonia virginica L. var. *virginica,* 2004 J.A. Isaac 17312
Portulaca oleracea L., 1949 Edgar T. Wherry s.n.

Potamogetonaceae

Potamogeton amplifolius Tuck., 2004 S.P. Grund and L. Miller 3509
Potamogeton crispus L., 2004 J.A. Isaac and J. Wagner 18538 Europe
Potamogeton diversifolius Raf., 1994 J.K. Bissell et al. 1994:173
Potamogeton epihydrus Raf., 2004 J.A. Isaac and J. Wagner 18545
Potamogeton foliosus Raf., 2004 S.P. Grund and L. Miller 3583
Potamogeton friesii Rupr., 2003 S. Ernst et al. 122 G4:S1
Potamogeton gramineus L., 1933 O.E. Jennings s.n. G5:SH
Potamogeton hillii Morong, 1865 Thomas C. Porter s.n. G3:S1
Potamogeton illinoensis Morong, 2003 S. Ernst and L. Speedy 82
Potamogeton natans L., 2004 J.A. Isaac and J. Wagner 18539
Potamogeton nodosus Poir., 2002 J.K. Bissell and B. Danielson 2002:154
Potamogeton perfoliatus L., 2003 S. Ernst et al. 79
Potamogeton praelongus Wulfen, 2003 S. Ernst et al. 78 G5:SH
Potamogeton pulcher Tuck., 1909 O.E. Jennings s.n. G5:S1
Potamogeton pusillus L. ssp. *pusillus,* 1907 J.A. Shafer s.n.
Potamogeton pusillus L. ssp. *tenuissimus* (Mert. & Koch) Haynes & C.B. Hellq., 2004 S.P. Grund and L. Miller 3577
Potamogeton richardsonii (Benn.) Rydb., 2003 S. Ernst et al. 65 G5:S3
Potamogeton robbinsii Oakes, 2004 S.P. Grund and L. Miller 3591
Potamogeton spirillus Tuck., 2004 S.P. Grund and L. Miller 3580
Potamogeton vaseyi J.W. Robbins, 2004 L. Miller and S.P. Grund 19 G4:S1
Potamogeton zosteriformis Fern., 2003 S. Ernst et al. 142 G5:S2S3
Stuckenia pectinata (L.) Boerner, 2002 J.K. Bissell and B. Danielson 2002:154

Primulaceae

Lysimachia ciliata L., 2005 L. Speedy LSB733
Lysimachia nummularia L., 2005 L. Speedy LSB724
Lysimachia quadrifolia L., 1972 R.C. Leberman s.n.
Lysimachia terrestris (L.) B.S.P., 2005 L. Speedy, M. Bowers and M. Fodse LSB1625
Lysimachia thyrsiflora L., 1992 J.K. Bissell et al. 1992:064
Lysimachia vulgaris L., 2004 J.A. Isaac et al. 17667 Eurasia
Samolus valerandi L. ssp. *parviflorus* (Raf.) Hultén, 2003 R. Coxe and M. Bradburn s.n.
Trientalis borealis Raf. spp. *borealis,* 1985 J.K. Bissell 1985:048

Pyrolaceae

Chimaphila maculata (L.) Pursh, 1998 R. Leberman s.n.
Chimaphila umbellata (L.) W. Bart. ssp. *cisatlantica* (Blake) Hultén, 1901 J.A. Shafer s.n.
Monotropa hypopithys L., 2004 J.A. Isaac 18416
Monotropa uniflora L., 2005 L. Speedy LSB1094
Pyrola americana Sweet, 1995 R.C. Leberman s.n.
Pyrola chlorantha Sw., 1890 J.S. Ogden s.n. G5:S1
Pyrola elliptica Nutt., 2004 J.A. Isaac 17614

Ranunculaceae

Actaea pachypoda Elliott, 1982 R.C. Leberman s.n.
Actaea racemosa L. var. *racemosa,* 1909 O.E. Jennings s.n.
Actaea rubra (Ait.) Willd., 1970 R.C. Leberman s.n.

Anemone canadensis L., 1990 J.K. Bissell and B. Danielson 1990:192

Anemone quinquefolia L. var. *quinquefolia,* 2005 L. Speedy LSB342.

Anemone virginiana L. var. *virginiana,* 1997 R.C. Leberman s.n.

Aquilegia canadensis L., 1972 W.E. Buker s.n.

Caltha palustris L. var. *palustris,* 2005 L. Speedy LSB338

Clematis virginiana L., 2005 L. Speedy LSB1125

Coptis trifolia (L.) Salisb., 2004 J.A. Isaac 17331

Hepatica nobilis Schreb. var. *acuta* (Pursh) Steyermark, 2004 J.A. Isaac 17318

Hydrastis canadensis L., 1883 J. Whitesides s.n.

Ranunculus abortivus L., 2005 L. Speedy LSB333

Ranunculus acris L., 2005 L. Speedy LSB762 Europe

Ranunculus ambigens S. Watson, 1918 E.M. Gress Field No. 422 G4:S3

Ranunculus aquatilis L., 2001 J.K. Bissell 2001:146 G5T5:S3

Ranunculus flabellaris Raf., 1909 O.E. Jennings s.n. G5:S2

Ranunculus hispidus Michx. var. *hispidus,* 1971 W.E. Buker s.n.

Ranunculus hispidus Michx. var. *nitidus* (Chapman) T. Duncan, 1950 L.K. Henry and W.E. Buker s.n.

Ranunculus longirostris Godr., 1988 J.K.Bissell et al. 1988:134

Ranunculus pensylvanicus L. f., 1984 J.K. Bissell 1984:105

Ranunculus recurvatus Poir. var. *recurvatus,* 1960 L.K. Henry s.n.

Ranunculus repens L., 2004 J.A. Isaac 17348 Europe

Thalictrum dioicum L., 1972 W.E. Buker s.n.

Thalictrum pubescens Pursh, 2004 S.P. Grund and L. Miller 3483

Thalictrum revolutum DC., 1885 none s.n.

Thalictrum thalictroides (L.) Eames & Boivin, 1919 O.E. Jennings s.n.

Rhamnaceae

Ceanothus americanus L., 1986 R.C. Leberman s.n.

Frangula alnus P. Mill., 2003 S. Ernst et al. 145 Exotic

Rhamnus alnifolia L'Hér., 2004 J.A. Isaac 18439

Rhamnus cathartica L., 1998 K. Marsh s.n. Europe

Rosaceae

Agrimonia gryposepala Wallr., 2005 L. Speedy LSB1122

Agrimonia parviflora Ait., 2005 R. Thompson 05-714

Agrimonia pubescens Wallr., 1962 R.C. Leberman s.n.

Agrimonia striata Michx., 1904 O.E. Jennings s.n.

Amelanchier arborea (Michx. f.) Fern. var. *arborea,* 2005 L. Speedy LSB310

Amelanchier laevis Wieg., 2004 J.A. Isaac 17594

Amelanchier stolonifera Wieg., 2004 J.A. Isaac 17485

Amelanchier × intermedia Spach (pro sp.) [*arborea × canadensis*], 1972 R.C. Leberman s.n.

Comarum palustre L., 1997 J.K. Bissell and G. Buckley 1997:104

Crataegus chrysocarpa Ashe var. *chrysocarpa,* 1963 P.B. Monk s.n.

Crataegus crus-galli L., 1929 J. Bright 1779

Crataegus dissona Sarg., 1905 O.E. Jennings s.n.

Crataegus macrosperma Ashe, 2001 J.A. Isaac 13645

Crataegus mollis Scheele, 1922 J. Bright s.n. G5:SU

Crataegus monogyna Jacq., 1933 O.E. Jennings s.n. Eurasia

Crataegus prona Ashe, 1907 O.E. Jennings tree 82

Crataegus pruinosa (Wendl. f.) K. Koch, 1907 O.E. Jennings tree 84

Crataegus punctata Jacq., 1997 R.C. Leberman s.n.

Dalibarda repens L., 1994 J.D. Wagner and L.L. Smith 642

Filipendula rubra (Hill) B.L. Rob., 1970 R.C. Leberman s.n. G4G5:S1S2

Filipendula ulmaria (L.) Maxim., 1968 R.C. Leberman s.n. Eurasia

Fragaria vesca L. ssp. *americana* (Porter) Staudt, 1904 O.E. Jennings s.n.

Fragaria vesca L. ssp. *vesca,* 1950 L.K. Henry and W.E. Buker s.n.

Fragaria virginiana Duchesne ssp. *grayana* (S. Watson) Staudt, 1904 O.E. Jennings s.n.

Fragaria virginiana Duchesne ssp. *virginiana,* 1930 W.R. Van Dersal 1273

Geum aleppicum Jacq., 1952 L.K. Henry and W.E. Buker s.n.

Geum canadense Jacq. var. *canadense,* 2005 L. Speedy LSB747

Geum laciniatum Murr. var. *laciniatum,* 1951 L.K. Henry and W.E. Buker s.n.

Geum rivale L., 2004 J.A. Isaac 17689

Malus coronaria (L.) P. Mill, 2005 L. Speedy LSB1117

Malus floribunda Sieb. ex Van Houtte, 1995 R.C. Leberman s.n. Asia

Malus pumila P. Mill, 2005 R. Thompson 05-573 Eurasia [*Pyrus malus* L.]

Photinia floribunda (Lindl.) Robertson & Phipps, 1994 J.D. Wagner et al. 119

Photinia melanocarpa (Michx.) Robertson & Phipps, 1991 R.C. Leberman s.n.

Photinia pyrifolia (Lam.) Robertson & Phipps, 1993 J.A. Isaac 4635

Physocarpus opulifolius (L.) Maxim. var. *opulifolius, 1997* R.C. Leberman s.n.

Potentilla norvegica L. ssp. *monspeliensis* (L.) Aschers. & Graebn, 2001 J.A. Isaac and C.F. Chuey 13649

Potentilla recta L., 2004 J.A. Isaac 17688 Europe

Potentilla simplex Michx. var. *simplex,* 1907 O.E. Jennings s.n.

Prunus americana Marsh., 1924 O.E. Jennings s.n.

Prunus pensylvanica L. f. var. *pensylvanica,* 2005 L. Speedy LSB327

Prunus serotina Ehrh. var. *serotina,* 2005 L. Speedy LSB1081

Prunus virginiana L. var. *virginiana,* 2004 J.A. Isaac 17591

Rosa carolina L. var. *carolina,* 1973 R.C. Leberman s.n.

Rosa eglanteria L., 1907 J.A. Shafer s.n. Europe

Rosa micrantha Borrer ex Sm., 1954 W.E. Buker s.n. Europe

Rosa multiflora Thunb. ex Murr., 2005 L. Speedy LSB1124 Asia

Rosa palustris Marsh., 1997 J.A. Isaac 9866

Rubus allegheniensis Porter var. *allegheniensis,* 2004 S.P. Grund and L. Miller 3617

Rubus canadensis L., 1927 J. Bright s.n.

Rubus flagellaris Willd., 1955 H.A. Davis and T. Davis 10981

Rubus hispidus L., 2005 L. Speedy LSB763

Rubus idaeus L. ssp. *strigosus* (Michx.) Focke, 1992 J.K. Bissell et al. 1992:064
Rubus ithacanus Bailey, 1955 H.A. Davis and T. Davis 10982
Rubus laudatus Berger, 1955 H.A. Davis and T. Davis 10971
Rubus occidentalis L., 1980 C.E. Jenkins and F.Q. Jenkins 2861
Rubus odoratus L. var. *odoratus,* 1980 R.C. Leberman s.n.
Rubus pensilvanicus Poir., 2004 S.P. Grund and L. Miller 3527
Rubus pergratus Blanch., 1955 H.A. Davis and T. Davis 10962
Rubus plicatifolius Blanch., 1955 H.A. Davis and T. Davis 10961
Rubus pubescens Raf. var. *pubescens,* 2005 L. Speedy LSB1135
Rubus roribaccus (Bailey) Rydb., 1904 O.E. Jennings s.n.
Rubus uvidus Bailey, 1955 H.A. Davis and T. Davis 10972
Rubus wheeleri (Bailey) Bailey, 1955 H.A. Davis and T. Davis 10973
Sanguisorba canadensis L., 1987 J.K. Bissell and B. Danielson 1987:269
Sorbus americana Marsh., 1915 J. Bright s.n.
Sorbus decora (Sarg.) Schneid., 1992 J.K. Bissell and B. Danielson 92:173 G4G5:S1
Spiraea alba Du Roi var. *latifolia* (Ait.) Dippel, 1991 R.C. Leberman s.n.
Spiraea tomentosa L., 2005 L. Speedy LSB1602
Waldsteinia fragarioides (Michx.) Tratt. ssp. *fragarioides,* 2004 J.A. Isaac 17334

Rubiaceae
Cephalanthus occidentalis L., 2005 L. Speedy LSB1093
Galium aparine L., 1980 C.E. Jenkins et al. 2812
Galium asprellum Michx., 2004 S.P. Grund and L. Miller 3623
Galium boreale L., 1996 R.C. Lebermans.n.
Galium circaezans Michx. var. *circaezans,* 1981 R.C. Leberman s.n.
Galium circaezans Michx. var. *hypomalacum* Fern., 1932 W.R. VanDersal s.n.
Galium concinnum Torr. & A. Gray, 1952 L.K. Henry and W.E. Buker s.n.
Galium labradoricum (Wieg.) Wieg., 1994 J.K. Bissell et al. 94:024 G5:S1
Galium lanceolatum Torr., 1942 Richard W. Pohl 3976
Galium obtusum Bigelow ssp. *obtusum,* 2005 L. Speedy LSB1088
Galium palustre L., 2004 L. Miller and S.P. Grund 25
Galium pilosum Aiton, 1969 W.E. Buker s.n.
Galium tinctorium (L.) Scop., 2005 L. Speedy LSB734
Galium trifidum L. ssp. *trifidum,* 1993 J.K. Bissell and B. Danielson 1993:188 G5:S2
Galium triflorum Michx., 2005 L. Speedy LSB319
Houstonia caerulea L., 1905 O.E. Jennings s.n.
Mitchella repens L., 2005 L. Speedy LSB748

Salicaceae
Populus alba L., 1985 J.K. Bissell 85:055 Eurasia
Populus deltoides Bartr. ex Marsh. ssp. *deltoids,* 1930 O.E. Jennings and G.K. Jennings s.n.
Populus grandidentata Michx., 1933 O.E. Jennings s.n.
Populus tremuloides Michx., 1997 R.C. Leberman s.n.
Populus × *jackii* Sarg., [*balsamifera* × *deltoides*] 1990 A.W. Cusick 29024
Salix alba L., 2004 L. Miller and S.P. Grund 54 Eurasia
Salix amygdaloides Andersson, 2005 L. Speedy LSB1574
Salix bebbiana Sarg., 2004 J.A. Isaac 17541
Salix discolor Muhl., 2005 L. Speedy LSB307-1
Salix eriocephala Michx., 2003 R. Coxe and M. Bradburn s.n.
Salix exigua Nutt., 2003 S. Ernst et al. 74
Salix fragilis L., 2003 S. Ernst et al. 72 Europe
Salix humilis Marsh. var. *humilis,* 1907 O.E. Jennings s.n.
Salix interior Rowlee, 2004 L. Miller and S.P. Grund 42
Salix lucida Muhl. ssp. *lucida,* 1988 J.K. Bissell and B. Danielson 1988:86
Salix myricoides Muhl. var. *albovestita* (Ball) Dorn, 1933 O.E. Jennings s.n. G4:S2
Salix nigra Marsh., 2003 S. Ernst et al. 73
Salix petiolaris Sm., 1994 J.K. Bissell et al. 94:048 G5:SNA
Salix purpurea L., 1933 O.E. Jennings s.n. Europe
Salix sericea Marsh., 2003 S. Ernst et al. 96
Salix serissima (Bailey) Fern., 2001 J.A. Isaac and C.F. Chuey 13650 G4:S2

Sarraceniaceae
Sarracenia purpurea L. var. *gibbosa* (Raf.) Wherry, 1929 O.E. Jennings s.n.

Saururaceae
Saururus cernuus L., 2003 S. Ernst et al. 144

Saxifragaceae
Chrysosplenium americanum Schewein. ex Hook., 2004 J.A. Isaac 17328
Heuchera americana L. var. *americana,* 1979 R.C. Leberman s.n.
Hydrangea arborescens L., 1966 R.C. Leberman s.n.
Mitella diphylla L., 2005 L. Speedy LSB760
Penthorum sedoides L., 2004 S.P. Grund and L. Miller 3624
Ribes americanum P. Mill., 2005 L. Speedy LSB721
Ribes cynosbati L., 1997 R.C. Leberman s.n.
Ribes glandulosum Grauer, 1915 J. Bright s.n.
Ribes hirtellum Michx., 2004 J.K. Bissell 2004:089
Ribes lacustre (Pers.) Poir., 1966 R.C. Leberman s.n. G5:S1
Ribes rotundifolium Michx., 1924 O.E. Jennings s.n.
Ribes rubrum L., 2004 J.A. Isaac 17345 Eurasia
Ribes triste Pall., 2004 J.A. Isaac 17365 G5:S2
Saxifraga pensylvanica L., 2004 J.A. Isaac17349
Saxifraga virginiensis Michx. var. *virginiensis,* 1971 W.E. Buker s.n.
Tiarella cordifolia L. var. *cordifolia,* 2004 J.A. Isaac 17362

Scrophulariaceae
Aureolaria virginica (L.) Pennell, 1969 R.C. Leberman s.n.
Chaenorhinum minus (L.) Lange, 2004 J.A. Isaac and R. Coxe 17587 Europe
Chelone glabra L., 1994 J.D. Wagner 674
Gratiola neglecta Torr., 1995 R.C. Leberman s.n.
Linaria vulgaris P. Mill., 1928 J.A. Murray s.n. Eurasia
Lindernia dubia (L.) Pennell var. *dubia,* 1988 J.K. Bissell et al. 88:273

Melampyrum lineare Desr. var. *americanum,* 1965 J.K. Bissell and B.W. Danielson 1997:069
Mimulus alatus Ait., 1959 H.A. Wahl 19405
Mimulus ringens L. var. *ringens,* 2004 S.P. Grund and L. Miller 3503
Nuttallanthus canadensis (L.) D.A. Sutton, 1952 W.E. Buker s.n. [*Antirrhinum canadensis* L.]
Pedicularis canadensis L. spp. *canadensis,* 2004 J.A. Isaac 17462
Pedicularis lanceolata Michx., 2004 J.A. Isaac 18462 G5:S1S2
Penstemon digitalis Nutt. ex Sims, 1981 R.C. Leberman s.n.
Penstemon laevigatus Aiton, 1972 R.C. Leberman s.n. G5:S3
Scrophularia lanceolata Pursh, 2004 J.A. Isaac 17608
Scrophularia marilandica L., 1970 W.E. Buker s.n.
Verbascum blattaria L., 2004 J.A. Isaac and R. Coxe 17581 Eurasia
Verbascum thapsus L., 1963 P.B. Monk s.n. Eurasia
Veronica americana Schwein. ex Benth., 2004 J.A. Isaac 17472
Veronica arvensis L., 1919 O.E. Jennings s.n. Eurasia
Veronica chamaedrys L., 1996 J.K. Bissell et al. 1996:091 Eurasia
Veronica officinalis L. var. *officinalis,* 2004 J.A. Isaac 17459 Europe
Veronica peregrina L. ssp. *xalapensis* (Kunth) Pennell, 2004 J.A. Isaac 17353
Veronica persica Poir., 1919 H.W. Mossman s.n. Eurasia
Veronica scutellata L., 1997 J.K. Bissell and G. Buckley 1997:103
Veronica serpyllifolia L. ssp. *serpyllifolia,* 1924 O.E. Jennings s.n. Europe
Veronicastrum virginicum (L.) Farw., 1962 R.C. Leberman s.n.

Smilacaceae

Smilax herbacea L., 1995 R.C. Leberman s.n.
Smilax rotundifolia L., 1919 O.E. Jennings s.n.
Smilax tamnoides L., 1981 R.C. Leberman s.n.

Solanaceae

Physalis heterophylla Nees var. *heterophylla,* 1948 W.E. Buker s.n.
Solanum carolinense L. var. *carolinense,* 1998 R. Leberman s.n.
Solanum dulcamara L. var. *dulcamara,* 2005 L. Speedy LSB726 Eurasia

Sparganiaceae

Sparganium americanum Nutt., 2004 S.P. Grund and L. Miller 3485
Sparganium erectum L. ssp. *stoloniferum* (Graebn.) Hara, 2004 J.A. Isaac 18473
Sparganium eurycarpum Engelm. ex Gray, 2005 L. Speedy LSB729

Staphyleaceae

Staphylea trifolia L., 1997 R.C. Leberman s.n.

Thymelaeaceae

Dirca palustris L., 2004 J.A. Isaac 18469

Tiliaceae

Tilia americana L. var. *americana,* 1997 R.C. Leberman s.n.

Typhaceae

Typha angustifolia L., 2005 J.K. Bissell 2005:043 Exotic
Typha latifolia L., 2005 L. Speedy LSB740
Typha × glauca Godr. (pro sp.) [angustifolia or domingensis], 1988 J.K. Bissell 1988:141

Ulmaceae

Ulmus americana L., 2004 S.P. Grund and L. Miller 3663
Ulmus rubra Muhl., 2004 S.P. Grund and L. Miller 3537

Urticaceae

Boehmeria cylindrica (L.) Sw., 2004 S.P. Grund and L. Miller 3492
Laportea canadensis (L.) Wedd., 1909 O.E. Jennings s.n.
Pilea fontana (Lunell) Rydb., 2005 L. Speedy LSB1561
Pilea pumila (L.) Gray var. *pumila,* 2004 S.P. Grund and L. Miller 3611
Urtica dioica L. ssp. *gracilis* (Ait.) Seland., 1944 O.E. Jennings s.n.

Valerianaceae

Valeriana officinalis L., 2004 J.A. Isaac 17613 Eurasia

Verbenaceae

Phyla lanceolata (Michx.) Greene, 2000 J.K. Bissell and P. Houghton 2000:086
Verbena hastata L. var. *hastata,* 2004 S.P. Grund and L. Miller 3491
Verbena urticifolia L. var. *urticifolia,* 1901 J.A. Shafer s.n.
Verbena × engelmannii Moldenke [*hastata × urticifolia*], 1901 J.A. Shafer s.n.

Violaceae

Viola arvensis Murr., 1947 W.E. Buker s.n. Europe
Viola blanda Willd. var. *blanda,* 2004 J.A. Isaac 17493
Viola canadensis L. var. *canadensis,* 1930 W.R. VanDersal 1301
Viola cucullata Ait., 2005 L. Speedy LSB316
Viola hastata Michx., 2004 J.A. Isaac 17324
Viola labradorica Schrank, 2005 L. Speedy LSB317
Viola macloskeyi Llyod ssp. *pallens* (Banks ex Ging) M.S. Baker, 2004 J.A. Isaac 17322
Viola pubescens Ait. var. *pubescens,* 1942 O.E. Jennings s.n.
Viola pubescens Ait. var. *scabriuscula* Schwein. ex Torr. & A. Gray, 1993 J.A. Isaac 4629
Viola rostrata Pursh, 2004 J.A. Isaac 17323
Viola rotundifolia Michx., 1952 L.K. Henry and W.E. Buker s.n.
Viola sororia Willd., 2005 L. Speedy LSB313
Viola striata Ait., 2004 J.A. Isaac 17347
Viola × bissellii House [cucullata × sororia], 1955 L.K. Henry s.n.

Vitaceae

Parthenocissus quinquefolia (L.) Planch., 2005 L. Speedy LSB728
Parthenocissus vitacea (Knerr) A.S. Hitchc., 1990 A.W. Cusick 29027 [*Ampelopsis quinquefolia* var. *vitacea* Knerr]
Vitis aestivalis Michx. var. *bicolor* Deam, 1997 R.C. Leberman s.n.
Vitis riparia Michx., 2005 L. Speedy LSB722

Zannichelliaceae

Zannichellia palustris L., 1881 J. Whitesides s.n.

GYMNOSPERMS

Pinaceae

Larix deciduas P. Mill, 2005 R. Thompson 05-1066 Europe

Larix laricina (Du Roi) K. Koch, 1997 J.K. Bissell and B. Gordon 1997:106

Pinus banksiana Lamb., 2005 L. Speedy LSB326

Pinus strobus L., 2005 L. Speedy LSB321

Pinus sylvestris L., 1975 W.E. Buker s.n. Eurasia

Tsuga canadensis (L.) Carr., 2005 L. Speedy LSB1083-2

Taxaceae

Taxus canadensis Marsh., 1999 J.K. Bissell 1999:091

LYCOPHYTES

Lycopodiaceae

Huperzia lucidula (Michx.) Trevisan, 2004 J.A. Isaac 17326

Lycopodium annotinum L., 1990 J.K. Bissell and B. Danielson 1990:196

Lycopodium clavatum L., 1984 J.K. Bissell 1984:106

Lycopodium dendroideum Michx., 1966 R.C. Leberman s.n.

Lycopodium digitatum Dill. ex A. Braun, 2005 L. Speedy LSB1133

Lycopodium hickeyi W.H. Wagner, Beitel & Moran, 1965 D.L. Pearth s.n.

Lycopodium obscurum L., 2005 L. Speedy LSB1090

Lycopodium tristachyum Pursh, 1962 R.C. Leberman s.n.

Lycopodium × *habereri* House [*digitatum* × *tristachyum*], 1997 J.K. Bissell and G. Buckley 1997:156

Lygodiaceae

Lygodium palmatum (Bernh.) Sw., 1968 R.C. Leberman s.n.

PTERIDOPHYTES

Aspleniaceae

Asplenium platyneuron (L.) B.S.P. var. *platyneuron,* 1991 B.L. Isaac and J.A. Isaac 3550

Blechnaceae

Woodwardia virginica (L.) Sm., 2004 J.A. Isaac 18476

Dennstaedtiaceae

Dennstaedtia punctilobula (Michx.) T. Moore, 1997 R.C. Leberman s.n.

Pteridium aquilinum (L.) Kuhn var. *latiusculum* (Desv.) Underwood ex Heller, 2004 S.P. Grund and L. Miller 3666

Dryopteridaceae

Athyrium filix-femina (L.) Roth ssp. *angustum* (Willd.) Clausen, 1984 J.K. Bissell 1984:126

Cystopteris bulbifera (L.) Bernh., 1965 J. Stull and D. Stull s.n.

Cystopteris tenuis (Michx.) Desv., 1982 R.C. Leberman s.n.

Deparia acrostichoides (Sw.) M. Kato, 1984 J.K. Bissell 1984:126

Diplazium pycnocarpon (Spreng.) Broun, 2004 J.A. Isaac 18430

Dryopteris carthusiana (Vill.) H.P. Fuchs, 2004 S.P. Grund and L. Miller 3542

Dryopteris clintoniana (D.C. Eat.) Dowell, 2004 J.A. Isaac 18465 G5:S2

Dryopteris cristata (L.) Gray, 2005 L. Speedy, M. Bowers and M. Fodse LSB1621

Dryopteris goldiana (Hook. ex Goldie) Gray, 2004 J.A. Isaac et al. 17718

Dryopteris intermedia (Muhl. ex Willd.) Gray, 2005 L. Speedy LSB750

Dryopteris marginalis (L.) Gray, 1962 R.C. Leberman s.n.

Dryopteris × *boottii* (Tuck.) Underwood (pro sp.) [*cristata* ×, 2004 J.A. Isaac 18467

Dryopteris × *triploidea* Wherry [*carthusiana* × *intermedia*], 1984 J.K. Bissell 1984:120

Gymnocarpium dryopteris (L.) Newman, 2004 J.A. Isaac 17498

Matteuccia struthiopteris (L.) Todaro, 2004 J.A. Isaac 18423

Onoclea sensibilis L., 2005 L. Speedy LSB1131

Polypodium appalachianum Haufler & Windham, 1906 O.E. Jennings s.n.

Polypodium virginianum L., 1914 C.A. Darling s.n.

Polystichum acrostichoides (Michx.) Schott var. *acrostichoides,* 2005 L. Speedy LSB746

Equisetaceae

Equisetum arvense L., 1994 J.D. Wagner and J.K. Bissell 344

Equisetum fluviatile L., 2005 L. Speedy, J. Bissell, M. Bowers and T. Pearson LSB1584

Equisetum hyemale L. var. *affine* (Engelm) A.A. Eat., 1970 W.E. Buker s.n.

Equisetum sylvaticum L., 2005 L. Speedy LSB340

Isoetaceae

Isoëtes tenella Léman, 1933 W.R. Van Dersal s.n. [*Isoëtes braunii* Durieu]

Ophioglossaceae

Botrychium dissectum Spreng., 1985 J.K. Bissell and M. Hoberecht 1985:048

Botrychium lanceolatum (Gmel.) Angstr. var. *angustisegmentum* Pease & Moore, 1930 O.E. Jennings and G.K. Jennings s.n.

Botrychium matricariifolium (A. Braun ex Dowell) A. Braun ex Koch, 1993 J.K. Bissell and B. Danielson 1993:091

Botrychium multifidum (Gmel.) Trev., 1984 A.W. Cusick 23366

Botrychium oneidense (Gilbert) House, 1985 J.K. Bissell and M. Hoberecht 1985:048

Botrychium simplex E. Hitchc., 1982 R.C. Leberman s.n. Europe

Botrychium virginianum (L.) Sw., 1984 J.K. Bissell 1984:106

Ophioglossum pusillum Raf., 1939 J. Wurdach s.n.

Ophioglossum vulgatum L., 1970 R.C. Leberman s.n. G5:S4

Osmundaceae

Osmunda cinnamomea L. var. *cinnamomea,* 2005 L. Speedy LSB304

Osmunda claytoniana L., 2004 J.A. Isaac 17470

Osmunda regalis L. var. *spectabilis* (Willd.) Gray, 2005 L. Speedy LSB 306

Pteridaceae

Adiantum pedatum L., 1997 R.C. Leberman s.n.

Selaginellaceae

Selaginella apoda (L.) Spring, 2004 J.A. Isaac 17486

Thelypteridaceae

Phegopteris connectilis (Michx.) Watt, 1955 L.K. Henry s.n.

Phegopteris hexagonoptera (Michx.) Fée, 1968 R.C. Leberman s.n.

Thelypteris noveboracensis (L.) Nieuwl., 2005 L. Speedy LSB751

Thelypteris palustris Schott var. *palustris,* 1999 J.K. Bissell 1999:079

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BOOK NOTICES

R.J. Chinnock. 2007. **Eremophila and Allied Genera: A Monograph of the Myoporaceae.** (ISBN 978-1-877-05816-5, hbk). Rosenberg Publishing Pty Ltd, PO Box 6125, Dural Delivery Centre, NSW 2158, Australia. (**Orders:** www.isbs.com, 503-287-3093, 503-280-8832 fax). $99.95, 672 pp., 335 color plates, 300 maps, 325 line drawings, 8½" × 11½".

The seven genera of Myoporaceae are described up, down, sideways, and in yet intangible dimensions. Treatments include formal taxonomy, detailed descriptions and maps, beautiful and informative line drawings, many interspersed color photos of plants and flowers, and notes on distribution, ecology, conservation status and relationships. Three new genera, 94 new species, and 37 new subspecies are described, and revised infrageneric classifications of *Eremophila* and *Myoporum* are proposed. All this is presented in such an elegant fashion that it invites being laid on the coffee table for recreational reading (not to belittle its academic value).

Contents: **1)** Introduction; **2)** History of the Myoporaceae; **3)** Morphology and Anatomy; **4)** Trichomes; **5)** Floral and Fruit Morphology; **6)** Palynology; **7)** Cytology and Cytogeography; **8)** Reproductive Biology; **9)** Distribution and Ecology; **10)** Phytochemistry and Toxicity; **11)** Traditional and Economic Uses; **12)** Horticultural Uses; **13)** Phylogeny and Relationships of the Myoporaceae; **14)** Taxonomic Treatment of the Family Myoporaceae

Five of the seven genera of Myoporaceae occur in Australia, where all but one of these, *Myoporum*, are endemic. *Bontia* and *Pentacoelium* each contain a single species and are restricted to the Caribbean (plants have recently been found in Florida, near Miami) and to southern China, Japan, and northern Vietnam. *Myoporum* is largely Australian but species extend into the Pacific (including New Zealand and Hawaii) and one species to the Indian Ocean.

The high salt tolerance and drought resistance of Myoporaceae combined with attractive flowers has made this family, especially *Myoporum*, a popular horticultural introduction in drier regions around the world. Most species are shrubs with a variety of flower colour and form and flowering often is prolific. *Myoporum laetum* G. Forst. is naturalized and weedy in coastal areas of southern California.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

Alan E. Bessette, William C. Roody, Arleen R. Bessette, and Dail L. Dunaway. 2007. **Mushrooms of the Southeastern United States.** (ISBN 978-0-8156-3112-5, hbk). Syracuse University Press, 621 Skytop Road, Suite 110, Syracuse, NY, 13244-5290, U.S.A.. (**Orders:** www.syracuseuniversitypress.syr.edu, 315-443-5534, 315-443-5545 fax). $95.00, 400 pp., 517 color images, 1 map, 7¼" × 10¼".

More than 450 species are treated, with 517 color photographs (on 75 pages) and detailed descriptions, for an area that includes Texas, Oklahoma, and Kansas east to West Virginia, Virginia, and southward to (and including) Florida. The authors note that the book provides a "relatively comprehensive guide" and that "the number of species described and illustrated in color is substantially higher than has previously appeared in any other single work devoted to the mushrooms of the southeastern United States. We provide cross-references to additional species occurring in the region that are illustrated in *Mushrooms of Northeastern North America*" (the companion volume, also Syracuse Univ. Press). For use by a general audience, the book emphasizes identification based primarily on macroscopic field characters but the authors note that it also provides necessary detail required by advanced students and professional mycologists.

There are lots of field guides and other books on mushrooms of eastern North America, some with large pictures and numerous species, but this one apparently is the ticket. On the other hand, local field guides remain indispensable. For example, from *Texas mushrooms: a field guide* (Metzler & Metzler 1992), there are 43 species (8 in *Amanita*) and 8 genera (*Lentaria*, *Oudemansiella*, *Phlogiotis*, *Sarcodon*, *Scutellina*, *Sphaerobolus*, *Steccherinum*, *Tremellodendron*) not accounted for in the index of Bessette et al. It's not easily apparent whether this is because of taxonomic/ nomenclatural issues or because the southern and western edges of Texas include the ranges of primarily western species (or a combination of both factors).—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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VASCULAR FLORA OF THE FOUR CANYONS PRESERVE, ELLIS COUNTY, OKLAHOMA

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ABSTRACT

This paper reports the results of an inventory of the vascular plants from The Nature Conservancy's Four Canyons Preserve in Ellis County, Oklahoma. A total of 371 taxa of vascular plants in 244 genera and 77 families were collected, with the most species occurring in the families Asteraceae (69), Poaceae (64), and Fabaceae (38). One hundred-twelve species were annuals, four biennials, and 255 perennials. Fifty-one species of woody plants were present. Twenty-nine exotic species were collected representing 7.8% of the flora. Six tracked by the Oklahoma Natural Heritage Inventory were found.

RESUMEN

En este artículo se presentan los resultados de un inventario de plantas vasculares de The Nature Conservancy's Four Canyons Preserve en Ellis County, Oklahoma. Se colectaron un total de 371 taxa de plantas vasculares de 244 géneros y 77 familias, siendo la mayoría de las especies pertenecientes a las familias Asteraceae (69), Poaceae (64), y Fabaceae (38). Ciento doce especies fueron anuales, cuatro bienales, y 255 perennes. Están presentes cincuenta y una especies de plantas leñosas. Se colectaron veintinueve especies exóticas que representan el 7.8% de la flora. Se encontraron seis especies a las que hace un seguimiento el Oklahoma Natural Heritage Inventory.

INTRODUCTION

There are currently 501 taxa of vascular plants known to occur in Ellis County, Oklahoma (Hoagland et al. 2006). The first collections in the county were made in 1913 by G.W. Stevens, who deposited 69 species. In the following year, 63 collections were deposited at the University of Oklahoma Herbarium (OKL) by R.L. Clifton. No collections from Ellis County were deposited in state herbaria between 1915 and 1927. After that time, there was steady collection in the county. The 1970s were an active decade for botanical study of Ellis County, culminating in the deposit of 101 specimens at (OKL) collected by Barber, K. Pearce, and R. Thompson in 1976. From 1985 to 1986, F.B. Erteeb deposited 405 specimens from Ellis County at the Oklahoma State University (OKLA) herbarium as part of a floristic study of Northwest Oklahoma. In 1998, N. McCarty and B. Hoagland deposited 226 specimens at OKL in conjunction with a study of wetland and woody plants. Since that time there has been little collection effort in Ellis County. The objective of this study was to provide a floristic inventory to aid Nature Conservancy personnel in management of the Four Canyons Preserve (FCP) and remedy a gap in our knowledge of the flora of western Oklahoma.

STUDY AREA

The FCP (Fig. 1) was established by The Nature Conservancy in 2004 and protects 1,376 hectares. It is within the Subtropical Humid (Cf) climate zone (Trewartha 1968). Summers are warm (mean July temperature = 26.6° C) and humid, and winters are relatively short and mild (mean January temperature = 0.3° C). Mean annual precipitation is 60.4 cm (Oklahoma Climatological Survey 2006).

Physiographically, the study area is located in the Western Redbed Plains (Curtis & Ham 1979) of Osage Plains Physiographic Province (Hunt 1974). The topography consists of gently rolling hills with deeply eroded canyons. The surface geology is comprised of Permian age sandstones and shale in the uplands and quaternary alluvial deposits on the Canadian River floodplain (Branson & Johnson 1979). The Quinlan-Woodward soil association, a reddish loamy upland soil predominates at the site. The Lincoln-Spur Associa-

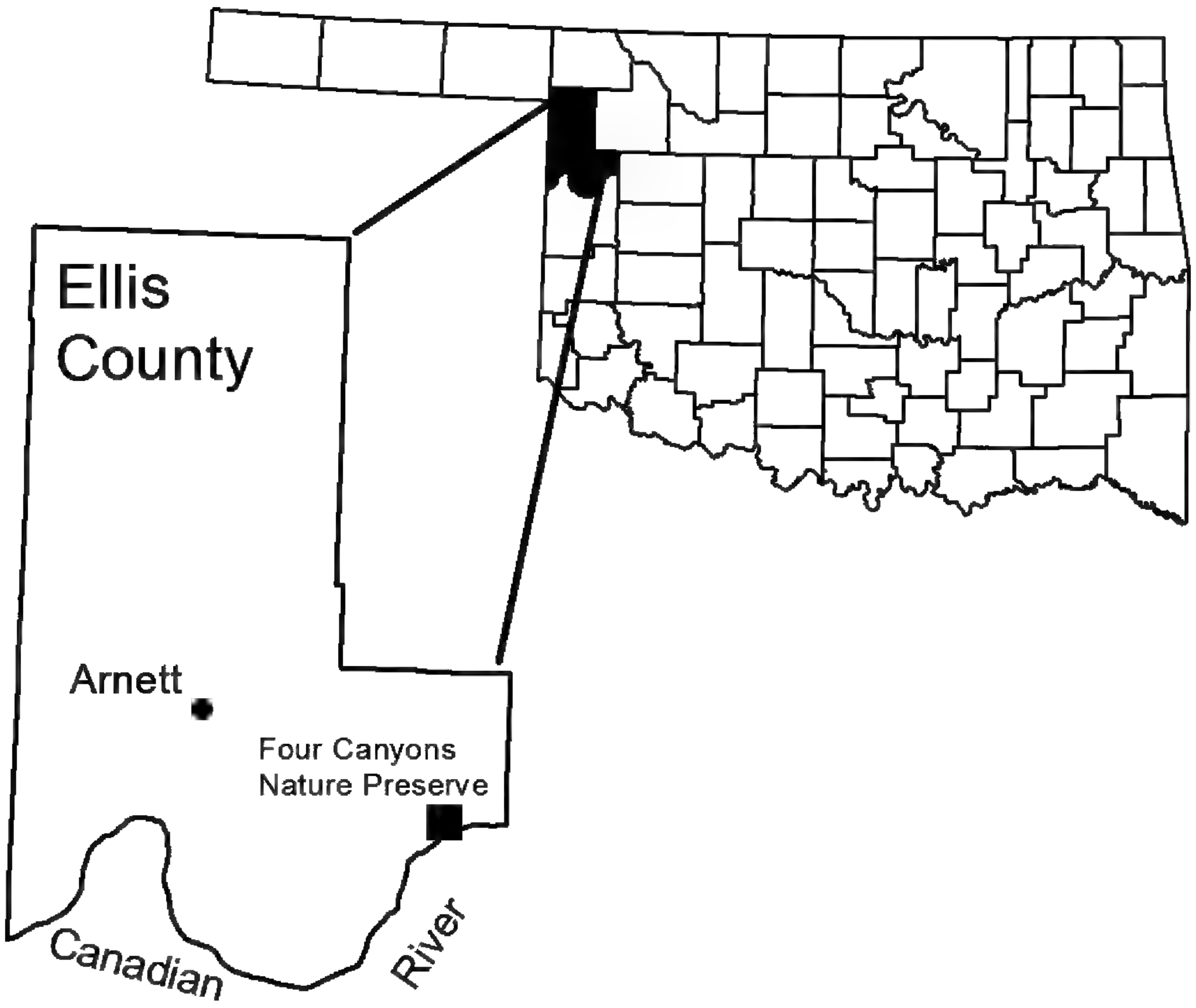

Fig. 1. Location of The Nature Conservancy Four Canyons Preserve in Ellis County, Oklahoma.

tion, consisting of sandy to laomy soils, predominates on the Canadian River floodplain (Cole 1961). Duck and Fletcher (1943) classified the study area as part of the mixedgrass eroded plains, defined as having a "...mixed grass composition and a definite ravine relief which is generally wooded. It is part of an extensive area of similar vegetational conditions extending as an overlapping of tall grass species from the east, with short grass species from the west northward across the United States." Vegetation along the Canadian River was classified as bottomland, a category that was not clearly defined, but would include cottonwoods and riparian shrubs and herbaceous species in the study area.

METHODS

Five collection sites were regularly visited for intensive floristic sampling. Additional collections were also made randomly throughout the site. Collecting began on March through October 1999. Sites were selected following a review of U. S. Geological Survey 1:24,000 topographic maps and field reconnaissance. The predominant vegetation association at these sites was classified according to Hoagland (2000). Vouchers for exotic species were made from naturalized populations only, thus excluding cultivated and ornamental plants. Specimens were processed at the Robert Bebb Herbarium of the University of Oklahoma (OKL) following standard procedures. Manuals used for specimen identification included Correll and Johnston (1970), Great Plains Flora Association (1986), and Waterfall (1973). Origin, either native or introduced, was determined using Taylor and Taylor (1991) and USDA-NRCS (2006). Nomenclature follows the United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS 2006). Voucher specimens were deposited at the Robert Bebb Herbarium (OKL) at the University of Oklahoma.

RESULTS AND DISCUSSION

A total of 371 taxa of vascular plants in 77 families and 244 genera were collected (Appendix 1). Among the angiosperms, 86 were monocots and 283 were dicots. In addition, there were two ferns and allies and one gymnosperm. The Asteraceae (69), Poaceae (64), and Fabaceae (38) had the greatest number of species. The genus *Asclepias* had the greatest number of species (10). One hundred-twelve species were annuals, four biennials, and 255 perennials. Fifty-one species of woody plants were collected. One hundred and eleven species previously unreported from Ellis County were collected in this study.

Thirty taxa (8.1% of the flora) from 14 families were exotic. The families with the greatest number of introduced species were Poaceae with twelve, Asteraceae with four, and Fabaceae with two. Genera with the most exotic species were *Bromus* with three and *Vulpia* with two. The percentage of exotic species in this flora is comparable with reports from other floras in Oklahoma (7–15% exotic) (Hoagland & Johnson 2001, 2004a, 2004b; Hoagland & Buthod 2003, 2004; Hoagland & Wallick 2003; Hoagland et al. 2004; Hoagland et al. 2004; Hoagland & Buthod 2005a; Hoagland & Buthod 2005b; Hoagland & Johnson 2005), with the exception of two sites in McCurtain County, where 6.6% of the flora consisted of exotic species (Hoagland & Johnson 2004c). See Table 1 for a floristic summary of FCP.

No federally listed threatened or endangered species were encountered. However, five species tracked by the ONHI (2005) were present: *Argythamnia mercurialina* (G5,S2S3), *Echinocereus reichenbachii* (G5, S2), *Escobaria vivipara* (G5, S2S3), *Muhlenbergia bushii* (G5, S1S2), *Vitis rupestris* (G3, S?) and *Zinnia grandiflora* (G4G5, S?). Species are ranked according to level of imperilment at the state (S) and global (G) levels on a scale of 1–5; 1 representing a species that is imperiled and 5 one that it is secure. A "?" indicates a species with rank influx (Groves et al. 1995).

The five collection sites at Four Canyons occurred within six vegetation associations. A brief description of each follows:

1. Disturbed areas and old-fields were locations exhibiting signs of physical disruption, such as roadsides and home sites. This includes a portion of the Canadian River floodplain that was converted to *C. dactylon* in years prior to acquisition by The Nature Conservancy. Common plants in disturbed areas included *Aegilops cylindrica*, *Bothriochloa laguroides*, *Bromus catharticus*, *Cucurbita foetidissima*, *Eragrostis cilianensis*, *Geranium carolinianum*, *Hordeum pusillum*, *Mollugo verticillata*, *Oxalis stricta*, *Phytolacca americana*, *Polygonum aviculare*, *Portulaca halimoides*, *Quincula lobata*, *Rhus glabra, and Tribulus terrestris.*

2. *Quercus muehlenbergii-Juniperus virginiana* woodland association occupied deep sandstone canyons at the FCP. This vegetation type does not appear in Hoagland (2000). Although *Q. muehlenbergii* has been reported from counties immediately south of Ellis, it does not occur as a dominant species. The co-occurrence of *J. virginiana* is likely the result of fire suppression, but additional research is necessary to character species composition and stand history. Associated species included *Acalypha ostryifolia, Celastrus scandens*, *Cornus drummondii, Elymus canadensis, Galium aparine, Juglans microcarpa, Parietaria penslvanica, Pellaea atropurpurea, Ribes aureum*, *Sideroxylon lanuginosum, Smilax tamnoides, Symphoricarpos orbiculatus*, *Toxicodendron radicans, Tridens flavus*, and *Ulmus rubra*. *Muhlenbergia bushii*, a species tracked by ONHI, occurred in this habitat.

3. *Quercus havardii-Sporobolus cryptandrus-Schizachyrium scoparium* shrubland association was limited to a deposit of sandy soils on the western edge of the preserve. Extensive occurrences of this vegetation association are west of the FCP on deep sandy soils. Associated species included *Artemisia filifolia, Bouteloua gracilis, Indigofera miniata, Mentzelia multiflora, Oenothera grandis*, *Prunus gracilis*, and *Yucca glauca*.

4. *Schizachyrium scoparium-Bouteloua curtipendula-Bouteloua gracilis* herbaceous association occurred on the well-drained soils and rocky slopes. It was the most abundant vegetation type at FCP. Plant cover was sparse on sandstone outcrops Associated forb species included *Amorpha canescens, Argemone polyanthemos, Astragalus gracilis, Calylophus hartwegii, Ceanothus herbaceous, Comandra umbellata, Croton texensis, Dalea aurea, Desmodium sessilifolium, Hedeoma drummondii, Hedyotis nigricans*, *Ipomoea leptophylla, Ipomopsis longiflora, Lesquerella ovalifolia*, *Krameria lanceolata, Monarda clinopodioides, Pediomelum cuspidatum*, *Ptelea trifoliata, Sorghastrum nutans*, *Sphaeralcea coccinea, Stillingia sylvatica*, *Streptanthus hyacinthoides*, and *Symphyotrichum ericoides*. Species tracked by the ONHI that occurred in this association were *Argythamnia mercurialina*, *Escobaria vivipara* and *Zinnia grandiflora*.

5. *Schizachyrium scoparium—Castilleja purpurea* var. *citrina—Lesquerella gordonii* herbaceous association occurred on shallow soils over gypsum. The extent of vegetation cover varies with the degree of gypsum exposure. Associates include *Bouteloua hirsuta, Erioneuron pilosum, Chaetopappa ericoides, Liatris punctata*, *Phacelia integrifolia*, *Psilostrophe tagetina*, and *Tetraneuris scaposa*. *Echinocereus reichenbachii*, which is tracked by the Oklahoma Natural Heritage Inventory, occurred in this habitat type.

6. Wetland and Riparian vegetation included the margins of small ponds at FCP and wet areas along the floodplain of the Canadian River. Although multiple wetland vegetation associations are present at the FCP, they are limited in aerial extent and readily intergrade. Classifying Canadian River floodplain vegetation is further confounded by land use/land conversion practices of the landowner prior to The Nature Conservancy. Possible wetland vegetation types present include *Polygonum pensylvanicum-Polygonum lapathifolium* herbaceous association, *Schoenoplectus americanus—Eleocharis montevidensis* herbaceous association, and the *Tamarix chinensis* shrubland association.

APPENDIX 1

Annotated species list for The Nature Conservancy's Four Canyon Preserve. The first entry indicates habitat (**DAOF** = disturbed areas and old fields, **QHSC** = *Quercus havardii-Sporobolus cryptandrus-Schizachyrium*

TABLE 1. Summary of floristic collections from the Four Canyons Preserve, Ellis County, Oklahoma.*

Taxonomic Group	**Species**	**Native**	**Exotic**
Pteridophyta	2	2	0
Coniferophyta	1	1	0
Magnoliophyta	364	337	27
Magnoliopsdia	277	261	16
Liliopsida	87	76	11

Table follows the format of Palmer et al. 1995.

scoparium shrubland association, **QMJV** = *Quercus muehlenbergii-Juniperus virginiana* woodland association, **SSBC** = *Schizachyrium scoparium-Bouteloua curtipendula-Bouteloua gracilis* herbaceous association, **SSCP** = *Schizachyrium scoparium-Castilleja purpurea* var. *citrina-Lesquerella gordonii* herbaceous association, **WETL** = wetland and riparian) followed by life history is designated as **A**=annual, **B**=biennial, or **P**=perennial, and collection number. Introduced species are noted with an asterisk.

PTERIDOPHYTA

Equisetaceae
Equisetum laevigatum A. Braun—DAFL, WETL; P; 4C-103

Pteridaceae
Pellaea atropurpurea (L.) Link—QMJV; P; 4C-030

CONIFEROPHYTA

Cupressaceae
Juniperus virginiana L.—GMJV, DAUP, SSBC; P; 4C-019

MAGNOLIOPHYTA—MAGNOLIOPSIDA

Acanthaceae
Ruellia humilis Nutt.—SSBC; P; 4C-330

Amaranthaceae
Amaranthus albus L.—DAUP; A; 4C-329

Anacardiaceae
Rhus aromatica Aiton—QHSC, SSBC; P; 4C-027
Rhus glabra L.—SSBC; P; 4C-214
Toxicodendron radicans (L.) Kuntze—QMJV; P; 4C-307

Apiaceae
Ammoselinum popei Torr. & A. Gray—SSBC; A; 4C-075
Cymopterus acaulis (Pursh) Raf.—SSBC; P; 4C-015
Eurytaenia texana Torr. & A. Gray—SSBC; A; 4C-288
Spermolepis echinata (Nutt. ex DC.) A.Heller—DAUP, SSBC; A; 4C-121

Apocynaceae
Apocynum cannabinum L.—DAFL, DAUP, SSBC; P; 4C-187

Asclepiadaceae
Asclepias arenaria Torr.—SSBC; P; 4C-280
Asclepias asperula (Dcne.) Woods.—SSBC; P; 4C-078
Asclepias engelmanniana Woods.—SSBC; P; 4C-266
Asclepias latifolia (Torr.) Raf.—SSBC; P; 4C-434
Asclepias pumila (A. Gray) Vail—QHSC; P; 4C-378
Asclepias stenophylla A. Gray—SSBC; P; 4C-239
Asclepias syriaca L.—DAFL; P; 4C-432
Asclepias tuberosa L.—SSBC; P; 4C-164
Asclepias verticillata L.—SSBC; P; 4C-336
Asclepias viridiflora Raf.—SSBC; P; 4C-345

Asteraceae
Ambrosia psilostachya DC.—DAFL, DAUP, QMJV, SSBC; P; 4C-346
Amphiachyris dracunculoides (DC.) Nutt.—DAUP, SSBC; A; 4C-291
Aphanostephus skirrhobasis (DC.) Trel.—QHSC, SSBC; a; 4C-217
Artemisia dracunculus L.—SSBC; P; 4C-293
Artemisia filifolia Torr.—QHSC, SSBC; P; 4C-292
Artemisia ludoviciana Nutt.—DAUP, SSBC; P; 4C-037
Baccharis salicina Torr. & A. Gray—DAFL; P; 4C-340
Brickellia eupatorioides (L.) Shinners—SSBC; P; 4C-398
Centaurea americana Nutt.—DAUP, SSBC; A; 4C-290
Chaetopappa ericoides (Torr.) G.L. Nesom—SSCP; P; 4C-013
Chloracantha spinosa (Benth.) G.L. Nesom—DAFL; P; 4C-232
Cirsium ochrocentrum A. Gray—DAUP, SSBC; P; 4C-180
Cirsium undulatum (Nutt.) Spreng.—DAUP, SSBC; P; 4C-274
Conyza canadensis (L.) Cronquist—DAUP, QMJV, SSCP; A; 4C-305
Croptilon hookerianum (Torr. & A. Gray) House—SSBC; A; 4C-326
Echinacea angustifolia DC.—SSBC; P; 4C-264
Engelmannia peristenia (Raf.) Goodman & C.A.Lawson—SSBC; P; 4C-056
Erigeron bellidiastrum Nutt.—QHSC; A; 4C-112
Erigeron divergens Torr. & A. Gray—SSBC; P; 4C-419
Erigeron strigosus Muhl. ex Willd.—SSBC; A; 4C-165
Euthamia gymnospermoides Greene—SSBC; P; 4C-384
Evax prolifera Nutt. ex DC.—DAUP, SSBC; A; 4C-110
Flaveria campestris J.R.Johnst.—DAFL, DAUP; A; 4C-377
Gaillardia aestivalis (Walter) H.Rock—QHSC, SSBC; P; 4C-385
Gaillardia pulchella Foug.—QHSC, SSBP; A; 4C-052
Gaillardia suavis (AGray & Engelm.) Britt & Rusby—SSCP; P; 4C-060
Grindelia lanceolata Nutt. SSBC; P; 4C-366

Grindelia nuda Wood var. *nuda*—DAUP; P; 4C-349
*Grindelia squarrosa (*Pursh) Dunal—DAUP; A; 4C-372
Gutierrezia sarothrae (Pursh) Britt & Rusby—SSBC; P; 4C-294
Haloesthes greggii A. Gray—SSCP; P; 4C-289
Helenium amarum (Raf.) H.Rock—DAUP, SSBC; A; 4C-043
Helianthus annuus L.—DAFL, DAUP, WETL; A; 4C-312
Helianthus petiolaris Nutt.—DAFL; A; 4C-352
Heterotheca stenophylla (A. Gray) Shinners var. *stenophylla*—SSBC; P; 4C-286
Heterotheca subaxillaris (Lam.) Britt & Rusby—SSBC; A; 4C-296
Hymneopappus flavescens A. Gray—SSBC; B; 4C-170
Hymneopappus tenuifolius Pursh—QHSC, SSBC; P; 4C-237
Iva annua L.—DAFL; A; 4C-354
Lactuca serriola L.*—DAUP; A; 4C-343
Liatris mucronata DC.—SSBC; P; 4C-416
Liatris punctata Hook.—SSBC, SSCP; P; 4C-371
Liatris squarrosa (L.) Michx.—SSBC; P; 4C-331
Lygodesmia juncea (Pursh) D.Don ex Hook.—SSBC; P; 4C-271
Machaeranthera pinnatifida (Hook.) Shinners—SSBC; P; 4C-285
Packera plattensis (Nutt.) W.A.Weber & Á. Löve—SSBC; B; 4C-018
Pluchea odorata (L.) Cass.—DAFL, WETL, QMJV; A; 4C-361
Psilostrophe tagetina (Nutt.) Greene var. *cerifera* (A.Nels.) B.L. Turner—SSCP; B; 4C-031
Pyrrhopappus grandiflorus (Nutt.) Nutt.—DAUP, SSBC; P; 4C-094
Ratibida columnifera (Nutt.) Wooten & Standl.—SSBC; P; 4C-303
Senecio riddellii Torr. & A. Gray—DAFL; P; 4C-040
Solidago altissima L.—SSBC; P; 4C-415
Solidago canadensis L. var. *canadensis*—QMJV, SSBC; P; 4C-428
Solidago gigantea Aiton—WETL, SSBC; P; 4C-419
Solidago petiolaris Aiton—SSBC; P; 4C-411
Sonchus asper (L.) Hill*—DAUP, QMJV; A; 4C-186
Symphyotrichum ericoides (L.) G.L. Nesom var. *ericoides*—SSBC; P; 4C-394
Symphyotrichum fendleri (A. Gray) G.L. Nesom—SSBC; P; 4C-414
Symphyotrichum oblongifolium (Nutt.) G.L. Nesom—SSBC; P; 4C-298
Symphyotrichum subulatum (Michx.) G.L. Nesom—DAFL, WETL; A; 4C-035
Taraxacum officinale G.Weber ex AWigg.*—DAUP; P; 4C-029
Tetraneuris linearifolia (Hook.) Greene—SSBC; A; 4C-010
Tetraneuris scaposa (DC.) Greene—SSCP; P; 4C-011
Thelesperma megapotamicum (Spreng.) Kuntze—SSBC; P; 4C-038
Townsendia exscapa (H.Richards.) Porter—SSBC; P; 4C-003
Tragopogon dubius Scop.*—DAUP; A; 4C-105
Vernonia baldwinii Torr.—DAUP, QMJV; P; 4C-319
Xanthium strumarium L.—DAFL, WETL; A; 4C-356
Zinnia grandiflora Nutt.—SSCP; P; 4C-316

Boraginaceae

Cryptantha minima Rydb.—SSBC; A; 4C-084
Lappula occidentalis (S.Watson) Greene var. occidentalis—DAUP; A; 4C-141
Lithospermum caroliniense (Walter ex J.F.Gmel.) MacMil..—SSBC; P; 4C-144
Lithospermum incisum Lehm.—SSCP, SSBC; P; 4C-016

Brassicaceae

Camelina microcarpa DC.*—DAUP; A; 4C-072
Descurainia pinnata (Walter) Britt—DAUP; A; 4C-020
Draba cuneifolia Nutt. ex Torr. & A. Gray—DAUP, SSBC; A; 4C-022
Lepidium densiflorum Schrad.—DAUP, SSBC; A; 4C-093
Lepidium oblongum Small—DAUP, SSBC; A; 4C-017
Lesquerella gordonii (A. Gray) S.Watson—SSCP; A; 4C-024
Lesquerella ovalifolia Rydb.ex Britt—SSBC; P; 4C-118
Streptanthus hyacinthoides Hook.—SSBC; A; 4C-258

Cactaceae

Echinocereus reichenbachii (Terscheck ex Walp.) Haage f.—SSBC, SSCP; P; 4C-136
Escobaria vivipara (Nutt.) Buxb.—SSBC; P; 4C-174
Opuntia macrorhiza Engelm.—DAUP, SSBC; P; 4C-424

Campanulaceae

Triodanis holzingeri McVaugh—DAUP, SSBC; A; 4C-246
Triodanis perfoliata (L.) Nieuwl.—DAUP, SSBC; A; 4C-273

Capparaceae

Polanisia dodecandra (L.) DC.—QHSC, SSBC; A; 4C-379

Caprifoliaceae

Symphoricarpos orbiculatus Moench—QMJV; P; 4C-147

Caryophyllaceae

Dianthus armeria L.*—SSBC; A; 4C-088
Paronychia jamesii Torr. & A. Gray—SSCP; P; 4C-247

Celastraceae

Celastrus scandens L.—QMJV; P; 4C-039

Chenopodiaceae

Atriplex canescens (Pursh) Nutt.—SSBC; P; 4C-104
Chenopodium leptophyllum (Moq.) Nutt. ex S.Watson—DAUP; A; 4C-268
Chenopodium simplex (Torr.) Raf.—QMJV; A; 4C-376
Monolepis nuttalliana (Schult.) Greene—WETL; A; 4C-143
Salsola tragus L.*—DAFL, DAUP; A; 4C-341

Convolvulaceae

Convolvulus arvensis L.*—DAUP; P; 4C-210
Evolvulus nuttallianus Schult.—SSCP; P; 4C-051
Ipomoea leptophylla Torr.—SSBC; P; 4C-218

Cornaceae

Cornus drummondii C.A.Mey.—QMJV; P; 4C-203

Cucurbitaceae

Cucurbita foetidissima Kunth—DAUP; P; 4C-178

Elaeagnaceae

Elaeagnus angustifolia L.*—DAFL; P; 4C-374

Euphorbiaceae

Acalypha ostryifolia Riddell—DAUP, QMJV; A; 4C-185
Argythamnia mercurialina (Nutt.) Müll.Arg.—SSBC; P; 4C-197

Chamaesyce fendleri (Torr. & A. Gray) Small—DAUP, QHSC; P; 4C-099
Chamaesyce glyptosperma (Engelm.) Small—DAUP, SSBC; A; 4C-334
Chamaesyce missurica (Raf.) Shinners—SSBC; A; 4C-359
Chamaesyce serpens (Kunth) Small—SSBC; A; 4C-335
Croton texensis (Klotzsch) Müll.Arg.—QHSC; A; 4C-227
Euphorbia marginata Pursh—DAUP, SSBC; A; 4C-304
Euphorbia spathulata Lam.—SSCP; A; 4C-085
Stillingia sylvatica Garden ex L.—SSBC; P; 4C-163
Tragia ramosa Torr.—SSCP; P; 4C-355

Fabaceae
Amorpha canescens Pursh—SSBC; P; 4C-150
Amorpha fruticosa L.—DAFL; P; 4C-160
Astragalus gracilis Nutt.—SSBC; P; 4C-132
Astragalus lotiflorus Hook.—SSBC; P; 4C-007
Astragalus missouriensis Nutt.—SSBC; P; 4C-008
Astragalus mollissimus Torr.—SSBC; P; 4C-445
Astragalus plattensis Nutt.—SSBC; P; 4C-133
Baptisia australis (L.) R.Br. ex Aiton—SSBC; P; 4C-044
Baptisia bracteata Muhl. ex Elliot—SSBC; P; 4C-106
Caesalpinia jamesii (Torr. & A. Gray) Fisher—SSBC; P; 4C-323
Dalea aurea Nutt. ex Pursh—SSBC; P; 4C-212
Dalea candida Michx. ex Willd.—SSBC; P; 4C-265
Dalea enneandra Nutt.—SSBC; P; 4C-220
Dalea lanata Spreng—DAFL; P; 4C-284
Dalea purpurea Vent.—SSBC; P; 4C-213
Dalea villosa (Nutt.) Spreng.—DAFL; P; 4C-283
Desmanthus illinoensis (Michx.) MacMil.. ex B. L. Rob. & Fernald—DAFL; P; 4C-313
Desmodium sessilifolium (Torr.) Torr. & A. Gray—SSBC; P; 4C-369
Glycyrrhiza lepidota Pursh—DAFL; P; 4C-184
Gymnocladus dioicus (L.) K. Koch—QMJV; P; 4C-406
Indigofera miniata Ortega—QHSC; P; 4C-444
Lespedeza capitata Michx.—SSBC; P; 4C-440
Lespedeza stuevei Nutt.—SSBC; P; 4C-381
Melilotus officinalis (L.) Lam.*—DAFL, DAUP; A; 4C-309
Mimosa borealis A. Gray—SSBC; P; 4C-161
Mimosa nuttallii (DC.) B.L. Turner—SSBC; P; 4C-062
Oxytropis lambertii Pursh var. *artciulata* (Greene) Barneby—SSBC; P; 4C-426
Oxytropis lambertii Pursh var. *lambertii*—SSBC; P; 4C-134
Pediomelum cuspidatum (Pursh) Rydb.—SSBC; P; 4C-156
Pediomelum digitatum (Nutt. ex Torr. & A. Gray) Isely—SSBC; P; 4C-238
Pediomelum linearifolium (Torr. & A. Gray) J. W. Grimes—SSBC; P; 4C-250
Psoralidium tenuiflorum (Pursh) Rydb.—SSBC; P; 4C-263
Robinia pseudoacacia L.—QMJV; P; 4C-504
Senna marilandica (L.) Link—QMJV; P; 4C-342
Sophora nuttalliana B.L. Turner—SSBC; P; 4C-425
Strophostyles leiosperma (Torr. & A. Gray) Piper—SSBC; A; 4C-321
Vicia americana Muhl. ex Willd.—SSBC; P; 4C-096
Vicia ludoviciana Nutt.—SSBC; A; 4C-113

Fagaceae
Quercus havardii Rydb.—QHSC; P, 4C-046
Quercus muehlenbergii Engelm. -QMJV; P; 4C-034
Quercus stellata Wangenh.—QHSC; P; 4C-446

Fumariaceae
Corydalis micrantha (Engelm. ex A. Gray) A. Gray—SSBC; A; 4C-004

Gentianaceae
Eustoma exaltatum (L.) Salisb. ex G.Don—DAFL; P; 4C-297

Geraniaceae
Geranium carolinianum L.—DAUP; A; 4C-087

Grossulariaceae
Ribes aureum Pursh var. *villosum* DC.—QMJV; P; 4C-014

Hydrophyllaceae
Nama stevensii C.L. Hitchc.—SSCP; A; 4C-142
Phacelia integrifolia Torr.—SSCP; A; 4C-125

Juglandaceae
Juglans microcarpa Berl.—QMJV; P; 4C-205

Krameriaceae
Krameria lanceolata Torr.—SSBC; P; 4C-148

Lamiaceae
Hedeoma drummondii Benth.—SSBC; P; 4C-222
Hedeoma hispida Pursh—DAUP, SSCP; A; 4C-090
Monarda clinopodioides A. Gray—SSCP; A; 4C-272
Monarda punctata L. var. *occidentalis* (Epling) Palmer & Steyerm.—SSBC; A; 4C-254
Salvia azurea Michx. ex Lam.—SSBC; P; 4C-272
Scutellaria drummondii Benth.—SSBC; P; 4C-100
Scutellaria resinosa Torr.—SSBC; P; 4C-102
Teucrium canadense L.—QMJV, WETL; P; 4C-182

Linaceae
Linum lewisii Pursh var. *lewisii*—SSBC; A; 4C-006
Linum rigidum Pursh—SSBC; A; 4C-120

Loasaceae
Mentzelia decapetala (Pursh ex Sims) Urb. & Gilg ex Gilg—SSBC; P; 4C-370
Mentzelia multiflora (Nutt.) A. Gray—QHSC; A; 4C-370
Mentzelia nuda (Pursh) Torr. & A. Gray—SSBC; P; 4C-324
Mentzelia oligosperma Nutt. ex Sims—SSCP; P; 4C-193

Malvaceae
Callirhoe involucrata (Torr. & A. Gray) A. Gray—SSBC; P; 4C-054
Sphaeralcea coccinea (Nutt.) Rydb.—SSBC; P; 4C-079

Molluginaceae
Mollugo verticillata L.—DAUP, WETL; A; 4C-308

Moraceae
Maclura pomifera (Raf.) Schneid.—QMJV; P; 4C-196
Morus alba L.*—QMJV; P; 4C-259
Morus rubra L.—QMJV; P; 4C-422

Nyctaginaceae
Mirabilis linearis (Pursh) Heimerl—SSBC; P; 4C-257
Mirabilis nyctaginea (Michx.) MacMil..—QMJV; P; 4C-179

Onagraceae
Calylophus berlandieri Spach—SSBC; P; 4C-041
Calylophus hartwegii (Benth.) P.H.Raven—SSBC; P; 4C-071
Calylophus serrulatus (Nutt.) P.H.Raven—SSBC; P; 4C-097
Gaura coccinea Nutt. ex Pursh—SSBC; P; 4C-126
Gaura longiflora Spach—DAUP; A; 4C-241
Gaura villosa Torr.—QHSC; P; 4C-410
Oenothera grandis (Britt) Smyth—DAUP, QHSC; P; 4C-089
Oenothera jamesii Torr. & A. Gray—WETL; B; 4C-387
Oenothera laciniata Hill—DAUP, SSBC; A; 4C-059
Oenothera macrocarpa Nutt.—SSBC; P; 4C-050
Oenothera rhombipetala Nutt. ex Torr. & A. Gray—QHSC; A; 4C-400
Stenosiphon linifolius (Nutt. ex James) Heynh.—SSBC; P; 4C-208

Oxalidaceae
Oxalis stricta L.—DAUP, SSBC; P; 4C-067
Oxalis violacea L.—SSBC; P; 4C-058

Papaveraceae
Argemone polyanthemos (Fedde) G.B. Ownbey—SSBC; A; 4C-061

Phytolaccaceae
Phytolacca americana L.—QMJV; P; 4C-198

Plantaginaceae
Plantago patagonica Jacq.—DAUP, SSBC; A; 4C-111
Plantago rhodosperma Dcne.—DAUP, SSBC; A; 4C-114

Polemoniaceae
Ipomopsis longiflora (Torr.) V.E.Grant—QHSC, SSBC; A; 4C-395

Polygalaceae
Polygala alba Nutt.—SSBC, SSCP; P; 4C-055

Polygonaceae
Erigonum annuum Nutt.—SSBC; A; 4C-306
Erigonum longifolium Nutt.—SSBC; P; 4C-032
Polygonum amphibium L.—WETL; P; 4C-262
Polygonum aviculare L.*—DAUP; A; 4C-328
Polygonum lapathifolium L.—WETL; A; 4C-209
Polygonum pensylvancium L.—WETL; A; 4C-360
Polygonum ramosissimum Michx.—DAUP, WETL; A; 4C-322

Portulacaceae
Portulaca halimoides L.—DAUP; A; 4C-436
Portulaca oleracea L.—DAUP; A; 4C-358

Primulaceae
Androsace occidentalis Pursh—DAUP, SSBC; A; 4C-021
Samolus ebracteatus Kunth—DAFL; P; 4C-318

Ranunculaceae
Anemone caroliniana Walter—SSBC; P; 4C-025
Delphinium carolinianum Walter—SSBC; P; 4C-155
Ranunculus sceleratus L.—WETL; A; 4C-091

Rhamnaceae
Ceanothus herbaceous Raf.—SSBC; P; 4C-076

Rosaceae
Prunus angustifolia Marsh—QHSC, SSBC; P; 4C-005
Prunus gracilis Engelm. & A. Gray—QHSC; P; 4C-443
Pyrus communis L.*—QMJV; P; 4C-437

Rubiaceae
Cephalanthus occidentalis L.—WETL; P; 4C-183
Galium aparine L.—DAUP, QMJV; A; 4C-190
Hedyotis nigricans (Lam.) Fosberg—SSBC, SSCP; P; 4C-216

Rutaceae
Ptelea trifoliata L.—SSBC; P; 4C-047

Salicaceae
Populus deltoides Bartram ex Marsh—DAFL, WETL; P; 4C-066
Salix exigua Nutt.—DAFL, WETL; P; 4C-108
Salix nigra Marsh—DAFL, WETL; P; 4C-107

Santalaceae
Comandra umbellata (L.) Nutt.—SSBC; P; 4C-109

Sapindaceae
Sapindus saponaria L. var. *drummondii* (Hook. & Arn.) L.D. Benson—QMJV; P; 4C-317

Sapotaceae
Sideroxylon lanuginosum Michx.—QMJV; P; 4C-200

Scrophulariaceae
Agalinis aspera (Douglas ex Benth.) Britt—SSBC; A; 4C-386
Castilleja purpurea (Nutt.) G.Don var. *citrina* (Pennell) Shinners—SSCP; P; 4C-081
Castilleja sessiliflora Pursh—SSBC; P; 4C-023
Nuttallanthus texanus (Scheele) D.A.Sutton—SSBC; A; 4C-095
Penstemon albidus Nutt.—SSCP; P; 4C-083
Penstemon buckleyi Pennell—SSBC; P; 4C-115
Penstemon cobaea Nutt.—SSBC; P; 4C-049
Veronica arvensis L.*—DAUP; A; 4C-080
Veronica peregrina L.—SSBC; A; 4C-116

Solanaceae
Chamaesaracha conioides (Moric. ex Dunal) Britt—DAUP, SSBC; P; 4C-009
Datura stramonium L.—QMJV; A; 4C-423
Physalis longifolia Nutt.—DAUP; P; 4C-234
Physalis mollis Nutt. var. *mollis*—DAUP; P; 4C-117
Quincula lobata (Torr.) Raf..—DAUP, SSBC; P; 4C-234
Solanum elaeagnifolium Cav.—DAUP, QMJV, SSBC; P; 4C-045
Solanum dimidiatum Raf..—DAUP, SSBC; P; 4C-269
Solanum rostratum Dunal—DAUP; A; 4C-206

Tamaricaceae
Tamarix chinensis Lour.*—DAFL; P; 4C-048

Ulmaceae
Celtis laevigata Willd.—QMJV; P; 4C-215
Ulmus americana L.—QMJV; P; 4C-042
Ulmus pumila L.*—QMJV; P; 4C-442
Ulmus rubra Muhl.—QMJV; P; 4C-396
Urticaceae
Parietaria penslvanica Muhl. ex Willd.—QMJV; A; 4C-202

Verbenaceae
Glandularia pumila (Rydb.) Umber—DAUP, SSBC; A; 4C-086

Phyla nodiflora (L.) Greene—DAFL, WETL; P; 4C-221
Verbena bracteata Lag. & Rodr.—DAUP; A; 4C-140
Verbena stricta Vent.—DAUP; P; 4C-235

Vitaceae

Cissus trifoliata (L.) L.—QMJV; P; 4C-065
Parthenocissus quinquefolia (L.) Planch.—QMJV; P; 4C-057
Vitis acerifolia Raf.—QMJV; P; 4C-074
Vitis rupestris Scheele—QMJV; P; 4C-074

Zygophyllaceae

Tribulus terrestris L.*—DAUP, QHSC; A; 4C-367

MAGNOLIOPHYTA—LILIOPSIDA

Agavaceae

Yucca glauca Nutt.—DAUP, QHSC, SSBC; P; 4C-146

Commelinaceae

Commelina erecta L.—DAUP, SSBC; P; 4C-226
Tradescantia occidentalis (Britt) Smyth—SSBC; P; 4C-137
Tradescantia ohiensis Raf.—SSBC; P; 4C-162

Cyperaceae

Carex gravida Bailey—WETL; P; 4C-231
Carex festucacea Schkuhr ex Willd.—WETL; P; 4C-287
Cyperus schweinitzii Torr.—SSBC; P; 4C-204
Eleocharis erythropoda Steud.—DAFL, WETL; P; 4C-168
Eleocharis montevidensis Kunth—DAFL, WETL; P; 4C-167
Eleocharis obtusa (Willd.) Schult.—DAFL, WETL; A; 4C-223
Eleocharis tenuis (Willd.) Schult. var. *verrucosa* (Svenss.) Svenss.—DAFL, WETL; P; 4C-168
Schoenoplectus pungens (Vahl) Palla—DAFL, WETL; P; 4C-101

Iridaceae

Sisyrinchium angustifolium P.L.Mill—SSBC; P; 4C-082

Juncaceae

Juncus brachyphyllus Wiegmann—DAFL, WETL; P; 4C-224
Juncus interior Wiegmann—DAFL, WETL; P; 4C-169
Juncus torreyi Coville—DAFL, WETL; P; 4C-344

Liliaceae

Allium drummondii Regel—SSBC; P; 4C-012
Allium perdulce S.V.Fraser—SSBC; P; 4C-077
Androstephium caeruleum (Scheele) Greene—SSBC; P; 4C-002

Najadaceae

Naja guadalupensis (Spreng.) Magnus—WETL; A; 4C-350

Poaceae

Aegilops cylindrica Host*—DAUP; A; 4C-053
Agrostis hyemalis (Walter) B.S.P.—WETL; P; 4C-348
Andropogon glomeratus (Walter) B.S P.—DAFL; P; 4C-300
Andropogon hallii Hack.—SSBC; G, P; 4C-311
Aristida adscensionis L.—DAUP, QHSC; A; 4C-389
Aristida oligantha Michx.—DAUP, QHSC, SSBC; A; 4C-382
Aristida purpurea Nutt. var. *longiseta* (Steud.) Vasey—DAUP, SSBC; P; 4C-252
Aristida purpurea Nutt. var. *purpurea*—DAUP, SSBC; P; 4C-277
Bothriochloa laguroides (DC.) Herter—DAUP, SSBC; P; 4C-278
Bothriochloa saccharoides (Sw.) Rydb.—DAUP, SSBC; P; 4C-413
Bouteloua curtipendula (Michx.) Torr. SSBC; P; 4C-195
Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths—DAUP, QHSC, SSBC; P; 4C-333
Bouteloua hirsuta Lag.—SSCP; P; 4C-195
Bromus catharticus Vahl*—DAUL; A; 4C-068
Bromus japonicus Thunb. ex Murr*—DAUL; A; 4C-261
Bromus tectorum L. *—DAUL, SSBC; A; 4C-064
Buchloe dactyloides (Nutt.) Engelm.—SSBC; P; 4C-070
Calamovilfa gigantea (Nutt.) Scribn. & Merr—DALF; P; 4C-302
Cenchrus spinifex Cav.—DAUP, QHSC; P; 4C-255
Chloris verticillata Nutt.—DAUP; P; 4C-207
Cynodon dactylon (L.) Pers.*—DAUP, DAFL; P; 4C-194
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *fasiculatum* (Torr.) Freckmann—SSBC; P; 4C-233
Dichanthelium clandestinum (L.) Gould—QHSC, SSBC; P; 4C-122
Dichanthelium villosissimum (Nash) Freckmann var. *praecocius* (A.S. Hitchc. & Chase) Freckmann—SSBC; P; 4C-332
Distichlis spicata (L.) Greene—DAFL; P; 4C-151
Echinochloa muricata (P.Beauv.) Fernald—WETL; A; 4C-253
Elymus canadensis L.—DAUP, QMJV, SSBC; P; 4C-230
Elymus virginicus L.—DAUP, QMJV, SSBC; P; 4C-405
Eragrostis cilianensis (All.) Vignet ex Janch.*—DAUP; A; 4C-390
Eragrostis secundiflora J.Presl—DAUP, SSBC; P; 4C-236
Eragrostis spectabilis (Pursh) Steud.—DAUP, SSBC; P; 4C-337
Eragrostis trichodes (Nutt.) Wood—DAUP, QHSC; P; 4C-383
Erioneuron pilosum (Buckl.) Nash—QHSC, SSBC; P; 4C-191
Hordeum jubatum L.—DAFL, DAUP; P; 4C-175
Hordeum pusillum Nutt.—DAUP; A; 4C-069
Leptochloa fusca (L.) Kunth—WETL; A; 4C-431
Lolium arundianceum (Schreb.) Darbysh.*—DAUP; P; 4C-427
Monroa squarrosa (Nutt.) Torr.—QHSC, SSBC; P; 4C-211
Muhlenbergia asperifolia (Nees & Meyen ex Trin.) Parodi—DAFL; P; 4C-408
Muhlenbergia bushii Pohl—QMJV; P; 4C-202
Muhlenbergia racemosa (Michx.) B.S.P.—QMJV; P; 4C-420
Panicum capillare L.—DAUP, SSBC; A; 4C-314
Panicum hallii Vasey—SSBC; P; 4C-392
Panicum obtusum Kunth—DAFL, SSBC; P; 4C-199
Panicum virgatum L.—DAFL, SSBC; P; 4C-325
Pascopyrum smithii (Rydb.) Á. Löve—DAUP; P; 4C-171
Paspalum setaceum Michx.—QHSC, SSBC; P; 4C-225
Phalaris caroliniana Walter—-WETL; A; 4C-138
Phragmites australis (Cav.) Trin. ex Steud.—DAFL; P; 4C-438
Poa arachnifera Torr.—DAUP, SSBC; P; 4C-135
Polypogon monspeliensis (L.) Desf.*—DAFL, WETL; G, A; 4C-139
Saccharum ravennae (L.) L.* DAFL, WETL; G, P; 4C-301
Schizachyrium scoparium (Michx.) Nash—QHSC, SSBC; P; 4C-363
Setaria parviflora (Poir.) Kerguélen—DAFL, DAUP; P; 4C-338
Sorghastrum nutans (L.) Nash—SSBC; P; 4C-357
Sorghum halepense (L.) Pers.*—DAUP; P; 4C-177
Spartina pectinata Bosc ex Link—DAFL; P; 4C-315

Sphenopholis obtusata (Michx.) Scribn.—WETL; A; 4C-153
Sporobolus cryptandrus (Torr.) A. Gray—QHSC, SSBC; P; 4C-391
Sporobolus neglectus Nash—DAUP, QHSC; A; 4C-399
Tridens albescens (Vasey) Wooten & Standl.—SSBC, QHSC; P; 4C-380
Tridens flavus (L.) A.S. Hitchc.—QMJV, SSBC; P; 4C-310
Vulpia octoflora (Walter) Rydb.—DAUP; A; 4C-130
Vulpia sciurea (Nutt.) Henry—DAUP; G, A; 4C-131

Smilacaceae

Smilax tamnoides L.—QMJV; P; 4C-201

Typhaceae

Typha domingensis Pers.—DAFL, WETL; P; 4C-249

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THE VASCULAR FLORA OF THREE ABANDONED RICE FIELDS, GEORGETOWN, SOUTH CAROLINA: A 39 YEAR COMPARISON

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ABSTRACT

The vascular plant species at three adandoned rice fields, Alderly, Airport, and Thousand Acre Rice Field at the Belle W. Baruch Institute for Marine Biology and Coastal Research, Georgetown, South Carolina were sampled and compared over a 39 year period, 1967–2006. One hundred twenty-four species in 91 genera and 44 families were identified at the three marshes, including eight non-native species. The Institute experienced a category 4 hurricane, Hurricane Hugo, on September 22, 1989. The number of vascular plant species decreased at the two least saline marshes, by 32% at Alderly and by 30% at Airport, immediately after Hugo. The number of species at Alderly increased when surveyed in 2002–2006, while there was no change in the number of species at the Airport marsh since Hugo. There was little change in the number of species at Thousand Acre Rice Field, the most saline marsh, during the 39 year study. *Phragmites* has recently invaded Airport Marsh and Alderly and may out compete and exclude native vascular plant species in the future.

Key Words: vascular flora, South Carolina, abandoned rice fields, brackish marshes, Hurricane Hugo

RESUMEN

Se muestrearon y compararon durante un periodo de 39 años, 1967–2006, las plantas vasculares de tres campos de arroz abandonados, Alderly, Airport, y Thousand Acre Rice Field en el Belle W. Baruch Instituto de Biología Marina e Investigación Costera, Georgetown, Carolina del Sur. Se identificaron ciento veinticuatro especies de 91 géneros y 44 familias en los tres lugares, incluyendo ocho especies no nativas. El Instituto sufrió un huracán de categoría 4, Huracán Hugo, el 22 de septiembre de 1989. El número de plantas vasculares decreció en las dos últimas lagunas salinas, en un 32% en Alderly y en el 30% en Airport, inmediatamente después del Hugo. El número de especies en Alderly aumentó cuando fue revisado en 2002–2006, mientras que no hubo cambio en el número de especies en la laguna de Airport desde el Hugo. Hubo pocos cambios en el número de especies en Thousand Acre Rice Field, la laguna más salina durante los 39 años de estudio. *Phragmites* ha invadido recientemente Airport Marsh y Alderly y puede que comita y excluya especies vasculares nativas en el futuro.

INTRODUCTION

The objective of the present study was to compile a vascular flora of three abandoned rice fields and to describe changes in the flora of the three brackish marshes in which they exist, on the Belle W. Baruch Institute for Marine Biology and Coastal Research Georgetown, South Carolina, over a 39 year period, 1967–1971, 1987–1991 and 2002–2006. The marshes, Alderly, Airport, and the 1000 Acre Rice Field, were selected in 1967 by John Baden for a masters degree project when he was a graduate student at the University of South Carolina (Baden 1971). Airport marsh, 62.9 hectares, 33.3467 N, 79.2488 W, was the smallest study site. Alderly, 33.3544 N, 79.2439 W and the 1000 Acre Rice Field, 33.3029 N, 79.2514 W, are 173.3 and 248.6 hectares, respectively (Fig. 1).

The vascular flora of these marshes was first catalogued by Barry (1968) in relation to soil types during the growing season of 1967–1968. The brackish marsh soils are acid, continually saturated, and very poorly drained. Baden (1971) examined the effect of tidal flooding, salinity, pH, soil texture and organic content on the composition of vascular plants in these three brackish marshes. Baden et al. (1975) found that salinity, pH, texture, and organic matter were not important edaphic factors influencing the zonation of vegetation in Alderly and the Airport Marshes.

Stalter and Baden (1994) compared the vascular flora of Airport, Alderly, and Thousand Acre Rice Field in 1987–91 with the vascular flora at the same three marshes in 1967–68, concluding that there was little change during the 20 year interval. The Jaccard indices of similarity were high (> 0.8) in pairwise comparisons

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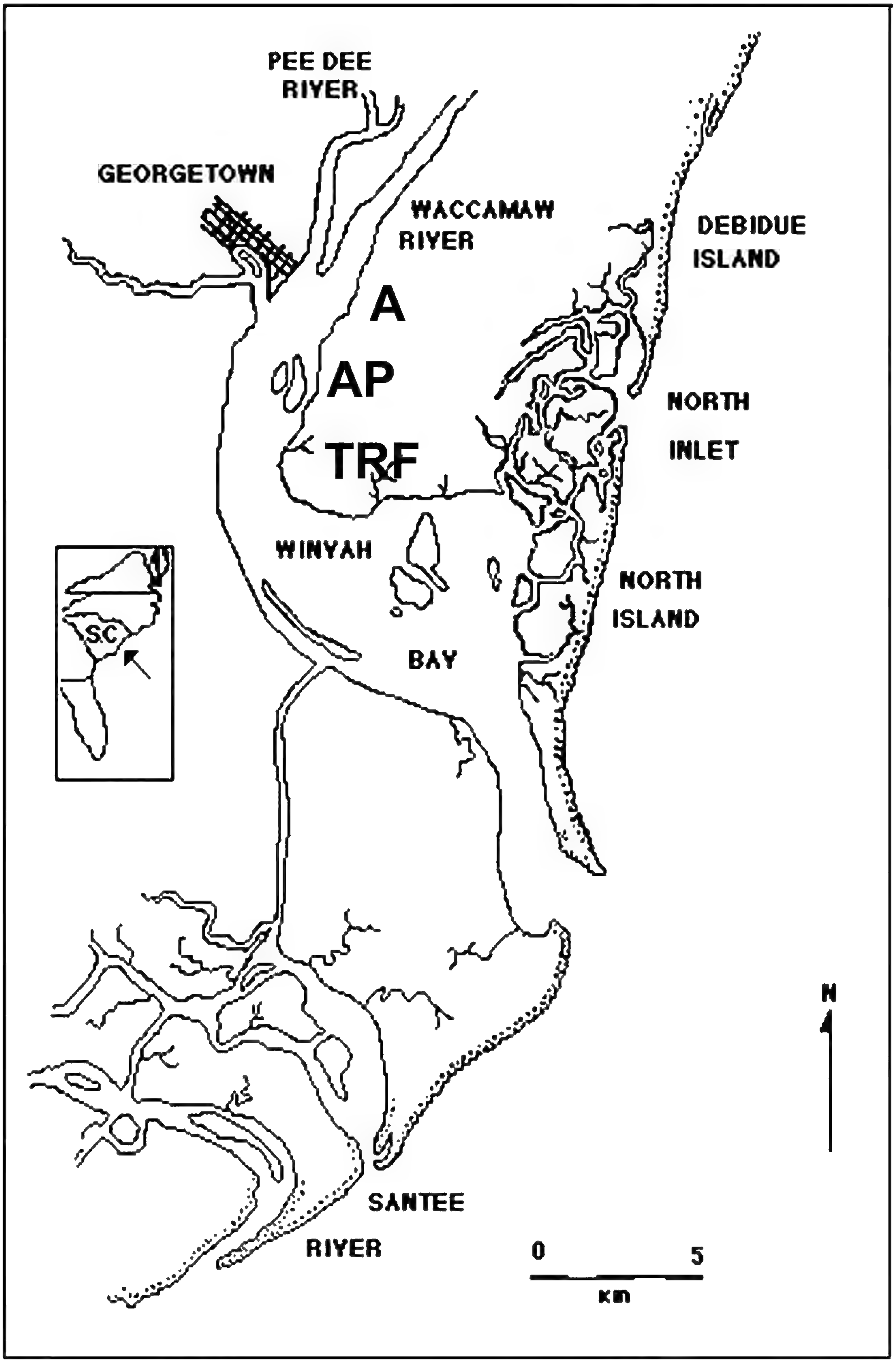

Fig. 1. Location of three study sites, Alderly (A), Airport (AP), and Thousand Acre Rice Field (TRF) at the Baruch Institute, South Carolina.

of vascular plant species among marshes from 1967–68 to 1987–91. Of the species observed in 1968 and 1991, 91% were native to the United States. By comparison, native vascular plant species comprised 72.5% of the flora at Fort Sumter, South Carolina (Stalter & Lamont 1993); 65.6% of the flora at Cape May Point State Park, New Jersey (Sutton et al. 1990) and 76.3% of the flora at Assateague Island, Virginia (Stalter & Lamont 1990).

Stalter (1973) studied the factors influencing the distribution of vascular plant species in the Cooper River estuary, South Carolina, in July 1971. The marsh vegetation was sampled by transects at 23 sites from Sullivan Island at the mouth of the Cooper River to freshwater marshes well inland. The transects were laid out perpendicular to the Cooper River and marked at the elevated end by a concrete post or, if available, by a Coast and Geodetic Survey bench mark. Forty nine vascular plant species were identified in Stalter's (1973) study. Zonation of vegetation was pronounced in salt marshes. *Spartina alterniflora* was the most flood tolerant taxon and occupied the widest range in elevation. Zonation of vascular plant species in the brackish marshes (salinity 1.0 ppt to 15 ppt) was less pronounced than in the salt marshes. *Spartina cynosuroidies*, *Juncus roemerianus* and *Scirpus validus* occupied the most flood prone zone of the brackish marshes. Freshwater marshes (those with salinity values less than 1.0 ppt) were populated by *Alternanthera philoxerodies*, *Ludwigia* spp., *Pontederia cordata*, *Saururus cernuus* and *Zizaniopsis miliacea*. All of the aformentioned species at Cooper River were present in the abandoned rice field marshes at Baruch.

Eleuterius (1972) described the marshes of Mississippi based on extensive field work in 1968 and 1969. Vegetation was sampled by line transects and list-count quadrats at 19 stations in all the estuarine marshes of Mississippi. He reported over 300 species of vascular plants in Mississippi marshes; no species list was published (Eleuterius 1972). He reported that there was a greater diversity of vascular plant species in freshwater marshes than in brackish or salt marshes; these results are similar to those in the abandoned rice fields of the Baruch Institute. Distribution of species at the Baruch brackish marshes was also similar to that reported by Stalter (1973) at the Cooper River. Eleuterius also noted the effect of salt water on vegetation during a growing season. *Crinum americanum* and *Iris virginica*, were present in brackish marshes in April when water salinity value were low. By June, these same species, "were dead or disappeared." *Crinum* and *Iris virginica* were growing vigorously and producing flowers in freshwater marshes.

Stalter (1972) conducted a survey of the summer and fall flora at Brookgreen Gardens from July to December 1970. He reported 639 species of vascular plants though he did not describe the plant communities at Brookgreen. Many of the taxa reported by Stalter (1972) at the brackish marshes at Brookgreen, notably *Juncus* and *Spartina*, were also present in brackish marshes at the Baruch Institute.

Stalter (1971) reported the summer and fall flora of Huntington Beach State Park, Georgetown County, South Carolina. Included in the 321 taxa were 66 wetland species, though not all of these species were found at the abandoned rice fields at the Baruch Institute. Common to both sites are species of *Carex*, *Eupatorium*, *Hydrocotyle*, *Juncus*, *Rhynchospora*, *Sagittaria*, *Spartina*, *Taxodium*, and *Typha*.

A study at the Yawkey Center, a site adjacent to the Baruch Institute, was conducted by Nelson from early spring 1990 to September 1992. Ten plant communities were described by Nelson, in an unpublished inhouse document. One of his communities was old rice fields. Nelson stated that these sites, depending on flood history and salinity may be highly complex and botanically diverse. Nelson cites 21 taxa specifically found in the adandoned rice fields. Most of these taxa were also identified at the abandoned rice fields at the Baruch Institute.

History

The marshes in the study are located on Waccamaw Neck, bordering Winyah Bay (Fig. 1). In 1718, George II granted Lord Carteret 7500 hectares that composed the original Hobcaw Barony. Carteret sold his land to a land speculator, John Roberts in 1735, who subdivided the property and sold it to developers. Ultimately, the area was settled and the tidal wetlands bordering the Waccamaw River were diked and drained for rice production. By the beginning of the Civil War (1861), 13 major rice plantations at Hobcaw were producing approximately a half a million pounds of rice annually (Porcher 1976).

At the end of the Civil War (1865), plantation owners lost their slaves who provided the labor that sustained the rice industry (Porcher 1976). The few rice growing plantations that survived were devastated by a series of hurricanes in the 1890s and early 1900s (Baden 1971). The most severe hurricane, the storm of 1893, rivaled Hurricane Hugo (1989) in intensity and destruction. The devastating hurricane of 1893 plus additional hurricanes and competition from rice growers in the Gulf States terminated the rice industry in South Carolina by the early 20th century.

Many took advantage of the demise of the coastal plantation system. South Carolinian Bernard Baruch purchased 7,500 hectares along Waccamaw Neck between 1905 and1907, as a hunting preserve. Baruch (1957), claimed the salt marshes (at Hobcaw Barony), "once offered the finest duck hunting in the United States."

After his daughter's demise, Bernard Baruch established the Belle Baruch foundation in his daughter's honor as a natural laboratory for research and teaching. Today, two research institutes, one dealing with marine science and affiliated with the University of South Carolina and the other with forestry and affiliated with Clemson University, pursue scientific studies in the forest and marshes at Hobcaw and in the Atlantic Ocean. The foundation was selected by NSF in the mid 1980s as a Long Term Ecological Research Site.

Climate

Coastal South Carolina has a subtropical climate. Average rainfall at Georgetown is 1,368 mm. August is the wettest month averaging 180 mm while November is the driest month averaging 75.4 mm. Snowfall is rare; 10 mm falls in an average year. July is the warmest month with an average temperature of 27.1 C. January, the coldest month, has an average temperature of 8.7 C. The growing season averages 254 days (Anonymous 1996).

Soils

Soils at Alderly are Levy silty clay loams. Levy soils are, "fine mixed superactive acid (pH 5.0–5.5) thermic Typic Hydraquents. Organic content of the soils at Alderly ranged from 24–30% (Baden 1971). The average mineral component at Alderly was sand (25%) silt (51.5%) and clay (23.5%). Table 3 reports the soil data of Baden (1971).

Soils at the more saline Airport and 1000 Acre Rice Field are included in the Bohicket Series. These soils are very poorly drained, very permeable soils that formed in marine sediments in tidal marshes. The taxonomic class: Fine mixed Typic Sulfaquents. Soils at Airport and Thousand Acre Rice Field are acid in reaction at the two sites with pH ranging from 5.0 to 6.0 and 5.0 to 5.5 at the two respective sites. The organic content of soils at Airport marsh ranged from 25–28%; organic content of soils at Thousand Acre Rice Field from 19–33%. Silt was the dominant soil fraction at both sites. Soil fractions at Airport were sand (18%), silt (57.5%) and clay (24.5%). At the Thousand Acre Rice Field the fractions were 24% sand, 41.2% silt and 34.8% clay (Table 3).

Elevation measurements within the marshes were made using a surveryors transit and stadia pole. Transit measurements indicated that there was little difference in elevation across the abandoned rice fields (Baden 1971).

Hurricane Hugo

Hurricanes have struck the South Carolina coast an average of once every 2.5 years in the 20th century (Gentry 1971). The most notable during the course of this study was Hurricane Hugo in 1989 (Gardner et al. 1991), which was a "storm of the century" hurricane, causing catastrophic damage to upland forests at the Baruch Institute (Blood et al. 1991; Gardner et al. 1991). Sustained winds of 122 km/m with gusts as high as 150 km/hr were recorded in Charleston, 75 km south. Winds at Georgetown peaked at 112 km/hr. Many trees were toppled and/or broken (Stalter & Baden 1994). Hugo's storm surge in the Thousand Acre Rice Field, Airport and Alderly marshes was approximately four meters, depositing debris up to 0.5 meters at the Thousand Acre and Airport marshes (Stalter and Baden 1994). The resulting raft of vegetation was colonized by vascular plant species not normally associated with brackish marshes (Stalter and Baden 1994). These were *Cakile edentula*, a dune species; *Erectites hieracifolia*, a disturbed site invader; *Eupatorium capillifolium* and *Glottidium vesicarum*, a disturbed field associate; *Panium amarum*, an upper, rarely flooded salt marsh fringe associate; *Pinus taeda*, an upland species; *Triadica sebifera*, an Asiatic tree that invades disturbed sites; *Solidago sempervirens*, an occupant of coastal dunes and the upper, rarely flooded salt marsh fringe; and *Strophostyles helvola*, a coastal dune associate (Stalter and Baden 1994). Thirteen years later, by 2002, the raft of "wrack" had decomposed or washed away along with the aforementioned ephemeral vascular plants.

METHODS

The vegetation in three brackish marshes, Thousand Acre Rice Field, Airport and Alderly was sampled at least once a month during the growing seasons beginning July 2002 and terminating in May 2006. The flora was compared with the vascular flora reported by Baden et al. (1975) during the collecting seasons of 1968–69 and Stalter and Baden (1994) during the growing seasons of 1987–91 (Appendix). Voucher specimens collected in 1968–69, 1987–91 and 2002–06 were deposited in the herbarium at the University of South Carolina, with the exception of taxa mailed to experts for verification. Accession numbers will be assigned to the voucher specimens by Dr. John Nelson, Batson Herbarium, University of South Carolina.

The Appendix contains an inventory of the vascular plant species reported in 1968–69 by Baden et al. (1975), the growing season of 1987–91 by Stalter and Baden (1994) and the present study 2002–06. Only species that reproduce and persist longer than a single growing season without cultivation are tabulated in Table 1. Non-native species are designated by an asterisk; non-native status follows Gleason and Cronquist (1991) and Wunderlin (1998). Nomenclature presented in this flora agrees with Kartesz (1994). When differences in nomenclature occur, the older name, listed in Radford et al. (1968) is listed as a synonym and enclosed in brackets. The families, genera and species in the Appendix are listed alphabetically.

Salinity data presented by Baden et al. (1975) were combined with that recorded by Dr. Dennis Allen, Director, Baruch Institute (2002 pers. comm.) and Conner and Inabinette (2005) over a twenty year period (Table 2).

Pairwise among the three sites, floristic similarity was measured by Jaccard coefficients (Kaufman and Rousseeum 1990, Jaccard 1908), calculated from 2 × 2 contingency tables, and tested for significance by approximate randomization (Noreen 1989). Each coefficient (test statistic) was compared to its sampling distribution under the null hypothesis (Ho) of a random distribution of taxa across the three study sites. These sampling distributions were achieved after 99,999 randomizations of the species labels in the JMP (SAS) row-by-column data, with the observed data also considered as a randomization under Ho. P-values were calculated in standard fashion as $P = (NGE + 1) / (NS + 1)$ where NGE is the number of null coefficients in the sampling distribution that were greater than or equal to the test statistic and with NS as the number of randomizations performed (Manly 1997). For reference in Table 4, the mean of the null distribution is given for each observed Jaccard coefficient.

RESULTS AND DISCUSSION

The vascular flora at the three brackish marshes of the Baruch Institute includes 124 species in 91 genera within 44 families. Dicots (64 species) are more numerous than monocots (55 species) (Table 1). Eight species, *Alternanthera philoxeroides*, *Arundo donax*, *Chenopodium album*, *Echinochloa crus-galli*, *Murdania keisak*, *Phragmites australis*, *Triadica sebifera* and *Verbena brasiliensis* are non-native (Appendix). Seventy-one species occurred exclusively at only one site, while only 26 species occurred at all three sites. Alderly, the least saline marsh, contained the greatest number of species (110). Wass and Wright (1969) working in coastal wetlands of Virginia, reported a greater species diversity in fresh water marshes than in salt water marshes. Airport and Thousand Acre Rice Field had 54 and 39 species, respectively. *Cyperus drummondii* collected at Alderly was the rarest species identified in this study. It has been collected only once before in South Carolina, in the 1940s (Nelson, Director, Batson Herbarium, USC, 2003 pers. comm.). This is the first South Carolina record of this taxon in nearly 60 years.

Feral pigs are a major source of soil disturbance at all marsh sites, especially at the intertidal zone and

Table 1. Summary of the vascular flora at three brackish marshes, Georgetown, South Carolina.

	Ferns	Conifers	Dicots	Monocots	Total
Families	3	1	30	10	44
Genera	3	1	55	32	91
Species	4	1	64	55	124
Native Species	4	1	60	51	116
Introduced species	0	0	4	4	8

Table 2. Water salinity at three brackish marsh sites. Data from Baden 1975, Stalter and Baden (1994), and Conner and Innabinette (2005). Values at all sites were greater than 20 ppt during the Hurricane Hugo storm surge.

Study site	Salinity, (ppt)
Thousand Acre Rice Field	0–23
Airport marsh	0–16
Alderly	0–18.5

Table 3. Organic content and soil fraction (%) at three abandoned rice fields. Data from Baden (1971).

Study Site	Range of Organic Content (%)	% of Soil Fractions Sand	Silt	Clay
Thousand Acre Rice Field	19–33	24.0	41.2	34.8
Airport	25–28	18.0	57.5	24.5
Alderly	24–30	25.0	51.5	23.5

Table 4. Species similarity measured by Jaccard coefficients among three sites. Statistical significance determined by appoximate randomization tests involving 99,999 randomizations of the species label in the row-by-column JMP (SAS) data file. The null, mean Jaccard coefficients are from the sampling distribution of the Jaccard achieved after the randomizations.

Site comparison	Jaccard coefficient	Null mean	P-value	Species in common/total
Thousand Acre Rice Field vs. Airport	0.388	0.124	0.00001	26/67
Thousand Acre Rice Field vs. Alderly	0.263	0.157	0.00019	31/118
Airport vs. Alderly	0.414	0.197	0.00001	48/116

upland border. Disturbance may enhance species diversity at the three marshes since disturbed areas may be colonized by *Chamaecrista* (*Cassia*) and *Chenopodium album* as well as by true brackish marsh species, e.g., *Pluchea camphorata* and *P. foetida*.

Ten woody species are reported at Alderly for the first time: *Ilex cassine* var. *cassine, Ilex opaca, Itea virginica, Nyssa sylvatica* var. *biflora, Rosa laevigata, Rosa palustris, Salix caroliniana, Sambucus canadensis, Triadica sebifera*, and *Viburnum nudum*. These woody taxa occupy the upper wooded fringe of Alderly marsh that experiences tidal flooding at the time of the new and full moon. While the aforementioned taxa are not true marsh associates they all can be found in fresh water swamps (Radford et al. 1968).

Among the three study sites, there is great variability with respect to species composition, dominance and diversity. The most saline marsh, Thousand Acre Rice Field, supports the fewest number of species, was least affected by Hurricane Hugo, and is little changed in species composition over 39 years. Airport marsh supports a large expanding population of *Phragmites*, a non-native species not observed here 39 years ago. Alderly, the least saline marsh, contained the highest number of vascular taxa, 110. Alderly was most impacted by Hurricane Hugo resulting in a loss of species diversity when sampled immediately after Hurricane Hugo (Stalter and Baden 1994).

The two sites, Alderly and Airport, with 48 species in common, had the greatest floristic similarity (0.414, P = 0.00001). Alderly, the least saline site, and the Thousand Acre site, the most saline site, had the lowest floristic similarity (0.263, P = 0.00019, Table 4).

Species diversity was greatest at the least saline sites, Alderly and Airport, with 110 and 54 species, respectively. Twenty six species occur at all sites while 71 occur at only one site. Seven species including salt marsh associates *Borrichia frutescens*, *Distichlis spicata*, *Limonium carolinianum*, *Spartina alterniflora* and *S. patens* occur exclusively at Thousand Acre Rice Field, the most saline site. *Ipomoea sagittata*, a salt marsh fringe species was also found exclusively at Thousand Acre Rice Field. The genera *Borrichia*, *Distichlis*, *Ipomoea* and *Limonium* were found exclusively at Thousand Acre Rice Field. *Baccharis halimifolia* was the only woody species occurring at all sites. *Baccharis* has been listed as a salt marsh associate (Gleason & Cronquist 1991; Radford et al. 1968) yet it grows in profusion in North and South Carolina along I-95, miles from salt marshes. *Triadica sebifera*, an exotic, was observed in the upper intertidal Airport marsh. *Iva frutescens* and *Borrichia frutescens* were the only woody salt marsh species found exclusively at the most saline Thousand Acre Marsh.

Alderly

The most notable change in species dominance at Alderly is the increase in cover of *Phragmites australis*, a non-native species not present in 1968. *Taxodium distichum* was planted at this site in 1999 by Clemson University researchers; seedling survival ranged from 0 to 73% (Conner and Inabinette 2005). Several mature *T. distichum* in the Waccamaw River, adjacent to the Alderly marshes, have died; these individuals were alive in 1993 (Stalter & Baden 1994, Fig. 2).

Seedlings of *Taxodium distichum* from eight estuarine areas, from Mississippi to Virginia, were planted at Alderly in 1999 (Conner and Inabinette 2005). Only seedlings from Louisiana, Alabama and Florida survived the severe drought of 2001 when salinity values peaked at 18.5 parts per thousand (ppt) November 30, 2001 (Table 2). Seedlings from Louisiana were the most salt tolerant as 73% survived, while survival rates for Florida and Alabama seedlings were approximately 20% and 14% respectively. Experimental data from Conner and Inabinette (2005) suggest that there may be a wide range of salinity tolerance within populations of *Taxodium distichum*.

Periodic wet and dry periods plus infrequent hurricane surges have affected salinity at the brackish marshes during the 39 year study. The highest water salinity at Alderly occurred during Hurricane Hugo, when salt water in excess of 20 ppt penetrated up to 5 km inland (Blood et al. 1991; Gardner et al. 1991). “Normal” water salinity for the Alderly marshes is 1 ppt (Conner & Innabinette 2005). During a dry period from May 2002 to August 2002 salinity values at Alderly were above 8 ppt peaking at 14.6 ppt and 16.3 ppt in June and August, respectively. The high salinity values for Alderly followed the dry year of 2001, where salinity values ranged from 4 to 6 ppt from April to October; salinity values peaked at 18.5 ppt on November 30, 2001. Salinity values were generally l ppt or lower from 2003 to the spring of 2004.

Common species at Alderly are *Crinum americanum* and *Lilaeopsis chinensis* which grow in profusion around the edge of the marsh. *Crinum* is abundant around the boat dock today but nowhere else at Alderly. Other common vascular plants are *Alternanthera philoxeroides*, *Aster subulatus*, *Aster tenuifolias*, *Bidens laevis*, *Phragmites australis*, *Pontederia cordata*, *Sagittaria falcata*, *Scirpus americanus*, *S. robustus*, *S. validus*, *Spartina cynosuroides*, *Typha angustifolia* and *T. domingensis*.

Alderly may have been most affected by Hurricane Hugo’s storm surge that brought salt water and salinity of up to 20 ppt to the marsh. In 1991, following Hurricane Hugo, 34 vascular plant species were identified. Forty seven species were reported in 1968 (Baden 1971). The latest survey 2002–2006, was conducted over a time of relatively high water salinity followed by a wet period when salinity values were less than 1 ppt. High vascular plant diversity in 2002–06 (86 species) compared to the studies of 1968 and 1991 may be a function of varying water salinity (Table 2). Eight woody taxa, those experiencing tidal flooding during

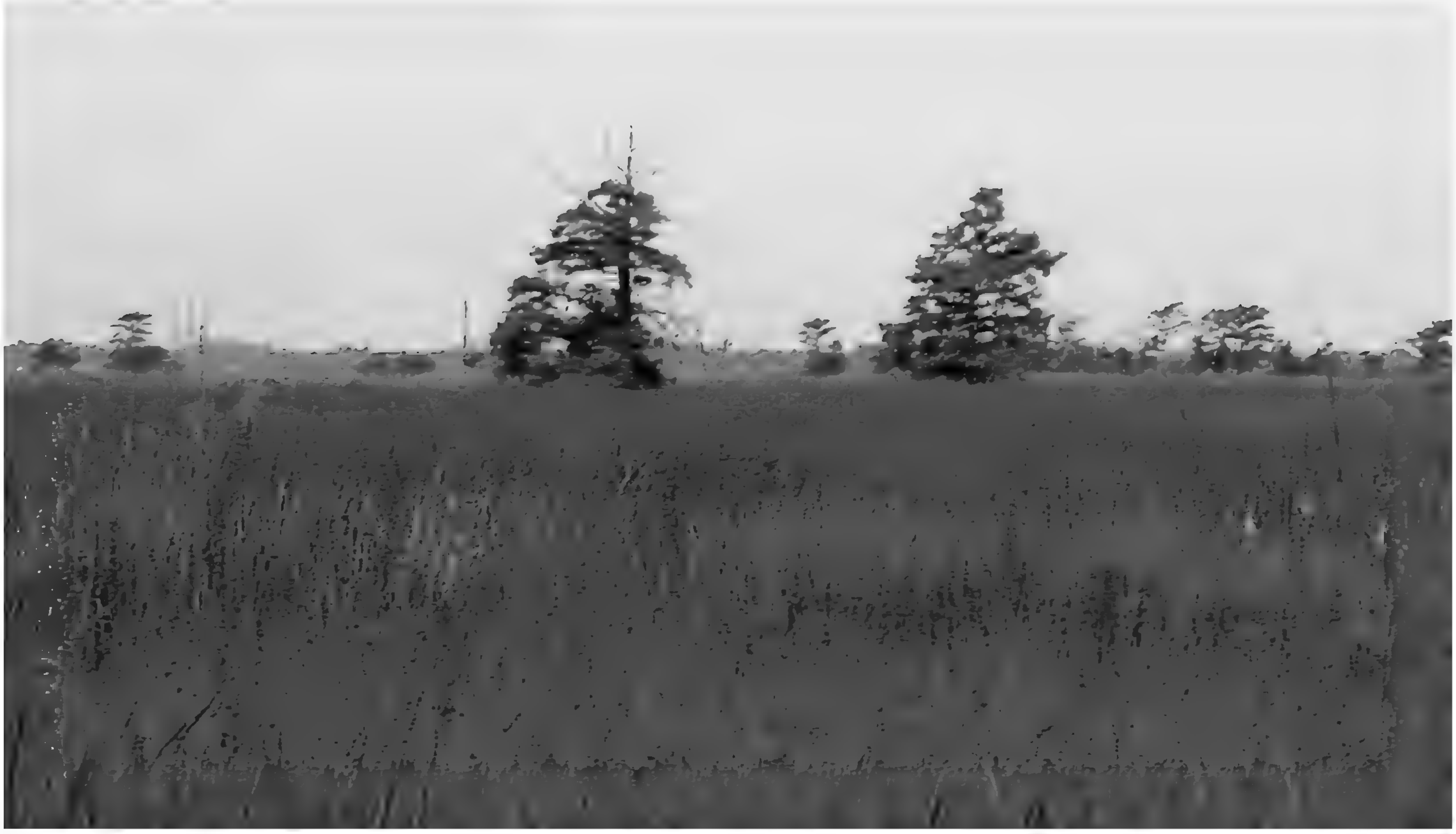

Fig. 2. ***Taxodium distichum*** **at the Thousand Acre Rice Field.**

new and full moon tides, reported earlier in the paper, are reported at Alderly for the first time. If the eight woody taxa were excluded from the list, the 78 vascular plant species at Alderly 2002–2006 would still be significantly higher than the 47 species reported at Alderly in 1968. A total of 105 species have been identified at Alderly during the 39 year study.

Thousand Acre Rice Field

Water salinity is highest in the Thousand Acre Rice Field (Table 2). Common species observed here were *Spartina cynosuroides*, *Cladium jamaicense*, *Juncus roemerianus*, *Scirpus robustus*, *Aster tenuifolius*, *A. subulatus*, *Lilaeopsis chinensis*, *Scirpus* spp. and *Typha* spp. The Thousand Acre Rice Field also supports salt marsh species, notably *Spartina alterniflora*, *S. patens*, *Distichlis spicata* and *Aster tenuifolius*. *Spartina alterniflora* borders the creeks and ditches that meander through this marsh and which experience flooding during every tide. Over half of the bald cypress, *Taxodium distichum*, at Thousand Acre Rice Field have died since the marsh was inundated by Hurricane Hugo's storm surge in 1989. The severe drought of 2001 and "high" salinity may also have contributed to the demise of *Taxodium* (Fig. 2).

Thousand Acre Rice Field supports the fewest number of vascular plant species. Twenty three taxa were reported in 1968, while 28 were identified here following Hurricane Hugo and 24 in 2006. The brackish plant species at the Thousand Acre Rice Field were little affected by Hurricane Hugo's storm surge. Disturbance by feeding pigs opening new habitats may account for the increase in number of plant species in 2006.

Prominent species in the Thousand Acre Rice Field were *Juncus roemerianus*, *Scirpus robustus*, *S. americanus*, *Spartina cynosuroides*, *Typha angustifolia* and *Rhynchospora miliacea*. Barry (1968) reported 12 vascular plant species at Thousand Acre Rice Field. The smaller number of species noted by Barry (1968) compared with 24 species collected during 2002–06 and 39 species over the 39 year study period, represents differences in sampling techniques. Barry sampled vegetation within small quadrats, placed along line transects; in the present study, the vascular flora in the whole marsh was sampled.

Barry (1980) noted the preference of *Juncus roemerianus* in less saline portions of salt marsh where salinity was less than 15 ppt. Where salinity exceeded 15 ppt, *Spartina alterniflora* replaced *J. roemerianus*.

Spartina alterniflora tolerated longer and deeper tidal flooding than *J. roemerianus*, and borders *J. roemerianus* along the Waccamaw River.

The vegetation noted by Barry (1968) in the Airport marsh and abandoned Thousand Acre Rice Field is similar to that observed today. Both Barry (1968) and Baden (1971) reported *Spartina cynosuroides* and *Scirpus robustus* growing in profusion on the western border of the old rice field along with the more numerous *Typha angustifolia*, *T. latifolia* with *Juncus* spp. Barry (1968) and Baden (1971) observed *Pontederia cordata*, *Sagittaria falcata*, *Peltandra virginica*, *Lilaeopsis chinensis* and *Hymenocallis crassifolia*. *Hymenocallis crassifolia* disappeared after Hurricane Hugo (Stalter and Baden 1994) and was not observed in 2002–2006.

Airport

The most significant change in vascular plant composition at the Airport Marsh is the increase of the non-native, *Phragmites australis*. *Phragmites* was first reported in a marsh bordering the west side of the Waccamaw River by Stalter (1975). Dikes and dredge spoils deposited on Baruch property in the 1970s may have created habitat favorable for the invasion of *Phragmites* (Stalter & Baden 1994).

The Airport Marsh experienced a decline in species composition over the 39 year study. Forty three species were identified in 1968–1969 (Baden 1971) while 30 were identified in 2002–2006. *Phragmites* has invaded Airport Marsh, outcompetes native species, and may be responsible for the decline in species diversity and absence of some vascular plant species reported in 1968. High salinity < 15 ppt during the drought of 2001 and 2002 may have killed salt intolerant taxa (Table 2).

Common taxa at Airport Marsh include *Spartina cynosuroides*, *Zizania aquatica*, *Juncus* spp., *Typha angustifolia*, *Cladium jamaicense*, *Scirpus robustus*, *Scirpus validus*, *Pontederia cordata*, *Aster subulatus*, *A. tenuifolius*, *Pluchea foetida* and *Lythrum lineare*. *Lilaeopsis chinensis* and *Ptilimnium capillaceum* are common at the edge of the marsh as are *Juncus biflorus*, *J. coriaceus*, *J. marginatus*, *J. nodosus*, *Hibiscus moscheutos* and *Samolus parviflorus*. Species diversity at Airport Marsh is greatest within the intertidal area.

APPENDIX

Species composition in three brackish marshes on the Belle W. Baruch Institute for Marine Biology and Coastal Research, Georgetown, South Carolina. Species observed in 1967–1971 are compared with those observed in 1987, 1991 and 2002–2006. Taxa in brackets are synonyms. Non-native taxa are scored with an asterisk (*) preceding the scientific name. Collection dates are omitted for woody taxa occurring at the upper marsh fringes flooded at the new and full moon.

POLYPODIOPHYTA

Blechnaceae

Woodwardia areolata (L.) Moore; occasional at marsh edge, Alderly, 2002–06

Osmundaceae

Osmunda cinnamomea L.; occasional at marsh edge, Alderly, 2002–06

Osmunda regalis (L.) var. *spectabilis* (Willd.) A. Gray; rare at marsh edge, 1968–06 Airport; occasional at Alderly, 2004–06

Thelypteridaceae

Thelypteris palustris Schott; occasional at marsh edge, Alderly, 2002–06

PINOPHYTA

Cupressaceae

Taxodium distichum (L.) Rich; occasional at 1000 Acre Rice field and Alderly, 1968–06; declining at both sites due to Hugo 1989 and drought of 2003.

MAGNOLIPHYTA—MAGNOLIOPSIDA

Amaranthaceae

Alternanthera philoxeroides (Mart.) Griseb.; common at Alderly 1991–06

Amaranthus cannabinus (L.) Sauer; occasional at marsh edge Airport and Alderly, 1968–06

Apiaceae

Eryngium aquaticum L.; rare at Airport 1991; occasional at Alderly 1991; rare at Alderly 2004

Hydrocotyle sp.; common at marsh border at all three marshes

Lilaeopsis chinensis (L.) Kuntze; common at marsh border at all three marshes

Ptilimnium capillaceum (Michx.) Raf.; common at marsh border at all three marshes

Sium suave Walt.; occasional at Airport 1991–06; occasional at Alderly 1968–06

Aquifoliaceae

Ilex cassine L. var. *cassine;* rare at marsh edge Alderly

Ilex opaca Ait.; occasional at marsh edge Alderly

Asteraceae

Aster carolinianus Walt.; occasional at Alderly, 2004–06

Aster subulatus Michx.; frequent at 1000 Acre Rice Field 1968 and 1991; frequent at marsh edge Airport 1968–06; occasional at Alderly 1968 and 1991

Aster tenuifolius L.; occasional at marsh edge 1000 Acre Rice Field 1968 and 1991; occasional at Airport 1968–06; occasional at Alderly 1968–06

Baccharis halimifolia Michx.; occasional at marsh edge, Alderly, 2004–06

Bidens laevis (L.) BSP.; occasional at marsh edge Airport and Alderly 1968 and 1991

Boltonia asteroides (L.) L' Hér.; rare at marsh edge Airport 1968

Borrichia frutescens (L.) DC.; occasional at edge of marsh, 1000 Acre Rice Field, 1968–06

Eupatorium album L.; occasional at Airport and Alderly immediately after Hurricane Hugo, 1991

Eupatorium coelestinum L.; occasional at marsh edge, Alderly, 2002–06

Eupatorium perfoliatum L.; occasional at marsh edge, Alderly, 2004–06

Iva frutescens L.; occasional, upper fringe of marsh at 1000 Acre Rice Field 1968–2006

Mikania scandens (L.) Willd.; occasional, upper fringe of marsh at 1000 Acre Rice Field and Alderly 1968–2006

Pluchea camphorata (L.) DC.; rare, 1000 Acre Rice Field, 1968

Pluchea foetida (L.) DC.; occasional at Airport, 1968–2006; occasional at Alderly 1968 and 1991

Solidago sempervirens L.; occasional at edge of marsh, 1000 Acre Rice Field 1991; Airport 1968 and 1991; Alderly 1968–06

Verbesina occidentalis (L.) Walt.; frequent at marsh border of Alderly, 1991–06

Betulaceae

Alnus serrulata (Ait.) Willd.; rare, marsh border of Alderly

Callitrichaceae

Callitriche peploides L.; occasional, marsh edge, Alderly, 2004–06

Caprifoliaceae

Sambucus canadensis L.; rare at edge of Alderly

Viburnum nudum L.; rare at edge of Alderly

Chenopodiaceae

**Chenopodium album* L.; rare at edge of Airport and Alderly, 1968

Convolvulaceae

Calystegia sepium (L.) R. Br.; occasional, Alderly 2006

Dichondra carolinianus Michx.; frequent at marsh edge of Alderly, 2004–06

Ipomoea sagittata Poir.; occasional upper fringe of 1000 Acre Rice Field 1991–2006

Cuscutaceae

Cuscuta pentagona Engelm. [*Cuscuta campestris* Yunker]; occasional on assorted taxa, Alderly 1968 and 2004

Euphorbiaceae

**Triadica sebifera* (L.) Small [*Sapium sebiferum* (L.) Roxb.]; occasional on marsh fringe of Airport, 2004–06

Fabaceae

*Chamaecrista fasciculata (*Michx.) Greene [*Cassia fasiculata* Michx.]; occasional upper marsh fringe of Airport and Alderly, 1968

Gentianaceae

Sabatia calycina (Lam.) Heller; rare, 1000 Acre Rice Field 1968;Alderly 1968 and 1991

Sabatia stellaris Pursh.; frequent 1000 Acre Rice Field and Alderly 1968–06; occasional Airport 1968

Grossulariaceae

Itea virginica L.; rare, upper marsh fringe of Alderly

Lamiaceae

Lycopus virginicus L.; occasional at marsh edge, Alderly, 2004–06

Scutellaria integrifolia L.; rare, Alderly, 2004–06

Stachys floridana Shuttlew. ex Benth.; abundant, Alderly 2006

Lythraceae

Lythrum lineare L.; abundant at all marshes 1968–06

Malvaceae

Hibiscus moscheutos L.; occasional at edge of marsh, Airport and Alderly 1968–06

Nymphaeaceae

Nuphar lutea (L.) Sm. ssp. *sagittifolia* (Walt.) E.O. Beal; occasional at small ponds at Alderly, 1968–06

Nymphaea odorata Ait.; rare by culvert, Alderly 2004–06

Nyssaceae

Nyssa biflora Walt. [*Nyssa sylvalica var. biflora* (Walt.) Sarg.]; occasional at marsh fringe, Alderly

Plumbaginaceae

Limonium carolinianum (Walt.) Britt.; rare, 1000 Acre Rice Field 1968 and 2004

Polygonaceae

Polygonum hydropiperoides Michx.; frequent at edge of marsh1000 Acre Rice Field, 1991–06 and Airport 1968 and 2006, and Alderly, 1968–06

Polygonum sagittatum L.; rare at Alderly, 2004–06

Rumex verticillatus L.; rare at Airport, 1968; occasional at Alderly 1968–06

Potamogetonaceae

Potamogeton diversifolius Raf.; rare, Alderly at pool near culvert 2004–06

Primulaceae

Samolus valerandi L. ssp. *parviflorus* (Raf.) Hulten [*S. parviflorus* Raf.]; frequent at edge of marsh at all sites 1968–2006; occasional upper marsh fringe of Alderly, 1968–06

Rosaceae

Rosa laevigata Michx.; rare, upper marsh fringe of Alderly

Rosa palustris Marsh.; occasional upper marsh fringe of Alderly

Rubiaceae

Cephalanthus occidentalis L.; rare, upper fringe of Airport 1968–06; occasional, upper marsh fringe of Alderly 1968–06

Galium obtusum Bigel.; frequent, Alderly 2006

Salicaceae

Salix caroliniana Michx.; occasional, upper marsh fringe of Alderly

Saururaceae

Saururus cernuus L.; frequent at Alderly 1968–06

Scrophulariaceae

Bacopa caroliniana (Walt.) B.L. Robins.; occasional at Alderly, 2004–06

Bacopa monnieri (L.) Pennell; rare at edge of marsh, Airport 1968

Urticaceae

Boehmeria cylindrica (L.) Swartz.; occasional at Alderly, 1991–06

Verbenaceae

Phyla lanceolata (Michx.) Geene; occasional at marsh edge, 1000 Acre Rice Field 1968–06; abundant at marsh edge, Airport 1968–06

*_Verbena brasiliensis_ Vell.; rare, Alderly, 2006

MAGNOLIOPHYTA—LILIOPSIDA

Alismataceae

Sagittaria lancifolia L. [*S. falcata* Pursh]; occasional at Airport, 1991–06; abundant at Alderly 1968–06

Araceae

Orontium aquaticum L.; rare at Alderly, 1968–06

Peltandra virginica (L.) Schott; frequent at Airport and Alderly 1968–06

Commelinaceae

*_Murdannia keisak_ (Hassk.) Hand.-Maz. [*Aneilema keisak* Hassk.]; abundant at Alderly, 2004–06

Cyperacaeae

Cladium jamaicense Crantz; abundant at all marshes 1968–06

Carex alata Torr.; occasional at marsh edge Airport and Alderly 1968–06

Carex atlantica L.H. Bailey; occasional, Alderly 2006

Carex lurida Wahleng.; occasional, Alderly 2006

Carex stipata Willd.; rare, Alderly 2006

Cyperus drummondii; rare at Alderly 2004

Cyperus refractus Engelm. ex Boeckl.; occasional at Aldery 2004–06

Cyperus strigosus L.; occasional at edge of marsh Alderly 2004–06

Eleocharis engelmannii Steud.; occasional at all 3 marshes, 1968; and at 1000 Acre Rice Field and Alderly, 1991

Eleocharis flavescens (Poir.) Urb.; occasional, Alderly, 2006

Eleocharis quadrangulata(Michx.) R.& S.; rare at Airport and Alderly 1968; rare at Alderly 2004–06

Fimbristylis thermalis S. Wats. [*Fimbristylis spadicea* auct. non (L.) Vahl]; frequent at 1000 Acre Rice Field and Airport 1968–06; rare at Alderly 68

Rhynchospora colorata (L.) H. Pfeiffer [*Dichromena colorata* (L.) Hitchc.]; occasional at marsh edge at Alderly 1968–06

Rhynchospora miliacea (Lam.) Gray; rare at 1000 Acre Rice Field, 2004–06; occasional to locally abundant at Adlerly, 1968–06

Scirpus cyperinus (L.) Kunth*;* occasional at Alderly 1968–06

Scirpus pungens Vahl. [*S. americanus* Pers.]; abundant at 1000 Acre Rice Field and Airport 1968–06; occasional at Alderly 1968–91.

Scirpus tabernaemontani K.C. Gmel. [*Scirpus validus* Vahl]; abundant at 1000 Acre Rice Field 1968–2006 and at Alderly 1968–91.

Iridaceae

Iris virginica L.; frequent at Alderly 1968–06

Juncaceae

Juncus acuminatus Michx.; rare at Alderly 1968

Juncus biflorus Ell.; occasional at 1000 Acre Rice Field 1968 and 1991; rare at Airport and Alderly, 1968

Juncus coriaceus Mackenzie; occasional at marsh edge, 1000 Acre Rice Field 1968 and 1991; occasional at Airport and Alderly 1968–06

Juncus dichotomus Ell.; occasional at Alderly 2006

Juncus effusus L.*;* occasional at Alderly 2006

Juncus marginatus Rostk.; occasional at Airport 1968–06

Juncus nodosus L.; occasional at Airport 1991 and 2004

Juncus roemerianus Scheele.; abundant at 1000 Acre Rice Field 1968–06 and Alderly at the border of the Waccamaw River 1968–06; occasional at Airport 1968

Liliaceae

Crinum americanum L.; abundant in vicinity of Taylor boat landing, Alderly at the edge of the marsh 1968–06

Hymenocallis floridana (Raf.) Morton [*Hymenocallis crassifolia* Herbert]; occasional at Alderly 1968, extirpated by Hurricane Hugo 1989

Poaceae

Arundo donax L.;* rare at marsh edge 1000 Acre Rice Field 1968 and 1991; rare at marsh edge Airport 1991; occasional at Alderly near Waccamaw River 1968–06

Chasmanthium latifolium (Michx.) Yates [*Uniola latifolia* Michx.]; occasional at edge of marsh, Alderly, 1968–1991

Chasmanthium laxum (L.) Yates [*Uniola laxa* (L.) B.S.P]; occasional at edge of marsh, Alderly 1968–06

Cinna arundinacea L.; frequent at marsh border Airport and Alderly 1968–06

Distichlis spicata (L.) Greene*;* abundant at 1000 Acre Rice Field 1968–06

Echinochloa crus-galli (L.) P. Beauv.;* occasional at marsh border Airport 1968–06; occasional at marsh border Alderly 1968–06

Erianthus giganteus (Walt.) Muhl.; frequent at marsh edge Alderly 1968–06

Leersia oryzoides (L.) Sw.; abundant at Alderly 2004–06

Panicum virgatum L.*;* frequent at marsh border 1000 Acre Rice

Field 1991 and 2006; frequent at marsh border Airport and Alderly 1968–06

Panicum sp.; occasional at marsh border Alderly 2004–06

Paspalum distichum L.; occasional at marsh border, Airport 1968 and 2004–06

**Phragmites australis* (Cav.) Trin.; abundant at all marshes 2004–06; see text for additional information

Setaria magna Griseb.; occasional at marsh border, all marshes 1968

Spartina alterniflora Loisel; abundant along ditches, 1000 Acre Rice Field 1968–06

Spartina cynosuroides (L.) Roth; abundant at all marshes 1968–06

Spartina patens (Ait.) Muhl.; abundant at 1000 Acre Rice Field 1968–06

Tripsacum dactyloides (L.) L.; rare at 1000 Acre Rice Field edge 2004–06; occasional at marsh edge Alderly 1968–06

Zizania aquatica L.; occasional at 1000 Acre Rice Field 2004; abundant at Airport and Alderly 1968–06

Zizaniopsis miliacea (Michx.) Doell & Aschers.; frequent at Airport and Alderly 1968–06

Pontederiaceae

Pontederia cordata L.; rare at Alderly 2004–06

Typhaceae

Typha angustifolia L.; frequent at all marshes 1968–06

Typha domingensis Pers.; frequent at 1000 Acre Rice Field 1991–06, occasional at Alderly 1991–06

Typha latifolia L.; abundant at 1000 Acre Rice Field 1968–06; occasional at Alderly 1968–06

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BOOK NOTICES

Geraldine Ellis Watson. 2006. **Big Thicket Plant Ecology: An Introduction (3rd Ed.).** (ISBN 978-1-57441-214-7, pbk). University of North Texas Press, PO Box 311336, Denton, TX 76203-1336, U.S.A. (**Orders:** www.unt.edu/untpress, 940-565-2142, 940-565-4590 fax, 1-800-826-8911). $14.95, 144 pp., 20 illustrations, 15 maps, 8 figures, 6" × 9".

This small volume is the starting point for anyone interested in the biology of the Big Thicket -- an expanded and updated edition of the original from 1975. Included are discussions of the definition of the "Big Thicket," geological history, plant communities and succession, and descriptions of the subdivisions ("units") of the Big Thicket National Preserve. Good maps, diagrams, and photos.

Other useful books on Big Thicket biology:

—Ajilvsgi, G. 1979. Wildflowers of the Big Thicket, East Texas, and Western Louisiana. Texas A&M Univ. Press, College Station
—Gunter, P. 1971. The Big Thicket: A Challenge for Conservation. Viking Press, New York.
—Gunter, P.A.Y. 1993. Big Thicket: An Ecological Reevaluation. Univ. North Texas Press, Denton
—Peacock, H. 1994. Nature Lover's Guide to the Big Thicket. Texas A&M Univ. Press, College Station.

An All-Taxa-Biological-Inventory (ATBI) is underway for the Big Thicket National Preserve. For detailed information on this project, contact Linda C. Brindle, Executive Director, Big Thicket Association <director@bigthicket.org>.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

Kris M. Havstad, Laura F. Huenneke, and William H. Schlesinger (eds.). 2006. **Structure and Function of a Chihuahuan Desert Ecosystem: The Jornada Basin Long-Term Ecological Research Site.** (ISBN 978-0-195-11776-9, hbk). Oxford University Press, 2001 Evans Road, Cary, NC 27513, U.S.A. (**Orders:** www.oup.com, 1-800-451-7556, 919-677-1303 fax). $74.50, 492 pp., 98 b/w halftones, maps, line drawings, 6" × 9¼".

The Jornada Basin Long-Term Ecological Research Site is located in south-central New Mexico (25 km northeast of Las Cruces). It includes the 78,000 ha Jornada Experimental Range operated by the USDA Agricultural Research Service and the 22,000 ha Chihuahuan Desert Rangeland Research Center (CDRRC) operated by New Mexico State University. Research toward understanding the causes and consequences of desertification began in this basin in 1912, and the site was established in 1982 as one of NSF's Long-Term Ecological Research (LTER) sites. Research reported and summarized here is collaborative across a number of disciplines. The book has 18 chapters, written by 36 contributors.

Contents.—**1)** Introduction (Havstad & Schlesinger); **2)** Regional Setting of the JB; **3)** Climate and Climatological Variations in the JB; **4)** Soil Development in the JB; **5)** Patterns and Controls of Soil Water in the JB; **6)** Nutrient Cycling within an Arid Ecosystem; **7)** Biogeochemical Fluxes across Piedmont Slopes of the JB; **8)** Water and Energy Balances within the JB; **9)** Eolian Processes on the JB; **10)** Plant Communities in the JB: The Dynamic Landscape; **11)** Patterns of Net Primary Production in Chihuahuan Desert Ecosystems; **12)** Chihuahuan Desert Fauna: Effects on Ecosystem Properties and Processes; **13)** Grazing Livestock Management in an Arid Ecosystem; **14)** Remediation Research in the JB: Past and Future; **15)** Applications of Remotely Sensed Data From the JB; **16)** Modeling the Unique Attributes of Arid Ecosystems: Lessons from the JB; **17)** A Holistic View of an Arid Ecosystem: A Synthesis of Research and Its Applications; **18)** Future Directions in Jornada Research: Applying an Interactive Landscape Model to Solve Problems.

Two websites provide information on Jornada Basin research, "including archived and active data sets, current projects, research protocols, access authorization forms, program descriptions, and an interactive bibliography of the history of publications in the Jornada Basin:<http://usda-ars.nmsu.edu> and <http://jornada-www.nmsu.edu>.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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THE VASCULAR FLORA OF NASH PRAIRIE: A COASTAL PRAIRIE REMNANT IN BRAZORIA COUNTY, TEXAS

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ABSTRACT

An intensive survey of the vascular flora of Nash Prairie, a ca. 120 ha Coastal Prairie remnant in Brazoria County, Texas, resulted in a checklist of 311 species of vascular plants representing 63 families and 197 genera. The seven families containing the most species are Poaceae (70), Cyperaceae (37), Asteraceae (46), Fabaceae (17), Euphorbiaceae (10), Apiaceae (7), and Scrophulariaceae (7). Rich native genera include *Carex* (11 spp.), *Cyperus* (9 spp.), *Juncus* (7 spp.), *Panicum* (7 spp.), and *Paspalum* (7 spp.). Non-native species account for only 7% of the total, 50% (11) of which are grasses. The native flora comprises 289 species distributed in 63 families. The native grass flora includes 59 species in five subfamilies, 71% of which were C_4 species, with most of these belonging to the Panicoideae (35 spp.). Noteworthy collections of globally and regionally rare species and species with temperate amphitropical distributions from Nash Prairie are discussed, and an annotated checklist of vascular plants is provided. This research suggests previous estimates of species richness for climax Coastal Prairie in Texas are low and that historic and potential losses of botanical diversity are greater than previously thought.

RESUMEN

Un seguimiento intensivo de la flora vascular de Nash Prairie, de unas 120 ha de restos de pradera costera en Brazoria County, Texas, dio como resultado un listado de 311 especies de plantas vasculares de 63 familias y 197 géneros. Las siete familias con mayor número de especies son Poaceae (70), Cyperaceae (37), Asteraceae (46), Fabaceae (17), Euphorbiaceae (10), Apiaceae (7), y Scrophulariaceae (7). Los géneros nativos ricos en especies incluyen *Carex* (11 spp.), *Cyperus* (9 spp.), *Juncus* (7 spp.), *Panicum* (7 spp.), y *Paspalum* (7 spp.). Las especies exóticas son sólo el 7% del total, siendo el 50% (11) gramíneas. La flora nativa comprende 289 especies distribuidas en 63 familias. Las gramíneas nativas incluyen 59 especies de cinco subfamilias, de las que el 71% son especies C_4, perteneciendo la mayoría de ellas a las Panicoideae (35 spp.). Se discuten las colecciones notables de especies raras tanto a nivel regional como global y las especies con distribución templada y amfitropical de Nash Prairie, y se aporta un catálogo de las plantas vasculares. Esta investigación sugiere que las estimaciones previas de riqueza de especies de la climax de la Coastal Prairie de Texas son bajas y que las pérdidas históricas y potenciales de diversidad botánica son mayores de lo que se había pensado antes.

INTRODUCTION

The original extent of the Coastal Prairie region encompassed ca. 3,800,000 ha extending from southcentral Louisiana to south Texas along the northwestern Gulf of Mexico, and contributed about 1% to the total of all major grassland types of the contiguous United States (Sims & Risser 2000). Most of the original vegetation of the Coastal Prairie has been altered by overgrazing, conversion to various agricultural uses, encroachment of woody vegetation due to fire protection, or destroyed by industrial, commercial, and residential development (Diamond & Smiens 1984; Smeins et al. 1991; Sims & Risser 2000). The Coastal Prairie was characterized in detail by Smeins et al. (1991), and divided in Texas into an upper and lower section based on variation in soil and climate (Diamond & Smiens 1984). A full account of the flora of the Coastal Prairie would be difficult to compile since 99% of the original vegetation has been destroyed and the best and largest remaining remnants occur on private property. Several years ago, I was presented with the opportunity to survey a relatively large and intact example of this rare plant community.

METHODS

Nash Prairie is a ca. 120 ha remnant Coastal Prairie on the Kittie Nash Groce (KNG) Ranch. Nash Prairie is managed as a native hay meadow and has been maintained for decades by frequent mowing, haying, and burning. The entire prairie is seldom dry enough to burn or hay all at once, which results in a random

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pattern of disturbance across the landscape. The topography of Nash Prairie is intact and includes wetland depressions and abandoned stream meanders, numerous pimple mounds, and inter-mound flats (Fig. 1). Discussions with KNG Ranch personnel revealed that the prairie has probably never been subjected to overgrazing, and the native sod has never been broken. Access for an intensive floristic survey was arranged through cooperation between the KNG Ranch and the Nature Conservancy of Texas.

Nash Prairie is located in southwest Brazoria County, Texas, ca. 35 km south of the Houston metropolitan area (Fig. 2). The prairie is bounded on all sides by agricultural land subject to various uses, including rice and row crop farming, improved pasture, and grazing. A barbed-wire fence along the south, west, and north boundaries accounts for some of the woody species that occur in the annotated checklist. Nash Prairie occurs roughly in the geographic center of the Upper Coastal Prairie region, which lies within the Coastal Plain Province at the northern limit of the subtropical vegetation zone (Fenneman 1928; Good 1953). The regional climate is moist subhumid mesothermal characterized by long hot summers and mild winters (Thornthwaite 1948). Average annual rainfall is 132 cm, with 60% occurring from April through September (Crenwelge et al. 1981). The average daily summer temperature is 27°C, and average daily winter temperature is 13°C (Crenwelge et al. 1981).

Soils mapped in Nash Prairie are Edna fine sandy loam and Edna-Aris complex (Crenwelge et al. 1981). The Edna-Aris complex is generally associated with older stream meanders and is distinguished by the distinctive pimple mounds, with Aris fine sandy loam soils occupying the mounds, and Edna clayey soils occurring on the flats in between (Crenwelge et al. 1981). Pimple mounds are characteristic of remnant Coastal Prairie sites which are topographically intact, and they are a reliable indicator that the native sod is unbroken. Pimple mounds, like prairie wetlands (Fig. 3), also provide a microhabitat differing in soil texture, slope, soil moisture and elevation from the surrounding landscape.

Collecting trips were made to the prairie from August 2003 through September 2006. The prairie was visited on average three times a month from March to October throughout the study with the exception of a single visit in December, 2005. A complete set of voucher specimens are housed at the University of Texas at Austin Plant Resources Center Herbarium (TEX). Some duplicate specimens can also be found at BRCH, BRIT, MICH, SBSC, TAES, VSC and US (acronyms follow Holmgren et al. 1995). Plant identifications were made using the *Flora of North America* (2000; 2002a; 2002b; 2003) and various regional manuals, including Correll and Johnston (1970), Gould (1975), Isely (1990), and Smith (1994).

RESULTS AND DISCUSSION

This research resulted in collections of 311 species of vascular plants representing 63 families and 197 genera (Table 1; Appendix I). The seven families containing the most species are Poaceae (70), Cyperaceae (37), Asteraceae (46), Fabaceae (17), Euphorbiaceae (10), Apiaceae (7), and Scrophulariaceae (7). Rich native genera include *Carex* (11 spp.), *Cyperus* (9 spp.), *Juncus* (7 spp.), *Panicum* (7 spp.), and *Paspalum* (7 spp.). Non native species accounted for 7% of the total species, 50% (11) of which were grasses. A subjective estimate of the dominant and sub-dominant species of climax plant assemblages occurring at various landscape positions is presented in Table 2. This is meant to aid managers and restorationists by providing lists of target species for different cover types from a relatively intact Coastal Prairie remnant. During the study, species occurrence and dominance varied seasonally, and dominance roles appeared to shift with seasonal and annual precipitation patterns and disturbance from mowing and haying. Because mowing and haying occurred sporadically across the site during the study years, it is difficult to know what role disturbance played in the distribution and abundance of species in each cover type. Long-term quantitative vegetation studies at Nash Prairie are greatly needed.

Infrafamilial Diversity in Poaceae

The native grass flora of Nash Prairie includes 59 species in five subfamilies and comprises 71% C_4 species (Table 3). As indicated by Smeins et al. (1991) for the Coastal Prairie, the native grass flora of Nash Prairie

Fig. 1. Aerial photograph of Nash Prairie (boundary outlined in white), Brazoria County, Texas.

is dominated by the Panicoideae. The greatest number of C_4 taxa also belong to the Panicoideae (33 spp.), followed by the Chloridoideae (14 spp.; Table 3). Sixty-four percent of the introduced grass species found use the C_4 photosynthetic pathway, including potentially aggressive species such as *Cynodon dactylon*, *Paspalum dilatatum*, *P. notatum*, *P. urvillei*, and *Sorghum halepense*. The dominance of C_4 species in the Coastal Prairie is expected given their competitive advantage over C_3 species in a subtropical climate regime (Diamond & Smeins 1988).

Endemic and Rare Taxa

This survey yielded collections of several rare or otherwise noteworthy taxa. Species with distributions limited to the Coastal Prairie or with the greatest extent of their range occurring therein include *Amsonia repens*, *Asclepias linearis*, *Cooperia traubii*, *Euphorbia texana*, *Liatris bracteata*, *Rudbeckia texana*, and *Thalictrum texanum* (Correll & Johnston 1970). Species that are regionally rare and previously unreported from the Coastal Prairie (including some significant range extensions from collections previously mapped by Turner et al. 2003a; Turner et al. 2003b) include the Great Plains *Eleocharis compressa* var. *acutisquamata* and the eastern species *E. wolfii*, *Scleria muhlenbergii*, *Juncus elliottii*. var. *elliottii*, and *Sporobolus silveanus*. Diamond and Smeins (1985) described a novel *S. silveanus-Carex meadii* grassland type from the northern end of the Blackland Prairie. The occurrence of members of this same assemblage at Nash Prairie suggests this community type might have been more widespread prior to European settlement.

Several species with temperate amphitropical distribution are known from the Coastal Prairie region

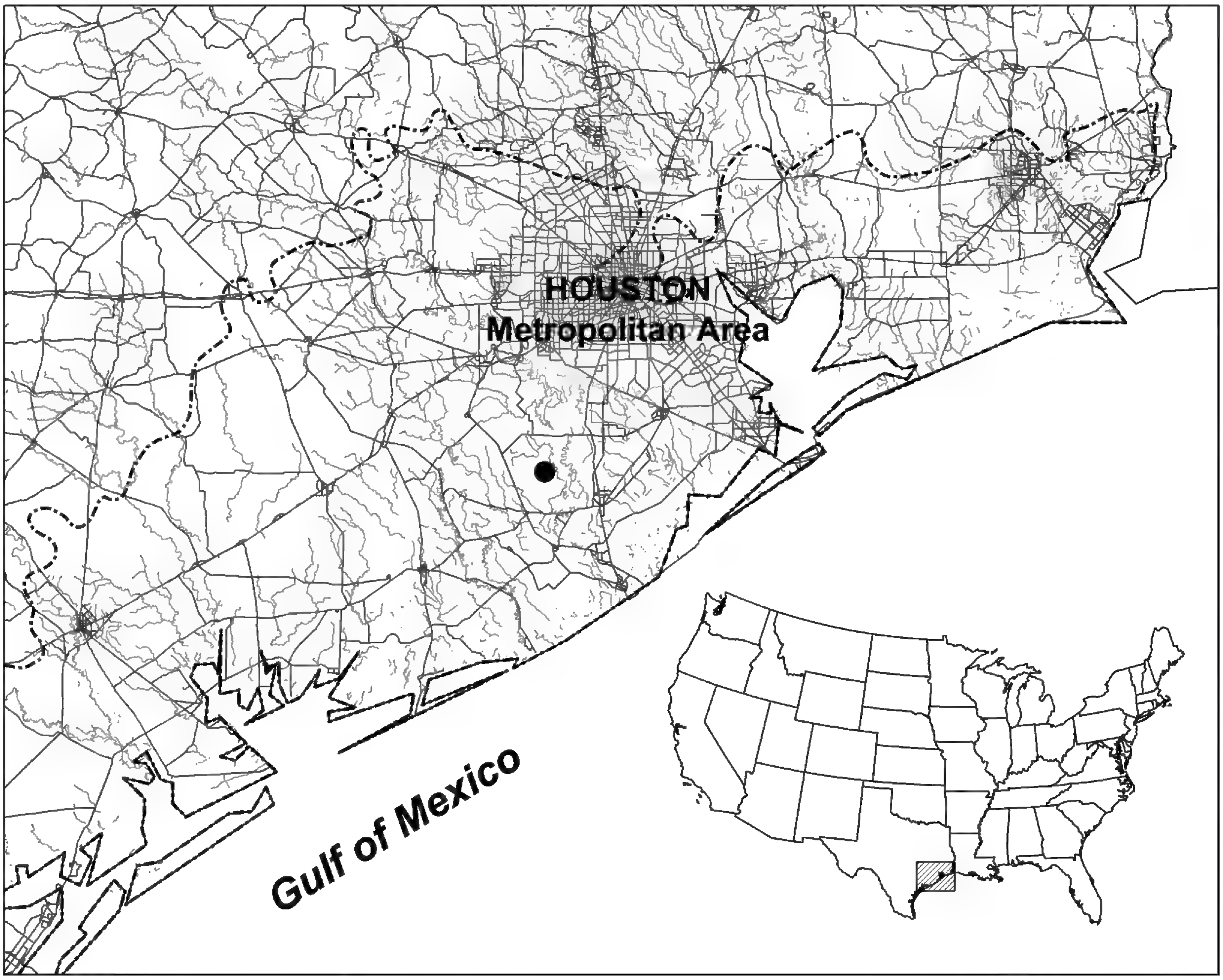

Fig. 2. General location of Upper Coastal Prairie of Texas (dashed-dotted line) and Nash Prairie (!).

and are considered by most botanists to be native taxa with disjunct distributions. Raven (1963) suggested a late Pliocene or Pleistocene introduction by long range dispersal for temperate amphitropical disjuncts in North America and considered coastal, seasonally wet, and/or open weedy grassland habitats particularly suitable for disjuncts to establish. Several amphitropical disjuncts listed by Raven (1963) occur at Nash Prairie, including *Soliva sessilis* [as *S. pterosperma* (Juss.) Less.], *Hordeum pusillum*, *Phalaris angusta*, *Lepuropetalon spathulatum*, and *Proserpinaca palustris*. The following discussion provides details of other amphitropical elements of the Coastal Prairie.

Bothriochloa exaristata is a relatively rare species known from sites with heavy soils in the Coastal Prairie of Texas and Louisiana, with a disjunct distribution in coastal areas of southern Brazil and adjacent Argentina, inland to Paraguay (Gould 1975; Allred 2003). Tucker et al. (2003) suggested that *Cyperus cephalanthus* might be naturalized in the United States. However, more detailed accounts support *C. cephalanthus* as a temperate amphitropical disjunct and a reliable indicator of undisturbed Coastal Prairie remnants in Texas and Louisiana (Carter & McInnis 1993; Grace et al. 2000). Collections of *C. cephalanthus* from Nash Prairie are only the second reported (and the only extant population known) in Texas since the type specimen was collected near Galveston Bay (Rosen & Christoffersen 2004). *Cyperus drummondii* is another reliable indicator of Coastal Prairie remnants in Texas and Louisiana, as well as other undisturbed habitats in the southeast United States (Carter et al. 1999; Rosen 2004). *Panicum bergii* is distributed in eastern South America and southeastern Texas. Although Gould (1975) considered *P. bergii* to be introduced, Correll and

Fig. 3. Examples of wetland habitats at Nash Prairie, Brazoria County, Texas. Foreground is an abandoned stream meander dominated by *Panicum hemitomon* with adjacent lowland prairie dominated by *P. virgatum* (photo by Marty Underwood).

Table 1. Taxonomic summary of vascular plants of Nash Prairie, Brazoria County, Texas.

Group	Species Families	Genera	Native	Non-native	Total
Monocots	13	58	117	14	131
Eudicots	50	139	172	8	180
Totals	**63**	**197**	**289**	**22**	**311**

Johnston (1970) suggested it might be bicentric in distribution. *Panicum bergii* has been established in the flora of the Coastal Prairie for some time, has a similar distribution to other amphitropical species, and does not appear to be aggressive. *Paspalum wrightii* occurs in Cuba, Mexico (Campeche), Bolivia, Paraguay, and Argentina (Allen & Hall 2003). Along the upper Texas coast *P. wrightii* occurs in prairie wetlands, where it has probably frequently been confused with *Paspalum plicatulum*. Although *Cuphea glutinosa* is considered native to South America, my experiences with this species have been restricted to late successional vegetation in Coastal Prairie remnants in Louisiana and Texas, suggesting it is also native to the flora. Temperate amphitropical distributions have been reported for other grassland species, indicating floristic disjunctions might have played a role in the development of the Coastal Prairie flora, in addition to other origins reported by Smeins et al. (1991).

Invasive Species

Most introduced species at Nash Prairie were encountered along a paved public road that bounds the prairie to the East and unimproved roads that provide access for farm equipment into the prairie (Fig. 1). Several

Table 2. Subjective estimate of dominant and sub-dominant species of climax plant assemblages occurring at various landscape positions in Nash Prairie. Species occurrence and dominance varied seasonally and across study years. Species are listed in alphabetical order.

WETLANDS

Semi-permanently flooded depressions

Eleocharis quadrangulata
Hydrolea ovata
Hymenocallis liriosme
Iris brevicaulis
Juncus effusus var. *solutus*
Juncus nodatus
Panicum hemitomon
Paspalidium geminatum
Paspalum wrightii
Polygonum hydropiperoides
Pontederia cordata var. *cordata*
Proserpinaca palustris var. *amblyogona*
Rhynchospora corniculata
Sagittaria graminea subsp. *graminea*
Sagittaria papillosa
Sesbania drummondii
Thalia dealbata

Seasonally wet lowland prairie

Amsonia repens
Arnoglossum plantagineum
Axonopus fissifolius
Boltonia diffusa var. *diffusa*
Carex festucacea
Carex longii
Carex tetrastachya
Carex triangularis
Cyperus drummondii
Cyperus virens var. *virens*
Eleocharis compressa var. *acutisquamata*
Euthamia gymnospermoides
Helianthus angustifolius
Juncus brachycarpus
Juncus elliottii var. *elliottii*
Lobelia puberula
Neptunia lutea
Panicum rigidulum subsp. *rigidulum*
Panicum tenerum
Panicum virgatum
Paspalum floridanum
Paspalum praecox
Rhynchospora caduca
Rhynchospora globularis
Rudbeckia texana
Tridens strictus
Tripsacum dactyloides var. *dactyloides*
Vernonia missurica

UPLANDS

Upland prairie (incl. pimple mounds)

Acacia angustissima var. *hirta*
Andropogon gerardii subsp. *gerardii*
Andropogon ternarius var. *ternarius*
Aristida purpurascens var. *purpurascens*
Arnoglossum plantagineum
Baptisia bracteata var. *leucophaea*
Baptisia sphaerocarpa
Carex bushii
Carex meadii
Croton glandulosus var. *lindheimeri*
Cyperus echinatus
Dichanthelium aciculare subsp. *angustifolium*
Eragrostis spectabilis
Eryngium yuccifolium
Fimbristylis puberula var. *puberula*
Liatris acidota
Liatris pycnostachya
Mimosa hystricina
Muhlenbergia capillaris
Paspalum plicatulum var. *plicatulum*
Polytaenia nuttallii
Schizachyrium scoparium var. *scoparium*
Scleria ciliata var. *elliottii*
Scleria pauciflora var. *pauciflora*
Silphium gracile
Solidago stricta
Solidago tortifolia
Sorghastrum nutans
Symphyotrichum dumosum
Symphyotrichum ericoides var. *ericoides*
Tephrosia onobrychoides

species observed to disperse from disturbed sites into existing prairie vegetation include *Cyperus entrerianus*, *Paspalum urvillei*, *Sorghum halepense*, and *Triadica sebifera*. A good deal of research has been published on the invasive potential of *T. sebifera* in the Coastal Prairie of Texas and Louisiana (e.g., Bruce et al. 1997; Barrilleaux & Grace 2000). However, little attention has been given to other species that appear to be invasive in established vegetation in the Coastal Prairie region.

TABLE 3. Distribution of grass taxa and C_4 photosynthetic pathway by Subfamily for Nash Prairie, Brazoria County, Texas. Subfamilial classification follows the Catalogue of New World Grasses (Judziewicz et al. 2000; Peterson et al. 2001; Soreng et al. 2003; Zuloaga et al. 2003).

Subfamily	Genera	Species		%C_4 Species	
		Introduced	Native	Introduced	Native
Aristidoideae	1	0	1	–	100
Chloridoideae	7	2	12	100	100
Ehrhartoideae	1	0	1	–	100
Panicoideae	17	5	35	100	80
Pooideae	11	4	10	0	0

CONCLUSIONS

This research reports numerous taxa not previously cataloged in early descriptions of the Coastal Prairie (e.g., Bray 1906; Tharp 1926) or more recent accounts of the flora of the Upper Coastal Prairie (e.g., Butler 1979; Smeins et al. 1991). Indeed, the flora of the Coastal Prairie probably includes many more species not reported herein or previously by other authors. Given the overall geological and environmental diversity of the region (Smeins et al. 1991), the flora might approach ca. 600 species (Allain & Johnson 1997; Allen et al. 2001; D. J. Rosen, unpublished data & personal observation). Only continued intensive floristic research in remnants of Coastal Prairie will provide an accurate estimate. I believe that both historic and potential losses of botanical diversity in the Coastal Prairie are greater than previously thought. As this research has indicated, numerous plant taxa with their distributions centered in other habitat types extend into the Coastal Prairie. It has been suggested that the conservation of potentially genetically distinct populations is at least as important as the conservation of an entire species (Ehrlich 1988). Expanding populations in the Upper Coastal Prairie region, rapid urbanization of rural areas, a continued poor understanding of the flora, and the lack of an aggressive strategy for Coastal Prairie conservation could result in the loss of the remaining large remnants. The approach of ex-situ preservation of a few endangered Coastal Prairie plant and animal species will have little environmental value in the absence of large areas of suitable habitat (Jordan 1988).

APPENDIX 1

ANNOTATED CHECKLIST OF SPECIES

Families are arranged alphabetically, beginning with monocots, and followed by eudicots, following the classification presented in APGII (2003). Genera, species, and infraspecific names are arranged alphabetically under families and their classification generally follows Jones et al. (1997) with a few exceptions. Recent molecular data supports the recognition of *Dichanthelium* as a genus distinct from *Panicum* (Freckmann & Lelong 2003). I also follow APGII (2003) in considering Apocynaceae to include Asclepiadaceae. Some species names are preceded by special symbols to indicate nativity and conservation interest as follows: (1) non-native species are indicated by an asterisk (*), based on review of Hatch et al. (1990) and Correll and Johnston (1970); (2) endemic, rare, or regionally rare species are indicated by a superscript dagger (†), based on review of Correll and Johnston (1970), Turner et al. (2003a; 2003b), or personal experience; and (3) amphitropical species are indicated by a superscript bold capital **AT**. Synonyms, if considered useful, are provided in brackets following the species name. Following each name is an abbreviation from Palmer et al. (1995), representing one of the following subjective estimates of the relative abundance of that species in the particular habitat(s) where it was collected: **r** = rare (very difficult to find and limited to one or very few locations or uncommon habitats); **i** = infrequent (difficult to find with few individuals or colonies but found in several locations); **o** = occasional (widely scattered but not difficult to find); **f** = frequent (easily seen or found in one or more common habitats but not dominant in any common habitat); and **a** = abundant (dominant or codominant in one or more common habitats). Following the relative abundance, the habitat(s) where that species is typically found is indicated by the following general categories: **Prairie** = Infrequently flooded to upland elevation grassland throughout the study area; **Wetlands** = All wetland sites, including deep, seasonally flooded depressions and abandoned stream meanders and temporarily flooded inter-mound flats and lowland prairie; **Pimple mounds** = Distinctive circular mounds of various elevations and diameters that occur throughout the site; **Disturbed** = Sites where the native sod has been disturbed, including dirt roads, roadside ditches, and fence-lines with encroaching woody vegetation.

The abundances and habitat preferences indicated are based on my observations during the duration of this research. They may reflect the response of each species to management of Nash Prairie and recent rainfall conditions, but they are not meant to indicate the expected dominance or habitat preference for each species throughout the Coastal Prairie. Collection numbers are mine with the exceptions of a few specimens collected by William R. Carr (WRC). Annotations for grasses are followed with their designation as either C_3 or C_4 following Waller and Lewis (1979). Global and state conservation ranks following Carr (2004) are provided for some rare taxa.

MONOCOTS

Agavaceae

Manfreda virginica (L.) Salisb. ex Rose, prairie, i, 3004

Alismataceae

Sagittaria graminea Michx. subsp. *graminea*, wetlands, f, 2707

Sagittaria papillosa Buchenau, wetlands, i, 2859

Alliaceae

Nothoscordum bivalve (L.) Britton, prairie, f, 2690

Amaryllidaceae

†*Cooperia traubii* W. Hayw., prairie, i, 3155, G3QS3

Hymenocallis liriosme (Raf.) Shinners, wetlands, o, 2713

Commelinaceae

Commelina erecta L. var. *deamiana* Fernald, disturbed, i, 2923

Tradescantia ohiensis Raf., disturbed, pimple mounds, i, 2712

Cyperaceae

Carex bushii Mack., prairie, i, 2875

Carex cherokeënsis Schwein., prairie, o, 2717

Carex complanata Torr. & Hook., prairie, i, 2746

Carex festucacea Schkuhr ex Willd., wetlands, i, 2763

Carex flaccosperma Dewey, prairie, i, 2765

Carex leavenworthii Dewey, wetlands, r, 3659

Carex longii Mack., wetlands, i, 2848

Carex meadii Dewey, prairie, pimple mounds, a, 2688

Carex microdonta Torr. & Hook., prairie, i, 4048

Carex tetrastachya Scheele, wetlands, o, 2766

Carex triangularis Boeck., wetlands, o, 2764

**Cyperus articulatus* L., wetlands, i, 2899

†AT*Cyperus cephalanthus* Torr. & Hook., wetlands, r, 2950, G2QS1

Cyperus croceus Vahl, disturbed, pimple mounds, i, 2949

†AT*Cyperus drummondii* Torr. & Hook., wetlands, o, 2631

Cyperus echinatus (L.) Alph. Wood, prairie, o, 3013

**Cyperus entrerianus* Boeck., disturbed, i, 2960

Cyperus fraternus Kunth, prairie, r, 2896

**Cyperus haspan* L., wetlands, o, 2676

Cyperus pseudovegetus Steud. var. *pseudovegetus*, wetlands, i, 2898

Cyperus reflexus Vahl, prairie, r, 2865

Cyperus retrorsus Chapm. var. *retrorsus*, pimple mounds, i, 3586

Cyperus virens Michx. var. *virens*, wetlands, o, 2900

†*Eleocharis compressa* Sull. var. *acutisquamata* (Buckley) S.G. Sm., wetlands, f, 2911

Eleocharis microcarpa Torr. var. *microcarpa*, wetlands, i, 2832

Eleocharis montana (Kunth) Roem. & Schult., wetlands, i, 2846

Eleocharis palustris (L.) Roem. & Schult., wetlands, r, 2922

Eleocharis quadrangulata (Michx.) Roem. & Schult., wetlands, i, 2980

†*Eleocharis wolfii* (A. Gray) A. Gray ex Britton, wetlands, r, 2910

Fimbristylis puberula (Michx.) Vahl var. *puberula*, prairie, a, 2815

Rhynchospora caduca Elliott, wetlands, f, 2907

Rhynchospora corniculata (Lam.) A. Gray, wetlands, o, 2839

Rhynchospora globularis (Chapm.) Small, wetlands, f, 2816

Rhynchospora recognita (Gale) Kral, prairie, o, 2957

Scleria ciliata Michx. var. *elliottii* (Chapm.) Fernald, wetlands, o, 3370

†*Scleria muhlenbergii* Steud., wetlands, r, 3122

Scleria oligantha Michx., prairie, i, 2840

Scleria pauciflora Muhl. ex Willd. var. *pauciflora*, prairie, o, 3711

Hypoxidaceae

Hypoxis hirsuta (L.) Coville, pimple mounds, prairie, i, 2698

Iridaceae

Herbertia lahue (Molina) Goldblatt, prairie, i, 2755

Iris brevicaulis Raf., wetlands, r, 2852

Sisyrinchium angustifolium Mill., disturbed, i, 2825

Sisyrinchium minus Engelm. & A. Gray, disturbed, i, 2749

Juncaceae

Juncus acuminatus Michx., wetlands, o, 2871

Juncus brachycarpus Engelm., wetlands, o, 2818

Juncus effusus L. var. *solutus* Fernald & Wiegand, wetlands, i, 2847

†*Juncus elliottii* Chapm. var. *elliottii*, wetlands, i, 2817
Juncus marginatus Rostk., wetlands, o, 2814
Juncus nodatus Coville, wetlands, o, 2918
Juncus tenuis Willd. var. *dichotomus* (Elliott) Alph. Wood, wetlands, i, 2854

Marantaceae

Thalia dealbata Fraser ex Roscoe, wetlands, i, 3372

Orchidaceae

Spiranthes vernalis Engelm. & A. Gray, prairie, i, 2945

Poaceae

Agrostis elliottiana Schult., pimple mounds, o, 2743, C_3
Agrostis hyemalis (Walter) Britton, Sterns & Poggenb. var. *hyemalis*, pimple mounds, f, 2738, C_3
Andropogon gerardii Vitman subsp. *gerardii*, prairie, f, 3120, C_4
Andropogon glomeratus (Walter) Britton, Sterns & Poggenb. var. *glomeratus*, wetlands, i, 3148, C_4
Andropogon ternarius Michx. var. *ternarius*, prairie, f, 2662, C_4
Aristida purpurascens Poir. var. *purpurascens*, prairie, o, 2673, C_4
Axonopus fissifolius (Raddi) Kuhlm., prairie, pimple mounds, wetlands, f, 2944, C_4
Axonopus furcatus (Flüggé) Hitchc., wetlands, i, 3152, C_4
†AT*Bothriochloa exaristata* (Nash) Henrard, prairie, o, 3151, G3S3, C_4
Bothriochloa longipaniculata (Gould) Allred & Gould, disturbed, prairie, i, 3012, C_4
Bouteloua curtipendula (Michx.) Torr. var. *curtipendula*, prairie, r, 3128, C_4
**Briza minor* L., disturbed, i, 2770, C_3
**Chloris canterae* Arechav. var. *canterae*, disturbed, i, 2758, C_4
**Cynodon dactylon* (L.) Pers. var. *dactylon*, disturbed, i, 3149, C_4
Dichanthelium aciculare (Desv. ex Poir.) Gould & C.A. Clark subsp. *aciculare*, prairie, i, 2711, C_3
Dichanthelium aciculare (Desv. ex Poir.) Gould & C.A. Clark subsp. *angustifolium* (Elliot) Freckmann & Lelong, prairie, f, 2741, C_3
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark subsp. *acuminatum*, prairie, f, 2740, C_3
Dichanthelium dichotomum (L.) Gould subsp. *dichotomum*, prairie, i, 2912, C_3
Dichanthelium sphaerocarpon (Elliott) Gould, prairie, f, 2739, C_3
**Digitaria ciliaris* (Retz.) Koeler var. *ciliaris*, disturbed, i, 2988, C_4
Digitaria cognata (Schult.) Pilg., pimple mounds, o, 3583, C_4
Elymus virginicus L. var. *virginicus*, disturbed, r, 3658, C_3
Eragrostis elliottii S. Watson, pimple mounds, i, 3582, C_4
Eragrostis intermedia Hitchc. var. *intermedia* , prairie, o, 2952, C_4
Eragrostis lugens Nees, pimple mounds, o, 3584, C_4
Eragrostis refracta (Muhl. ex Elliott) Scribn., prairie, i, 3124, C_4
Eragrostis spectabilis (Pursh) Steud., prairie, o, 3583, C_4
Eriochloa contracta Hitchc., disturbed, i, 3008, C_4
AT*Hordeum pusillum* Nutt., disturbed, i, 2775, C_3
Leersia hexandra Sw., wetlands, r, 3042, C_3
Limnodea arkansana (Nutt.) L.H. Dewey, disturbed, i, 3376, C_3
**Lolium arundinaceum* (Schreb.) Darbysh., disturbed, i, 3348, C_3
**Lolium perenne* L. var. *perenne*, disturbed, o, 2705, C_3
Mnesithea cylindrica (Michx.) de Koning & Sosef [Sy = *Coelorachis cylindrica* (Michx.) Nash], wetlands, i, 3878, C_4
Muhlenbergia capillaris (Lam.) Trin., prairie, o, 3110, C_4
Nassella leucotricha (Trin. & Rupr.) R.W. Pohl, disturbed, i, 2849, C_3
Panicum anceps Michx. var. *anceps*, wetlands, i, 3471, C_4
AT*Panicum bergii* Arechav. [Sy = *Panicum pilcomayense* Hack.], pimple mounds, i, 3464, C_4
Panicum dichotomiflorum Michx. subsp. *dichotomiflorum*, disturbed, o, 3102, C_4
Panicum hemitomon Schult.,wetlands, a, 2908, C_3
Panicum rigidulum Bosc ex Nees subsp. *rigidulum*, wetlands, o, 2672, C_4
Panicum tenerum Beyr. ex Trin., wetlands, o, 2872, C_4
Panicum virgatum L., wetlands, a, 3118, C_4
Paspalidium geminatum (Forssk.) Stapf var. *geminatum*, wetlands, i, 2951, C_4
Paspalum denticulatum Trin. [Sy = *P. lividum* Trin.], wetlands, f, 3423, C_4
**Paspalum dilatatum* Poir., disturbed, i, 2895, C_4
Paspalum floridanum Michx., wetlands, o, 3014, C_4
**Paspalum notatum* Flüggé, disturbed, i, 2989, C_4
Paspalum plicatulum Michx. var. *plicatulum*, prairie, a, 2905, C_4
Paspalum praecox Walter, wetlands, r, 3119, C_4
Paspalum setaceum Michx. var. *muhlenbergii* (Nash) D.J. Banks, prairie, i, 2954, C_4
**Paspalum urvillei* Steud., disturbed, i, 2894, C_4
AT*Paspalum wrightii* Hitchc. & Chase [Sy = *P. texanum* Swallen], wetlands, o, 2990, C_4
AT*Phalaris angusta* Nees ex Trin., disturbed, i, 2774, C_3
Phalaris caroliniana Walter, disturbed, o, 2769, C_3
**Poa annua* L., disturbed, i, 2694, C_3
Schizachyrium scoparium (Michx.) Nash var. *scoparium*, prairie, a, 3109, C_4
Setaria parviflora (Poir.) Kerguélen, disturbed, prairie, i, 2948, C_4
Sorghastrum nutans (L.) Nash, prairie, a, 3121, C_4
**Sorghum halepense* (L.) Pers., disturbed, i, 2893, C_4
Sphenopholis obtusata (Michx.) Scribn. var. *obtusata*, disturbed, i, 2855, C_3
Sporobolus compositus (Poir.) Merr. var. *compositus*, prairie, i, 3877, C_4
Sporobolus compositus (Poir.) Merr. var. *macer* (Trin.) Kartesz & Gandhi, pimple mounds, i, 3153, C_4
Sporobolus indicus (L.) R. Br. var. *indicus*, disturbed, o, 2706, C_4
†*Sporobolus silveanus* Swallen, prairie, r, 3601, C_4
Steinchisma hians (Elliott) Nash, wetlands, o, 2946, C_3
Tridens strictus (Nutt.) Nash, wetlands, f, 3541, C_4
Tripsacum dactyloides (L.) L. var. *dactyloides*, wetlands, r, 2857, C_4

Urochloa platyphylla (Munro ex C. Wright) R.D. Webster, disturbed, i, 3879, C_4
Vulpia octoflora (Walter) Rydb. var. *octoflora*, pimple mounds, o, 2744, C_3

Pontederiaceae
Pontederia cordata L. var. *cordata*, wetlands, i, 2868

EUDICOTS

Acanthaceae
Hygrophila lacustris (Cham. & Schltdl.) Nees, wetlands, r, 3040
Justicia ovata (Walter) Lindau var. *lanceolata* (Chapm.) R.W. Long, wetlands, r, 3116
Ruellia humilis Nutt. var. *depauperata* Tharp & F.A. Barkley, prairie, o, 3043
Ruellia nudiflora (Engelm. & A. Gray) Urb. var. *nudiflora*, disturbed, o, 3006

Anacardiaceae
Toxicodendron radicans (L.) Kuntze, disturbed, i, 2877

Apiaceae
Chaerophyllum tainturieri Hook. var. *dasycarpum* (Nutt.) S. Watson, disturbed, r, 3603
Daucus pusillus Michx., mounds, r, 4090
Eryngium yuccifolium Michx., prairie, f, 2982
Hydrocotyle umbellata L., wetlands, i, 3375
Limnosciadium pinnatum (DC.) Mathias & Constance, prairie, i, 2915
Polytaenia nuttallii DC., prairie, o, 2936
Sanicula canadensis L. var. *canadensis*, disturbed, r, 2856

Apocynaceae (incl. **Asclepiadaceae**)
†*Amsonia repens* Shinners, wetlands, o, 2703
†*Asclepias linearis* Scheele, wetlands, r, 3115
Asclepias longifolia Michx. subsp. *longifolia*, wetlands, i, 2943
Asclepias verticillata L., prairie, o, 2937
Asclepias viridis Walter, disturbed, i, 2833

Asteraceae
Acmella oppositifolia (Lam.) R.K. Jansen var. *repens* (Walter) R. K. Jansen, wetlands, i, 2861
Ambrosia psilostachya DC., prairie, o, 2666
Ambrosia trifida L. var. *texana* Scheele, disturbed, r, 3596
Arnoglossum plantagineum Raf., prairie, o, 2813
Astranthium integrifolium (Michx.) Nutt. subsp. *ciliatum* (Raf.) DeJong, pimple mounds, r, 3607
Boltonia diffusa Elliott var. *diffusa*, wetlands, f, 3106
Calyptocarpus vialis Less., disturbed, r, 3422
Cirsium horridulum Michx. var. *elliottii* Torr. & A. Gray, prairie, r, 2786
Conoclinum coelestinum (L.) DC., wetlands, o, 3129
Conyza canadensis (L.) Cronquist var. *glabrata* (A. Gray) Cronquist, pimple mounds, i, 3924
Coreopsis tinctoria Nutt. var. *tinctoria*, dsturbed, o, 2892
Erigeron philadelphicus L., disturbed, i, 3347
Erigeron tenuis Torr. & A. Gray, prairie, f, 2708
Eupatorium lancifolium (Torr. & A. Gray) Small, prairie, r, 3925
Eupatorium serotinum Michx., disturbed, i, 3472
Euthamia gymnospermoides Greene, wetlands, f, 2663
Euthamia leptocephala (Torr. & A. Gray) Greene ex Porter & Britton, prairie, i, 3543
Gamochaeta purpurea (L.) Cabrera [Sy = *Gnaphalium purpureum* L.], disturbed, o, 2751
Gutierrezia texana (DC.) Torr. & A. Gray var. *texana*, prairie, i, 2670
Helenium amarum (Raf.) H. Rock var. *amarum*, disturbed, i, 2669
Helenium flexuosum Raf., wetlands, o, 2897
Helianthus angustifolius L., wetlands, a, 3469
Helianthus maximiliani Schrad., wetlands, r, 3592
**Hypochaeris microcephala* (Sch. Bip.) Cabrera var. *albiflora* (Kuntze) Cabrera , disturbed, i, 2748
Iva annua L., prairie, r, 3931
Krigia cespitosa (Raf.) K.L. Chambers, pimple mounds, r, 3609
Krigia dandelion (L.) Nutt., pimple mounds, i, 2696
Liatris acidota Engelm. & A. Gray, prairie, f, 3111
†*Liatris bracteata* Gaiser, prairie, r, 3101, G2G3S2S3
Liatris pycnostachya Michx. , prairie, f, 2904
Mikania scandens (L.) Willd. , wetlands, i, 3117
Packera glabella (Poir.) C. Jeffrey, prairie, i, 2716
Pityopsis graminifolia (Michx.) Nutt., pimple mounds, r, 3660
Pluchea baccharis (Mill.) Pruski, wetlands, i, 3928
Pyrrhopappus pauciflorus (D. Don) DC., disturbed, i, 2845
Ratibida columnifera (Nutt.) Wooton & Standl., disturbed, r, 3421
Rudbeckia hirta L. var. *angustifolia* (T.V. Moore) Perdue, pimple mounds, i, 2834
†*Rudbeckia texana* (Perdue) P.B. Cox & Urbatsch, wetlands, f, 2983
Silphium gracile A. Gray, prairie, pimple mounds, f, 2822
Solidago canadensis L. var. *scabra* (Muhl. ex Willd.) Torr. & A. Gray, prairie, i, 3544
Solidago stricta Aiton, prairie, pimple mounds, f, 2671
Solidago tortifolia Elliott, prairie, pimple mounds, f, 3610
AT*Soliva sessilis* Ruiz & Pav., disturbed, r, 2867
Symphyotrichum dumosum (L.) G. L. Nesom, prairie, pimple mounds, i, 2664
Symphyotrichum ericoides (L.) G. L. Nesom var. *ericoides*, prairie, pimple mounds, i, 2665
Symphyotrichum lanceolatum (Willd.) G. L. Nesom var. *lanceolatum*, wetlands, o, 3589
Symphyotrichum patens (Aiton) G.L. Nesom var. *gracile* (Hook.) G. L. Nesom, prairie, r, 3597
Symphyotrichum pratense (Raf.) G. L. Nesom, prairie, pimple mounds, r, 3104
Vernonia missurica Raf., wetlands, f, 3927

Boraginaceae
Lithospermum incisum Lehm., prairie, r, 2715
Myosotis macrosperma Engelm., wetlands, r, 3656

Brassicaceae
Lepidium densiflorum Schrad. var. *densiflorum*, disturbed, i, 3349
Lepidium virginicum L. var. *medium* (Greene) C.L. Hitchc., disturbed, o, 2823
Lepidium virginicum L. var. *virginicum*, disturbed, o, 2783

Callitrichaceae
Callitriche peploides Nutt., wetlands, i, 2761

Campanulaceae
Lobelia puberula Michx., prairie, i, 2667
Triodanis lamprosperma McVaugh, disturbed, i, 2874
Triodanis perfoliata (L.) Nieuwl. var. _biflora_ (Ruiz & Pav.) Bradley, prairie, pimple mounds, o, 2752
Triodanis perfoliata (L.) Nieuwl. var. _perfoliata_, prairie, pimple mounds, o, 2736

Caryophyllaceae
Cerastium glomeratum Thuill., prairie, i, 2709

Cistaceae
Lechea mucronata Raf., prairie, i, 2986

Clusiaceae
Hypericum hypericoides (L.) Crantz , prairie, r, 3712

Convolvulaceae
Dichondra carolinensis Michx., prairie, pimple mounds, i, 2750
Evolvulus sericeus Sw. var. _sericeus_, prairie, i, 3011
Ipomoea cordatotriloba Dennst., disturbed, i, 3007

Cornaceae
Cornus drummondii C.A. Mey., disturbed, i, 2880

Cuscutaceae
Cuscuta pentagona Engelm., wetlands, r, 3041

Droseraceae
Drosera brevifolia Pursh, pimple mounds, i, 2734

Ebenaceae
Diospyros virginiana L., disturbed, r, 2853

Euphorbiaceae
Acalypha gracilens A. Gray var. _gracilens_, prairie, r, 22178 (WRC)
*_Caperonia palustris_ (L.) A. St.-Hil., wetlands, r, 3930
Chamaesyce maculata (L.) Small, disturbed, o, 3127
Croton capitatus Michx. var. _lindheimeri_ (Engelm. & A. Gray) Müll. Arg., disturbed, o, 2675
Croton glandulosus L. var. _lindheimeri_ Müll. Arg., prairie, pimple mounds, o, 3045
Euphorbia bicolor Engelm. & A. Gray, disturbed, o, 3046
Euphorbia spathulata Lam., prairie, pimple mounds, o, 2757
†_Euphorbia texana_ Boiss., prairie, pimple mounds, i, 2737
Tragia betonicifolia Nutt., pimple mounds, o, 2941
*_Triadica sebifera_ (L.) Small (=_Sapium sebiferum_ (L.) Roxb.), wetlands, f, 2921

Fabaceae
Acacia angustissima (Mill.) Kuntze var. _hirta_ (Nutt. ex Torr. & A. Gray) B.L. Rob., prairie, pimple mounds, o, 2891
Baptisia bracteata Muhl. ex Elliott var. _leucophaea_ (Nutt.) Kartesz & Gandhi, prairie, i, 2902
Baptisia sphaerocarpa Nutt., prairie, f, 2837
Centrosema virginianum (L.) Benth., disturbed, i, 3015
Chamaecrista fasciculata (Michx.) Greene, disturbed, o, 2981
Dalea candida Willd. var. _candida_, prairie, i, 2959
Desmodium ciliare (Muhl. ex Willd.) DC. var. _ciliare_, pimple mounds, o, 3105
Galactia marginalis Benth., pimple mounds, r, 3112
Lathyrus pusillus Elliott, disturbed, i, 2753
*_Medicago lupulina_ L., disturbed, o, 2693
*_Medicago minima_ (L.) L., disturbed, i, 2844
*_Melilotus indicus_ (L.) All., disturbed, i, 2843
Mimosa hystricina (Small ex Britton & Rose) B.L. Turner, prairie, o, 2835
Mimosa nuttallii (DC.) B.L. Turner, prairie, o, 2938
Neptunia lutea (Leavenw.) Benth., wetlands, o, 2939
Neptunia pubescens Benth. var. _pubescens_, wetlands, r, 22175 (WRC)
Sesbania drummondii (Rydb.) Cory, wetlands, r, 3044
Stylosanthes biflora (L.) Britton, Sterns & Poggenb., prairie, r, 2953
Tephrosia onobrychoides Nutt., pimple mounds, o, 2942
*_Trifolium repens_ L. var. _repens_, disturbed, i, 2890
Vicia ludoviciana Nutt. ex Torr. & A. Gray subsp. _ludoviciana_, disturbed, i, 3604

Fagaceae
Quercus virginiana Mill. var. _virginiana_, disturbed, r, 2987

Gentianaceae
Sabatia campestris Nutt., pimple mounds, prairie, o, 2830

Geraniaceae
Geranium carolinianum L. var. _carolinianum_, disturbed, o, 2784

Haloragaceae
^{AT}_Proserpinaca palustris_ L. var. _amblyogona_ Fernald, wetlands, f, 2772

Hydrophyllaceae
Hydrolea ovata Nutt. ex Choisy, wetlands, f, 2999

Krameriaceae
Krameria lanceolata Torr., prairie, r, 3420

Lamiaceae
Hedeoma hispidum Pursh, prairie mounds, i, 2756
Physostegia intermedia (Nutt.) Engelm. & A. Gray, wetlands, o, 2850
Salvia lyrata L., disturbed, i, 3346
Scutellaria parvula Michx. var. _parvula_, pimple mounds, o, 2710

Linaceae
Linum medium (Planch.) Britton var. _texanum_ (Planch.) Fernald, prairie, f, 2903

Lythraceae
$^{AT?}$_Cuphea glutinosa_ Cham. & Schltdl., prairie, r, 3714
Lythrum alatum Pursh var. _lanceolatum_ (Elliott) Rothr., wetlands, i, 2947

Malvaceae
Callirhoë involucrata (Torr. & A. Gray) A. Gray var. _lineariloba_ (Torr. & A. Gray) A. Gray, prairie, o, 2836
Modiola caroliniana (L.) G. Don, disturbed, i, 2776
Sida ciliaris L. , disturbed, i, 3010
Sida rhombifolia L. , disturbed, i, 3009

Melastomataceae
Rhexia mariana L. var. *mariana*, wetlands, i, 2984

Myricaceae
Morella cerifera (L.) Small, prairie, i, 3264

Onagraceae
Gaura longiflora Spach, disturbed, o, 3039
Ludwigia glandulosa Walter, wetlands, o, 2901
Ludwigia linearis Walter, wetlands, i, 2985
Oenothera laciniata Hill, pimple mounds, i, 2735
Oenothera linifolia Nutt., prairie, r, 2785
Oenothera speciosa Nutt., disturbed, o, 2782

Oxalidaceae
Oxalis dillenii Jacq., disturbed, o, 2781
Oxalis violacea L., prairie, r, 3154

Passifloraceae
Passiflora incarnata L., disturbed, o, 2914

Plantaginaceae
Plantago aristata Michx., disturbed, o, 2841
Plantago virginica L., disturbed, i, 2826

Polemoniaceae
Phlox cuspidata Scheele, prairie, r, 2787

Polygalaceae
Polygala incarnata L., pimple mounds, prairie, f, 2828

Polygonaceae
Polygonum hydropiperoides Michx., wetlands, f, 2674
Rumex chrysocarpus Moris, disturbed, i, 2883

Primulaceae
Anagallis minima (L.) E.H.L. Krause, pimple mounds, f, 2714

Ranunculaceae
Anemone berlandieri Pritz., pimple mounds, i, 2699
Delphinium carolinianum Walter, pimple mounds, i, 2821
Ranunculus laxicaulis (Torr. & Gray) Darby, wetlands, r, 3605
Ranunculus pusillus Poir., wetlands, i, 2760
†*Thalictrum texanum* (A. Gray) Small, pimple mounds, r, 2701, G2QS2

Rosaceae
Prunus angustifolia Marsh. var. *angustifolia*, disturbed, i, 2879
Rubus argutus Link, disturbed, i, 2876

RUBIACEAE
Cephalanthus occidentalis L. var. *californicus* Benth., wetlands, r, 3933
Diodia virginiana L. var. *virginiana* , wetlands, i, 2920
Galium obtusum Bigelow subsp. *obtusum*, wetlands, i, 2759
Houstonia pusilla Schoepf, pimple mounds, f, 2689

Rutaceae
Zanthoxylum clava-herculis L., disturbed, i, 3371

Salicaceae
Salix nigra Marshall, wetlands, r, 2869

Saxifragaceae
AT*Lepuropetalon spathulatum* Elliott, pimple mounds, r, 2702

Scrophulariaceae
Agalinis heterophylla (Nutt.) Small ex Britton, prairie, f, 3107
Agalinis viridis (Small) Pennell, prairie, o, 3103
Buchnera americana L., pimple mounds, prairie, o, 2831
Castilleja indivisa Engelm., pimple mounds, prairie, f, 2692
Gratiola virginiana L. var. *virginiana*, wetlands, i, 2762
Mecardonia acuminata (Walter) Small var. *acuminata*, wetlands, r, 3123
Nuttallanthus canadensis (L.) D.A. Sutton [Sy = *Linaria canadensis* (L.) Dum. Cours.], disturbed, i, 2704

Solanaceae
Physalis cinerascens (Dunal) Hitchc. var. *cinerascens*, pimple mounds, i, 2771

Ulmaceae
Ulmus americana L., wetlands, r, 3373

Valerianaceae
Valerianella woodsiana (Torr. & A. Gray) Walp., disturbed, o, 2780

Verbenaceae
Phyla nodiflora (L.) Greene , disturbed, i, 2913
Verbena halei Small , prairie, o, 2754
**Verbena brasiliensis* Vell., disturbed, i, 2863
Verbena xutha Lehm., prairie, r, 3419

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THE VASCULAR FLORA OF A WOODLAND PARK SITE IN EAST HARRIS COUNTY, TEXAS

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ABSTRACT

An annotated, vouchered checklist is provided of the vascular plant taxa of a 50 ha segment of Herman Brown Park, Houston, Harris County, Texas. Four hundred forty eight taxa are documented for the site, of which 361 are native and 87 are non native. Weedy species constitute 56% of the native species and 68% of the non natives, but only a few are highly invasive. The native and non native taxa are predominantly from the southeastern or eastern USA. The non native taxa are predominantly Asian or European in origin, and approximately 25% are from Central or South America.

RESUMEN

Se aporta un catálogo con anotaciones y testigos de taxa de plantas vasculares de un segmento de 50 ha del Herman Brown Park, Houston, Harris County, Texas. Se documentan cuatrocientas cuarenta y ocho taxa para el lugar, de las que 361 son nativas y 87 no nativas. Las especies de malas hierbas constituyen el 56% de las especies nativas y el 68% de las no nativas, pero sólo unas pocas son invasoras. Los taxa nativos son predominantemente del sureste o del este de Estados Unidos. Los taxa no nativos son principalmente de origen asiático o europeo, y aproximadamente el 25% son de América Central o Sur América.

INTRODUCTION

This inventory was conducted as part of a biological assessment of a potential site for the Botanic Garden of Houston, TX (BGH). The main goal was to document the flora of an urban natural area and to consider factors influencing its floristic composition. An additional goal was to provide a baseline for assessment of biodiversity changes wrought by development as a botanical garden.

Floristic richness of a site should be a function of the size, habitat diversity, and disturbance history of the site. The number of species should increase with site size and habitat diversity. Disturbance could eliminate some species while providing new habitat for others, so its influence is unclear. The BGH site is small (50 ha) and site conditions are relatively homogeneous. Negative impacts to the site include timber cutting, grazing, oilfield activity and pipeline construction, as well as dredging for Hunting Bayou flood control, and urbanization of the surrounding area. Furthermore, the site appears to have undergone considerable ecological change, from prairie and riparian woodland to closed forest following cessation of grazing and burning.

Site location should also affect the relative size of the flora, considering that the pool of potential non native invaders would be higher in an urban setting. For example, rural nature preserves typically have a small fraction of non natives. In nearby Texas nature preserves, the values are in the range of 5–6% (Fleming et al. 2002; Singhurst et al. 2003; MacRoberts et al. 2004; Brown et al. 2005). Few studies have been reported for urban natural areas in the US, but values range from 26% (Middlesex Fells, metropolitan Boston; Drayton and Primack 1996) to 40% (Pelham Bay Park, New York City: DeCandido et al. 2004). In regional floras the non native fraction is as high as 43% (Great Britain: Crawley et al. 1997) or even 60% for some islands (Wu et al. 2004). In Central Europe non natives comprise about 40% of the floras of 54 cities, and the fraction of non natives increases with city size and decreases with increasing latitude (Pysek 1998). More studies from American cities are necessary to determine whether similar trends exist.

In addition to being in an urban setting, the site under study is of interest because it contains a remnant

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of a *Quercus similis* (bottomland post oak) woodland, a vegetation type that is poorly known ecologically and floristically. Also, it is located near the western boundary of the eastern deciduous forest biome where forests rapidly give way to woodlands, savannas, prairies and marshes moving west and south. In the northeast quadrant of Harris County, the forest communities resemble those of the outer coastal plain of the southeastern US, with an upland matrix of mixed pine-hardwood forest dissected by oak-gum bottomland hardwood forest. In the southwest quadrant, uplands are predominantly prairie while riparian zones are often dominated by *Quercus virginiana* (live-oak), *Q. nigra* (water oak), *Populus deltoides* (cottonwood), and *Celtis laevigata* (hackberry). The question addressed in this paper is whether an urban natural area near this ecotone might have elevated floristic richness since sources of post-disturbance colonists are more varied than they might be for a site within a uniform regional vegetation matrix. In addition, a substantial admixture of species with Western or Midwestern distributions may also occur.

To summarize, this paper focuses on the question of how the local flora reflects biogeography and human activity including whether there is a mix of species from different habitats and if the non native species ratio is high. The paper also establishes a baseline for investigating floristic change in an urban natural area.

SITE AND METHODS

The collection site was the section of Herman Brown Park (City of Houston, Harris County, TX) west of Hunting Bayou, herein called the Botanic Garden of Houston site. Herman Brown Park was acquired by the City of Houston in 1980. Land use at the BGH site has been varied. Deed records indicate timber sales in 1869. The site was later acquired by a local rancher and presumably grazed. Ages of canopy trees indicate that grazing ceased about 50 years ago. There are several abandoned oil wells on the site which appear to have been in operation from about 1937, when the Clinton Field was discovered, through the 1950s. Hunting Bayou was dredged for flood control purposes in the late 1940s, and a deep drainage ditch was constructed running east-west through the site. A residential subdivision was established on the south boundary of the site in 1952. The site is bordered on the north and west by pasture and industrial lands. The BGH is now predominantly wooded with two small mowed fields and several open drainage ditches.

The climate of the area is characterized by long hot summers and mild winters. Yearly average precipitation at Hobby Airport (3 km SW of the site) is 134.6 cm, well distributed throughout the year. Average annual temperature is approximately 21°C. January is the coldest month with mean daily temperatures of 12 °C. July is the warmest month with highs averaging 34 °C. The growing season is about 270 days (NCDC 2004).

Harris County lies within the Gulf Coastal Plain Physiographic Province (Fenneman 1938), which is a broad region of low relief stretching from the coast inland 100–150 miles and from Texas to western Georgia. Streams and rivers of the Gulf Coastal Plain drain into the Gulf of Mexico. The BGH site is situated on the Beaumont Geologic Formation (Shelby et al. 1993), a broad, flat, poorly drained sedimentary surface of sands and clays that appeared in the late Pleistocene when sea level was high during a warm interval (approximately 30–40,000 years ago) within the Wisconsin glacial period (Moore and Aronow 1994). The surface is cut, sometimes deeply, by shallow, short bayous draining into the Gulf of Mexico.

Houston is located on the edge of the Eastern Deciduous Forest Biome. The northern portion of the city is part of the Upper West Gulf Coastal Plain ecoregion (Weakley et al. 1998) often referred to as the Pineywoods (Gould 1975; Correll & Johnston 1970). In this ecoregion, *Quercus-Pinus* (oak-pine) forests dominate the landscape; stream and river bottoms are typically bottomland hardwood forest dominated by *Quercus* and *Liquidambar*. The southern portion of the city is part of the Gulf Prairies and Marshes ecoregion. In this ecoregion the original vegetation of the area was likely to have been mostly prairie, with bands of *Quercus-Pinus* forest on bluffs along bayous (Gould 1975; Correll & Johnston 1970) and *Ulmus americana, Fraxinus pennsylvanica,* and *Celtis laevigata* forest in the bottoms. Today, where native trees persist along drainages, *Quercus similis* Ashe (bottomland post oak) is sometimes one of the dominant oaks.

Three types of forest vegetation were identified at the site. On the flat uplands away from the bayou, *Ulmus americana, Fraxinus pennsylvanica,* and *Celtis laevigata* dominate [National Vegetation Classification System (NVCS) type *Ulmus americana-Celtis laevigata-Fraxinus pennsylvanica* Forest (NatureServe 2005)]. *Ligustrum* spp. and *Ilex decidua* are important shrubs. In the ground layer, coverage by graminoids is high, especially *Carex* spp. The second vegetation type occurs on flats and bluffs nearer the bayou. *Q. similis* and *Pinus taeda* are dominant but bands of *Quercus phellos* follow shallow drains. *Ilex decidua* and *Ilex vomitoria* form dense patches, and non native *Ligustrum* species are abundant. Coverage of graminoids in the ground layer is low to moderate. The only NVCS type containing *Q. similis* as a dominant is the *Quercus phellos-Q. similis/Crataegus marshallii-C. spathulata/Chasmanthium laxum* Forest (NatureServe 2005). All of these species except *C. spathulata* occur on the site. However, *Pinus taeda* is a canopy dominant, and *C. laxum* is of only modest importance in the ground layer. The likely interpretation is that the site vegetation represents a seral stage of this NVCS type. The third vegetation type on the site is a narrow riparian strip in the deeply incised ravine of Hunting Bayou dominated by *Platanus occidentalis, Salix nigra,* and *Populus deltoides*.

Soils of the site are clays, clay loam, and fine sandy loams of several series with Lake Charles Clay and Aldine Very Fine Sandy Loam being the most widespread (SCS 1976). The soils are poorly drained and of low agricultural productivity.

Plant collections were made during parts of three growing seasons, from Oct 2004 to Dec 2006. The site was visited sporadically Oct–Dec 2004, at approximately two-week intervals during Feb–Dec 2005, and occasionally Feb–June 2006. Approximately 700 specimens were collected and deposited at Rice University. In most cases, the nomenclature follows Jones et al. (1997) and Kartesz and Meacham (1999). Some recent literature sources were followed, especially some nomenclatural adjustments published in *Flora of North America* volumes (FNA 1993+).

Nativity was defined as presence in North America north of Mexico and was determined using Kartesz and Meacham (2001). Origins of non natives were determined using a variety of web sources, including Flora North America Online (www.efloras.org), Purdue University Dept of Horticulture (www.hort.purdue.edu/newcrop), University of California Jepson Herbarium (www.ucjeps.berkeley.edu/interchange.html), Global Compendium of Weeds (www.hear.org/gcw), Plants for a Future (www.pfaf.org/database), and Floridata (http://www.floridata.com).

The non native species were divided into four categories, ruderals (weedy herbs of waste places, disturbed areas, and dry,sandy soils), garden weeds, ornamentals (plants that appeared to have arrived at the site by dumping or planting), and invasives (species naturalized in native forests, wetlands or prairies). Native species were classed as ruderals, forest and woodland species, species of natural open habitats (savannas and prairies), or wetland species. Assignment to categories was based on the primary habitat as given by Correll and Johnston (1970) and modified by our experience. Classification of weedy species followed Kartesz and Meacham (2001).

Three major sources were used to check for possible county or state records: Turner et al. (2003) Diggs et al. (2006), and the collection at SBSC.

RESULTS

The vascular flora of the BGH site consists of 448 taxa in 259 genera in 97 families. The list may be found in the Appendix which contains information on life form, nativity, distribution, introduction, original source, habitat, and weediness.

All of the families are Angiosperms except five: two Gymnosperms (Pinaceae, Cycadaceae) and three Pteridophytes (Lygodiaceae, Polypodiaceae, Thelypteridaceae). Nearly half the families are represented by a single species, with only 18 containing more than five species. The top four familes contain more than one-third of the taxa. They are Asteraceae (59 taxa; 13.5%), Poaceae (57; 13.1 %), Cyperaceae (35; 7.6%), and Fabaceae (22; 5.0%). The largest genera are *Carex* (15 species), *Juncus* (9), *Cyperus* (9), *Euphorbia* (8), *Quercus* (7), and *Paspalum* (6).

More than half (54%) of the species are broad-leafed herbs (Monocots and Dicots). Graminoids are the second most important element (23%), with the remainder being split relatively equally between trees (9%), shrubs (6%), and vines (8%).

The species are mostly of broad distribution with more than half being from the southern US (Table 1). Only 6% are found primarily in Texas; one, (*Rhynchospora indianolensis*) is endemic to the state and another (*Zephyranthes traubii*) is known only from coastal Texas and NE Mexico (FNA 1993+ vol 19:302; Kartesz and Meacham 1999; Diggs et al. 2006). None of the species is known to be threatened or endangered (TOES 1993), though *R. indianolensis* and *Z. traubii* are poorly collected (Kartesz and Meacham 2001). Species of predominantly drier regions (central and southwest US) make up a very small fraction of the flora (ca 6%). About one-third of the species are from highly disturbed habitats, being either ruderals, garden weeds or ornamentals (Table 2). Open-habitat species (prairie, field and savanna) are slightly more common than closed-habitat species (forest or woodland). Approximately 58% of the taxa are classified as weeds according to Kartesz and Meacham (2001). None are on the Federal list of noxious weeds (USDA 2006). Two species (*Alternanthera philoxeroides* and *Triadica sebifera*) are listed as noxious in Texas (Texas Administrative Code 2005)

We found one new state record, *Syngonium podophyllum* (per Kartesz & Meacham 2001; Jones & Wipff 2003). This is a horticultural species introduced from Mexico which we have observed growing wild in several areas but apparently has not yet been formally documented as an escape from cultivation. Five new county records were found. *Cestrum nocturnum* is listed in Jones & Wipff (2003) as cultivated only. The specimen reported here is the first documentation of an escaped Texas population of this species. *Eleocharis acicularis, Rhynchospora indianolensis, Triodanis lamprosperma,* and *Zephyranthes pulchella* are indicated as absent from Harris County by Turner et al. (2003). Another species, *Juncus elliottii,* is known for Harris County only from a specimen at New York Botanical Garden (Diggs et al. 2006) and from the specimen collected in this study.

Species noteworthy for their showiness include one orchid (*Spiranthes vernalis*), spider lily (*Hymenocallis liriosme*), a *Crinum* cultivar, and two species of rain lily (*Zephyranthes pulchella, Z. traubii*).

Most of the species (81%) are native to the United States. Of non native species, about 76% are of Old World origin, 24% are from Mexico or South America, and 4% are of undetermined origin. The major Old World locations are Asia (29%), Europe (14%), and Eurasia (10%). Only 3 of the species are African in origin (*Cynodon dactylon, Crinum bulbispermum* and *Dioscorea bulbifera*).

DISCUSSION

The taxon count of 448 for the BGH site is somewhat lower than counts for most other sites in the region (401–930 taxa; Table 3). However, considering the relative uniformity of the site, as well as the absence of native prairie or savanna with their characteristically rich ground layer, the BGH site is surprisingly rich. This very small site (<50 ha) contains nearly 10% of all the species found in Texas. Species richness surpasses that of the 125 ha Hickory Creek Unit of Big Thicket National Preserve, which is approximately 200 km to the east (MacRoberts et al. 2002).

One contributor to the relative species richness of the site is non natives. They comprise 19% of the flora (87 spp), a substantially larger fraction than the 4–13% for natural areas in the region (Table 3). The largest number of non native species are ruderals (43 spp.; e.g., *Duchesnea indica, Stellaria media, Euphorbia nutans, Lamium amplexicaule*) or garden weeds (*Dioscorea bulbifera, Fatoua villosa, Ipomoea quamoclit, Oxalis debilis var. corymbosa, Phyllanthus urinaria*) that are adapted to highly disturbed sites and are commonly found at BGH in mowed areas of fields or along trails, pipelines or ditches. A second group of non natives (n=15), mostly ornamentals, appears to owe its presence at the site to more direct human agency, probably dumping from nearby homes (*Canna xgeneralis, Cestrum nocturnum, Citrus aurantium, Crinum bulbispermum, Cycas revoluta, Iris* sp., *Kalanchoe* sp., *Lycoris radiata, Mirabilis jalapa, Musa* sp., *Philodendron hederaceum* var. *oxycardium, Tradescantia pallida, Yucca* sp.). *Cyrtomium falcatum* (holly fern) appears to have arrived via floodwaters from upstream and *Pyracantha koidzumi* apparently germinated from bird-transported seed. The final group of non native species (n=22) appear to be naturalized components of native forests and prairies. This group

Table 1. Geographic distributions within USA of taxa at the BGH site (generalized from Kartesz & Meacham 2001).

	Number	Fraction
Central	16	0.04
East	80	0.18
South	82	0.18
Southeast	155	0.35
Southwest	8	0.02
TX	29	0.06
USA	73	0.16
Ornamental	5	0.01
Grand Total	448	1.00

Table 2. Numbers of taxa for which each listed habitat was considered to be the primary habitat (after Correll & Johnston 1970).

	Number	Fraction
Forest	119	0.27
Prairie, field, savanna	140	0.31
Wetland	50	0.11
Ruderal	114	0.25
Ornamental	15	0.03
Garden weed	6	0.01
Unknown	4	0.01
Total	448	1.00

Table 3. Species richness, total area and fraction non native for selected natural areas.

Site	Species	Area (ha)	Fraction Non native	Source
Botanic Garden of Houston, Harris Co., TX	446	50	0.19	This study
Hickory Creek Unit, BTNP, Tyler Co., TX	401	284	0.04	MacRoberts et al. 2002
Turkey Creek Unit, BTNP, Polk and Tyler Co., TX	738	3150	0.06	Brown et al. 2004
Big Branch NWR, St Tammany Parish, LA	563	5870	0.13	Rosen et al. 2003
Big Lake Bottom WMA, Anderson Co., TX	459	1685	0.05	Fleming et al. 2002
Gus Engeling WMA, Anderson Co., TX	930	4465	0.06	Singhurst et al. 2002
Middlesex Fells,Boston, MA	400	69	0.26	Drayton & Primack 1998
Pelham Bay Pk, New York City, NY	956		0.34	DeCandido & Lamont 2004
Highland Hts Community Pk, Cuyahoga County, OH	403	141	0.35	Jog et al. 2005
Shaker Median Park, Beachwood, Cuyahoga Co. OH	298	140	0.47	Delong et al. 2005

includes both herbaceous and woody plants (including shrubs and vines), some of which appear to be highly invasive locally. The most aggressive invaders at the BGH site are *Paederia*, *Lygodium*, *Ligustrum* spp, and *Triadica*. *Paederia* is very dense in parts of the BGH site, and it has been reported to be extremely aggressive at another nearby site (Brown 1992).

Ecologically, the non native flora differs from the native flora of the site in several ways. A slightly larger percentage of the non-natives is widely distributed in the USA (26%) than natives (14%) and more of the non native species are weedy and/or ruderal (68%) than natives (56%). Habitat designations are strongly skewed to disturbed sites and waste areas for non natives (56%) as opposed to natives (20%). It is also worth noting that the contribution of non native species from Latin America is substantially higher at BGH (21%)

than has been reported farther north (Central New York; 3%), as would be expected, considering location and climate.

Although the non natives are important at the BGH site, the non native percentage (19%) is somewhat lower than reported in other urban preserves (26–47%). Perhaps the percentage is lower because most of the site is either closed forest or frequently-mowed parkland. Areas of early successional vegetation are quite small. Also, urbanization has been more recent around the BGH site than around the other urban preserves listed in Table 3, so non native species may still be accumulating at the site. If insufficient time has passed for the full complement of non natives to have colonized the site, then it may explain lack of a southward increase in the fraction of non natives such as the trend identified by Pysek (1998) for central European cities. Clearly, more published data on the floras of urban preserves are required to identify important trends and their causes.

Generally speaking, a large fraction of the non native flora of the USA arrived via purposeful introduction for ornamentals, gardens, crops, forage or soil stabilization (Mack and Lonsdale 2001; Reichard and White 2001). For example, 49% of the non native flora of the Cayuga region of NY was planted at some time in that region or elsewhere in the USA (Marks et al. 2006). This appears true of the BGH site, as well. A substantial fraction (41%) of the non native species appear to have been introduced for some specific human use. The most notorious Texas example of escape from cultivation is *Triadica sebifera* (Chinese tallow tree), originally introduced as an ornamental by Benjamin Franklin, and subsequently as a potential oil-seed crop by the US Bureau of Plant Industry (Bruce et al. 1997).

Aside from non native plants, another important cause of high richness at the BGH site is the large percentage of native weeds (45% of the site flora). While weediness generally has a negative connotation, it must be emphasized that native weeds are a heterogeneous group, including not only native ruderals that are mostly restricted to disturbed and waste areas such as *Erigeron philadelphicus, Helianthus annuus,* and *Euphorbia nutans* (12% of the flora), but also many forest, prairie or marsh species that, because of broad ecological tolerances, high fecundity, and wide dispersal, are good colonizers of disturbed areas (32% of the flora), and consequently are present in many forest types. This latter group includes several important canopy dominant trees at the site, including *Ulmus, Celtis, Pinus,* and *Fraxinus.*

The importance of weediness is illustrated by the fact that, combining natives and non natives, 58% of flora is classed as weeds according to Kartesz and Meacham (2001). The weedy nature of the flora highlights, in turn, the long history of human use for grazing and logging and its role in determining species richness. Following cessation of burning and grazing nearly 50 years ago, there was ample opportunity for vagile members of native communities to colonize the site.

The final class of species that constitute the flora is non-weedy species that are commonly associated with less-disturbed habitats, and by definition are less fecund, vagile, or tolerant of a range of conditions than those species classified as weedy. They amount to 36% of the flora, and include species of both forested and non-forested habitats. The most notable forest species in this class is *Quercus similis*, one of the original site dominants which remains important. Many species of prairies and marshes (43% of the flora) are still present, but the prairie imprint has undoubtedly been substantially diluted by succession of prairie to forest on the western part of the site.

It is interesting to note that few species in the flora of the site have predominantly Western or Midwestern distributions. We found only one woody species that is more typical of drier regions to the west (*Maclura pomifera*) than to the humid region to the east. Other species such as *Symphoricarpos orbiculatus, Sapindus drummondii,* and *Acacia farnesiana,* which are present in the Houston area, were absent at this site. The prominence of eastern and southeastern taxa was previously identified for another protected area approximately 200 km North (MacRoberts and MacRoberts 2004). Together the results support the finding of MacRoberts and MacRoberts (2003) that the broad transition from eastern to western floras begins just west of Houston. Consequently, in spite of marked differences in appearance of the plant communities and the landscape across the transition from forest to prairies and woodlands that occurs in Houston, the flora remains predominantly Eastern. The richness of the flora of the site does not appear to be a result of mixing of species from different habitats or different regions.

With respect to disturbance, our results show that the list of habitat generalists is large and site heterogeneity is low, and so the effect of disturbance is to offer opportunity for weedy species to colonize and persist. Thus, richness is high because of the abundance of native and non native weedy species that tend to be habitat generalists of broad distribution.

These observations on the BGH site clearly illustrate the importance of weeds and non natives in modern urban floras. Because of this and the low abundance of habitat specialists, there seems little risk of harm through escape of additional non natives. Indeed, the opportunity exists to enhance diversity by controlling woody invasives and by reintroducing elements of the prairie vegetation that once occupied part of the site.

APPENDIX

Ecological characteristics of taxa at Herman Brown Park, Houston, Harris County, Texas. Column heads are as follows: **F**=life form; **O**=origin; **D**=Distribution in US; **I**=reason for introduction; **H**=habitat; **W**=weed status; **C**=specimen collection numbers (I.S.Elsik & W.W. Pruess unless otherwise noted). See below for key to column entries.

FAMILY	F	O	D	I	H	W	C
Acanthaceae							
Dicliptera brachiata (Pursh) Spreng.	H	N	SE		F	N	4602
Hygrophila lacustris (Schlecht. & Cham.) Nees	H	N	SE		P	W	4432
Justicia ovata (Walter) Lindau var. *lanceolata* (Chapm.) R.W. Long	H	N	SE		F	N	4161
Ruellia caroliniensis (J.F. Gmel.) Steud.	H	N	E		P	W	4282, 4434
Ruellia nudiflora (Engelm. & A. Gray) Urb.	H	N	TX		P	N	4445
Aceraceae							
Acer negundo L.	T	N	US		F	W	4187
Agavaceae							
Yucca aloifolia L.	S	N	SE	O	Or	N	4490, 4660
Yucca sp. L.	S				Or		4665
Alismataceae							
Sagittaria platyphylla (Engelm.) J.G. Sm.	H	N	SE		W	W	4429, 4304
Amaranthaceae							
Alternanthera philoxeroides (Mart.) Griseb.	H	SA	S	U	R	W	4165
Anacardiaceae							
Toxicodendron radicans (L.) Kuntze	V	N	E		F	W	4146, 4561
Apiaceae							
Bowlesia incana Ruiz & Pav.	H	N	SW		R	W	4094
Centella erecta (L. f.) Fernald	H	N	SE		R	W	4276
Chaerophyllum tainturieri Hook. var. *dasycarpum* Hook. ex S. Wats	H	N	TX		P	W	4426
Chaerophyllum tainturieri Hook. var. *tainturieri*	H	N	S		P	W	4064
Cyclospermum leptophyllum (Pers.) Sprague ex Britton & Wilson	H	SA	S	A	F	W	4266, 4202
Cynosciadium digitatum DC.	H	N	SE		P	N	4308
Eryngium hookeri Walp.	H	N	TX		P	N	4450
Hydrocotyle verticillata Thunb. var. *triradiata* (A. Rich.) Fernald	H	N	S		W	N	4265
Hydrocotyle verticillata Thunb. var. *verticillata*	H	N	S		W	N	4170
Limnosciadium pumilum (Engelm. & A. Gray) Mathias & Constance	H	N	SE	O	F	W	4193
Ptilimnium capillaceum (Michx.) Raf.	H	N	E		W	W	4310
Sanicula canadensis L.	H	N	E		F	N	4159
Torilis arvensis (Huds.) Link	H	EA	S	A	R	W	4209
Trepocarpus aethusae Nutt. ex DC.	H	N	SE		P	W	4377

FAMILY	F	O	D	I	H	W	C
Apocynaceae							
Trachelospermum difforme (Walter) A. Gray	V	N	E		F	W	4531
Aquifoliaceae							
Ilex decidua Walter	S	N	SE		F	W	4103
Ilex opaca Aiton	T	N	SE		F	N	4685
Ilex vomitoria Aiton	S	N	SE		F	W	4132
Araceae							
Colocasia esculenta (L.) Schott	H	P	SE	O	F	W	4466
Philodendron hederaceum (Jacq.) Schott var. *oxycardium* (Schott) Croat	V	SA	C	O	Or	N	4644
Syngonium podophyllum Schott	V	SA	SE	A	F	N	4538
Xanthosoma sagittifolium (L.) Schott	H	SA	TX	O	F	N	4444
Araliaceae							
Hedera helix L.	V	EA	SE	O	F	W	4333
Arecaceae							
Sabal minor (Jacq.) Pers.	S	N	SE		F	W	4301
Asclepiadaceae							
Asclepias viridis Walter	H	N	SE		P	W	4376
Matelea gonocarpos (Walter) Shinners	V	N	SE		F	N	4381, 4307
Asteraceae							
Acmella oppositifolia (Lam.) Jansen var. *repens* (Walter) Jansen	H	N	SE		W	N	4535
Ageratina altissima (L.) King & H. Rob.	H	N	E		P	W	4648
Ambrosia psilostachya DC.	H	N	US		P	W	4585
Ambrosia trifida L.	H	N	US		R	W	4428
Arnoglossum ovatum (Walter) H. Rob.	H	N	SE		P	N	4449
Baccharis halimifolia L.	S	N	E		P	W	4591, 4590
Bidens bipinnata L.	H	N	E		P	W	4575
Calyptocarpus vialis Less.	H	N	S		W	W	4070
Cirsium horridulum Michx.	H	N	S		P	W	4183
Cirsium texanum Buckley	H	N	C		R	N	4321
Conoclinium coelestinum (L.) DC.	H	N	E		F	W	4052
Conyza canadensis (L.) Cronquist var. *canadensis*	H	N	US		R	W	4424, 4417
Coreopsis tinctoria Nutt.	H	N	US		P	W	4395
Eclipta prostrata (L.) L.	H	N	S		W	W	4481, 4245
Elephantopus carolinianus Raeusch.	H	N	SE		F	N	4031
Erigeron philadelphicus L.	H	N	US		R	W	4068
Erigeron tenuis Torr. & A. Gray	H	N	S		R	N	4081, 4812
Eupatorium capillifolium (Lam.) Small	H	N	SE		R	W	4635
Eupatorium semiserratum DC.	H	N	SE		P	N	4472
Eupatorium serotinum Michx.	H	N	E		R	W	4027
Eupatorium X pinnatifidum Elliott	H	N	SE		R	W	4634
Euthamia leptocephala (Torr. & A. Gray) Greene ex Porter & Britton	H	N	SE		P	N	4586
Gaillardia aestivalis (Walter) H. Rock var. *aestivalis*	H	N	SE		P	N	4494
Gamochaeta coarctata (Willd.) Kerguelen	H	N	S		P	N	4230, 4200
Gamochaeta purpurea (L.) Cabrera	H	N	E		P	W	4092, 4198
Helenium flexuosum Raf.	H	N	E		R	W	4271
Helianthus annuus L.	H	N	US		R	W	4309
Helianthus simulans E.E. Wats.	H	N	TX		P	N	4589
Heterotheca subaxillaris (Lam.) Britton & Rusby	H	N	S		P	W	4447, 4129
Hypochaeris microcephala (Sch. Bip.) Cabrera var. *albiflora* (Kuntze) Cabrera	H	SA	TX	A	R	N	4084, 4199
Iva angustifolia Nutt. ex DC.	H	N	S		P	N	4636
Iva annua L.	H	N	C		W	W	4584
Krigia cespitosa (Raf.) K.L. Chambers forma *cespitosa*	H	N	S		P	W	4190, 4126

FAMILY	F	O	D	I	H	W	C
Krigia cespitosa (Raf.) K.L. Chambers forma *gracilis* (DC.) K.J. Kim	H	N	S		P	W	4172
Lactuca floridana (L.) Gaertn.	H	N	E		P	W	4506, 4587
Mikania scandens (L.) Willd.	V	N	E		P	W	4402
Packera tampicana (DC.) C. Jeffrey	H	N	SE		P	W	4156
Pluchea camphorata (L.) DC.	H	N	SE		P	W	4452, 4599
Pluchea foetida (L.) DC.	H	N	SE		P	N	4608
Pluchea odorata (L.) Cass.	H	N	S		P	W	4034
Pterocaulon virgatum (L.) DC.	H	N	TX		P	N	4632
Pyrrhopappus pauciflorus DC.	H	N	TX		P	N	4087
Rudbeckia amplexicaulis Vahl	H	N	SE		P	N	4264
Rudbeckia hirta L.	H	N	US		R	W	4367
Rudbeckia texana (Perdue) P.B. Cox & Urbatsch	H	N	SE		P	N	4407, 4505
Solidago canadensis L.	H	N	US		R	W	4656, 4013
Solidago gigantea Aiton	H	N	US		P	W	4597
Solidago stricta Aiton	H	N	SE		P	N	4631
Soliva sessilis Ruiz & Pav.	H	SA	SE	A	R	W	4201
Sonchus asper (L.) Hill	H	E	US	A	R	W	4086
Symphyotrichum divaricatum (Nutt.) G.L. Nesom	H	N	C		R	W	4629
Symphyotrichum dumosum (L.) G.L. Nesom	H	N	SE		P	N	4315
Symphyotrichum lanceolatum (Willd.) G.L. Nesom var. *lanceolatum*	H	N	C		P	N	4658
Symphyotrichum racemosum (Elliott) G.L. Nesom	H	N	E		P	N	4058
Symphyotrichum subulatum (Michx.) G.L. Nesom	H	N	E		R	W	4037
Taraxacum erythrospermum Andrz. ex Besser	H	C	US	A	R	W	4102
Verbesina virginica L.	H	N	S		P	W	4543
Vernonia missurica Raf.	H	N	S		P	N	4015
Youngia japonica (L.) DC.	H	As	S	A	R	W	4083, 4077
Betulaceae							
Carpinus caroliniana Walter	T	N	E		F	N	4389
Bignoniaceae							
Campsis radicans (L.) Seem.	V	N	E		F	W	4366
Catalpa bignonioides Walter	T	N	E		F	N	4387
Boraginaceae							
Heliotropium procumbens Mill.	H	N	SE		R	W	4461
Myosotis macrosperma Engelm.	H	N	E		F	N	4082
Brassicaceae							
Brassica juncea (L.) Czern.	H	As	US	A	R	W	4150
Cardamine debilis D. Don	H	P	S	A	R	N	4096, 4409
Lepidium virginicum L.	H	N	E		R	W	4215
Bromeliaceae							
Tillandsia usneoides (L.) L.	H	N	SE		F	N	4262, 4113
Cactaceae							
Opuntia sp. (L.) Mill.	S		TX		P		4489
Callitrichaceae							
Callitriche heterophylla Pursh	H	N	US		W	N	4176, 4242
Campanulaceae							
Lobelia appendiculata A. DC. var. *appendiculata*	H	N	E		F	W	4673
Lobelia puberula Michx.	H	N	E		P	N	4568
Triodanis lamprosperma McVaugh	H	N	S		P	N	4224
Triodanis perfoliata (L.) Nieuwl. var. *biflora* (Ruiz & Pav.) T.R. Bradley	H	N	US		R	W	4167
Cannaceae							
Canna x generalis L.H. Bailey	H		E	O	Or	N	4596
Caprifoliaceae							
Lonicera japonica Thunb.	V	As	E	O	F	W	4144

FAMILY	F	O	D	I	H	W	C
Sambucus nigra L. subsp. *canadensis* (L.) R. Bolli	S	N	US		F	N	4356
Viburnum dentatum L.	S	N	E		F	N	4340
Caryophyllaceae							
Cerastium glomeratum Thuill.	H	EA	US	A	R	W	4088
Sagina decumbens (Ell.) Torr. & A. Gray	H	N	SE		R	W	4243
Stellaria media (L.) Vill.	H	C	US	A	R	W	4069
Clusiaceae							
Hypericum hypericoides Crantz	S	N	E		P	W	4471, 4035
Commelinaceae							
Commelina caroliniana Walter	H	N	SE		F	N	4628
Commelina diffusa Burm.f. var. *diffusa*	H	N	S		F	N	4600
Commelina erecta L.	H	N	E		R	W	4662
Gibasis pellucida (M. Martens & Galeotti) D.R. Hunt	H	SA	SE	O		N	4443
Tradescantia pallida (Rose) D.R. Hunt	H	SA	SE	O	Or	N	4642
Convolvulaceae							
Dichondra carolinensis Michx.	H	N	S		R	W	4136
Ipomoea cordatotriloba Dennst. var. *cordatotriloba*	V	N	SE		R	W	4504
Ipomoea quamoclit L.	V	SA	S	O	G	W	*
Cornaceae							
Cornus drummondii C.A. Mey.	S	N	E		P	N	4155
Cornus foemina Mill.	S	N	S		W	N	4311
Nyssa sylvatica Marsh.	T	N	E		F	N	4360
Crassulaceae							
Kalanchoe cv. Adans.	H			O	Or	N	4643
Cycadaceae							
Cycas revoluta Thunb.	S	As	SE	O	Or	N	4580
Cyperaceae							
Carex caroliniana Schwein.	G	N	S		F	N	4229
Carex cherokeensis Schwein.	G	N	SE		F	W	4101
Carex complanata Torr. & Hook.	G	N	SE		F	N	4305
Carex corrugata Fernald	G	N	SE		F	N	4285
Carex flaccosperma Dewey	G	N	SE		F	N	4147, 4272
Carex frankii Kunth	G	N	S		P	W	4415, 4292
Carex intumescens Rudge	G	N	E		P	N	4100, 4353
Carex leavenworthii Dewey	G	N	E		P	N	4223
Carex louisianica L.H.Bailey	G	N	SE		P	W	4249
Carex lupulina Muhl. ex Willd.	G	N	E		P	W	4687
Carex oxylepis Torr. & Hook.	G	N	SE		F	W	4231
Carex reniformis Small	G	N	SE		P	N	4284
Carex retroflexa Muhl. ex Willd.	G	N	E		F	W	4226
Carex triangularis Boeckeler	G	N	SE		P	W	4268, 4287
Carex tribuloides Wahlenb.	G	N	E		W	N	4251
Cyperus croceus Vahl	G	N	SE		P	W	4363, 4550
Cyperus entrerianus Boeckeler	G	SA	SE	A	F	W	4051
Cyperus esculentus L.	G	N	US		R	W	4624
Cyperus ochraceus Vahl	G	N	SE		W	N	4612, 4059
Cyperus odoratus L.	G	N	US		P	W	4577
Cyperus pseudovegetus Steud.	G	N	SE		P	W	4253
Cyperus retrorsus Chapm.	G	N	SE		P	W	4574
Cyperus thyrsiflorus Schltdl.	G	N	SE		F	N	4355, 4548
Cyperus virens Boeckeler	G	N	SE		P	W	4234
Eleocharis acicularis (L.) Roem. & Schult.	G	N	US		W	N	4263, 4293
Eleocharis montana Roem. & Schult.	G	N	SW		W	N	4252
Eleocharis montevidensis Kunth	G	N	SW		P	N	4236, 4253
Fimbristylis dichotoma Vahl	G	N	SE		P	W	4578

FAMILY	F	O	D	I	H	W	C
Fimbristylis miliacea Vahl	G	N	SE		P	N	4462
Kyllinga brevifolia Rottb.	G	N	S		R	W	4238, 4482
Kyllinga odorata Vahl	G	N	SE		P	N	4579
Rhynchospora caduca Ell.	G	N	SE		P	N	4278
Rhynchospora corniculata (Lam.) A. Gray	G	N	SE		P	W	4288
Rhynchospora indianolensis Small	G	N	TX		P	N	4283, 4519
Scleria oligantha Michx.	G	N	S		P	N	4365
Dioscoreaceae							
Dioscorea bulbifera L.	V	Af	S	O	G	W	4351
Ebenaceae							
Diospyros virginiana L.	T	N	C		F	W	4259, 4194
Euphorbiaceae							
Acalypha gracilens A. Gray	H	N	E		P	W	4459
Acalypha rhomboidea Raf.	H	N	E		P	W	4416
Croton capitatus Michx. var. *lindheimeri* (Engelm. & A. Gray) Muell.-Arg.	H	N	SE		R	W	4394, 4457
Croton monanthogynus Michx.	H	N	C		P	W	4397
Euphorbia bicolor Engelm. & A. Gray	H	N	S		P	N	4475
Euphorbia dentata Michx.	H	N	E		P	W	4148
Euphorbia heterophylla L.	H	N	S		P	W	4540
Euphorbia maculata L.	H	N	US		P	W	4463
Euphorbia nutans Lag.	H	N	E		R	W	4458, 4507
Euphorbia prostrata Aiton	H	N	S		R	W	4241
Euphorbia serpens Kunth	H	N	US		R	W	4559
Euphorbia spathulata Lam.	H	N	US		R	W	4130
Phyllanthus pudens L.C. Wheeler	H	N	S		R	N	4562
Phyllanthus urinaria L.	H	As	SE	A	G	W	4547
Ricinus communis L.	H	M	US	O	F	N	4556
Triadica sebifera (L.) Small	T	Ch	SE	C	F	W	4258, 4588
Fabaceae							
Albizia julibrissin Durazz.	T	Ch	S	O	P	W	4373
Cercis canadensis L. var. *canadensis*	T	N	E		F	N	4419
Chamaecrista fasciculata (Michx.) Greene	H	N	E		R	W	4024, 4440
Desmanthus virgatus(L.) Willd.	H	N	TX		P	W	4011
Desmodium glabellum DC.	H	N	SE		F	N	4645, 4570
Desmodium paniculatum (L.) DC.	H	N	E		F	N	4510, 4647
Erythrina herbacea L.	S	N	SE		F	N	4649
Gleditsia triacanthos L.	T	N	US		F	N	4653, 4542
Glottidium vesicarium R.M. Harper	H	N	SE		R	W	4512
Kummerowia striata (Thunb. ex Murray) Schindl.	H	As	S	F	R	W	4565
Lathyrus pusillus Ell.	V	N	S		P	W	4151
Medicago polymorpha L.	H	EA	US	A	R	W	4079
Mimosa strigillosa Torr. & A. Gray	H	N	SE		P	W	4341
Neptunia pubescens Benth.	H	N	SE		P	N	4396
Rhynchosia minima (L.) DC.	V	N	SE		P	N	4573
Sesbania drummondii (Rydb.) Cory	S	N	SE		P	W	4385
Sesbania herbacea (Mill.) McVaugh	H	N	S		P	W	4621
Strophostyles helvola (L.) Elliott	V	N	E		P	W	4508, 4509
Trifolium incarnatum L.	H	E	E	C	R	W	4207
Trifolium repens L.	H	As	US	C	R	W	4116
unknown	V						4652, 4557, 4661
Vicia minutiflora D. Dietr.	H	N	SE		P	N	4143
Vicia tetrasperma (L.) Schreb.	H	E	E	F	R	W	4080
Fagaceae							
Quercus alba L.	T	N	E		F	N	4553

FAMILY	F	O	D	I	H	W	C
Quercus falcata Michx.	T	N	E		F	N	4532
Quercus laurifolia Michx.	T	N	SE		F	N	4674
Quercus nigra L.	T	N	SE		F	N	4479
Quercus phellos L.	T	N	SE		F	N	4133, 4464
Quercus similis Ashe	T	N	SE		F	N	4609, 4603
Quercus virginiana Mill.	T	N	SE		F	N	4500
Gentianaceae							
Centaurium pulchellum (Sw.) Druce	H	E	E	A	R	N	4260
Sabatia campestris Nutt.	H	N	TX		P	N	4298
Geraniaceae							
Geranium carolinianum L.	H	N	US		R	W	4063
Haloragaceae							
Myriophyllum pinnatum (Walter) Britton, Sterns & Poggenb.	H	N	S		W	W	4289
Proserpinaca palustris L. var. *amblyogona* Fernald	H	N	E		W	W	4303
Hamamelidaceae							
Liquidambar styraciflua L.	T	N	E		P	N	4124
Hydrophyllaceae							
Hydrolea ovata Nutt.	H	N	SE		W	W	4412
Hydrolea uniflora Raf.	H	N	SE		W	W	4403
Iridaceae							
Herbertia lahue (Molina) Goldblatt	H	N	TX		F	N	4164
Iris sp. L.	H						4484
Sisyrinchium langloisii Greene	H	N	TX		R	N	4131
Sisyrinchium minus Engelm. & A. Gray	H	N	TX		P	N	4180
Sisyrinchium rosulatum E.P. Bicknell	H	N	SE		R	N	4163, 4141
Juglandaceae							
Carya illinoensis K. Koch	T	N	C		F	N	4386
Juncaceae							
Juncus acuminatus Michx.	G	N	US		W	W	4233
Juncus bufonius L.	G	N	US		W	W	4244
Juncus diffusissimus Buckley	G	N	SE		P	N	4290
Juncus effusus L.	G	N	C		P	W	4185
Juncus elliottii Chapm.	G	N	SE		P	N	4257
Juncus marginatus Rostk.	G	N	SE		P	N	4392, 4227
Juncus repens Michx.	G	N	SE		P	N	4313
Juncus tenuis Willd.	G	N	US		F	W	4306, 4221
Juncus validus Coville	G	N	SE		P	W	4404
Lamiaceae							
Hedeoma hispida Pursh	H	N	US		P	W	4273
Lamium amplexicaule L.	H	EA	US	A	R	W	4122
Lycopus rubellus Moench.	H	N	SE		F	N	4607
Lycopus virginicus L.	H	N	E		F	N	4025
Micromeria brownei Benth.	H	N	SE		F	N	4317
Monarda citriodora Cerv. ex Lag.	H	N	US		P	W	4339
Prunella vulgaris L.	H	N	E		R	W	4191
Salvia coccinea Juss. Ex Murr.	H	N	SE		P	N	4676
Salvia lyrata L.	H	N	E		F	W	4076
Scutellaria drummondii Benth.	H	N	SW		R	N	4378
Scutellaria parvula Michx.	H	N	E		R	N	4177, 4127
Stachys crenata Phil.	H	N	TX		F	N	4089
Teucrium canadense L.	H	N	US		W	W	4026, 4354
Lemnaceae							
Lemna aequinoctialis Welw.	H	N	S		W	W	4483, 4473
Spirodela punctata (G. Mey.) C.H. Thomps.	H	N	SE		W	W	4299

FAMILY	F	O	D	I	H	W	C
Lentibulariaceae							
Utricularia gibba L.	H	N	E		W	W	4314
Liliaceae							
Allium canadense L. var. *canadense*	H	N	E		P	N	4075
Allium canadense L. var. *mobilense* (Regel) Ownbey	H	N	SE		P	N	4186
Crinum bulbispermum (Burm.) Milne-Redh. & Schweick.	H	Af	SE	O	Or	N	4686, 4641
Hymenocallis liriosme (Raf.) Shinners	H	N	SE		P	N	4312
Lycoris radiata Herb.	H	Ch	SE	O	Or	N	4536
Nothoscordum bivalve (L.) Britton	H	N	S		R	W	4074
Zephyranthes pulchella J.G. Sm.	H	N	S		P	N	4534, LB30762
Zephyranthes traubii (Hayward) Moldenke	H	N	TX		P	N	4515
Linaceae							
Linum medium (Planch.) Britton var. *texanum* (Planch.) Fernald	H	N	US		W	N	4295, 4493
Loganiaceae							
Gelsemium sempervirens (L.) Aiton	V	N	SE		P	W	4119
Mitreola petiolata (Gmel.) Torr. & A. Gray	H	N	SE		P	N	4522
Polypremum procumbens L.	H	N	S		R	W	4640
Lygodiaceae							
Lygodium japonicum (Thunb.) Sw.	V	As	SE	A	F	W	4323
Lythraceae							
Ammannia coccinea Rottb.	H	N	S		W	W	4142
Lagerstroemia indica L.	S	As	SE	O	P	W	4425
Lythrum alatum Pursh var. *lanceolatum* (Ell.) Torr. & A. Gray ex Rothrock	H	N	SE		W	W	4393
Magnoliaceae							
Magnolia grandiflora L.	T	N	SE		F	N	4324
Malvaceae							
Malvaviscus arboreus Cav. var. *drummondii* (Torr. & A. Gray) Schery	S	N	SE		P	N	4350
Modiola caroliniana (L.) G. Don	H	N	S		R	W	4152
Sida rhombifolia L.	H	N	S		P	W	4071, 4296
Sida spinosa L.	H	N	E		R	W	4572
Meliaceae							
Melia azedarach L .	T	As	S	O	F	W	4418
Menispermaceae							
Cocculus carolinus DC.	V	N	SE		F	W	4357
Moraceae							
Fatoua villosa Nakai	H	As	S	A	G	W	4485
Maclura pomifera (Raf.) C.K. Schneid.	T	N	US		P	W	4604
Morus alba L.	T	Ch	US	O	F	W	4567
Morus rubra L.	T	N	C		F	W	4106
Musaceae							
Musa sp. L.	H			O	Or	N	4488
Myricaceae							
Myrica cerifera L.	S	N	SE		P	W	4406
Nyctaginaceae							
Mirabilis jalapa L.	H	SA	SW	O	Or	W	4486
Oleaceae							
Chionanthus virginicus L.	T	N	SE		F	N	4437, 4362
Forestiera ligustrina Poir.	S	N	SE		F	N	4539, 4325
Fraxinus americana L.	T	N	E		F	W	4216
Fraxinus berlandieriana DC.	T	N	SW		F	W	4560, 4382
Fraxinus pennsylvanica Marshall	T	N	C		F	W	4173, 4411

FAMILY	F	O	D	I	H	W	C
Ligustrum lucidum Aiton	S	As	SE	O	W	W	4623
Ligustrum sinense Lour.	S	As	SE	O	F	W	4192
Onagraceae							
Gaura lindheimeri Engelm. & A. Gray	H	N	TX		P	N	4503, 4492
Gaura parviflora Dougl. ex Lehm.	H	N	US		R	W	4427
Ludwigia decurrens Walter	H	N	E		W	W	4521
Ludwigia glandulosa Walter	H	N	SE		W	N	4281
Ludwigia octovalvis (Jacq.) P.H. Raven	H	N	SE		W	W	4018
Ludwigia palustris (L.) Elliott	H	N	US		W	W	4212, 4430
Oenothera speciosa Nutt.	H	N	S		P	W	4162
Orchidaceae							
Spiranthes vernalis Engelm. & A. Gray	H	N	E		P	N	4294
Oxalidaceae							
Oxalis corniculata L. var. *wrightii* (A. Gray) B.L. Turner	H	N	C		R	N	4014
Oxalis debilis Kunth var. *corymbosa* (DC.) Lourteig	H	SA	SE	O	G	W	4062
Oxalis violacea L.	H	N	US		P	W	4555
Passifloraceae							
Passiflora incarnata L.	V	N	SE		F	W	4516
Passiflora lutea L.	V	N	SE		F	N	4474
Phytolaccaceae							
Phytolacca americana L.	H	N	E		F	W	4442
Pinaceae							
Pinus taeda L.	T	N	SE		F	W	4491
Plantaginaceae							
Plantago rhodosperma Dcne.	H	N	S		P	N	4091, 4134
Plantago virginica L.	H	N	US		R	W	4160
Platanaceae							
Platanus occidentalis L.	T	N	E		F	W	4361
Poaceae							
(Walter) Britton, Sterns & Poggenb.	G	N	E		R	W	4181, 4197
Andropogon glomeratus (Walter) Britton, Sterns & Poggenb. var. *pumilus* (Vasey) L.H. Dewey	G	N	S		P	W	4593, 4657
Andropogon virginicus L.	G	N	S		R	W	4619
Aristida purpurascens Poir. var. *virgata* (Trin.) Allred	G	N	SE		P	W	4620
Avena sativa L.	G	E	US	C	R	W	4208
Bothriochloa ischaemum (L.) Keng var. *songarica* (Rupr. ex Fisch. & C.A. Mey.) Celarier & Harlan	G	As	SW	F	R	W	4639
Bothriochloa longipaniculata (Gould) Allred & Gould	G	N	TX		P	N	4371
Briza minor L.	G	E	S	A	F	W	4178
Bromus catharticus Vahl	G	SA	US	F	R	W	4120
Chasmanthium latifolium (Michx.) H.O. Yates	G	N	S		F	N	4528
Chasmanthium laxum (L.) H.O. Yates var. *laxum*	G	N	SE		F	N	4438
Chasmanthium laxum (L.) H.O. Yates var. *sessiliflorum* (Poir.) Wipff & S.D. Jones	G	N	SE		F	N	4467
Chloris canterai Arech.	G	SA	TX	U	R	N	4368
Cynodon dactylon (L.) Pers.	G	Af	US	F	R	W	4267
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark var. *densiflorum* (E.L. Rand & Redfield) Gould & C.A. Clark	G	N	E			N	LB30549
C.A. Clark var. *lindheimeri* (Nash) Gould & C.A. Clark							
Dichanthelium commutatum (Schult.) Gould subsp. *commutatum*	G	N	S		P	N	4109
Dichanthelium acuminatum (Sw.) Gould &	G	N	E		R	N	4157, 4274
Dichanthelium dichotomum (L.) Gould subsp. *microcarpon* (Muhl. ex Ell.) Freckmann & Lelong	G	N	E		P	N	4246, 4614

FAMILY	F	O	D	I	H	W	C
Dichanthelium dichotomum (L.) Gould subsp. *roanokense* (Ashe) Freckmann & Lelong	G	N	E		P	N	LB30556
Dichanthelium laxiflorum (Lam.) Gould	G	N	SE		P	N	4256, 4364
Dichanthium aristatum (Poir.) C.E. Hubb.	G	I	S	F	R	N	4622
Digitaria ciliaris (Retz.) Koeler	G	N	S		R	N	4514
Echinochloa colonum (L.) Link	G	I	S	A	R	W	4423
Echinochloa muricata (P.Beauv.) Fernald	G	N	US		R	W	4204, 4627
Echinochloa walteri (Pursh) in A. Heller	G	N	E		P	W	4530
Eleusine indica (L.) Gaertn.	G	EA	US	A	R	W	4626
Elymus virginicus L.	G	N	C		P	W	4149
Eragrostis intermedia Hitchc.	G	N	S		P	N	4513
Hordeum pusillum Nutt.	G	N	US		R	W	4093
Leersia virginica Willd.	G	N	E		F	N	4280
Lolium perenne L.	G	EA	US	C	R	W	4179
Melica mutica Walter	G	N	SE		F	N	4108
Oplismenus hirtellus (L.) Beauv. subsp. *setarius* (Lam.) Mez	G	N	SE		F	N	4551
Panicum anceps Michx.	G	N	SE		F	W	4615
Panicum dichotomiflorum Michx.	G	N	US		R	W	4571
Panicum gymnocarpon Elliott	G	N	SE		W	N	4520
Panicum rigidulum Bosc ex Nees	G	N	S		W	W	4480, 4446
Paspalum dilatatum Poir.	G	SA	S	F	R	W	4145
Paspalum langei (E. Fourn.) Nash	G	N	SE		F	N	4254, 4222
Paspalum lividum Trin. Ex Schltdl.	G	N	TX		W	N	4451
Paspalum notatum Flueggé	G	SA	S	F	R	W	4239
Paspalum pubiflorum Rupr.	G	N	S		R	N	4237
Paspalum urvillei Steud.	G	SA	SE	F	R	W	4320, 4659
Phalaris caroliniana Walter	G	N	S		R	W	4300
Poa annua L.	G	E	US	A	R	W	4073
Polypogon monspeliensis (L.) Desf.	G	E	US	A	R	W	4211
Saccharum giganteum (Walter) Pers.	G	N	SE		W	W	4633
Schizachyrium scoparium (Michx.) Nash var. *divergens* (Hack.) Gould	G	N	SE		P	N	4616
Setaria parviflora (Poir.) Kerguélen	G	N	S		R	W	4331, 4433
Sorghum halepense (L.) Pers.	G	M	US	F	R	W	4196
Sphenopholis obtusata (Michx.) Scribn.	G	N	US		R	W	4203
Sporobolus compositus Merr. var. *drummondii* (Trin.) J. Kartesz & Gandhi	G	N	TX		R	N	4569
Sporobolus indicus (L.) R. Br.	G	SA	SE	A	R	N	4286
Steinchisma hians (Elliott) Nash	G	N	SE		W	N	4189, 4401
Stenotaphrum secundatum (Walter) Kuntze	G	N	SE		G	W	4335
Tridens strictus Nash	G	N	SE		F	W	4617
Urochloa reptans (L.) Stapf	G	N	TX		R	W	4455
Polygalaceae							
Polygala verticillata L.	H	N	C		P	N	4277
Polygonaceae							
Brunnichia ovata (Walter) Shinners	V	N	SE		F	W	4527, 4653, 4672
Polygonum densiflorum Meisn.	H	N	SE		W	N	4554
Polygonum hydropiperoides Michx.	H	N	US		W	W	4175, 4020
Rumex crispus L.	H	E	US	A	R	W	4319
Polypodiaceae							
Cyrtomium falcatum (L. f.) C. Presl	F	As	US	O	Or	N	4663
Polygonum punctatum Elliott	H	N	US		W	W	4630
Pleopeltis polypodioides (L.) E.G. Andrews & Windham subsp. *michauxiana* (Weatherby) E.G. Andrews & Windham	F	N	SE		F	N	4670

FAMILY	F	O	D	I	H	W	C
Pontederiaceae							
Heteranthera limosa Vahl	H	N	C		W	W	4408
Portulacaceae							
Portulaca oleracea L.	H	N	US		P	W	4460
Primulaceae							
Anagallis arvensis L.	H	E	US	A	R	W	4090
Anagallis minima (L.) K. Krause	H	N	US		P	W	4302, 4228
Samolus valerandi L. subsp. *parviflorus* (Raf.) Hultén	H	N	US		W	N	4316
Ranunculaceae							
Anemone berlandieri Pritz.	H	N	SE		P	W	4135
Clematis crispa L.	H	N	S		P	N	4110, 4469
Clematis terniflora DC.	V	J	E	O	R	N	4439
Ranunculus muricatus L.	H	E	S	A	R	W	4078
Ranunculus pusillus Poir.	H	N	S		R	W	4125
Ranunculus sardous Crantz	H	E	SE	A	P	W	4112
Rhamnaceae							
Berchemia scandens (Hill) K. Koch	V	N	SE		F	W	4085, 4174
Rosaceae							
Crataegus marshallii Eggl.	T	N	SE		F	W	4104
Crataegus viridis L.	T	N	SE		F	N	4105, 4275
Duchesnea indica (Andrews) Focke	H	As	E	O	R	W	4114
Prunus caroliniana (P. Mill.) Ait.	T	N	SE		F	N	JC3
Pyracantha koidzumi (Hayata) Rehd.	S	As	SE	O	Or	N	4558
Rubus argutus Link	V	N	S		R	W	4061
Rubus trivialis Michx.	V	N	SE		R	W	4552
Rubiaceae							
Diodia virginiana L.	H	N	SE		P	W	4332
Galium aparine L.	H	N	US		F	W	4065
Galium tinctorium L.	H	N	E		W	N	4072, 4138
Houstonia pusilla Schoepf	H	N	S		R	N	4107
*Mitchella repens*L.	H	N	E		F	N	JC1
Paederia foetida L.	V	As	TX	O	F	W	4405, 4345, 4655
Sherardia arvensis L.	H	M	E	A	R	W	4118
Rutaceae							
Citrus aurantium L.	T	As	SE	C	Or	N	4526
Zanthoxylum clava-herculis L.	T	N	SE		F	W	4217, 4400
Salicaceae							
Populus deltoides subsp. *deltoides* Bartram ex Marshall	T	N	US		F	W	4206
Salix nigra Marshall	T	N	E		F	W	4115, 4117
Sapotaceae							
Sideroxylon lanuginosum Michx.	T	N	S		F	N	4487, 4359, 4370
Scrophulariaceae							
Agalinis heterophylla (Nutt.) Small	H	N	SE		P	N	4592, 4646
Bacopa monnieri (L.) Pennell	H	N	S		W	W	4166
Gratiola virginiana L.	H	N	S		W	N	4169
anagallidea (Michx.) Cooperr.							
Mazus pumilus (Burm. f.) Steenis	H	EA	S	A	P	W	4261
Mecardonia procumbens Small	H	N	SW		W	N	4171
Penstemon tenuis Small	H	N	TX		P	N	4153
Veronica arvensis L.	H	EA	US	A	P	W	4095, 4128
Micranthemum umbrosum (J.F. Gmel.) S.F. Blake	H	N	SE		W	W	4210
Veronica peregrina L. subsp. *peregrina*	H	N	US		P	N	4139
Veronica persica Poir.	H	As	US	A	R	W	4137
Smilacaceae							
Smilax bona-nox L.	V	N	SE		F	W	4399, 4601

FAMILY	F	O	D	I	H	W	C
Smilax rotundifolia L.	V	N	E		F	W	4523
Smilax smallii Morong	V	N	SE		F	W	4111
Solanaceae							
Calibrachoa parviflora (Jussieu) D'Arcy	H	N	S		P	W	4240
Cestrum nocturnum L.	S	SA	TX	O	Or	N	4689, 4598
Solanum capsicastrum Link ex Schauer	S	U	S	O	R	N	4010, 4067
Solanum carolinense L.	H	N	US		R	W	4184
Solanum ptychanthum Dun.	H	N	US		R	W	4012
Sterculiaceae							
Melochia pyramidata L.	H	N	TX		R	N	4625
Thelypteridaceae							
Thelypteris kunthii (Desv.) C.V. Morton	F	N	SE		F	N	4420, 4650
Typhaceae							
Typha domingensis Pers.	H	N	US		W	W	4338
Typha latifolia L.	H	N	US		W	W	4337
Ulmaceae							
Celtis laevigata Willd.	T	N	US		F	W	4501, 4097
Ulmus alata Michx.	T	N	E		F	W	4529
Ulmus americana L.	T	N	E		F	W	4098, 4517
Ulmus crassifolia Nutt.	T	N	S		F	N	4654, 4390
Urticaceae							
Boehmeria cylindrica (L.) Sw.	H	N	E		F	W	4476
Valerianaceae							
Valerianella woodsiana Walp.	H	N	SE		F	W	4066
Verbenaceae							
Callicarpa americana L.	S	N	SE		P	W	4478, 4336
Lantana camara L.	S	N	SE		R	W	4441, 4391
Phyla nodiflora (L.) Greene	H	N	S		R	W	4372
Verbena brasiliensis Vell.	H	SA	S	A	R	W	4195
Verbena halei Small	H	N	S		F	N	4297
Verbena xutha Lehm.	H	N	S		R	N	4495
Violaceae							
Viola sororia Willd. var. *missouriensis* (Greene) McKinney	H	N	C		F	W	4318
Viscaceae							
Phoradendron serotinum (Raf.) M.C. Johnston subsp. *serotinum*	H	N	SE		P	N	4322
Vitaceae							
Ampelopsis arborea Koehne	V	N	SE		R	W	4422, 4344
Ampelopsis cordata Michx.	V	N	SE		F	W	4421, 4270
Parthenocissus quinquefolia (L.) Planch	V	N	E		F	W	4380
Vitis cinerea (Engelm.) Millardet var. *cinerea*	V	N	S		F	N	4497, 4269
Vitis mustangensis Buckley	V	N	TX		R	W	4021
Vitis rotundifolia Michx.	V	N	SE		F	W	4398

Life form. Tree **(T)**; shrub or subshrub **(S)**; vine **(V)**; broad-leaved herb (Monocot or Dicot) **(H)**; graminoid **(G)**; fern **(F)**.
Origin. United States **(N)**; Asia **(As)**; Africa **(Af)**; cosmopolitan **(C)**; China **(Ch)**; Europe **(E)**; Eurasia **(Ea)**; India **(I)**; Japan **(J)**; Mediterranean **(M)**; South America **(SA)**.
Distribution. Throughout US **(US)**; mostly limited to Texas **(TX)**; Southern **(S)**; Southeastern **(SE)**; Southwestern **(SW)**; Eastern **(E)**; Central **(C)**.
Introduction reason. Accidental arrival **(A)**; Crop **(C)**; forage **(F)**; ornamental **(O)**; ; unknown **(U)**.
Habitat. Forest or woodland **(F)**; prairie, field or savanna **(P)**; wetland **(W)**; ruderal **(R)**; garden weed **(G)**; ornamental **(Or)**.
Weed status. Weedy **(W)**; non-weedy **(N)** per Kartesz & Meacham (2001).
Collection Number. All specimens were collected by I.S. Elsik & W.W. Pruess, except for a few collected by L. Brown denoted by (LB) or Jeremy Caves (JC). *One species, *Ipomoea quamoclit*, is listed as sight record only.

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BOOK NOTICES

WU ZHENGYI and PETER H. RAVEN (EDITORIAL CO-CHAIRS). 1994. **Flora of China Illustrations, Vol. 14: Apiaceae through Ericaceae.** (ISBN 1-930723-51-2, hbk.). Missouri Botanical Garden Press, P.O. Box 299, Saint Louis, MO 63166-0299, U.S.A. (**Orders:** www.mbgpress.org, orders@mbgpress.org, 314-577-9547, 314-577-9594 fax). $125.00, 726 pp., line drawings, 8¾" × 11¼".

"This publication is the 11th in a series of 25 volumes of the *Flora of China Illustrations*. It accompanies the *Flora of China* (FOC) Volume 14, which was published in 2005 and treated 132 genera with 1498 species in nine familes. This volume of illustrations includes 697 figures representing a total of 1013 species in the Apiaceae (479 species), Aucubaceae (7 species), Clethraceae (7 species), Cornaceae (23 species), Diapensiaceae (5 species), Ericaceae (484 species), Helwingiaceae (4 species), Mastixiaceae (2 species), and Toricelliaceae (2 species)." The FOC Illustrations include line drawings previously published in the Chinese language *Flora Reipublicae Popularis Sinicae* (FRPS) and additional ones for taxa not or insufficiently illustrated in FRPS.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

MARY E. BARKWORTH, KATHLEEN M. CAPELS, SANDY LONG, LAUREL K. ANDERTON, and MICHAEL B. PIEP (eds.). 2007. **Flora of North America North of Mexico, Vol. 24: Magnoliophyta: Commelinidae (in part): Poaceae, Part 1.** (ISBN 978-0-19-531071-9, hbk.). Oxford University Press, 2001 Evans Road, Cary, NC 27513, U.S.A. (**Orders:** www.oup.com, 1-800-451-7556, 919-677-1303 fax). $95.00, 944 pp., line drawings, 8¾" × 11¼".

This volume is, both logically and numerically, the first of the two volumes in the Flora of North America devoted to the Poaceae (Grass Family). [Volume 25 was published in 2003]. It contains the family description and a key to all the tribes recognized in the two volumes. In addition, it includes treatments for genera in four subfamilies: **Pharoideae** [Phareae], **Bambusoideae** [Bambuseae, Olyreae], **Ehrhartoideae** [Ehrharteae, Oryzeae], and **Poöideae** [Brachyelytreae, Nardeae, Diarrheneae, Meliceae, Stipeae, Brachypodieae, Bromeae, Triticeae, Poeae]." "For the most part, the authors of the treatments determined the limits of the genera, species, and infraspecific taxa. The most controversial generic decisions are those in the Triticeae. At the species level, changes from existing treatments will be found in several genera, notably *Poa*, *Elymus*, *Calamagrostis*, *Deschampsia*, and *Puccinellia*." In all, 236 genera and 1373 species are treated in the two FNA grass volumes. Native species represent 65% of the total.

The county-level distribution maps are an outstanding feature of the FNA grass volumes. The maps are prepared from a geographic database maintained at the Intermountain Herbarium. "Larger, more informative versions of the maps are available on the Web at http://herbarium.usu.edu/webmanual/. They are updated as well-documented information is submitted." Combined [literature] citations for the two volumes are available at http://herbarium.usu.edu/grassbib.htm."—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

FLORA OF NORTH AMERICA EDITORIAL COMMITTEE (eds.). 2007. **Flora of North America North of Mexico, Vol. 27, Bryophyta, Part 1.** (ISBN 978-0-19-531823-4, hbk.). Oxford University Press, 2001 Evans Road, Cary, NC 27513, U.S.A. (**Orders:** www.oup.com, 1-800-451-7556, 919-677-1303 fax). $95.00, 944 pp., line drawings, 8¾" × 11¼".

Press Release from Oxford University Press.—"Flora of North America Volume 27 is the result of the collaboration of respected U.S. and Canadian botanical institutions. It treats the first half of the mosses, including 32 of the acrocarpous families, with introductory chapters on bryophyte morphology, the history of North America floristic bryology, and economic uses. The 84 species of sphagnum, of considerable economic importance, are examined fully, as well as the 37 genera and 621 species that make up the taxa."

Features include: **1)** full descriptions of the taxa; **2)** 136 panels of detailed line drawings; **3)** geographic distributions at the province and state level; **4)** distribution maps for native and established species, and **5)** a list of synonyms currently in use for the accepted names.—*Barney Lipscomb, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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HYPERICUM ADPRESSUM (CLUSIACEAE) NEW TO ARKANSAS AND THE OUACHITA MOUNTAINS, U.S.A

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ABSTRACT

Hypericum adpressum Bart. (Clusiaceae) is reported as new to the state of Arkansas. It was collected from a complex of natural depression wetlands in the eastern Ouachita Mountains of Saline County. A description of the habitat and list of associated species is provided.

RESUMEN

Se cita *Hypericum adpressum* Bart. (Clusiaceae) como nuevo del estado de Arkansas, en un complejo de depresiones pantanosas naturales en las montañas Ouachita del este del condado de Saline. Se aporta una descripción del hábitat y una lista de especies asociadas.

INTRODUCTION

Creeping St. John's wort, *Hypericum adpressum* Bart., (Fig. 1) is endemic to the eastern United States and is considered to be a species of conservation concern in all 19 states from which it is known (NatureServe 2006). Based on data from state natural heritage programs, this species is considered to be extant in 14 states, with a state conservation status rank of either S1 (critically imperiled) or S2 (imperiled), and is considered to be extirpated or possibly extirpated in 5 states. It has a global conservation status rank of G3 (vulnerable) and has the following ranks in each state: CT (SH), DE (S2), GA (S2?), IL (S1), IN (S1), KY (SH), MD (S1), MA (S2), MI (S1), MO (S1), NJ (S2), NY (S2), NC (SH), PA (SX), RI (S2), SC (S1), TN (S1), VA (S1), and WV (SH), where S1 = critically imperiled, S2 = imperiled, SH = possibly extirpated, and SX = presumed extirpated (NatureServe 2006). Habitats listed for the species include marshes, shores, marshy shores, wet meadows, bogs, swales, ditches, moist depressions in sand prairies, and along the shores and in shallow water zones of freshwater ponds (Gleason & Cronquist 1991; Godfrey & Wooten 1981; Radford et al. 1968; Yatskievych 2006; Enser 2001).

Hypericum adpressum was listed (as a woody plant) for Arkansas without comment or citation of a voucher by Moore (1941) and was also listed without comment or citation by Demaree (1943). Tucker (1976) excluded it from his treatment of the woody flora of Arkansas, noting its inclusion by Moore (1941) in a checklist of the ligneous flora of Arkansas despite the species being "wholly herbaceous." Smith (1988; 1994) excluded the species altogether from the flora of Arkansas noting that while Moore (1941) and Demaree (1943) included it, Adams (1973) did not include Arkansas in the range for *H. adpressum*. No specimens of the species have been reported in the recent inventory of herbaria by the Arkansas Vascular Flora Committee, who excluded it from the 2006 *Checklist of the Vascular Plants of Arkansas* (Arkansas Vascular Flora Committee 2006).

On 12 April 2006, while surveying a complex of natural depression wetlands on a terrace of the Alum Fork Saline River in northern Saline County, I observed several large colonies of young sterile stems and the previous year's dead stems of a rhizomatous, perennial *Hypericum* growing on the margins of two ponds (Fig. 2). Based on the habitat and rhizomatous character of the plants, I thought the plants might be *H. adpressum*, which I had seen in southeastern Missouri the previous year. Two rammets were removed from the Alum Fork population and maintained in cultivation until mid June 2006, when the plants began to flower. Based on reproductive features I confirmed that the plants were *H. adpressum*. I returned to the site on 21 June 2006 to collect voucher specimens, take photographs, and collect data for the Arkansas Natural Heritage

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Fig. 1. ***Hypericum adpressum*. Saline County, Arkansas. Note revolute leaf margins. 20 June 2006.**

Fig. 2. Habitat for *H. adpressum* in abandoned channel depression ponds on terrace of Alum Fork Saline River. Saline County, Arkansas. Emergent plants in foreground are stems of *H. adpressum*. 20 June 2006.

Program. I visited the ponds again on 17 August 2006 to collect fruiting specimens and conduct additional inventory. Tens of thousands of stems of *Hypericum adpressum* were found along the margins of these ponds within the zone of seasonal water fluctuation. The ponds were nearly dry on 17 August 2006.

Voucher Specimens: **ARKANSAS. Saline Co.:** Ouachita Mountains, locally common in zone of seasonal water fluctuation around several natural ponds on terrace above Alum Fork Saline River, 0.4 mi (0.6 km) SW of Lake Winona Dam, N34.79247, W92.85592 (NAD 83, Zone 15), Paron 7.5' quad. (specimen in flower), 20 Jun 2006, *T. Witsell & J. Pelton* 06-273 (anhc [herbarium of the Arkansas Natural Heritage Commission], MO, UARK); same locality (specimen in fruit), 17 Aug 2006, *T. Witsell* 06-397 (anhc [herbarium of the Arkansas Natural Heritage Commission], MO, UARK).

DISCUSSION

Natural depression wetlands are found along several of the larger streams in the Ouachita Mountains and are known to support disjunct or relict populations of plant species more typical of the Gulf Coastal Plain and Mississippi Alluvial Plain Ecoregions (e.g. *Pinus taeda* L., *Quercus lyrata* Walter, *Myrica cerifera* L., *Carex hyalinolepis* Steud., *C. gigantea* Rudge., *C. lupuliformis* Sartwell ex L.H. Dewey, *Eleocharis microcarpa* Torr., *Panicum verrucosum* Muhl., *Eupatorium album* L. var. *glandulosum* (Michx.) DC., *Acer rubrum* L. var. *drummondii* (Hook. & Arn. ex Nutt.) Sarg., *Lyonia mariana* (L.) D. Don., *Planera aquatica* J. F. Gmel., and *Taxodium distichum* (L.) Rich). Geomorphologically, these wetlands occur in abandoned stream channel scars on older stream terraces above present day floodplains. Along the Alum Fork Saline River, Middle Fork Saline River, and North Fork Saline River in the eastern Ouachita Mountains, these wetlands typically occur as small 0.1

to 1.6 ha (0.25 to 4 acre) forested depressions similar in appearance and species composition to the hydric flatwoods of the Mississippi Alluvial Plain and Gulf Coastal Plain. These wetlands are poorly drained, have clay soils, and typically have standing water up to 10 cm deep in the winter and spring but dry out on the surface in the summer. They are typically dominated by *Quercus phellos* L., *Quercus nigra* L., *Liquidambar styraciflua* L., *Fraxinus pennsylvanica* Marshall (and in rare cases support *Planera aquatica*, *Quercus lyrata* and *Taxodium distichum*) with scattered shrubs and a graminoid understory rich in sedges (*Carex* and *Eleocharis* spp.) and rushes (*Juncus* spp.) and often with extensive bryophyte cover (particularly *Sphagnum* spp.).

In at least three sites on the Alum Fork and North Fork in northern Saline County, these wetlands occur with deeper, open water ponds fringed by concentric zones of emergent herbaceous vegetation and shrubs. Water levels fluctuate throughout the growing season as water is lost to evaporation, exposing a ring of mudflats colonized primarily by annual species. The ponds at the Alum Fork site are dominated by open water with a fringe of scattered *Cephalanthus occidentalis* and dense stands of emergent vegetation dominated by perennial species including *Juncus effusus* L., *Juncus nodatus* Coville, *Carex lurida* Wahlenb., *Carex joorii* L.H. Bailey, *Carex ozarkana* P. Rothr. & Reznicek, *Carex gigantea* Rudge*, *Dulichium arundinaceum* (L.) Britton*, *Rhynchospora glomerata* (L.) Vahl, *Scirpus cyperinus* (L.) Kunth, *Rhexia virginica* L., *Xyris jupicai* Rich., *Viola lanceolata* L., *Eleocharis quadrangulata* (Michx.) Roem. & Schult. in Roem. et al, *Sagittaria platyphylla* (Engelm.) J.G. Sm., *Hypericum lobocarpum* Gatt., *Triadenum walteri* (J.F. Gmel.) Gleason, and *Panicum rigidulum* Bosc ex Nees. As the water recedes over the course of the summer, *Hypericum mutilum* L., *Eleocharis obtusa* (Willd.) Schult., *Eleocharis microcarpa* Torr.*, *Oldenlandia boscii* (DC.) Chapm., *Lindernia dubia* (L.) Pennell, and *Gratiola brevifolia* Raf.* dominate the exposed soil of the pond margins along with the perennial *Juncus repens* Michx. [* = species tracked as elements of conservation concern by the Arkansas Natural Heritage Commission].

The presence of small spoil piles with trees growing on them around several of the ponds at the Alum Fork site indicate that they were partially excavated in the past in an attempt to deepen them, perhaps as a source of water for cattle. However, it is clear from the size of the ponds relative to the size of the spoil piles as well as the physical, geomorphological, and floristic similarity of these ponds to undisturbed terrace wetlands nearby that they are natural wetlands.

Aside from *H. adpressum*, there are 15 taxa of *Hypericum* known from Arkansas (Arkansas Vascular Flora Committee 2006). Of these, *H. sphaerocarpum* Michx., which is also often rhizomatous and herbaceous, is the most likely to be confused with *H. adpressum*. It can be distinguished from *H. adpressum* by its flat leaf margins (vs. revolute in *H. adpressum*), its broadly ovoid to globose seed capsules with 4 to 8 seeds (vs. ellipsoid to ovoid capsules with numerous seeds in *H. adpressum*), and 2.0 to 2.7 mm long seeds (vs. 0.6 to 0.8 mm in *H. adpressum*) (Yatskievych 2006). *H. sphaerocarpum* often also has suffrutescent lower stems and rootstock (vs. entirely herbaceous in *H. adpressum*) (Yatskievych 2006). In Arkansas *H. sphaerocarpum* is typically found in calcareous glades and woodlands, shale barrens, and prairies, but is reported also from banks of streams and rivers, fens, and margins of ponds and lakes in Missouri by Yatskievych (2006). *H. punctatum* Lam., *H. perforatum* L., and *H. pseudomaculatum* Bush ex Britton are occasionally rhizomatous but differ from *H. adpressum* by having characteristic black glands on the sepals and/or petals.

The nearest known extant site to the Saline County population for *H. adpressum* is approximately 395 km (245 miles) to the northeast in Scott County, Missouri where it occurs in a moist depression in a sand prairie near Blodgett in the Mississippi Alluvial Plain (Tim Smith pers. comm.; NatureServe 2006). There are also two historical collections from Mississippi and Scott Counties, Missouri, both from 1933. (Tim Smith pers. comm., Yatskievych 2006); Aside from these records, *H. adpressum* is known only from east of the Mississippi River (NatureServe 2006). It is possible that the inclusion of *H. adpressum* for Arkansas by Moore (1941) and Demaree (1943) was based on a misidentified specimen that has since been annotated as another *Hypericum* species or that it was based on a properly-identified sight record or a specimen now lost.

When garden-grown plants of *H. adpressum* were compared to in situ plants of their parent population it was apparent that the cultivated plants, which grew in pots with well-drained soil that was allowed to dry out on occasion, branched profusely from the axils of the lower leaves (a condition absent in the wild plants). Wild plants also frequently had a shiny upper leaf surface compared to dull upper leaf surfaces in the cultivated plants. Both wild and cultivated plants grew in full sun. Wild plants in the wettest zones of the pond margins had a spongy, thickened lower stem consistent with plants called variety *spongiosum* by Robinson (1902) which was later downgraded to forma *spongiosum* by Fernald (1949). Both this form and the more typical form without this character were present in the population and were obviously correlated to the amount of water present where they grew.

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MONARDA LINDHEIMERI (LAMIACEAE): NEW TO ARKANSAS

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ABSTRACT

Monarda lindheimeri is reported as new to Arkansas. The overall distribution of the species in Louisiana and Texas and a comparison with a similar species are also discussed.

RESUMEN

Se cita como nueva para Arkansas *Monarda lindheimeri*. También se comenta la distribución total de la especie en Louisiana y Texas, y una comparación con una especie semejante.

Monarda lindheimeri Engelm. & A. Gray ex A. Gray occurs mainly in east Texas, where Turner et al. (2003) mapped it in 15 counties (Anderson, Brazos, Cass, Fannin, Galveston, Gonzales, Grayson, Grimes, Harris, Harrison, Montgomery, Morris, Walker, Waller, and Upshur). Additional Texas records include Colorado (*Brown 7472*, SBSC), Hardin (*Singhurst 2161*, BAYLU), Liberty (*Brown 15414*, SBSC), Madison (*Neill 1732*, TAMU), Marion (*Holmes 9967 & Singhurst*, BAYLU), and San Jacinto (*Brown 7566*, SBSC) counties. The few scattered records from Louisiana include Calcasieu Parish (Correll & Correll 1941), St. Landry Parish (McClintock & Epling 1942), Acadia and Jefferson Davis parishes (Thomas & Allen 1998), and Rapides Parish (Camp Beauregard, *Leonard 1560*, US!, determined and annotated by R. Scora).

The species is characterized by its single, terminal flower cluster (glomerule) composed of white flowers. The stamens are exserted beyond the upper lip of the corolla. Plants are more or less unbranched above and have midstem petioles 3–7 mm long or longer (~ 9 mm) if spreading pilose hairs are present. Although closely related to *Monarda fistulosa* L. var. *mollis* (L.) Benth., *M. lindheimeri* has been maintained as distinct by McClintock and Eppling (1942), Scora (1967), and Turner (1994, 2003). The cited variety of *M. fistulosa* may be distinguished from *M. lindheimeri* by being branched above, thus having several glomerules in a loose corymb, has flowers that are more pinkish to lavender, but occasionally white with a pinkish tint, and its midstem petioles are 8 mm or greater in length and are never spreading pilose.

Based upon the specimens cited below, we report the occurrence of *Monarda lindheimeri* in Arkansas.

Specimens: **ARKANSAS. Miller Co.:** County Road 32, 0.1 mi E of jct. with County Road 107 near Brightstar, 24 May 2006, *Holmes 13620 & Singhurst* (BAYLU); County Road 107, 0.7 mi S of jct. with AR Hwy 160 near Brightstar, 24 May 2006, *Holmes 13628 & Singhurst* (BAYLU).

Three populations of *Monarda lindheimeri* were found growing in red clay soils on exposed iron ore ridges on the Weches Geologic Formation (University of Texas Bureau of Economic Geology 1979). The first population mentioned above consisted of 55 genets, while the second population included 20 genets. Specimens were not collected from the third population, which was located about 200 m west from the first collection mentioned above. This population was comprised of 37 genets. Characteristic vegetation included *Pinus elliottii*, *Quercus marilandica*, *Q. stellata*, *Liquidambar styraciflua*, *Diospyros virginiana*, *Juniperus virginiana*, *Viburnum rufidulum*, *Vaccinium arboreum*, *Rhus copallina*, *Aesculus pavia*, *Berchemia scandens*, *Toxicodendron radicans*, *Schizachyrium scoparium*, *Panicum sphaerocarpon*, *Symphyotrichum patens*, *Hypericum punctatum*, *Helianthus hirsuta*, *Liatris elegans*, *Vernonia missurica*, *Stylosanthes biflora*, *Hypochaeris hirsuta*, *Lechea tenuifolia*, *Ascyrum hypericoides*, *Tephrosia virginiana*, *Echinacea angustifolia*, *Plantago aristata*, and *Ruellia humilis*.

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NEW RECORDS OF WETLAND AND RIPARIAN PLANTS IN SOUTHERN CALIFORNIA, WITH RECOMMENDATIONS AND ADDITIONS TO THE NATIONAL LIST OF PLANT SPECIES THAT OCCUR IN WETLANDS

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ABSTRACT

Panicum coloratum, *Panicum virgatum*, and *Setaria megaphylla* are exotic species reported for the first time for California. The following new or noteworthy records of native and non-native vascular plants are reported from wetland and riparian habitats in coastal southern California: *Amaranthus blitum* subsp. *emarginatus, Atriplex polycarpa*, *Bacopa monnieri*, *Beta vulgaris* subsp. *maritima*, *Chloris truncata*, *Ehrharta erecta*, *Elytrigia repens*, *Epilobium brachycarpum*, *Eriochloa aristata*, *Glinus radiatus*, *Limonium ramosissimum*, *Limonium* indet., *Oncosiphon piluliferum, Panicum dichotomiflorum* subsp. *dichotomiflorum*, *Paspalum urvillei*, *Psilocarphus chilensis*, *Salvinia molesta*, and *Setaria adhaerens*. Of these, *Amaranthus blitum* subsp. *emarginatus*, *Beta vulgaris* subsp. *maritima*, *Chloris truncata*, *Ehrharta erecta*, *Limonium ramosissimum*, *Oncosiphon piluliferum*, *Panicum coloratum*, *Panicum virgatum*, *Psilocarphus chilensis*, *Salvinia molesta*, *Setaria adhaerens*, and *Setaria megaphylla* are facultative wetland plants in California herein proposed for addition to the National List of Plants that Occur in Wetlands. Supplemental information is also provided to revise the current wetland indicator status for *Epilobium brachycarpum*, *Glinus radiatus*, and *Paspalum urvillei*. The new records presented herein suggest that focused floristic studies are needed to thoroughly document the flora of wetland and riparian communities in the South Coast region. In addition, watershed urbanization and exotic species established in suburban communities and in the wildland-urban interface have significantly modified the character of the native vegetation and integrity of many wetland and riparian ecosystems in coastal southern California.

Key Words: exotic species, hydrophytes, riparian, *Salvinia molesta*, urban runoff, wetlands, wetland indicator status, wetland plant lists, wildland-urban interface

RESUMEN

Panicum coloratum, *Panicum virgatum*, y *Setaria megaphylla* son especies exóticas citadas por vez primera para California. Se citan nuevos o importantes registros de plantas vasculares nativas y no nativas de humedales y zonas ribereñas de la costa sureña de California: *Amaranthus blitum* subsp. *emarginatus, Atriplex polycarpa*, *Bacopa monnieri*, *Beta vulgaris* subsp. *maritima*, *Chloris truncata*, *Ehrharta erecta*, *Elytrigia repens*, *Epilobium brachycarpum*, *Eriochloa aristata*, *Glinus radiatus*, *Limonium ramosissimum*, *Limonium* indet., *Oncosiphon piluliferum, Panicum dichotomiflorum* subsp. *dichotomiflorum*, *Paspalum urvillei*, *Psilocarphus chilensis*, *Salvinia molesta*, y *Setaria adhaerens*. Las siguientes especies: *Amaranthus blitum* subsp. *emarginatus*, *Beta vulgaris* subsp. *maritima*, *Chloris truncata*, *Ehrharta erecta*, *Limonium ramosissimum*, *Oncosiphon piluliferum*, *Panicum coloratum*, *Panicum virgatum*, *Psilocarphus chilensis*, *Salvinia molesta*, *Setaria adhaerens*, y *Setaria megaphylla* son plantas facultativas de humedales en California que son propuestas aquí para añadirlas a la Lista Nacional de Plantas que Habitan en Humedales. Se proporciona también información suplementaria para revisar el actual status indicador en humedales de *Epilobium brachycarpum*, *Glinus radiatus*, y *Paspalum urvillei*. Los nuevos registros presentados aquí sugieren que son necesarios estudios florísticos para documentar la flora de los humedales y las comunidades ribereñas de la región de la Costa Sur, además demuestra que la urbanización de la cuenca hidrográfica y la presencia de especies exóticas en comunidades suburbanas y en el punto de contacto entre tierras silvestres y urbanas han modificado considerablemente el aspecto de la vegetación nativa y la integridad de muchos humedales y ecosistemas ribereños in la costa sureña de California.

INTRODUCTION

Wetlands are lands periodically covered by shallow water or where saturation is the dominant factor that determines the nature of soil development and the types of plants and animals living in the soil and on its surface (Tiner 1999; USFWS 2004). Thus, flooding or soil saturation occurs at a duration and frequency that excludes many organisms not tolerant of the wetland environment (Brinson & Malvárez 2002). Wetlands are generally characterized by one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the

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substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin et al. 1979). The attributes of hydrology, hydric soils, and hydrophytic vegetation implicit to wetland definitions, were introduced by the U.S. Fish and Wildlife Service (USFWS) and remain an important and recurring theme in wetland regulatory policy in the United States (Shaw & Fredine 1956; Mitsch & Gosselink 2000; Somerville & Pruitt 2006).

As wetland policy evolved, the U.S. Army Corps of Engineers (USACE), the primary agency responsible for regulating wetlands, adopted a slightly different, but more restrictive definition than Cowardin et al. (1979). The term wetlands is defined as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (USACE 1987, 2006). This definition requires that each of the three attributes of hydrology, hydric soils, and hydrophytic vegetation typically be present to identify legal (or jurisdictional) wetlands. Although it is implicit that all wetlands have wetland hydrology, the Cowardin et al. (1979) and other definitions indicate that only one of the three parameters needs to be present (Batzer & Sharitz 2006). The USACE Wetland Delineation Manual, and the Arid West Regional Supplement for the western states, provide the technical guidance and procedures necessary to identify and delineate wetlands that may be subject to regulatory jurisdiction under Section 404 of the Clean Water Act (USACE 1987). Wetland delineations are based on a three-parameter approach involving regional indicators of hydrophytic vegetation, hydric soil, and wetland hydrology (USACE 2006).

Riparian habitats on the other hand are “mesic islands” of vegetation associated with narrow corridors of land that border lakes, creeks, rivers or other waters (Gregory et al. 1991; Malanson 1993). Riparian ecosystems are highly variable. They can support hydrophytic vegetation, upland vegetation, unvegetated areas, or a mosaic of these types, but usually exhibit distinctive geomorphic features and vegetation that develops in response to periodic flooding or exchange of surface or ground waters between rivers and streams and adjacent habitats (USFWS 2004; USACE 2006). In addition, riparian habitats support many facultative species adapted to and/or are tolerant of high soil moisture conditions that are not usually present elsewhere in western arid landscapes, including many species of deciduous trees that are often restricted to riverine or floodplain communities (Brinson et al. 1981; Holstein 1984; Smith et al. 1989; Pattern 1998). The indicators of hydrophytic vegetation, hydrology, and hydric soils, are therefore important attributes used to classify and characterize riparian habitats, which are also typically used to delineate and separate them from jurisdictional wetlands (Bennett et al. 1989; USACE 2006).

Wetlands of the California Floristic Province are extremely varied and complex (Ferren & Fiedler 1993). Rapid urbanization, poor historical documentation, and uncoordinated conservation efforts have often resulted in the widespread and unmitigated loss of wetland resources in southern California (Ferren & Fiedler 1993). Approximately 91% of California’s historic wetlands no longer exist, or the remaining habitats are often highly degraded (USFWS 1977; Dahl 1990, 2000). In addition, many wetland types have been underestimated in their diversity, richness, and unique functions and values. Since these losses occurred prior to detailed study, biologists and the general public may never fully understand or appreciate the composition, diversity, and functional values of many unique and regionally rare wetland communities in southern California (Ferren et al. 1996).

Riparian ecosystems have also suffered great losses. Estimates of 90-98% of the historic riparian habitats of central and southern California have been lost or seriously degraded by agricultural development, expanding urbanization, flood control projects, and other human-caused impacts (Katibah 1984; Swift 1984; Faber et al. 1989). Long-term human activities have also physically modified or permanently altered riparian ecosystems, which have frequently resulted in a decline of native species diversity (Bowler 1989; Brinson 1990). Thus, structurally complex riparian communities that support a diverse assemblage of native species are threatened in southern California (Bowler 1989; Ferren & Fiedler 1993).

Paradoxically, as a result of expanding urbanization, the extent of wetland and riparian vegetation communities has significantly increased in many suburban and urban watersheds. Expanding wetland and riparian habitat in urban settings can be attributed to new water sources generated by over-irrigation of lawns and landscaping in commercial and residential development projects, discharge of municipal water treatment plant effluent into drainages, and increased dry-season stream flows associated with decreased precipitation infiltration and increased hard-surface runoff following storm events (Arnold & Gibbons 1996; Paul & Meyer 2001; Greer & Stow 2003; Burkhart & Kelly 2005; Burkhart 2006; White & Greer 2006). In a San Diego County case study, the acreage of riparian vegetation in the lower Los Peñasquitos Creek watershed increased by 56–74% between 1969 and 1982, and increased by 118–129% between 1988 and 2000, which was accompanied by a shift from an historic oak-dominated riparian community, characterized by intermittent stream flows, to a willow-dominated community associated with urban-induced perennial stream flows (White & Greer 2006). With ongoing development, more buildings and paved areas mean greater quantities of storm runoff, and growth in population and industry will also generate a proportional increase in wastewater discharges into stream and river channels. In Orange County, it is predicted that base flows for the Santa Ana River may increase by 100,000 acre-feet over the next 20 years due to urban development in upstream areas (OCWD 2006). This phenomenon is especially important since almost no perennial streams existed in southern California prior to urban development (Ellis & Lee 1919; Troxell 1948; Poland 1959; Bader 1969). In addition, escalating urban development in the upper reaches of coastal watersheds is also the likely source of new exotic plant propagules that are actively being dispersed downstream via urban drainage systems into native plant communities. Similar circumstances have been documented in expanding desert urban communities. In Las Vegas, Nevada, urban growth has generated increased discharge of municipal waters, hard-surface runoff, and storm water flows into ephemeral washes that has promoted development of extensive native wetland communities, which, over time, have been degraded by erosion and the invasion of exotic species as population pressures increase (Shanahan & Crear 2004).

Although species richness may be high, many urban wetlands are floristically degraded, often with 15% to more than 50% of the plants present being introduced species (Magee et al. 1999; Burkhart & Kelly 2005; Burkhart 2006). However, there has been little research published on the influence of urbanization-induced hydrologic changes on wetland and riparian vegetation communities, and the distributions of native and exotic plants in multi-use urban watershed environments (Poff et al. 1997; Dwire et al. 2000; Paul & Meyer 2001; Burkhart 2006). Other examples of large intermittent streams in the urban environments of southern California that are now characterized by increased dry-season base flows and other altered hydrologic regimes, and/or that support perennial flows across large segments of their drainage, include the lower watersheds of the Los Angeles River and Arroyo Seco Creek in Los Angeles County, the Santa Ana River, San Gabriel River, San Diego Creek, and San Juan Creek in Orange County, and Temescal Wash in Riverside County. The composition and areal extant of the pre- and post-urban development of wetland and riparian vegetation communities relative to new inputs of municipal water supplies has not been critically studied in many of these and other watersheds in southern California.

The natural hydrologic regimes of many of our coastal waters have now become altered owing to the advent of urbanization. Because identification of individual hydrophytes and hydrophytic vegetation communities is a major determinant of federally regulated wetlands, it has become increasingly important to identify native and exotic plants as wetland indicators in urban and urban fringe environments, which can further assist biologists during wetland delineations (Tiner 1991, 1993, 2006). During wetland delineations, hydrophytic vegetation decisions are based primarily on the wetland indicator status assigned to individual plant species compiled on the National List of Plant Species that Occur in Wetlands (Reed 1988; USACE 2006).

The purpose of this paper is to identify overlooked native or previously unreported exotic hydrophytes that would: 1) improve the accuracy and efficiency of wetland delineation procedures; 2) identify native and exotic elements of hydrophytic vegetation communities important to the conservation and restoration of wetland and riparian habitats in coastal southern California; and 3) demonstrate the need to carefully inventory unique seasonal wetland habitats prior to development, and to establish ongoing floristic monitoring of anthropogenic changes to wetland and riparian vegetation in southern California's rapidly urbanizing communities.

THE NATIONAL LIST OF PLANT SPECIES THAT OCCUR IN WETLANDS

The distribution and abundance of hydrophytes in the flora and vegetation of southern California often define or characterize wetland and riparian ecosystems. The USFWS developed lists of wetland plants in order to assist in the field identification and classification of wetland communities according to the Cowardin et al. (1979) system (Reed 1988). Plant species that occur in wetlands (hydrophytes) are defined as species that demonstrate the ability to achieve maturity and reproduce in an environment where all or portions of the soil within the root zone is periodically saturated, continuously saturated, or inundated with water, and/or the substrate is at least periodically deficient in oxygen due to excessive wetness during the growing season (Reed 1988; Mitsch & Gosselink 2000; Tiner 1991, 2006). Roughly one third of the nation's vascular plants have some potential for being hydrophytes (Tiner 2006).

Two editions of the National List of Plant Species that Occur in Wetlands (National List) are currently published and available for use, an approved list compiled by Reed (1988) and a revised draft list prepared by the USFWS (1996); hereafter referred to as the 1988 list and the 1996 draft list (respectively). The National List was generated from 13 regional lists, including a list for California, which is Region 0 (Reed 1988; Tiner 2006). A given plant species may be a better indicator of wetlands in one region than it is in another; the regional wetland plant lists have been used to help identify wetland communities that can be recognized entirely on their vegetation components (Tiner 1991, 2006). Accordingly, wetland indicator categories of individual plant species on the regional lists have been created in order to further assist biologists with the delineation of wetland and riparian habitats throughout the United States (Tiner 1993, 2006; Mitsch & Gosselink 2000; USACE 2006). Each native or non-native species on these lists is assigned an indicator status reflecting its frequency of occurrence (not degree of wetness) in wetlands (Reed 1988), which is described in Table 1.

METHODOLOGY

Voucher specimens and other data were collected during wetland delineations, focused botanical surveys, and casual floristic surveys of wetland and riparian habitats associated with urbanized watersheds in southern California. Primary areas of study included the coastal bays and estuaries of Los Angeles, Orange, and San Diego counties, Arroyo Seco Creek and the San Gabriel River drainage in Los Angeles County, Aliso Creek, San Diego Creek, San Juan Creek, and the Santa Ana River drainage in Orange County, and the Lake Elsinore basin and San Jacinto River-Salt Creek drainage in western Riverside County.

Our approach to identifying previously unreported hydrophytes follows the "individualistic concept" of a hydrophyte defined by Tiner (1988). The individualistic concept recognizes that plant species may exhibit considerable plasticity or ecological amplitude in their adaptations to wet environments, which may represent the entire population of a species or only a subset of individuals (Tiner 1988, 1991). The potential adaptation and behavior of a species that functions as a hydrophyte in new environments is particularly important in coastal southern California where new sources of urban water has effected the spread and establishment of several exotic plant introductions that would not likely occur in this otherwise arid environment.

Field experiences in southern California, a review of the literature, a review of habitats and species data available from local herbaria (RSA-POM, UCR) and online from the Consortium of California Herbaria (2006), and well-known wetland species with which it is commonly associated were used to assign an indicator status for each of the unreported hydrophytes evaluated for addition to the National List. Identification of associated hydrophytic vegetation, wetland hydrology, and/or hydric soils of the plant community in which the suspected hydrophyte occurs follows the methodology described in the USACE Wetland Delineation Manual and the Arid West Regional Supplement (USACE 1987, 2006).

In addition, evaluation of landform position and plant community type in which the suspected hydrophyte is typically found (i.e., streamside riparian scrub), widespread wetland types (i.e., coastal bay salt marsh), aquatic sites (i.e., shallow ponds and slow-moving streams), location of its microhabitat community along moisture gradients (i.e., depressions in vernal alkali flats), man-made or man-modified habitats that

TABLE 1. Wetland Indicator Status for the National List of Wetland Plant Species that Occur in Wetlands.

Definitions for Wetland Indicator Status

Indicator Category	*Estimated Probability of Occurrence in Wetlands*
Obligate Wetland (OBL)	Plants that almost always occur in wetlands; >99% of the time.
Facultative Wetland (FACW)	Plants that usually occur in wetlands; 67–99% of the time.
Facultative (FAC)	Plants that are just as likely to occur in wetland and in non-wetland areas; 34–66% of the time.
Facultative Upland (FACU)	Plants that occasionally occur in wetlands; 1–33% of the time.
Upland (UPL)	Plants that almost always occur in uplands; 99% of the time.
No Indicator (NI)	Assigned to plants that lack sufficient information to base an indicator status.
No Agreement (NA)	Assigned where reviewers could not achieve a unanimous agreement for an indicator.
Asterisk (*)	Assigned to indicators derived with limited ecological information, which indicates a tentative assignment that requires further review.

In addition, a plus (+) or minus (-) designation, respectively, indicates the higher or lower range for a particular indicator.

exhibit minimal hydric characteristics (i.e., ditches with seasonal flowing water or seasonal saturation that support a predominance of facultative weedy species), and/or easily recognized morphological adaptations to wet areas (e.g., shallow root systems developed on or near the soil surface) were observed during this study and further indicate these plants are functioning as hydrophytes in southern California.

NEW RECORDS OF WETLAND AND RIPARIAN PLANTS

Voucher specimens, generalized distribution, habitat association, taxonomic notes (where appropriate), a literature review, and the wetland indicator status for California are cited for each taxon discussed in this paper. References to biogeographic provinces follow Hickman (1993). Common names provided in the species discussions follow the treatments of generic experts, or if not available, we use the common name provided by Roberts (1998), DiTomaso & Healy (2003), Roberts et al. (2004), and Rebman & Simpson (2006). Facultative plants proposed for addition to the California regional list, and revisions and/or recommendations to the wetland indicator status for other species currently on the list are provided. Where appropriate, additional representative voucher specimens with notes on habitat and associated facultative plants are also provided to further establish the facultative behavior of each taxon discussed, which follows:

Amaranthus blitum L. subsp. **emarginatus** (Uline & Bray) Carretero (Amaranthaceae)

CALIFORNIA. **Los Angeles Co.:** City of Pico Rivera, San Gabriel River, Thienens Rd. near confluence with San Jose Creek, UTM (NAD 83) 11S 0405107E 3766943N, elev. 74 m (243 ft), uncommon on river banks and in wet sand, 28 Aug 2004, *Riefner 04-406* (RSA). **Orange Co.:** City of Anaheim, Santa Ana River bottom near 57-Freeway between Orangewood St. and Chapman Ave., UTM (NAD 83) 11S 0418311E 3739098N, elev. 41 m (135 ft), locally abundant in disturbed wetlands and on sandbars, 8 Aug 2004, *Riefner 04-370* (RSA); City of Yorba Linda, N floodplain of Santa Ana River near Yorba Linda Regional Park, UTM (NAD 83) 11S 0430355E 3748269N, elev. 98 m (321 ft), common in wet river wash sand, 25 Sep 2004, *Riefner 04-442* (RSA); City of Huntington Beach, Huntington Central Park at Goldenwest St., UTM (NAD 83) 11S 0406898E 3730128N, elev. 1.5 m (5 ft), locally common and highly invasive in wet ditches, drying streambeds, and margins of riparian woodlands, 9 Jul 2005, *Riefner 05-546* (RSA); City of Irvine, San Diego Creek at Alton Pkwy., UTM (NAD 83) 11S 0429107E 3724401N, elev. 45 m (148 ft), locally common in wet sand along slow-moving waters, 30 Sep 2006, *Riefner 06-458* (RSA).

Previous knowledge.—Amaranthus blitum L. (purple amaranth, livid amaranth), of tropical origin, is well established in many disturbed habitats in the eastern United States and Canada (Mosyakin & Robertson 2003). The distribution of the infraspecific taxa of the *A. blitum* complex is poorly known in North America however, and requires additional study (Mosyakin & Robertson 2003). *Amaranthus blitum* subsp. *emarginatus* was not treated in The Jepson Manual (Henrickson 1993). It was first reported in California from waste ground and potted plant containers in Los Angeles and Riverside counties (Hrusa et al. 2002). Additional localities for *A. blitum* subsp.

emarginatus, including populations from cultivated ground, have been reported for western Riverside County, but not from Orange County (Roberts 1998; Roberts et al. 2004). *Amaranthus blitum* (infraspecific taxon not cited) has been reported from a yard in San Diego County (Consortium of California Herbaria 2006; Rebman & Simpson 2006).

Wetland Indicator Status.—*Amaranthus blitum* subsp. *emarginatus* was not assigned a wetland indicator status for any region on the 1988 list or the 1996 draft list, but *A. blitum* has been assigned a FAC wetland indicator status for Hawaii on the 1996 draft list.

Significance and Recommended Indicator Status.—First report of *A. blitum* subsp. *emarginatus* documented for Orange County, and second report for Los Angeles County. Adapted to tropical and subtropical climates, *A. blitum* subsp. *emarginatus* was expected to be only a minor weed of greenhouse or garden situations in California (Hrusa et al. 2002). However, it has naturalized and is spreading from yards and fields to disturbed vernally moist soils, seasonal wetlands, and riparian habitats in the mild Mediterranean climate of coastal southern California. In Huntington Beach, this taxon is highly invasive in disturbed riparian scrub and wetland habitats. These new habitat records indicate *A. blitum* subsp. *emarginatus* is undergoing a range expansion and will likely colonize numerous disturbed wetlands and other moist sites associated with urbanized watershed habitats.

Based on field observations, and information available in the literature and the Consortium of California Herbaria (2006), *A. blitum* subsp. *emarginatus* should be added to the California regional list. We propose a FAC* wetland indicator status. Additional regional review is needed to specifically define its frequency of occurrence in wetlands as the species undergoes further expansions of range and invasion of new habitats.

Atriplex polycarpa (Torr.) S. Watson (Chenopodiaceae)

CALIFORNIA. **Riverside Co.:** City of Lake Elsinore, back basin of Lake Elsinore, W ca. 0.5 mi off Pete Lehr Dr. at Diamond Stadium in Wildlife Viewing Area, UTM (NAD83) 11S 0471224E 3723561N, elev. 402 m (1320 ft), locally common in *Distichlis* grassland, 7 Jul 2004, *Riefner 04-306* (RSA, UCR).

Previous knowledge.—*Atriplex polycarpa* (desert saltbush) inhabits fine-textured saline soils of warm desert shrub and saltgrass communities from 60-1500 m elevation in Arizona, California, Nevada, Utah, and northern Mexico (Welsh 2003). In California, it occupies alkaline flats and dry lakes in the San Joaquin Valley, Transverse and Peninsular Ranges, and the region lying east of the Sierra Nevada south through the California deserts (Taylor & Wilken 1993). It has not been recorded from Orange County or western Riverside County (Roberts 1998; Roberts et al. 2004; Consortium of California Herbaria 2006). With the exception of the alkali plains of the Hemet and San Jacinto River Valleys, and the coastal salt marshes, little attention has been paid to the study of alkaline soil plant communities in southern California (Riefner & Boyd 2005a).

Wetland Indicator Status.—*Atriplex polycarpa* has been assigned a FACU wetland indicator status for California on the 1988 list and the 1996 draft list.

Significance and Recommended Indicator Status.—First report of *A. polycarpa* documented for western Riverside County. This is one of a suite of seasonal wetland species, including *Eleocharis obtusa* (Willd.) Schultes var. *engelmannii* (Steud.) Gilly and *Psilocarphus chilensis* (*P. tenellus* Nutt. var. *globiferus* [DC.] Morefield), that is more typical of California's Central Valley (Boyd & Ross 1996; Riefner et al. 2002). No changes to the wetland indicator status are proposed at this time.

Bacopa monnieri (L.) Wettst. (Scrophulariaceae)

CALIFORNIA. **Orange Co.:** City of Yorba Linda, Santa Ana River bottom near Yorba Linda Regional Park, UTM (NAD 83) 11S 0429795E 3747941N, elev. 96 m (315 ft), locally common in wet river wash sand, 3 Sep 2004, *Riefner 04-419* (RSA).

Previous knowledge.—*Bacopa monnierii* (Monnier water hyssop), native to tropical and subtropical regions nearly worldwide, grows in wet soil or in shallow water in the Sonoran Desert (eastern Riverside County) to the southern United States (Strother 1993; DiTomaso & Healy 2003). It is apparently a recent alien, just becoming naturalized in our area, including San Diego County (Strother 1993; Consortium of California Herbaria 2006; Rebman & Simpson 2006). *Bacopa monnierii*, however, has not been recorded from western Riverside County or Orange County (Roberts 1998; Roberts et al. 2004).

Wetland Indicator Status.—*Bacopa monnierii* was not assigned a wetland indicator status for California on the 1988 list, but has been assigned an OBL wetland indicator status on the 1996 draft list.

Significance and Recommended Indicator Status.—First record of *B. monnierii* documented for Orange County. *Bacopa monnierii* is one of many subtropical and tropical weeds that are adapting well to disturbed urban wetlands in the South Coast region. We concur with the revised OBL indicator status assigned on the 1996 draft list.

Beta vulgaris L. subsp. **maritima** (L.) Arcangeli (Chenopodiaceae)

CALIFORNIA. **Los Angeles Co.:** Torrance, Victoria Park, Dominguez Channel, vicinity of Del Amo Blvd. and Carson Plaza Dr., UTM (NAD 83) 11S 0382502E 3746087N, elev. m (28 ft), uncommon, growing with *Distichlis* and *Atriplex lentiformis* in seasonally saturated alkali grasslands, 29 Jul 2006, *Riefner 06-329* (RSA). **Riverside Co.:** City of Wildomar, near Lake Elsinore, N ca. 0.25 mi from the intersection of Union St. and Corydon Rd., UTM (NAD 83) 11S 0471584E 3720254N, elev. 367 m (1205 ft), uncommon, growing with *Distichlis*, *Plantago elongata*, *Nitrophila occidentalis*, and *Centromadia pungens* subsp. *laevis* in seasonally saturated soils of depressions in alkali meadows, 22 Apr 1998, *Riefner 98-266* (RSA).

Previous knowledge.—*Beta vulgaris* subsp. *maritima* (sea beet), native to southern Europe, inhabits waste areas and moist, sandy places near the coast in New Jersey and southern California (Shultz 2003). In California, it has been collected from low-lying and upland habitats in Los Angeles, San Diego, and Santa Barbara counties, but not Orange or Riverside counties (Roberts 1998; Roberts et al. 2004; Consortium of California Herbaria 2006; Rebman & Simpson 2006).

Wetland Indicator Status.—*Beta vulgaris* subsp. *maritima* was not assigned a wetland indicator status for California or any other region on the 1988 list or the 1996 draft list.

Significance and Recommended Indicator Status.—First report of *B. vulgaris* subsp. *maritima* documented for Riverside County. Based on field observations, and information available in the literature and the California Consortium of Herbaria (2006), *B. vulgaris* subsp. *maritima* should be added to the California regional list. We propose a FAC* wetland indicator status and recommend additional regional review to specifically define its frequency of occurrence in wetlands as the species undergoes further expansions of range in southern California. *Beta vulgaris* subsp. *vulgaris* (cultivated beet) is sporadic in waste areas, roadsides, and fields (Shultz 2003); it has been assigned a FACU wetland indicator status on the 1988 list and on the 1996 draft list.

Chloris truncata R. Br. (Poaceae)

CALIFORNIA. **Riverside Co.:** Menifee Valley, along Newport Rd. 1 mi E of Goetz Rd. intersection, UTM (NAD 83) 0479208E, 3727278N, elev. 442 m (1450 ft), locally common in wet ditch with *Chloris virgata*, 21 Oct 2003, *Riefner 03-461* (RSA); Perris Valley, Rider Street near Perris Valley Storm Drain, UTM (NAD 83) 11S 0480399E 3742338N, elev. 483m (1585 ft), common in irrigated alfalfa fields, in disturbed seasonal wetlands with *Polypogon* and *Cyperus*, and disturbed margin of *Salix* scrub, 27 May 2003, *Riefner 03-254* (RSA); Homeland, State Hwy. 74 near 1st St., UTM (NAD 83) 11S 0483321E 3734325N, elev. 439m (1439 ft), locally common in roadside swale with *Cynodon dactylon*, *Cyperus alternifolius*, and *Echinochloa colona*, 3 Aug 2006, *Riefner 06-354* (RSA). **San Bernardino Co.:** City of Chino, along Edison Ave. at Magnolia Ave., UTM (NAD 83) 11S 0437972E 3762021N, elev. 230 m (755 ft), uncommon, agricultural ditch with *Cyperus* and *Eleusine* in fallow farmland, 31 Jul 2006, *Riefner 06-343* (RSA).

Chloris truncata (black wind-mill grass), native to Australia, is known as a weed of alfalfa fields, orchards, irrigated turf grass nurseries, and roadsides in Imperial, Merced, and Riverside counties, but not from Los Angeles, Orange or San Bernardino counties (Hrusa et al. 2002; Barkworth 2003; Roberts et al. 2004; Consortium of California Herbaria 2006; Rebman & Simpson 2006). It has also been collected in South Carolina (Barkworth 2003).

Wetland Indicator Status.—*Chloris truncata* was not assigned a wetland indicator status for California or any other region on the 1988 list or the 1996 draft list.

Significance and Recommended Indicator Status.—First report of *C. truncata* documented for San Bernardino County. *Chloris truncata* is spreading from orchards and fields to disturbed vernally moist soils, seasonal wetlands, and riparian habitats. Based on field observations, information available in the literature, and review of the Consortium of California Herbaria (2006), *C. truncata* should be added to the California regional list. We propose a NI* wetland indicator status and recommend additional regional review to specifically define its frequency of occurrence in wetlands as the species undergoes further expansions of range and invasion of new habitats.

Ehrharta erecta Lam. (Poaceae)

CALIFORNIA. **Imperial Co.:** El Centro, Imperial Ave. at Ocotillo Rd., UTM (NAD 83) 11S 0633931E 3628013N, elev. -9 m (-31 ft), few plants growing in a moist gutter and in an irrigated commercial landscape, 9 Oct 2006, *Riefner 06-488* (RSA). **Los Angeles Co.:** Verdugo Mountains near Sunland, La Tuna Canyon, N of La Tuna Canyon Rd. along La Tuna Creek, S of 210-Fwy. and ca. 1.5 mi W of 210-Fwy. intersection with La Tuna Canyon Rd. exit, UTM (NAD 27) 0379653E 3788712N, elev. 411 m (1350 ft), common, growing with *Cyperus eragrostis* in damp sand along stream banks and with *Carex spissa* in shaded willow-oak riparian woodlands, 29 Aug 2000, *Riefner 00-764* (RSA); City of Pasadena, Arroyo Seco Creek, S of Arroyo Blvd., UTM (NAD 83) 11S 0392637E 3779048N, elev. 226 m (740 ft), common in wet sand along creek in oak-willow riparian woodland, 22 Aug 2004, *Riefner 04-381* (RSA); City of Pasadena, San Rafael Hills, canyon in vicinity of Candeo Pl. and Wierfield Dr., UTM (NAD 83) 11S 0391056E 3779872N, elev. 320 m (1049 ft), common in oak riparian woodland, growing with *Cyperus* on damp stream banks, 29 Apr 2006, *Riefner 06-159* (RSA). **Orange Co.:** City of Seal Beach, San Gabriel River at River's End Café, First St. and Ocean Blvd., UTM (NAD 83) 11S 0396779E 3734148N, elev. 3 m (10 ft), common in irrigated landscapes, 23 May 1994, *Riefner 94-387* (RSA); City of Buena Park, Lincoln Ave. at Magnolia Ave., UTM (NAD 83) 11S 0409756E 3743996N, elev. 36 m (117 ft), common in roadside gutter, 18 Jun 1994, *Riefner 94-441* (RSA); City of Laguna Beach, N of Laguna Beach Country Club along Aliso Creek, UTM (NAD 83) 11S 0431343E 3708831N, elev. 20 m (65 ft), locally common on stream banks with *Salix*, 4 Mar 2002, *Riefner 02-103* (RSA); City of Lake Forest, Serrano Creek, SE of Bake Pkwy., UTM (NAD 83) 11S 0434618E 3723575N, elev. 107 m (352 feet), locally abundant in mule fat scrub along margins of ephemeral streambed, 31 May 2004, *Riefner 04-194* (RSA, UCR); City of Rancho Santa Margarita, Los Flores Rd. near Santa Margarita Pkwy., UTM (NAD 83) 11S 0444330E 3722423N, elev. 292 m (958 ft), common in irrigated landscape, 5 Jul 2004, *Riefner 04-286* (RSA, UCR); City of Aliso Viejo, Aliso Creek near Entidad Rd. at Los Alisos Blvd., UTM (NAD 83) 11S 0439164E 3723107N, elev. 220 m (721 ft), common, growing with *Cyperus* on shaded stream banks in oak riparian woodland, 5 Oct 2005, *Riefner 05-709* (RSA). **Ventura Co.:** City of Simi Valley, Santa Susana Park, UTM (NAD 83) 11S 0347007E 3792286N, elev. 331 m (1087 ft), common on stream bank with *Epilobium ciliatum* in oak-willow riparian woodland, 9 Sep 2005, *Riefner 05-656* (RSA).

Previous knowledge.—Populations of *Ehrharta erecta* (panic veldt grass), a native of South Africa, have been reported from the San Francisco Bay Area, Santa Barbara, Ventura, Los Angeles, western Riverside, and San Diego counties (Bossard et al. 2000; Roberts et al. 2004; Rebman & Simpson 2006). Although it is a common urban weed in southern California, it has not been reported from Orange County (Roberts 1998; Bossard et al. 2000). However, it has been recently collected from roadside habitats in Orange and San Bernardino counties (Consortium of California Herbaria 2006). *Ehrharta erecta* infests wildlands in most or all of the North and Central Coast, but there are relatively few reports of it in southern California native habitats (Sigg 1996, 2003; Roberts et al. 2004). Its preference for moist environments suggests it might become a threat to wetlands and riparian habitats (Sigg 1996, 2003). *Ehrharta erecta* is also recognized as a species with the potential to spread explosively in California (CalEPPC 1999).

Wetland Indicator Status.—Although *E. erecta* inhabits moist environments in urban and wildland situations, it has not been assigned a wetland indicator status for California or any other region on the 1988 list or the 1996 draft list.

Significance and Recommended Indicator Status.—First report of *E. erecta* documented for Imperial County, where it has likely been introduced with landscape plantings for urban development projects; verification of a herbarium record for Orange County. Additional records of *E. erecta* are documented from native riparian and stream course habitats in Los Angeles, Orange, and Ventura counties. In Orange County, *E. erecta* is vigorously expanding its range from the coast into the foothills of the Santa Ana Mountains in many types of urban environments owing to landscape gardening practices associated with expanding urbanization. Based on field observations, information available in the literature, and review of the Consortium of California Herbaria (2006), *E. erecta* should be added to the California regional list and assigned a FAC wetland indicator status.

Elytrigia repens (L.) Nevski (Poaceae)

CALIFORNIA. **Orange Co.:** City of Costa Mesa, South Coast Dr. at Susan Rd., UTM (NAD 83) 11S 0415261E 3728412N, elev. 16 m (52 ft), swale and margin of mule fat scrub, 1 Oct 2005, *Riefner 05-704* (RSA).

Previous knowledge.—*Elytrigia repens* (*Agropyron repens* [L.] Beauv.; quackgrass), native to Eurasia, is a weed of cultivated ground and other disturbed sites throughout California (except the deserts and high elevation montane habitats) to the eastern United States (Jarvie & Barkworth 1993). However, it has not been reported from Orange, Riverside, or San Diego counties (Roberts 1998; Roberts et al. 2004; Rebman & Simpson 2006). Most records from the South Coast region are from Santa Barbara County (Consortium of California Herbaria 2006).

Wetland Indicator Status.—*Elytrigia repens* has been assigned a NI designation for California on the 1988 list (as *Agropyron repens*) and a FAC* wetland indicator status on the 1996 draft list.

Significance and Recommended Indicator Status.—First report of *E. repens* documented from Orange County. We concur with the revised FAC* indicator status as the species requires further review as it spreads in the South Coast region.

Epilobium brachycarpum C. Presl (Onagraceae)

CALIFORNIA. **Butte Co.:** along flood control slough, ca. 4 mi N of Chico on Hwy 99, 8 Sep 1978, *Taylor 1894* (CHSC). **Humboldt Co.:** Northern Coast region, near Hydesville, gravel bar on Yager Creek, 9 Sep 1900, *Tracy 946* (UC). **Lake Co.:** below the high water line of Indian Valley Reservoir, W of the causeway in the NW part of the reservoir, W side of Bartlett Springs Rd., 4 Oct 2004, *Ahart 11446* (CHSC); Mendocino National Forest, Stonyford Quadrangle, sag pond 1 mi N of Sheep Corral, 19 Sep 1936, *Schreiber 2334* (UC). **Los Angeles Co.:** Transverse Ranges, Liebre Mountains, Cow Spring Pond, sag pond on the San Andreas Fault at the N foot of Liebre Mtn. on the S side of West Oakdale Canyon Rd., ca 100 m W of the Cow Spring Canyon drainage, 34°44'12"N 118°38'45"W, 21 Sep 1994, *Ross & Boyd 8327* (RSA); Liebre Mountains, SW end of Quail Lake, seasonally flooded depression on S side of Hwy 138, 34°46'13.6"N 118°45'16.5"W, 14 Oct 1996, *Boyd & Raz 9086* (RSA). **Mendocino Co.:** Northern California Coast Range Preserve, Elder Creek, margins of creek about 0.5 to 1 mi upstream above confluence with South Fork Eel River, 23 Jun 1961, *Sharsmith 4905* (UC). **Mono Co.:** Leavitt Meadows, West Walker River, gravel bench along river, 1 Sep 1944, *Alexander & Kellogg 4174* (UC). **Orange Co.:** City of Yorba Linda, Santa Ana River, Horseshoe Bend in Santa Ana Canyon, UTM (NAD 83) 11S 0431466E 3749276N, elev. 99 m (323 ft), floodplain in *Baccharis salicifolia* scrub, 5 Oct 2005, *Riefner 05-705* (RSA). **Plumas Co.:** W side of Little Last Chance Creek, strand of Frenchman Lake, 29 Aug 2001, *Ahart 9254* (CHSC). **Riverside Co.:** Peninsular Ranges, Perris-Aguanga Basin region, floodplain E of dike along San Jacinto River, W of Sedco Hills community, 29 Sep 1994, *Boyd & Banks 837* (RSA); City of Hemet, vicinity of Warren Rd. at Florida Ave., UTM (NAD 83) 11S 0496489E 3724636N, 460 m (1510 ft), scattered in vernal alkali grassland with *Hordeum intercedens*, *Cressa truxillensis*, *Veronica peregrina* subsp. *xalapensis*, *Centromadia pungens* subsp. *laevis*, and *Chamomilla occidentalis*, 31 Jul 2004, *Riefner 04-347* (RSA); SE of Temecula and E of Pechanga Indian Reservation, Cleveland National Forest, Agua Tibia Wilderness, N slope of Agua Tibia Mountain, ca. 1.5 mi WNW of Woodchuck Rd., UTM (NAD 83) 11S 0497415E 3699899N, 665 m (2180 ft), scattered along bank and bed of unnamed blueline stream with *Baccharis salicifolia*, 31 Jul 2005, *Riefner 05-57* (RSA); San Jacinto Mountains, McCall Park, McCall Park Rd. near Hwy 74, UTM (NAD 83) 11S 0524882E 3729641N, 1360 m (4462 ft), growing with *Muhlenbergia rigens* along ephemeral stream, 7 Aug 2005, *Riefner 05-591* (RSA); San Jacinto Mountains, near McMullen Flat on SR 243, Valley Hi County Park, UTM (NAD 83) 11S 0516223E 3747936N, 1139 m (3737 ft), common, growing with *Crypsis* and *Amaranthus californicus* along edge of drying pond and ephemeral creek, 12 Aug 2005, *Riefner & Sanders 05-601* (RSA). **San Bernardino Co.:** Transverse Ranges, San Bernardino Mountains region, NW shore, alkaline margin of Baldwin Lake, s.d., *Thorne & Wisura 53689* (RSA). **San Diego Co.:** bank of stream 12 mi E on hwy to Santa Ysabel–Ramona, 29 Aug 1927, *Wiggins 2607* (UC); Agua Tibia Mtns., Rainbow Heights Rd. East, ca. 0.7 mi N from Rainbow Heights Rd. West, UTM (NAD 83) 11S 0490270E 3698344N, elev. 491 m (1611 ft), perennial seep with *Juncus* and *Cyperus*, 7 May 2006, *Riefner 06-182* (RSA). **Trinity Co.:** Van Duzen River, gravel bar, river 3 mi above Low Gap, 4 Sep 1939, *Tracy 16483* (UC). **Yuba Co.:** along a small stream, below the high water line of Sly Creek Reservoir, about 1/8 mi SW of Day Camp, Sly Creek Reservoir, 9 Oct 2002, *Ahart 9956* (CHSC).

Previous knowledge.—*Epilobium brachycarpum* (*E. paniculatum* Torr. & A. Gray; summer cotton weed) is common in dry open woodlands, grasslands, and roadsides below 3300 m elevation in the California Floristic Province (except the Channel Islands) and the Modoc Plateau north to British Columbia, and east to South Dakota, New Mexico, and eastern Canada (Hoch 1993). In the South Coast region, *E. brachycarpum* has been documented from Los Angeles, Riverside, and San Diego counties, but not from Orange County (Roberts 1998; Roberts et al. 2004; Consortium of California Herbaria 2006; Rebman & Simpson 2006).

Wetland Indicator Status.—*Epilobium brachycarpum* was not assigned a wetland indicator status on the 1988 list, but was included on the 1996 draft list with a UPL designation.

Significance and Recommended Indicator Status.—First report of *E. brachycarpum* documented from Orange County. In California, *E. brachycarpum* is found on open, usually dry disturbed ground in many plant communities (Munz & Keck 1959; Munz 1974; Hoch 1993). However, recent field work, review of local floras, and a search of local herbaria records indicates *E. brachycarpum* frequently inhabits floodplains, drying pond and lake margins, vernal alkali plains, gravel bars, banks and drying beds of ephemeral and intermittent streams, sloughs, ditches, sag ponds, seasonally flooded depressions, and perennial seeps (Yoder 1996; Banks 1999; Boyd 1999; Roberts et al. 2004; Consortium of California Herbaria 2006). Based on field observations, and information available in the literature and the Consortium of California Herbaria (2006), the status of *E. brachycarpum* should be revised and assigned a FACU wetland indicator status for California.

Eriochloa aristata Vasey (Poaceae)

CALIFORNIA. **Riverside Co.:** City of Hemet, Florida Ave. near Grant Ave., UTM (NAD 83) 0511109E 3734246N, elev. 547 m (1796 ft), locally common in wet ditch and roadside swales, 31 Jul 2004, *Riefner 04-352* (CS, RSA).

Previous knowledge.—*Eriochloa aristata* (bearded cupgrass) occupies seasonal streams and riverbanks in the San Francisco Bay region, Riverside, and Imperial counties in the Sonora Desert region of California, and in southern Arizona south through Mexico and Central America to Colombia (Munz 1974; Webster 1993a; Shaw et al. 2003). *Eriochloa aristata* has not, however, been reported from Orange, western Riverside, and San Diego counties (Roberts 1998; Roberts et al. 2004; Consortium of California Herbaria 2006; Rebman & Simpson 2006).

Wetland Indicator Status.—*Eriochloa aristata* has been assigned a FACW wetland indicator status on the 1988 list and the 1996 draft list.

Significance and Recommended Indicator Status.—First record of *E. aristata* documented from western Riverside County. Rarely collected in southern California (Webster 1993a), *E. aristata* is expected to expand its range and occupy moist roadside swale habitats in other inland valleys of western Riverside County and in eastern San Diego County. No changes to the wetland indicator status are proposed at this time.

Glinus radiatus (Ruiz Lopez & Pavon) Rohrb. (Molluginaceae)

CALIFORNIA. **Orange Co.:** City of Lake Forest, Upper Oso Reservoir, UTM (NAD 83) 11S 0441970E 3724638N, elev. 293 m (960 ft), drying margin of fluctuating lake, 24 Sep 2005, *Riefner 05-688* (RSA). **Riverside Co.:** City of Murrieta, ca. 1.5 mi E of I-15 Fwy. on Clinton Keith Rd., vicinity of Smith Ranch Rd., UTM (NAD 83) 11S 0479562E 3717088N, elev. ca. 427 m (1400 ft), uncommon in drying stock pond, 26 Sep 2003, *Riefner 03-379* (RSA, UCR).

Previous knowledge.—*Glinus radiatus* (radiate sweetjuice), native to tropical America, is known in California from the Sacramento Valley and the Peninsular Range Province (Ferren 1993). *Glinus radiatus* is local, but well documented from drainage courses, drying vernal pools and ponds, and receding shores of reservoirs and lakes in San Diego County (Beauchamp 1986; Consortium of California Herbaria 2006). It has not however, been reported from Orange or Riverside counties (Roberts 1998; Roberts et al. 2004; Consortium of California Herbaria 2006).

Wetland Indicator Status.—*Glinus radiatus* was not assigned a wetland indicator status on the 1988 list, but was included on the 1996 draft list with a NI designation.

Significance and Recommended Indicator Status.—First records of *G. radiatus* documented for Orange and Riverside counties. *Glinus radiatus* is easily confused with *G. lotoides* L., and it is likely more widespread than herbarium records indicate. *Glinus radiatus* is expected to occur at other large seasonal pond and drying lakeshore habitats in southern California. Based on field observations, and information available in the literature and the Consortium of California Herbaria (2006), the status of *G. radiatus* should be revised and assigned an OBL wetland indicator status for California. *Glinus lotoides*, which also occupies moist or seasonally dry margins of wetlands, has been assigned an OBL wetland indicator status on the 1988 and 1996 draft lists.

Limonium ramosissimum (Poir.) Maire (Plumbaginaceae)

CALIFORNIA. **Los Angeles Co.:** City of Long Beach, Belmont Shores, Colorado Lagoon in vicinity of Park Ave. and Colorado St., UTM (NAD 83) 11S 0394757E 3737423N, elev. 6 m (20 ft), uncommon in disturbed salt marsh, 21 Jan 2006, *Riefner 06-8* (RSA, UC). **Orange Co.:** City of Lake Forest, Aliso Creek near Portola Pkwy. at El Torro Rd., UTM (NAD 83) 11S 0439205E 3724613N, elev. 225 m (739 ft), drying streambed in alkaline soils, 9 Sep 2005, *Riefner 05-654* (RSA, UC); City of Newport Beach, E of Newport Bay, E of Bayside Dr. at Big Canyon Creek drainage, UTM (NAD 83) 11S 0418191E 3721588N, elev. 6 m (20 ft), common in salt marsh, 16 Sep 2005, *Riefner 05-669* (RSA); City of Irvine, Bonita Creek, along La Salud St. near Milano Dr., UTM (NAD 83) 11S 0420070E 3723153N, elev. 9 m (29 ft), common along bike trail, disturbed scrub, and on roadsides, 5 Oct 2005, *Riefner 05-707* (RSA, UC); City of Newport Beach, Newport Bay, Bay View Dr. E of Jamboree Rd., UTM (NAD 83) 11S 0419864E 3723987N, elev. 6 m (20 ft), uncommon, edge of salt marsh, 23 Nov 2005, *Riefner 05-772* (RSA, UC); City of Newport Beach, San Diego Creek near confluence with Newport Bay near SR 73 overpass, UTM (NAD 83) 11S 0419867E 3723886N, elev. 6 m (20 ft), common, edge of disturbed riparian woodland with *Saliconia*, *Euthamia occidentalis*, and *Pulicaria paludosa*, 12 Nov 2006, *Riefner 06-670* (RSA). **San Diego Co.:** San Onofre State Beach, near Echo Arch Campground, UTM (NAD 83) 11S 0449452E 3691583N, elev. 7 m (22 ft), uncommon in wet sand along edge of *Distichlis* seep, 31 Aug 2004, *Riefner 04-409* (RSA, UC); City of Carlsbad, N side of San Marcos Creek at Carlsbad Blvd., 0.2 mi S of Avenida Encinas, UTM (NAD 83) 11S 0470849E 3661229N, elev. 10 m (32 ft), uncommon on edge of mule fat-willow scrub, 7 Jan 2005, *Riefner 05-3* (RSA, UC).

Previous knowledge.—*Limonium ramosissimum* (Poir.) Maire (sea-lavender) is a European species not treated in The Jepson Manual, but recently reported from the Carpenteria salt marsh in Santa Barbara County as the subsp. *provinciale* (Pignatti) Pignatti, where it is abundantly naturalized (McClintock 1993; Hrusa et al. 2002; Smith 2005). Its identification is somewhat problematic, and due to the complexity of the genus, it is premature to assign a subspecies to this taxon without detailed comparison with European material (Smith 2005). *Limonium ramosissimum* has not been reported from Los Angeles, Orange, or San Diego counties (Roberts 1998; DiTomaso & Healy 2003; Consortium of California Herbaria 2006; Rebman & Simpson 2006). It has been cited by Roberts et al. (2004) from moist, low-lying alkaline habitats in western Riverside County, but this specimen (Lake Elsinore, *Riefner 03-241*, UCR) is referable to *Limonium* indet., which is discussed below. *Limonium ramosissimum* and *Limonium* indet. are superficially similar, often co-occur in disturbed wetland or moist ruderal habitats, are frequently used in the nursery trade, and are therefore easily confused.

Wetland Indicator Status.—*Limonium ramosissimum* has not been assigned a wetland indicator status for California or any other region on the 1988 list or the 1996 revised list.

Significance and Recommended Indicator Status.—First annotated reports of *L. ramosissimum* documented for Los Angeles, Orange, Riverside, and San Diego counties. Based on field observations and information available in the literature, *L. ramosissimum* should be added to the California regional list and assigned a FACW wetland indicator status. *Limonium ramosissimum* may be a threat to the endangered *Cordylanthus maritimus* Nutt. in salt marsh habitats at Carpenteria, Santa Barbara County (Smith 2005). *Limonium ramosissimum* is spreading rapidly, especially in salt marsh habitats, where it may also threaten sensitive species in Orange and San Diego counties. The California Invasive Plant Council should monitor it closely.

Limonium indet. (Plumbaginaceae)

CALIFORNIA. **Orange Co.:** City of Newport Beach, E of Newport Bay and E of Bayside Dr., Big Canyon Creek drainage, UTM (NAD 83) 11S 0418191E 3721588N, elev. 6 m (20 ft), common in salt marsh, 16 Sep 2005, *Riefner 05-667* (RSA, UC); City of Irvine, Bonita Creek, along La Salud St. near Milano Dr., UTM (NAD 83) 11S 0420070E 3723153N, elev. 9 m (29 ft), common along bike trail, disturbed scrub, and on roadsides, 5 Oct 2005, *Riefner 05-708* (RSA); City of Rancho Santa Margarita, along Robinson Ranch Rd. near North Peak Rd., UTM (NAD 83) 11S 0448529E 3724126N, elev. 500 m (1639 ft), common on disturbed roadside slopes, in ditches, and banks of ephemeral streambed, 4 Nov 2005, *Riefner 05-739* (RSA); City of Newport Beach, Upper Newport Bay, Bay View Dr. E of Jamboree Rd. at San Diego Creek, UTM (NAD 83) 11S 0419864E 3723987N, elev. 6 m (20 ft), uncommon, edge of salt marsh, 23 Nov 2005, *Riefner 05-774* (RSA); City of Newport Beach, E of Newport Bay, E of Back Bay Dr., flats along Big Canyon Creek, UTM (NAD 83) 11S 0418069E 3721609N, 6 m (18 ft), salt flats and scrub with *Salicornia* and *Atriplex glauca*, 11 Aug 2006, *Riefner 06-386* (RSA, UC); City of Newport Beach, Upper Newport Bay E of Jamboree Rd., UTM (NAD 83) 11S 0419547E 3723812N, elev. 6 m (20 ft), common, salt marsh with *Salicornia*, 13 Aug 2006, *Riefner 06-391* (RSA, UC); City of Newport Beach, San Diego Creek near confluence with Newport Bay near SR 73 overpass, UTM (NAD 83) 11S 0419867E 3723886N, elev. 6 m (20 ft), uncommon, edge of disturbed riparian woodland with *Salicornia*, *Euthamia occidentalis*, and *Pulicaria paludosa*, 12 Nov 2006, *Riefner 06-671* (RSA). **Riverside Co.:** Temescal Valley, W side of I-15 Freeway, ca. 1.1 mi N of Temescal Canyon Rd., UTM (NAD 83) 11S 0453861E 3739203N, 289 m (949 ft), common, planted in residential landscapes and spreading to roadsides, 2 Aug 2006, *Riefner 06-356* (RSA, UC); Corona-La Sierra area, vicinity of Green River Rd. and Palisades Dr., UTM (NAD 83) 11S 0440802E 3749217N, 141 m (462 ft), uncommon, spreading from nearby commercial/residential landscape plantings to edge of mule fat scrub, roadside ditch, and dirt lot, 22 Aug 2006, *Riefner 06-398* (RSA, UC).

Previous knowledge.—Another introduced and naturalized perennial *Limonium*, as yet unidentified to species, but probably originating from the Mediterranean region of Eurasia, has been recently collected from salt marshes in San Diego County (Smith 2005; Rebman & Simpson 2006). This unidentified taxon has not been reported from Orange or Riverside counties (Roberts 1998; Roberts et al. 2004). This species is actively being planted in tract home development projects in Orange and Riverside counties, and is spreading rapidly to native riparian and wetland habitats.

Wetland Indicator Status.—An indicator status has not been assigned to this currently unidentified species of *Limonium*.

Significance and Recommended Indicator Status.—First annotated records of the *Limonium* indet. reported for Orange and Riverside counties. This exotic perennial is more robust and aggressive than *L. ramosissimum*, and is abundantly naturalized in and around sensitive salt marsh ecological reserves. It is rapidly displacing native salt marsh species, and could also become a threat to the endangered *Cordylanthus maritimus* in the South Coast region. The California Invasive Plant Council should monitor it closely. After taxonomic problems have been resolved, it should be added to the California regional list and assigned a FACW wetland indicator status.

Oncosiphon piluliferum (L.f.) Källersjö (Asteraceae)

CALIFORNIA. **Imperial Co.:** E of El Centro, Ross Rd. ca. 0.2 mi E of Dogwood St., UTM (NAD 83) 11S 0637549E 3628051N, elev. -9 m (-28 ft), two plants on disturbed, vernally moist alkaline flats with *Atriplex* and *Suaeda*, 20 Aug 2005, *Riefner 05-644* (RSA). **Los**

Angeles Co.: Transverse Ranges, San Gabriel Mountains region, alluvial fan below San Antonio Canyon at southern base of the range, just west of Los Angeles/San Bernardino County line along north margin of the west-bound 210-Fwy. at Monte Vista/Baseline Ave. off-ramp, UTM (NAD 83) 11S 0436039E 3776202N, elev. 488 m (1600 ft), single plant along edge of road shoulder in hydroseeded scrub, 11 May 2006, *Boyd 11659* (RSA); City of Long Beach, Studebaker Rd. at 22-Fwy., UTM (NAD 83) 11S 0397935E 3737465N, elev. 6 m (20 ft), uncommon, ruderal alkaline plant community on dirt lot, 8 Jul 2006, *Riefner 06-294* (RSA); City of Long Beach, Shopkeeper Rd. at Westminster Blvd., UTM (NAD 83) 11S 0397433E 3735926N, elev. 3 m (9 ft), uncommon, edge of salt marsh and vernally moist alkaline flats, 8 Jul 2006, *Riefner 06-296* (RSA). **Riverside Co.:** Romoland, Sherman Rd. near Ethanac Rd., UTM (NAD 83) 11S 0483282E 3733376N, elev. 440 m (1443 ft), common in dry basin of seasonal pool with *Crypsis vaginiflora* and adjacent upland ruderal habitats, 30 May 2006, *Riefner 06-213* (RSA).

Previous knowledge.—Oncosiphon piluliferum (*Matricaria globifera* [Thunb.] Fenzl; stink-net or globe chamomile), a native to the Cape region of South Africa, was first reported in California from Orange and San Diego counties (Sanders 1996). It is now locally common and spreading rapidly across western Riverside County (Hrusa et al. 2002; Roberts et al. 2004; Riefner & Boyd 2005a). It has also been reported from Arizona, where it has been documented from roadside, desert scrub, and wash and floodplain riparian habitats (Landrum et al. 2005).

Wetland Indicator Status.—Oncosiphon piluliferum has not been assigned a wetland indicator status for California on the 1988 list or the 1996 draft list in any region of the United States.

Significance and Recommended Indicator Status.—First records of *O. piluliferum* documented for Imperial and Los Angeles counties. In western Riverside County, this species is well documented from alkali playa and vernal alkali plain habitats dominated by facultative wetland species including *Plagiobothrys leptocladus*, *Cressa truxillensis*, *Crypsis schoenoides*, *Rumex crispus*, and *Atriplex argentea* (Hrusa et al. 2002). It is spreading to low-lying vernal alkaline habitats in Imperial and Los Angeles counties. However, *O. piluliferum* is invading a variety of disturbed upland and seasonal wetlands habitats, including roadside, field, floodplain, seasonal pool, and scrub habitats in southern California and Arizona (Roberts et al. 2004; Riefner & Boyd 2005a; Landrum et al. 2005). *Oncosiphon piluliferum* is expected to become a widespread invasive species in Arizona, which serves as an example of the potential impacts to native vegetation when a non-native ornamental species becomes naturalized (Landrum et al. 2005). It is also spreading explosively in southern California, and the California Invasive Plant Council should monitor *O. piluliferum* closely. Based on field observations, information available in the literature, and review of the Consortium of California Herbaria (2006), *O. piluliferum* should be added to the California regional list. We propose a FACU* wetland indicator status and recommend additional regional review to specifically define its frequency of occurrence in wetlands as the species undergoes further expansions of range and invasion of new habitat types in California.

Panicum coloratum L. (Poaceae)

CALIFORNIA. **Imperial Co.:** S of El Centro, Bowker Rd. near McCabe Rd., UTM (NAD 83) 11S 0643807E 3624673N, elev. 2 m (6 ft), uncommon in wet irrigation ditch, 9 Oct 2006, *Riefner 06-497* (RSA); S of El Centro, Heber Rd. near Hwy. 86, UTM (NAD 83) 11S 0635522E 3622345N, elev. 2 m (6 ft), uncommon in ditch with *Typha* and *Chloracantha spinosa*, 9 Oct 2006, *Riefner 06-500* (RSA); E of El Centro, along Ross Rd. near Bass Cove Rd., N of Hwy 8., UTM (NAD 83) 11S 0638008E 3628013N, elev. -9 m (-30 ft), common and widespread in ditches, along irrigation canals, and in low-lying wet fields, 9 Oct 2006, *Riefner 06-512* (RSA, UWSP). **Los Angeles Co.:** City of Altadena, along Calveras St. near Hollister Ave., UTM (NAD 83) 11S 0396508E 3783148N, 390 m (1280 ft), uncommon, street gutter in moist soil with *Eleusine*, 22 Aug 2004, *Riefner 04-378* (RSA). **Orange Co.:** City of Los Alamitos, Oak Middle School, vicinity of Oak St. at Catalina St., UTM (NAD 83) 11S 0400172E 3741242N, 14 m (45 ft), very rare, moist depressions in ball field turf grass with *Eleusine*, 3 Sep 2004, *Riefner 04-425* (RSA).

Previous knowledge.—Panicum coloratum (kleingrass) is an African species occasionally cultivated for forage that has been introduced into subtropical and tropical regions worldwide (Freckmann & Lelong 2003). In the United States, it is currently known only from New Mexico and Texas, where it grows in open, usually wet ground (Freckmann & Lelong 2003).

Wetland Indicator Status.—Panicum coloratum has not been assigned a wetland indicator status for California on the 1988 list or the 1996 draft list.

Significance and Recommended Indicator Status.—First record of *P. coloratum* documented for California, which likely represents a recent introduction. As with many other African grasses now established in southern California, this weedy species could spread rapidly to other disturbed, moist-soil habitats in the south coast region. Based on initial field observations and information available in the literature, *P. coloratum* should be added to the California regional list. We propose a FACW* wetland indicator status. Additional regional review is needed to refine its frequency of occurrence in wetlands, as the species will likely undergo further expansions of range and colonization of different habitat types in southern California.

Panicum dichotomiflorum Michx. subsp. **dichotomiflorum** (Poaceae)

CALIFORNIA. **Orange Co.:** City of Huntington Beach, Huntington Central Park at Goldenwest St., UTM (NAD 83) 11S 0406884E 3729853N, elev. 1 m (3 ft), common in and along the edge of shallow water ponds, 20 Sep 2005, *Riefner 05-674* (RSA, UWSP); City of Yorba Linda, Santa Ana River near Yorba Linda Regional Park, UTM (NAD 83) 11S 0430104E 3748155N, elev. 98 m (320 ft), common on sandbars and riverbanks with perennial waters, 27 Oct 2005, *Riefner 05-735* (RSA, UWSP). **Riverside Co.:** City of Corona, E of Santa Ana Canyon along Santa Ana River, ca. 0.5 mi S of 71 Freeway, UTM (NAD 83) 11S 0439689E 3749438N, elev. 135 m (442 ft), uncommon in wet river wash sand, 18 Sep 2004, *Riefner 04-435* (RSA).

Previous knowledge.—Panicum dichotomiflorum subsp. *dichotomiflorum* (fall panic grass), native to the eastern United States, is found in the San Joaquin Valley and the South Coast region of California (Webster 1993b). It grows in open, often wet disturbed areas in a wide variety of habitats, including cultivated and fallow fields, roadsides, ditches, stream banks, along receding shores of lakes, clearings in floodplains, and in shallow water (Freckmann & Lelong 2003). In southern California, *P. dichotomiflorum* has been collected from San Bernardino, San Diego, and Santa Barbara counties, but not from Orange or Riverside counties (Munz 1974; Roberts 1998; Roberts et al. 2004; Consortium of California Herbaria 2006, Rebman & Simpson 2006). This weedy species was not included in the treatment of aquatic and riparian weeds by DiTomaso & Healy (2003).

Wetland Indicator Status.—Panicum dichotomiflorum subsp. *dichotomiflorum* has been assigned a FACW wetland indicator status for California on the 1988 list and the 1996 draft list.

Significance and Recommended Indicator Status.—First records of *P. dichotomiflorum* subsp. *dichotomiflorum* documented for Orange and Riverside counties. This grass will likely become a common weed of disturbed wetland and riparian habitats throughout coastal southern California.

The *P. dichotomiflorum* complex shows great plasticity of growth forms in response to environmental conditions, which is the case of the extremely robust plants collected from the Santa Ana River in Orange and Riverside counties. These specimens have spikelets similar to *P. dichotomiflorum* subsp. *puritanorum* (Svenson) Freckmann & Lelong, but no other characters. Given the great variation in the *P. dichotomiflorum* complex and especially the effect of growing conditions on robustness, the Santa Ana River specimens are best treated as the subsp. *dichotomiflorum* (pers. com., R.W. Freckmann, October 2006). No changes to the wetland indicator status are proposed at this time.

Panicum virgatum L. (Poaceae)

CALIFORNIA. **Orange Co.:** near City of Anaheim, Santa Ana Canyon, N side of Santa Ana River channel, Santa Ana Canyon, W (downstream) ca. 1.25 mi from Green River Golf Course, UTM (NAD 83) 11S 0434148E 3748318N, elev. 120 m (387 ft), uncommon in moist swales, on river sandbars, and in *Baccharis salicifolia* scrub, 19 Sep 2006, *Riefner 06-439* (RSA, UWSP); City of Irvine, San Diego Creek near 405-Freeway, UTM (NAD 83) 11S 0429336E 3724184N, elev. 49 m (162 ft), uncommon on moist sandy banks and margin of riparian woodland, 8 Oct 2006, *Riefner 06-482* (RSA).

Previous knowledge.—Panicum virgatum (including *P. havardii* Vasey; switchgrass, panic raide) has not been reported previously for California (Webster 1993b; Freckmann & Lelong 2003). It grows in mesic to wet tallgrass prairies, and on dry slopes, sand, open oak or pine woodlands, shores, riverbanks, and brackish marshes. *Panicum virgatum* occurs primarily on the eastern side of the Rocky Mountains, extending from southern Canada to Mexico, Cuba, Bermuda, and Costa Rica, but is also found in Nevada, Utah, and Arizona (Freckmann & Lelong 2003). *Panicum virgatum* is planted for range and wildlife habitat improvement, and has been introduced as a forage grass to other parts of the world (Freckmann & Lelong 2003).

Wetland Indicator Status.—Not previously known from California, *P. virgatum* was not assigned a wetland indicator status on the 1988 California list, but it was included on the 1996 draft list with a FAC wetland indicator status for most other regions.

Significance and Recommended Indicator Status.—First records of *P. virgatum* documented for California, which likely represents an escape from cultivation or habitat enhancement plantings. Based on initial field observations and information available in the literature, *P. virgatum* should be added to the California regional list. We propose a FAC* wetland indicator status and recommend additional regional review to refine its frequency of occurrence in wetlands, as the species will likely undergo further expansions of range and colonization of different habitat types in southern California.

Paspalum urvillei Steudel (Poaceae)

CALIFORNIA. **Orange Co.:** City of Lake Forest, Alton Pkwy. at Bertea Rd., UTM (NAD 83) 11S 0434065E 3724402N, elev. 123 m (402 ft), common, growing with *Baccharis salicifolia* and *Picris* in ditches, swales, and fields, 4 Nov 2005, *Riefner 05-742* (RSA, UCR).

Previous knowledge.—Paspalum urvillei (vaseygrass), a native of South America, occupies disturbed, moist to wet places in the Sacramento Valley and the South Coast region (Webster 1993c; DiTomaso & Healy 2003). However, Allen & Hall (2003) did not report it from southern California. Local herbaria have specimens from San Bernardino and San Diego counties, where it occupies streambeds, margins of lakes and meadows, and roadside habitats, but it has not been collected from Riverside and Orange counties (Roberts 1998; Roberts et al. 2004; Consortium of California Herbaria 2006; Rebman & Simpson 2006). *Paspalum urvillei* is more common in the southern United States, but is expected to expand its range in California (DiTomaso & Healy 2003).

Wetland Indicator Status.—Paspalum urvillei has been assigned a NI* designation for California on the 1988 list and the 1996 draft list.

Significance and Recommended Indicator Status.—First record of *P. urvillei* documented for Orange County, and additional populations will likely be discovered in the South Coast region. Field observations, a literature review, and a review of herbarium data indicate this species frequently inhabits moist soil habitats in California (DiTomaso & Healy 2003; Consortium of California Herbaria 2006). A revised FACU wetland indicator status is proposed for the California regional list.

Psilocarphus chilensis A. Gray (Asteraceae)

CALIFORNIA. **Riverside Co.:** Winchester, Patton Rd. at Patterson Ave., UTM (NAD 83) 11S 0492961E 3728074N, elev. 452 m (1483 ft), common in shallow roadside depressions with *Plagiobothrys leptocladus*, 22 Apr 2005, *Riefner 05-239* (RSA, UCR); City of Lake Elsinore, back basin of Lake Elsinore, W ca. 0.5 mi off Pete Lehr Drive at Diamond Stadium in Wildlife Viewing Area, UTM (NAD 83) 11S 0471224E 3723561N, elev. 402 m (1320 ft), uncommon in shallow depressions with *Plagiobothrys acanthocarpus* and *Plantago elongata* in saltgrass meadows, 8 Apr 2006, *Riefner 06-306* (RSA, UCR); Romoland, Sherman Rd. near Ethanac Rd., UTM (NAD 83) 11S 0483293E 3733281N, elev. 440 m (1443 ft), uncommon in dry basin of detention pond with *Crypsis vaginiflora*, 30 May 2006, *Riefner 06-215* (RSA).

Previous knowledge.—Psilocarphus chilensis (*P. tenellus* Nutt. var. *globiferus* [DC.] Morefield; round woolly marbles) is an amphitropical disjunct, known in North America only from California, and from Chile in South America (Morefield 2006). *Psilocarphus chilensis* occupies saturated to drying vernal pools, seasonally inundated sites, and coastal interdune areas of the Sierra Nevada foothills to the Central Coast region and south to the San Joaquin Valley (Morefield 1993). In southern California, *P. chilensis* is known only from the Winchester and Domenigoni Valley region of western Riverside County (Boyd & Ross 1996; Roberts et al. 2004; Morefield 2006).

Wetland Indicator Status.—Psilocarphus chilensis (*P. tenellus* var. *globiferus*) has not been assigned a wetland indicator status for California on the 1988 list or the 1996 draft list.

Significance and Recommended Indicator Status.—First report of *P. chilensis* documented for the Romoland and Elsinore Valley regions of western Riverside County. This species is tolerant of disturbed conditions, occurs in man-made or modified seasonal pool habitats, and is expected to occur elsewhere in cismontane southern California, especially interior valleys in Riverside and San Diego counties. Based on field observations, information available in the literature, and review of the Consortium of California Herbaria (2006), *P. chilensis* should be added to the California regional list and assigned an OBL wetland indicator status.

Salvinia molesta D.S. Mitch. (Salviniaceae)

CALIFORNIA. **Orange Co.:** City of Huntington Beach, Huntington Central Park at Goldenwest St., UTM (NAD 83) 11S 0407062E 3730088N, elev. 1 m (3 ft), very rare in still-water pond with *Lemna* and *Eichhornia crassipes* in willow riparian woodland, 30 Sep 2005, *Riefner 05-700* (RSA); City of Irvine, along Jeffrey Rd. N of Barranca Rd., UTM (NAD 83) 11S 0427803E 3726479N, elev. 47 m (155 ft), uncommon, growing with *Eichhornia crassipes* in irrigation pond in agricultural field, 5 May 2005, *Riefner 05-304* (RSA).

Previous knowledge.—Salvinia molesta (giant salvinia) is an invasive, free-floating aquatic fern native to South America that has proven to be a troublesome weed in many warm freshwaters of the world (Barrett

1989). In the United States, this federally listed noxious weed occurs across the southern states from Florida to California (Barrett 1989; DiTomaso & Healy 2003). In California, *S. molesta* is well known from the lower Colorado River drainage in Imperial and Riverside counties, but small populations have also been reported along the coast in Orange, San Diego, and San Luis Obispo counties (Hrusa et al. 2002; Riefner & Boyd 2005b).

Salvinia molesta appears to only reproduce vegetatively in the United States, but is capable of rapid growth in warm, slow-moving waters where it can be devastating to aquatic native species by covering large areas (Mitchell et al. 1980; DiTomaso & Healy 2003). In most cases, the range of this plant is temperature limited. *Salvinia molesta* survives extremes of 3°C and 43°C, however optimal growth occurs at 24°C to 28°C (Whiteman & Room 1991). *Salvinia molesta* has been recognized as a species with the potential to spread explosively in California (CalEPPC 1999).

Wetland Indicator Status.—Salvinia molesta has not been assigned a wetland indicator status for California on the 1988 list or the 1996 draft list. *Salvinia auriculata* Aubl. is included on the 1996 draft list with an OBL wetland indicator status for the Caribbean and North Central regions, and a NI indicator status for the Northeast, Southeast, and South Plains regions, but not for California. *Salvinia auriculata* has been misapplied to *Salvinia* species in the United States, including *S. minima* Baker (*S. auriculata* auct. non Aubl.), which occurs in New Mexico and other southern states (Nauman 1993; DiTomaso & Healy 2003).

Significance and Recommended Indicator Status.—New locations of *S. molesta* documented for Orange County. This species is spreading, most likely by waterfowl, in the mild Mediterranean climate of southern California. *Salvinia molesta* may be expected to naturalize in the same areas where water hyacinth (*Eichhornia crassipes* [Mort.] Solms) is known to grow, including slow-moving freshwaters in regions that may experience frost but not the formation of ice (Whiteman & Room 1991; DiTomaso & Healy 2003; Riefner & Boyd 2005b). Based on field observations and information available in the literature, *S. molesta* should be added to the California regional list and assigned an OBL wetland indicator status.

Setaria adhaerens (Forssk.) Chiov. (Poaceae)

CALIFORNIA. **Los Angeles Co.:** City of Pasadena, Arroyo Seco Creek, S of Arroyo Blvd., UTM (NAD 83) 11S 0392637E 3779048N, 226 m (740 ft), uncommon along creek in wet sand and on sand bars with *Eleusine*, *Ehrharta erecta*, *Leptochloa fusca* subsp. *uninervia*, and *Xanthium strumarium*, 22 Aug 2004, *Riefner 04-383* (RSA). **Orange Co.:** City of Anaheim, Santa Ana River bottom, E of 57-Freeway between Orangewood St. and Chapman Ave., UTM (NAD 83) 11S 0418311E 3739098N, 41 m (135 ft), locally abundant, disturbed wetlands, margins of active channels, and on sandbars with *Echinochloa crus-galli*, *Leptochloa fusca* subsp. *uninervia*, and *Xanthium strumarium*, 8 Aug 2004, *Riefner 04-373a* (RSA); City of Irvine, San Diego Creek at Woodbridge High School, S of intersection of Barranca Rd. and West Yale Loop Rd., UTM (NAD 83) 11S 0425279E 3727007N, elev. 27 m (89 ft), uncommon, growing with *Cynodon dactylon* and *Xanthium strumarium* on disturbed creek terrace, 27 Aug 2004, *Riefner 04-389* (RSA); City of Irvine, San Diego Creek near 405-Freeway, UTM (NAD 83) 11S 0429336E 3724184N, elev. 51 m (166 ft), uncommon on moist sandy banks and wet sand along creek channel with *Echinochloa crus-galli*, *Leptochloa fusca* subsp. *uninervia*, and *Ludwigia repens*, 8 Oct 2006, *Riefner 06-480* (RSA); City of Santa Ana, 17th St. at 55-Fwy., UTM (NAD 83) 11S 0422908E 3735773N, elev. 49 m (160 ft), common along roadside in ruderal vegetation, 23 Jul 2006, *Riefner 06-310* (RSA); City of Huntington Beach, Atlanta St. at Surge Ln., UTM (NAD 83) 11S 0411693E 3724638N, elev. 11 m (35 ft), sidewalk weed, 6 Aug 2006, *Riefner 06-373* (RSA). **Riverside Co.:** City of Riverside, residential lots and roadside along Elderwood Ct. at Tequesquite Ave., UTM (NAD 83) 11S 0463408E 3759616N, elev. 237 m (777 ft), common in irrigated landscape and roadside seepage areas, 7 Oct 2005, *Riefner 05-723* (ASC, RSA); City of La Sierra; Gramercy Pl. near La Sierra Ave., UTM (NAD 83) 11S 0454476E 3754271N, elev. 227 m (746 ft), sidewalk and gutter weed, 30 Dec 2005, *Riefner 05-793* (RSA). **San Bernardino Co.:** City of Fontana, Merrill St. at Olive St., UTM (NAD 83) 11S 0459593E 3772444N, elev. 381 m (1250 ft), uncommon in drainage ditch with *Cyperus* in vacant dirt lot, 5 Oct 2005, *Riefner 05-722* (RSA). **San Diego Co.:** Kearny Mesa, Clairemont Mesa Rd. near Ruffner Rd., UTM (NAD 83) 11S 0485359E 3632725N, elev. 122 m (401 ft), irrigated landscape with *Agrostis*, 19 Nov 2006, *Riefner 06-679* (RSA).

Previous knowledge.—Setaria adhaerens (burr bristlegrass) grows in subtropical and tropical regions throughout the world (Rominger 2003). In North America, it occurs in the southern United States, northeastern Mexico, Cuba, and the Bahamas (Rominger 2003). In California, it is known only from the Kern County region, which may represent a recent introduction (Rominger 2003). *Setaria adhaerens* has not been collected from Los Angeles, Orange, Riverside, San Bernardino, or San Diego counties (Webster 1993d; Roberts 1998; Rominger 2003; Roberts et al. 2004; Consortium of California Herbaria 2006; Rebman & Simpson 2006).

Wetland Indicator Status.—Setaria adhaerans was not assigned a wetland indicator status on the 1988 list or the 1996 draft list for any region in the United States. *Setaria verticillata* (L.) P. Beauv., native to Europe, resembles *S. adhaerens* and also occupies disturbed moist-soil habitats in southern California. *Setaria verticillata* has been assigned a NI* wetland indicator status for California on the 1988 list and a FACU wetland indicator status on the 1996 draft list.

Significance and Recommended Indicator Status.—First documented report of *S. adhaerens* for Los Angeles, Orange, Riverside, San Bernardino, and San Diego counties. Based on initial field observations and information available in the literature, *S. adhaerens* should be added to the California regional list. We propose a FACU* wetland indicator status. This species will likely undergo further expansions of range and colonization of different habitat types in southern California, which will require further review to refine its frequency of occurrence in wetlands.

Setaria megaphylla (Steud.) T. Durand & Schinz (Poaceae)

CALIFORNIA. **Orange Co.:** City of Huntington Beach, Huntington Central Park near Goldenwest St., UTM (NAD 83) 11S 0406845E 3730055N, elev. 1 m (3 ft), uncommon in disturbed *Salix*-dominated riparian woodland with *Echinochloa crus-galli* and *Paspalum dilatatum*, 27 Oct 2005, *Riefner 05-731* (RSA); City of Newport Beach, urban creek draining into San Diego Creek near confluence with Newport Bay at SR 73 overpass, UTM (NAD 83) 11S 0419895E 3723901N, elev. 6 m (19 ft), locally common in moist disturbed riparian woodland with *Euthamia occidentalis* and *Pulicaria paludosa*, 12 Nov 2006, *Riefner 06-667* (ASC, RSA); City of San Juan Capistrano, San Juan Creek at La Novia Ave., UTM (NAD 83) 11S 0439744E 3707154N, elev. 22 m (72 ft), uncommon and widely scattered in riparian scrub, 19 Nov 2006; *Riefner 06-683* (RSA).

Previous knowledge.—*Setaria megaphylla* (bigleaf bristlegrass), native to tropical Africa and tropical America, has not been reported previously for California (Webster 1993d; Rominger 2003). In North America, it is apparently established only in Florida, although it is occasionally cultivated for its ornamental, plicate leaves (Rominger 2003).

Wetland Indicator Status.—*Setaria megaphylla* was not assigned a wetland indicator status on the 1988 list or the 1996 draft list for any region in the United States. *Setaria palmifolia* (J. König) Stapf, a species similar to *S. megaphylla*, has been assigned a NI wetland indicator status for the Southeast region and a FACU wetland indicator status for Hawaii.

Significance and Recommended Indicator Status.—First report of *S. megaphylla* documented for California, which likely represents an escape from cultivation. Based on initial field observations and information available in the literature, *S. megaphylla* should be added to the California regional list. We propose a NI wetland indicator status. This species may undergo further expansions of range and colonization of different habitat types in southern California, but may be restricted to moist soils and mild climate along the immediate coast. Additional monitoring of new populations is necessary to determine its frequency of occurrence in wetlands.

DISCUSSION

Wetlands, streams and their associated riparian vegetation communities are important natural resources in urban and suburban southern California (White & Greer 2006). The increased area of impervious surfaces and imported municipal water supplies associated with the urbanization of coastal watersheds have driven significant and often undocumented changes in many of coastal southern California's wetland and riparian vegetation communities by altering stream flow characteristics, channel geomorphology, and historic plant community composition (Greer & Stow 2003; Burkhart 2006). In southern California, and many other urban watersheds, these changes also include dramatic shifts from historic episodic stream flows following major storm events to perennial base flows, which is often accompanied by an expansion of wetland and riparian vegetation, including human-adaptive or disturbance-tolerant native species, and an overall decline in native species richness (Magee et al. 1999; Dwire et al. 2000; Shanahan & Crear 2004; Burkhart & Kelly 2005; Burkhart 2006; White & Greer 2006). Also, the direct effects of the introduction of exotic species in suburban and urban environments have significantly modified the character of the native vegetation and integrity of wetland and riparian ecosystems associated with many urban environments, which is directly related to available moisture, and secondarily to disturbance (Suarez et al. 1998; Magee et al. 1999; McKinney 2002; Radeloff et al. 2005). The effects of urban development on ecological communities have only recently become a topic

TABLE 2. Summary of distributional records for southern California, and proposed revisions and additions to the National List of Plant Species that Occur in Wetlands.

Species (*=exotic taxon)	Significance in California and Recommended Wetland Indicator Status
**Amaranthus blitum* subsp. *emarginatus*	New to Orange County; spreading to urban wetlands and stream course habitats; propose FAC* wetland indicator status.
Atriplex polycarpa	New to western Riverside County; alkaline soil habitats in southern California are in need of focused study; concur with current FACU indicator status.
**Bacopa monnierii*	New to Orange County; one of many subtropical and tropical weeds invading coastal southern California; concur with revised OBL indicator status.
**Beta vulgaris* subsp. *maritima*	New to Riverside County; propose FAC* wetland indicator status.
**Chloris truncata*	New to San Bernardino County; propose NI* wetland indicator status.
**Ehrharta erecta*	New to Imperial County and verification of an unreported Orange County herbarium record; spreading rapidly from urban to native habitats; new records documented from native riparian and stream course habitats in Los Angeles, Orange, and Ventura counties; assign FAC wetland indicator status.
**Elytrigia repens*	New to Orange County; concur with revised FAC* indicator status.
Epilobium brachycarpum	New to Orange County; revise from UPL and assign FACU wetland indicator status.
Eriochloa aristata	New to western Riverside County; expected elsewhere in disturbed wetland habitats in southern California; concur with current FACW indicator status.
**Glinus radiatus*	New to Orange and western Riverside counties; likely more widespread than current records indicate; revise from NI and assign OBL wetland indicator status.
**Limonium ramosissimum*	New to Los Angeles, Orange, Riverside, and San Diego counties; spreading rapidly; threat to the endangered *Cordylanthus maritimus* in salt marsh habitats; assign FACW wetland indicator status.
**Limonium* indet.	New to Orange and Riverside counties; spreading rapidly from cultivation; potential threat to the endangered *Cordylanthus maritimus* in salt marsh habitats; assign FACW wetland indicator status following identification to species.
**Oncosiphon piluliferum*	New to Imperial and Los Angeles counties; potential to spread explosively; propose FACU* wetland indicator status.
**Panicum coloratum*	New to California; African species with potential to spread explosively; propose FACW* wetland indicator status.
**Panicum dichotomiflorum* subsp. *dichotomiflorum*	New to Orange and Riverside counties; expected to invade disturbed wetland and riparian habitats throughout the South Coast region; concur with current FACW indicator status.
**Panicum virgatum*	New to California; propose FAC* wetland indicator status.
**Paspalum urvillei*	New to Orange County; revise from NI* and propose FACU wetland indicator status.
Psilocarphus chilensis	New to Romoland and Elsinore Valley regions of western Riverside County; assign OBL wetland indicator status.
**Salvinia molesta*	New populations reported for Orange County; federally listed noxious weed with potential to spread explosively; assign OBL wetland indicator status.
**Setaria adhaerens*	New to Los Angeles, Orange, Riverside, San Bernardino, and San Diego counties; subtropical and tropical weed spreading rapidly in coastal southern California; propose FACU* wetland indicator status.
**Setaria megaphylla*	New to California; recent introduction of another tropical species; propose NI wetland indicator status.

of study, however, and few comprehensive surveys have been carried out in coastal southern California, or in other regions, to document this relatively recent phenomenon (Dwire et al. 2000; Hansen et al. 2005; Burkhart 2006; White & Greer 2006). Botanists and ecologists have traditionally focused their research on wildland ecosystems, but the new records presented herein, and summarized in Table 2, suggest that detailed floristic studies are needed to thoroughly document the flora of wetland and riparian communities in urban ecosystems and in surrounding native habitats degraded by exotic species throughout the South Coast region.

Expected declines in native plant biodiversity of wetland and riparian ecosystems in or near wildland habitats, and in urban nature preserves and parks, pose major environmental problems to resource conservation planning, especially in California, which has the highest number of wildland-urban interface (WUI) housing units in the United States (McKinney 2002; Pysek et al. 2002; Hansen et al. 2005; Radeloff et al. 2005). As long as the amiable climate and the strong economy of coastal southern California continues to attract urbanization and other forms of high density human activity, and without coordinated land-use planning and ecologically-based conservation efforts, it will not be likely that substantial gains in area, native floristic diversity, and unique wetland- and riparian-related functions and values will occur (Brinson & Malvárez 2002; Broberg 2003).

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NOTEWORTHY PLANTS FROM NORTH FLORIDA. VIII

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ABSTRACT

Additions to the flora of north Florida are documented. *Bradburia pilosa* (Nutt.) Semple, *Hydrocotyle bowlesioides* Mathias & Constance, *Ottelia alismoides* (L.) Pers., *Ranunculus laxicaulis* (Torr. & A. Gray) Darby, and *Solidago gigantea* Ait. are new to the state; several species new to the panhandle are listed. Additionally, many first reports for counties within the Florida panhandle are given.

RESUMEN

Se documentan las adiciones a la flora del norte de Florida. *Bradburia pilosa* (Nutt.) Semple, *Hydrocotyle bowlesioides* Mathias & Constance, *Ottelia alismoides* (L.) Pers., *Ranunculus laxicaulis* (Torr. & A. Gray) Darby, y *Solidago gigantea* Ait. son nuevas para el estado; se listan varias especies nuevas para el "panhandle." Aditionalmente, se dan muchas primeras citas para condados del "panhandle" de Florida.

In most previous installments of this series (Anderson 1984, 1986, 1988, 1989, 1991, 1995), "north Florida" was defined as the Florida panhandle west of the Suwannee River. In Anderson 2000 the area of coverage was expanded to include selected counties of northeastern Florida. This installment returns to the original, more restricted area of coverage, i.e., the area covered by Clewell (1985). Nomenclature generally follows Wunderlin and Hansen (2003). Austin's study (1980) was used to identify *Cuscuta* species, and Flora of North America treatments were used for Cyperaceae. Herbarium specimens are at FSU unless noted otherwise.

These findings update species distributions as mapped by Wunderlin and Hansen (2004).

TAXA NEW TO THE AREA

Arachis prostrata Benth.—Calhoun Co.: Rte 20 on E edge of Blountstown, 22 Jul 2002, *Anderson 20353*, 26 Jun 2003, *Anderson 20736*. Florida Department of Transportation workers (pers. comm.) planted this here in 1999 as "*Arachis glabrata* cultivar. Ecoturf," and it is naturalized and spreading. New to the Florida panhandle.

Bradburia pilosa (Nutt.) Semple—Leon Co.: Capitol Circle NW at railroad crossing, Tallahassee, 23 May 2003, *Anderson 20728*, 22 May 2004, *Anderson 20931*. Population persisting but presently showing no signs of becoming invasive. New to Florida; Semple (2006) mentioned possible introduction in Leon County, based on my collections, but did not put a dot for Florida on the map.

Cichorium intybus L.—Escambia Co.: W of Cantonment, 26 May 2001, *J. Burkhalter 17811* (FSU, UWFP). New to the Florida panhandle.

Coccinia grandis (L.) Voigt.—Escambia Co.: vacant lot on Cervantes St, Pensacola, 16 Sep 2005, *J. Burkhalter 20502* (UWFP), 16 Oct 2005, *J. Burkhalter 20541* (FSU, UWFP). New to Florida panhandle..

Cuscuta obtusiflora HBK var. **glandulosa** Engelm.—Jackson Co.: limestone glade (Williams no. 2), NW of Marianna, 21 Jul 2005, *Anderson 21197*. New to the Florida panhandle.

Emilia sonchifolia (L.) DC.—Leon Co.: bordering Call St on FSU campus, Tallahassee, 17 Nov 2006, *Anderson 22642*; by Kosha Lab on campus, 27 Dec 2006, *Anderson 22708*. New to north Florida. Flowers of these population were exserted 2 mm from the involucre, thus the plants were not distinguishable from *E. fosbergii* Nicolson (which is also on campus) when using the Wunderlin and Hansen (2003) key. Distinguishing features (lyrate leaves and much shorter corolla lobes) as listed by Nicolson (1975) assured proper identification; also this species has lilac corollas, whereas *E. fosbergii* corollas are salmon to red-orange in color.

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Euphorbia graminea Jacq.—Escambia Co.: near Pensacola (6709 Pensacola Blvd.), 18 Dec 2004, *J. Burkhalter 20223* (FSU, UWFP); Leon Co.: 3606 Maclay Blvd, Tallahassee, 17 Nov 2006, *Anderson 22643*. New to the Florida panhandle.

Hydrocotyle bowlesioides Mathias & Constance.—Leon Co.: 3606 Maclay Blvd, Tallahassee, 17 Nov 2006, *Anderson 22645*. New to Florida and second report for the United States. The first known occurrence of this species in the United States was from southern Georgia (Anderson 1983). I monitored the Georgia population; it gradually died out by the early 1990's. Erection of the building and its associated landscaping for the Florida site occurred in 2003, so the Georgia population was not the source for this introduction into Florida.

Hyptis verticillata Jacq.—Bay Co.: S of Hwy 98 beside Liddon St., Panama City, 14 Sep 2005; *J.R. Burkhalter 20490* (FSU, UWFP). New to the Florida panhandle.

Kalanchoe daigremontiana Raym.-Hamet & H. Perrier.—Wakulla Co.: several plants at Rte 365 bridge over Wakulla River, 5 Jan 2006, *Anderson 21525*. New to Florida panhandle.

Momordica charantia L.—Leon Co.: St. Augustine Rd, ESE of Tallahassee, 25 Oct 2005, *Anderson 21467*. This population dies back each winter but increases in area coverage every following year. New to the Florida panhandle.

Ottelia alismoides (L.) Pers.—Escambia Co.: 11 Aug 2005, *J. Burkhalter 20479* (FSU, UWFP). First observed here in 2003 by J. Van Dyke of Florida Dept. Environmental Protection; Burkhalter (letter of 15 Dec 05) reported this invasive species occurs in "uncountable thousands" and has taken over Thompson's Bayou and Ferry Pass Bayou of the Escambia River delta. New to Florida; previously known only in the United States in Louisiana and California.

Ranunculus laxicaulis (Torr. & A. Gray) Darby.—Leon Co.: locally abundant in meadow N side of Hwy 90 (2.5 mi ENE of Baum community), 19 Apr 2006, *Anderson 21680*, 22 Apr 2006, *Anderson 21711*. New to Florida. Wunderlin and Hansen (2003) list the species as excluded from the state (specimens of *R. pusillus* misapplied with this name). My specimens key to *R. flaxicaulis*; the flowers have 5–6 petals which are 5–5.5 mm long, whereas petals are fewer and much smaller in flowers of *R. pusillus* Poir. (Whittemore 1997).

Ruellia ciliatiflora Hooker.—Leon Co.: North Monroe St (Hwy 27) at Old Bainbridge Rd, Tallahassee, 20 Nov 2004, *Anderson 20957*. New to the Florida panhandle.

Solidago gigantea Ait.—Liberty Co.: mesic woodland bordering Apalachicola River at Estiffanulga, 13 Sep 2001, *Anderson 19945*. New to Florida; Semple and Cook (2006) noted this collection was the only one they saw from Florida—all other Florida collections so named were *S. leavenworthii* Torrey & A. Gray.

Symphyotrichum kralii Nesom.—Santa Rosa Co.: edge of lake at Camp Paquette, 27 Oct 1995, *Anderson 16036*. This population plus some from Karick Lake and Krull Lake had been identified as *Aster laeve* L. var. *concinnum* Willd. by A. G. Jones and were the basis of reporting that species in Florida (Anderson 2000), but I was uncomfortable with that determination. Guy Nesom recently identified a duplicate of *Anderson 16036* (BRIT) as *S. kralii*. Semple (pers. comm.) suggests *S. kralii* may be included in *S. dumosum* (L.) Nesom or *S. simmondsii* (Small) Nesom, and Wunderlin and Hansen (2003) include it in the latter, but these specimens look like neither of those species as I understand them and are possibly new to Florida. Obviously, the taxonomy of the asters is still a work in progress.

Symphyotrichum laeve (L.) Löve & Löve var. **concinnum** (Willd.) Nesom.—Jackson Co.: edge of limestone glade, 30 Sep and 20 Oct 2005, *Anderson 21385* and *Anderson 21461*. Duplicates of these specimens were identified by J. Semple (WAT), so this taxon remains in the flora of Florida, but its presence is based on these more recently discovered, different plants.

Tradescantia pallida (Rose) D.R. Hunt—Leon Co.: naturalized in woodland remnant in N part of Tallahassee, 31 Jan 2006, *Anderson 21530*. New to the Florida panhandle.

Tridax procumbens L.—Leon Co.: edges of lawn adjacent to Richards Building, F.S.U. campus, Tallahassee, 18 Nov 2005, *Anderson 21514*, many plants in cracks of sidewalk and parking area at Nuclear Research Building, F.S.U. campus, Tallahassee, 13 May 2006, *Anderson 21803*. New to the Florida panhandle.

Zinnia violacea Cav.—Jackson Co.: frequent along Bumpnose Rd bordering open pasture, 2.2 mi N of Hwy 90 (Marianna), 20 Oct 2005, *Anderson 21465*. New to the Florida panhandle.

ADDITIONAL RANGE EXTENSIONS

Some of the following are county records that "fill in" gaps (and thus were expected occurrences); they are listed without additional notation. Other collections bear significance worthy of further comment.

Acer saccharinum L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21575*.

Aesculus pavia L.—Calhoun Co.: wooded calcareous slopes bordering Chipola River WSW of Altha, 12 Apr 2006, *Anderson 21639*.

Agalinis linifolia (Nuttall) Britton.—Leon Co.: moist depression beside Old Plank Rd, SE of Tallahassee, 25 Oct 2005, *Anderson 21474*.

Agrostis perennans (Walter) Tuck.—Calhoun Co.: wooded calcareous slopes bordering Chipola River WSW of Altha, 12 Apr 2006, *Anderson 21647*.

Albizia julibrissin Durazz.—Calhoun Co.: roadside ditch, Blountstown, 24 May 2006, *T. MacClendon 460*.

Ambrosia artemisiifolia L.—Calhoun Co.: Myers Dairy Rd, SW side of Blountstown, 27 Sep 2006, *T. MacClendon 524*.

Amsonia taberaemontana Walter.—Calhoun Co.: wooded calcareous slopes bordering Chipola River WSW of Altha, 12 Apr 2006, *Anderson 21646*.

Arenaria serpyllifolia L.—Calhoun Co.: disturbed roadside near landing at Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21580*.

Aeschynomene americana L.—Gulf Co.: under Overstreet bridge, 11 Nov 2006, *Anderson 22625*.

Aureolaria flava (L.) Farw.—Gadsden Co.: edge of Brickyard Glade, 23 May 2006 (atypical phenology), *Anderson 21869*.

Brickellia eupatorioides (L.) Shinners.—Gadsden Co.: hillside glade, 0.8 mi N of Dolan Rd, 8 Nov 2005, *Anderson 21504*.

Bromus commutatus Schrad.—Bay Co.: East Panama City Beach, 14 May 1996, *Keppner s. n.*; Jackson Co.: roadside depression along Rte 167 near Dry Creek, 12 May 2006, *Anderson 21781*; Leon Co.: Tallahassee, 23 Apr 1984, *Anderson 7075*; N of Tallahassee, 14 May 1984, *Godfrey 81299*; Hwy 90 roadside 0.8 mi E of Magnolia Rd, 19 Apr 2006, *Anderson 21686* (the two 1984 collections were originally identified as *B. japonicus* Thunb, but later annotated by L. E. Pavlich as *B. commutatus*).

Calyptocarpus vialis Less.—Jefferson Co.: moist shaded loam N side of Hwy 90 at Lake Miccosukee boat landing, 19 Apr 2006, *Anderson 21665*.

Campsis radicans (L.) Seem. ex Bureau—Calhoun Co.: Ocheesee Landing on Apalachicola River, 9 Nov 2006, *MacClendon 542*.

Carex alata Torr.—Wakulla Co.: hydric hammock at McBride Slough near Rte 267, 26 May 2006, *Anderson 21871*.

Carex aureolensis Mack.—Jefferson Co.: Lake Miccosukee boat landing by Hwy 90, 19 Apr 2006, *Anderson 21671*, 2 Aug 2006, *Anderson 22160*. Wunderlin and Hansen (2003) do not list this species, but may have included it under *C. frankii* Kunth. Ford and Reznicek (2002) consider the two species distinct with only *C. aureolensis* occurring in Florida—either way this is a new county record.

Carex chapmanii Steudel.—Gadsden Co.: Flat Creek, W of Rte 269, 20 Apr 2006, *Anderson 21741*; Jackson Co.: mesic woodland near boat ramp, Three Rivers State Park, 20 May 2006, *Anderson 21833*.

Carex cherokeensis Schwein.—Calhoun Co.: calcareous mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21553*.

Carex dasycarpa Muhl.—Calhoun Co.: sandy, wooded calcareous slopes bordering Chipola River WSW of Altha, 12 Apr 2006, *Anderson 21640*.

Carex festucacea Schkuhr ex Willd.—Wakulla Co.: hydric hammock, St. Marks Nat'l Wildlife Refuge headquarters, 26 May 2006, *Anderson 21879.*

Carex fissa Mack. var. **aristata** F.J. Herm.—Calhoun Co.: 0.5 mi E of Chipola River beside Rte 20, 5 May 2003, *Anderson 20698.*

Carex gigantea Rudge.—Jackson Co.: shallow waters of Dry Creek at Rte 167 bridge, 12 May 2006, *Anderson 21783.*

Carex kraliana Naczi & Bryson.—Jackson Co.: wooded edge of limestone glade NW of Marianna, 25 Mar 2006, *Anderson 21594.* This rare species is also found in Gadsden and Leon counties in Florida.

Carex leavenworthii Dewey.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21576.* Ball in Flora of North America (2002) lists this species as distinct from *C. cephalophora* Muhl. ex Willd., but Wunderlin and Hansen (2004) list the two species under the latter in their atlas. Either way, it is a new county record.

Carex leptalea Wahlenb.—Jackson Co.: hydric hammock W of Rte 73 along N side of Dry Creek, 12 May 2006, *Anderson 21790.*

Carex muhlenbergii Schkuhr.—Gadsden Co.: Booth Hill, W end of Dolan Rd, 16 Apr 2003, *Anderson 20679.*

Carex oxylepis Torr. & Hook.—glade like opening (Brooks # 3) in woods NW of Marianna, 2 Jun 2006, *Anderson 21926.*

Carex thornei Naczi.—Leon Co.: Lafayette Heritage Trail Park, Tallahassee, 2 Apr 2003, *Anderson 20615.* This rare species is also found in Gadsden and Liberty counties in Florida.

Carex typhina Michx.—Calhoun Co.: mesic hardwoods on low bluff along Apalachicola River, SE of Blountstown, 8 Jun 2006, *Anderson 2966.*

Carex venusta Dewy.—Gadsden Co.: seepage below Powerline Glade, 23 May 2006, *Anderson 21843.*

Centella erecta (L. f.) Fern.—Calhoun Co.: open firelane beside ti-ti thicket, ca. 7.8 air mi WSW of Altha, 5 Jun 2006, *Anderson 21956.* Wunderlin and Hansen (2003) list this species as *C. asiatica* (L.) Urb. Years ago, Lincoln Constance told me *C. asiatica* (a diploid) does not occur in the continental United States and that ours is *C. erecta* (a tetraploid). Either way, the species is new to the county.

Cercis canadensis L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21583.*

Chaerophyllum tainturieri Hook.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21574.*

Cinnamomum camphora (L.) Presl.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 16 Feb 2006, *Anderson 21532.*

Cocculus carolinus (L.) DC.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21557.*

Commelina virginica L.—Calhoun Co.: mesic woodland along Apalachicola River, SE of Blountstown, 4 Apr 2006, *Anderson 21620.*

Conyza bonariensis (L.) Cronquist.—Calhoun Co.: Myers Dairy Rd, SW side of Blountstown, 17 Aug 2006, *T. & K. MacClendon 521.*

Croton glandulosus L.—Calhoun Co.: Myers Dairy Rd, SW side of Blountstown, 19 Aug 2006, *T. & K. MacClendon 522.*

Cuscuta gronovii Willd. ex Schult. in Roem. & Schult.—Jackson Co.: limestone glade (Williams no. 2), NW of Marianna, 30 Sep 2005, *Anderson 21372.*

Cuscuta pentagona Engelm.—Jackson Co.: limestone glade (Williams no. 2), NW of Marianna, 30 Sep 2005, *Anderson 21380.*

Desmodium ochroleucum M.A. Curtis ex Canby—Jackson Co.: woods at edge of fairway, Marianna Caverns Golf Course, 30 Sep 2005, *Anderson 21360* (this doubles the known sites for this taxon in Florida). This species is listed as endangered in Florida (Coile & Garland 2003).

Dichanthelium leucothrix (Nash) Freckmann.—Calhoun Co.: ephemeral pond bottom, ca. 5.8 air mi WSW of Altha, 5 Jun 2006, *Anderson 21945.*

Dichanthelium oligosanthes (Schult.) Gould.—Jackson Co.: Williams glade # 2 , NW of Marianna, 2 Jun 20056, *Anderson 21913.*

Dichanthelium strigosum (Muhl. ex Elliott) Freckmann.—Calhoun Co.: fallow field (cutover flatwoods) along River St in Blountstown, 8 Jun 2006, *Anderson 21971*; Gadsden Co.: edge of Humphrey Glade between I-10 and Dolan Rd, 8 Nov 2005, *Anderson 21491.*

Dioscorea alata L.—Wakulla Co.: locally common on N side Hwy 98 at Newport, 30 Nov 2006, *Anderson 22684.*

Dioscorea bulbifera L.—Leon Co.: still in my yard in Tallahassee after 30 years of trying to eradicate, 2 Dec 2006, *Anderson 22692*; Wakulla Co.: frequent on N side Hwy 98 at Newport, 30 Nov 2006, *Anderson 22685.*

Eleocharis baldwinii (Torr.) Chapm.—Calhoun Co.: ephemeral pond bottom, ca. 5.8 air mi WSW of Altha, 5 Jun 2006, *Anderson 21944.*

Eleocharis tortilis (Link) Schultes.—Gadsden Co.: shaded floodplain of Flat Creek, 29 Apr 2006, *Anderson 21728.* This species is infrequently collected in the state; three 19th century Florida collections exist at NY. Two are labeled "Chapman s.n., Florida" and one is "Chapman s.n., Aspalaga, Florida." Aspalaga is a historic river landing in Gadsden County, so the current collection confirms the species' continued presence in the county.

Eragrostis cilianensis (All.) Vignolo ex Janch.—Leon Co.: near loading zone behind Conradi Bldg on Florida State University campus, Tallahassee, 18 Sep 2006, *Anderson 22388.* This is the third county of record for the state.

Erigeron annuus (L.) Pres.—Calhoun Co.: W side of Blountstown (3.7 mi E of Rte 71 on Rte 20), 1 Jun 2006, *Anderson 21898.*

Eryngium prostratum Nutt. ex DC.—Calhoun Co.: W side of Blountstown (3.7 mi E of Rte 71 on Rte 20), 1 Jun 2006, *Anderson 21897.*

Fimbristylis autumnalis (L.) Roem. & Schult.—Calhoun Co.: ephemeral pond bottom, ca. 5.8 air mi WSW of Altha, 5 Jun 2006, *Anderson 21943.*

Fragaria virginiana Duchesne.—Jackson Co.: rich calcareous woods, Three Rivers State Park, 4 Apr 1979, *A. K. Gholson 7587*; edge of limestone glade (Brooks no. 1), NW of Marianna, 21 Jul 2005, *Anderson 21206*; edge of limestone glade (Williams no. 2); 30 Sep 2005, *Anderson 21383.* This species was previously known only from Leon County from collections made by R. M. Harper in 1927 (NY), but it has apparently not been collected in that county since then.

Galium aparinae L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21573.*

Galium circaezans Michx.—Gadsden Co.: wooded slopes above Apalachicola River near Aspalaga, 29 Apr 2006, *Anderson 21745.*

Gelsemium sempervirens (L.) Ait. f.—Calhoun Co.: woodland along River St near Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21581.*

Gentiana pennelliana Fern.—Leon Co.: wet savanna in Gully Bay extension of Grand Bay, Apalachicola National Forest, 11 Dec 2002, *Anderson 20552.* This species is listed as endangered in Florida (Coile and Garland 2003).

Glyceria striata (Lam.) Hitchc.—Leon Co.: wet depression in powerline corridor on S side Hwy 90, 0.5 mi W of Lake Miccosukee boat landing, 19 Apr 2006, *Anderson 21674.*

Gymnopogon ambiguus (Michx.) BSP.—Jackson Co.: edge of limestone glade (Williams no. 2), NW of Marianna, 30 Sep 2005, *Anderson 21382.*

Gymnopogon brevifolius Trin.—Gulf Co.: wet flatwoods W of Depot Creek, S of Port St. Joe, 13 Oct 2005, *T. Mitchell s.n.*

Gymnostyles anthemifolia Juss.—Escambia Co.: E. Pensacola Beach, 8 Nov 2005, *J. Burkhalter 20341* (FSU, UWFP). New to western panhandle and second record for north Florida.

Hexaletris spicata (Walt.) Barnh.—Gadsden Co.: large population at hunt camp near Aspalaga, 27 Jul 2005, *Anderson 21247*. This species is listed as endangered in Florida (Coile and Garland 2003).

Hydrocotyle verticillata Thunb. var. **triradiata** (A. Rich.) Fern.—Jefferson Co.: shaded mud at Lake Miccosukee Hwy 90 boat landing, 2 Aug 2006, *Anderson 22162*. New county record for this variety.

Hypochaeris glabra L.—Jackson Co.: E of Rte 71 near Rocky Creek, 20 Apr 2006, *Anderson 21707*, picnic area, Three Rivers State Park, 20 May 2006, *Anderson 21834*.

Hypoxis rigida Chapm.—Gadsden Co.: E.B. Glade (recently burned), 23 May 2006, *Anderson 21854*.

Hypoxis wrightii (Baker) Brackett.—Gadsden Co.: E.B. Glade, 23 May 2006, *Anderson 21853*; Jackson Co.: Williams #2 Glade, 2 Jun 2006, *Anderson 21907*; Liberty Co.: N of Rte 20 opposite Rte 2224, 4 Aug 2006, *Anderson 22169*.

Ipomoea pandurata (L.) G. Mey.—Calhoun Co.: Abe Springs, SW of Blountstown, 15 Jun 2006, *T. & K. MacClendon 504*.

Ipomoea triloba L.—Liberty Co.: Apalachicola River floodplain under Rte 20 bridge, 19 Oct 2005, *Anderson 21428*. Listed as a Federal Noxious Weed.

Iva angustifolia Nutt. ex DC.—Calhoun Co.: Myers Dairy Rd, Blountstown, 21 Jun 2006, *T. & K. MacClendon 509*.

Iva imbricata Walter.—Gulf Co.: sand dunes N end of St. Joseph Peninsula, 17 Sep 2005, *Anderson 21326*.

Juncus repens Michx.—Calhoun Co.: ephemeral pond bottom, ca. 5.8 air mi WSW of Altha, 5 Jun 2006, *Anderson 21946*.

Lamium amplexicaule L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21545*; Gadsden Co.: Rte 12 roadside SW of Greensboro, 20 Mar 2006, *Anderson 21535*.

Landoltia punctata (G. Mey.) Les & D.J. Crawford.—Jefferson Co.: with *Wolffiella* in shallow water at Lake Miccosukee Hwy 90 boat landing, 2 Aug 2006, *Anderson 22176*.

Lemna valdiviana Phil.—Calhoun Co.: abundant along shaded pond margin, ca. 5.7 air mi WSW of Altha, 5 Jun 2006, *Anderson 21957*.

Lespedeza procumbens Michx.—Gadsden Co.: N edge of Humphrey Glade between I-10 and Dolan Rd, 8 Nov 2005, *Anderson 21480*.

Lespedeza repens (L.) Bart.—Calhoun Co.: oak-pine sandhill, ca. 5.8 air mi WSW of Altha, 5 Jun 2006, *Anderson 21940*.

Lindernia crustacea (L.) F. Muell.—Liberty Co.: Apalachicola River floodplain under Rte 20 bridge, 28 Sep 2005, *Anderson 21353*.

Lolium arundinaceum (Schreb.) Darbysh.—Jackson Co.: beside Rte 73 just NW of Marianna, 2 Jun 2006, *Anderson 21899*.

Lonicera sempervirens L.—Calhoun Co.: woods bordering Chipola River WSW of Altha, 12 Apr 2006, *Anderson 21664*.

Ludwigia glandulosa Walt.—Calhoun Co.: fallow field (cutover flatwoods) along River St in Blountstown, 8 Jun 2006, *Anderson 21973*.

Ludwigia leptocarpa (Nutt.) Hara.—Calhoun Co.: Ocheesee Landing on Apalachicola River, 9 Nov 2006, *MacClendon 541*.

Malvastrum coromandelianum (L.) Garcke.—Calhoun Co.: disturbed edge of mesic woodland along Apalachicola River, SE of Blountstown, 8 Jun 2006, *Anderson 21962*.

Matelea floridana (Vail) Woodson.—Jackson Co.: both flowering and fruiting, near E entrance of Florida Caverns State Park, 27 Jul 2005, *Anderson 21218*; W side of Florida Caverns State Park, 27 Jul 2005, *Anderson 21227*; both flowering and fruiting, Williams #3 Glade, 2 Jun 2006, *Anderson 21921*. This species is listed as endangered in Florida (Coile and Garland 2003).

Medicago arabica (L.) Huds.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21570.*

Medicago lupulina L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 8 Jun 2006, *Anderson 21963.*

Medicago polymorpha L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21540*; Jefferson Co.: Lake Miccosukee boat landing, 19 Apr 2006, *Anderson 21670.*

Melia azedarach L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21559.* This species is listed as a Category II invasive exotic (FLEPPC 2005).

Melilotus albus Medik.—Calhoun Co.: roadside ditch, Blountstown, 31 May 2006, *T. MacClendon 467*; beside Bear Head Rd., ca. 7.8 mi WSW of Altha, 5 Jun 2006, *Anderson 21958.*

Micromeria brownei (Sw.) Benth. var. **pilosiuscula** A. Gray.—Wakulla Co.: Rte 267 roadside by McBride Slough. 26 May 2006, *Anderson 21874.*

Mitchella repens L.—Calhoun Co.: woods bordering Chipola River WSW of Altha, 12 Apr 2006, *Anderson 21658.*

Modiola caroliniana (L.) G. Don.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21550.*

Muhlenbergia schreberi J. F. Gmel.—Gadsden Co.: wooded edge of E.B. Glade, 23 May 2006, *Anderson 21849.*

Murdannia keisak (Hask.) Handel-Mazz.—Gadsden Co.: shaded wet shoals in Flat Creek, 29 Apr 2006, *Anderson 21740.*

Murdannia nudiflora (L.) Brenan.—Calhoun Co.: roadside near Apalachicola River boat landing, SE side of Blountstown, 19 Oct 2005, *Anderson 21436.*

Myosotis macrosperma Engelm.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21543.*

Nemophila aphylla (L.) Brummitt.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 16 Feb 2006, *Anderson 21533*, 20 Mar 2006, *Anderson 21576*; fourth county of record and southernmost population in the state.

Oxalis debilis Kunth var. **corymbosa** (DC.) Lourteig.—Calhoun Co.: wooded floodplain of Apalachicola River, SE side of Blountstown, 1 Feb 2005, *Anderson 20958.*

Oxycaryum cubense (Poeppig & Kunth) Lye.—Jackson Co.: inflorescences monocephalous, shore of Lake Seminole at boat ramp, Three Rivers State Park, 20 May 2006, *Anderson 21830.* This species is "morphologically plastic" (Bruhl 2002); the typical form is polycephalous, but most plants in the panhandle have compactly monocephalous inflorescences and can be referred to as *O. cubense* forma *paraguayense* (Maury) T. M. Pedersen. Wunderlin and Hansen (2003) list this species as *Scirpus cubensis* Poeppig & Kunth. (either way new to the county).

Packera glabella (Poir.) C. Jeffrey.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21548.*

Parthenium hysterophorus L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21541.*

Pediomelum canescens (Michx.) Rydb.—Calhoun Co.: oak-pine sandhill, ca. 5.8 air mi WSW of Altha, 5 Jun 2006, *Anderson 21941.*

Phalaris angusta Nees ex Trin.—Jackson Co.: roadside ditch, W of Chipola River, 1.3 mi S of Rte 278 on Rte 73, 12 May 2006, *Anderson 21800*; Leon Co.: Conner Creek in Lafayette Heritage Trail Park, Tallahassee, 1 Jun 2002, *Anderson 20254*, wet depression along powerline S of Hwy 90 near Jefferson County line, 19 Apr 2006, *Anderson 21679.*

Phoradendron leucarpum (Raf.) Reveal & M. C. Johnst.—Calhoun Co.: in trees along River St. in Blountstown, 4 Apr 2006, *Anderson 21627.*

Physalis angulata L.—Calhoun Co.: with *P. heterophylla* and *P. pubescens* in fallow field (cutover flatwoods) along River St. in Blountstown, 8 Jun 2006, *Anderson 21972.*

Physalis pubescens L.—Calhoun Co.: fallow field (cutover flatwoods) along River St. in Blountstown, 8 Jun 2006, *Anderson 21969*.

Piriqueta cistoides (L.) Griseb. subsp. **caroliniana** (Walt.) Arbo.—Gadsden Co.: E.B. Glade, 23 May 2006, *Anderson 21851*.

Pityopsis flexuosa (Nash) Small.—Jefferson Co.: ca. 2.1 mi ESE of Wacissa, 27 Oct 05, *Neel 0502*. This endemic species is listed as endangered in Florida (Coile and Garland 2003).

Plantago rugelii Decne.—Jefferson Co.: shaded mud at Lake Miccosukee Hwy 90 boat landing, 2 Aug 2006, *Anderson 22159*. Third county of record in the state for this species (and best looking population).

Plantago wrightiana Decne.—Jackson Co.: drying shoulder of Rte 71 at Rocky Creek bridge, 12 May 2006, *Anderson 21806*.

Platanus occidentalis L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21543*.

Pluchea baccharis (Millet) Pruski.—Calhoun Co.: roadside ditch, Blountstown, 12 Apr 2006, *T. MacClendon 466*. This species is listed as *P. rosea* Godfrey by Wunderlin and Hansen (2003), but Nesom (2006) listed that species as a synonym for the earlier name.

Poa annua L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21576*.

Polygonum hirsutum Walt.—Calhoun Co.: ephemeral pond bottom, ca. 5.8 air mi WSW of Altha, 5 Jun 2006, *Anderson 21949*.

Prunus caroliniana (Mill.) Ait.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 16 Feb 2006, *Anderson 21584*.

Prunus persica (L.) Batsch—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 16 Feb 2006, *Anderson 21531*.

Pteris multifida Poir.—Gadsden Co.: limestone outcrop in maple, beech, magnolia, oak woodland above Apalachicola River floodplain near Aspalaga, 27 Jul 2005, *Anderson 21256*.

Pycnanthemum albescens T. & G. ex A. Gray.—Jefferson Co.: 4.5 mi W of Wacissa, 31 Oct 2005, *Neel 0504*.

Pycnanthemum setosum Nuttall.—Jackson Co.: limestone glade (Williams no. 3), NW of Marianna, 21 Jul 2005, *Anderson 21176*; limestone glade (Williams no. 2), NW of Marianna, 2 Jun 2006, *Anderson 21912*.

Ranunculus abortivus L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21547*.

Ranunculus sardous Crantz.—Jackson Co.: wet roadside depression of Rte 73 at edge of hydric hammock along Dry Creek, 12 May 2006, *Anderson 21788*.

Rhynchosia tomentosa Hook. & Arn. var. **tomentosa**.—Calhoun Co.: oak-pine sandhill, ca. 5.8 air mi WSW of Altha, 5 Jun 2006, *Anderson 21938*.

Rhynchospora compressa J. Caery ex Chapm.—Gadsden Co.: Powerline Glade, 23 May 2006, *Anderson 21862*.

Richardia humistrata (Cham. & Schltdl.) Schult. & Schult. f.—Jackson Co.: edge of fairway, Marianna Caverns Golf Course, 27 Jul 2005, *Anderson 21222*. New for county and significant range extension eastward within the state.

Sagittaria filiformis J. G. Sm.—Calhoun Co.: ephemeral pond bottom, ca. 5.8 air mi WSW of Altha, 5 Jun 2006, *Anderson 21948*.

Sanicula odorata (Raf.) Pryer & Phillippe.—Calhoun Co.: shaded mesic woodland along Apalachicola River, SE of Blountstown, 4 Apr 2006, *Anderson 21619*.

Sassafras albidum (Nutt.) Nees.—Calhoun Co.: woodland along River St near Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21582*.

Setaria pumila (Poir.) Roem. & Schult.—Calhoun Co.: Abe Springs, Blountstown, 26 Jul 2006, *T. & K. MacClendon 519*.

Sida elliottii Torr. & A. Gray.—Jackson Co.: limestone glade (Williams no. 3), NW of Marianna, 21 Jul

2005, *Anderson 21179*; limestone glade (Williams no. 2), 30 Sep 2005, *Anderson 21373*; limestone glade W of Rte 73, NW of Marianna, 20 Oct 2005, *Anderson 21453*.

Silene regia Sims.—Jackson Co.: both flowering and fruiting plants observed, W side of Florida Caverns State Park, 27 Jul 2005, *Anderson 21225*. King (1981) noted this species is well established in Missouri and "elsewhere, the species is rare and widely dispersed, if not extirpated." Its presence in Florida (Jackson County) was documented in 1940 by *Henry 2312* (ISC, MIN); this new report confirms the rare species is not extirpated in Florida (certainly a candidate for listing as endangered in Florida).

Smilax ecirrhata Wats.—Calhoun Co.: wooded calcareous slopes bordering Chipola River WSW of Altha, 12 Apr 2006, *Anderson 21644*.

Smilax lasioneuron Hook.—Calhoun Co.: wooded calcareous slopes bordering Chipola River WSW of Altha, 12 Apr 2006, *Anderson 21648*.

Sonchus asper (L.) Hill.—Calhoun Co.: roadside weed beside Rte 20 on E side of Blountstown, 20 Mar 2006, *Anderson 21585*.

Spermacoce densiflora (DC.) Alain.—Calhoun Co.: abundant along roadsides near Apalachicola River boat landing, SE side of Blountstown, 19 Oct 2005, *Anderson 21431*.

Spiranthes odorata (Nuttall) Lindley. —Gadsden Co.: partially shaded edge of Humphrey Glade between I-10 and Dolan Rd, 8 Nov 2005, *Anderson 21485*; Jefferson Co.: 7 air mi SE of Wacissa, 31 Oct 2005, *H. Neel 0503*.

Sporobolus vaginiflorus (Torr. ex A. Gray) A. W. Wood.—Jackson Co.: limestone glade (Williams no. 2), NW of Marianna, 30 Sep 2005, *Anderson 21390*; limestone glades (Brooks no. 1 and 4), 20 Oct 2005, *Anderson 21445*, *Anderson 21449*; Bumpnose glade, N of Marianna, 20 Oct 2005, *Anderson 21463*. Previously known only to Gadsden County in Florida.

Symphyotrichum fontinale (Alexander) G.L. Nesom.—Gadsden Co.: between Humphrey Glade and Dolan Rd, 8 Nov 2005, *Anderson 21495*.

Symphyotrichum shortii (Lindl.) G.L. Nesom.—Jackson Co.: limestone glade (Brooks no. 1), NW of Marianna, 20 Oct 2005, *Anderson 21440*. This aster was previously known in Florida only in Gadsden County .

Symphyotrichum simmondsii (Small) G.L. Nesom.—Calhoun Co.: Ocheesee Landing on Apalachicola River, 9 Nov 2006, *MacClendon 538*; Franklin Co.: Bloody Bluff, Apalachicola River, 15 Nov 1984, *Anderson 7776*, Hickory Landing, Owl Creek, 4 Dec 1984, *Anderson 7816*, St. Vincent Island, 25 Oct 1985, *Anderson 8993*, Van Horn Landing, Apalachicola River, 24 Jan 1986, *Anderson 9091*; Jefferson Co.: Wacissa Springs, 31 Oct 2002, *Anderson 20505;* Leon Co.: wet edge of stormwater pond N of Tallahassee, 30 Nov 2005, *Anderson 21521*; Madison Co.: lakeside in Greenville, 19 Dec 1986, *Anderson 10271*; Wakulla Co.: McBride Slough, 1 Nov 1984, *Anderson 7765*, ditch near St. Marks post office, 5 Nov 1985, *Godfrey 81961*.

Tilia americana L. var. **caroliniana** (Mill.) Castigl.—Calhoun Co.: wooded calcareous slopes bordering Chipola River WSW of Altha, 12 Apr 2006, *Anderson 21652*.

Tillandsia recurvata (L.) L.—Leon Co.: epiphytic on *Quercus geminata* Small and *Ulmus parvifolia* Jacq. along edge of commercial parking lot, Raymond Diehl Rd, Tallahassee, 16 Nov 2005, *Anderson 21513*. Naturalized; county record and new to central panhandle. These relatively young trees apparently came from nursery stock in south Florida; the bromeliads are healthy and laden with fruiting branches.

Tradescantia ohiensis Raf.—Gadsden Co.: maple, beech, magnolia, oak woodland near Aspalaga, 27 Jul 2005, *Anderson 21245*.

Tridens flavus (L.) Hitchc. var. **flavus**.—Calhoun Co.: roadsides near boat landing, SE side of Blountstown, 19 Oct 2005, *Anderson 21432*.

Trifolium campestre Schreber.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21542*.

Trifolium carolinianum Michx.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21578*.

Trifolium incarnatum L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21571*.

Trifolium nigrescens Viv.—Calhoun Co.: disturbed roadside just S of Rte 274 Chipola River bridge SW of Altha, 12 Apr 2006, *Anderson 21660.*

Urena lobata L.—Leon Co.: street side in Tallahassee, 8 Oct 2005, *Anderson 21427.* County record and new to central panhandle. This species is listed as a Category II exotic invasive species in Florida (FLEPPC 2005).

Verbena officinalis L. subsp. **halei** (Small) Barber.—Calhoun Co.: disturbed roadside just S of Rte 274 Chipola River bridge SW of Altha, 12 Apr 2006, *Anderson 21661.*

Veronica arvensis L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 16 Feb 2006, *Anderson 21534.*

Veronica peregrina L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21567.*

Veronica persica Poir.—Gadsden Co.: Rte 12 roadside SW of Greensboro, 20 Mar 2006, *Anderson 21537.*

Viburnum obovatum Walter.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21562.*

Vicia minutiflora Dietr.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21560.*

Vicia sativa L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21571.*

Vicia tetrasperma (L.) Schreb.—Jackson Co.: calcareous loam of disturbed site, W edge of Florida Caverns State Park, N of Marianna, 25 Mar 2006, *Anderson 21614.*

Wisteria sinensis (Sims) Sweet.—Calhoun Co.: woodland along River St near Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21579.*

Wolffiella gladiata (Hegelm.) Hegelm.—Jefferson Co.: shallow water at Lake Miccosukee Hwy 90 boat landing, 2 Aug 2006, *Anderson 22163.*

Xanthium strumarium L. var. **glabratum** (DC.) Cronquist.—Calhoun Co.: roadside near boat landing, SE side of Blountstown, 19 Oct 2005, *Anderson 21434.*

Youngia japonica L.—Calhoun Co.: disturbed mesic woodland along Apalachicola River, SE of Blountstown, 20 Mar 2006, *Anderson 21577.*

Yucca aloifolia (L.) DC.—Jackson Co.: Williams #2 Glade, 2 Jun 2006, *Anderson 21910.*

Zizia aptera (A. Gray) Fernald.—Calhoun Co.: wooded calcareous slopes bordering Chipola River WSW of Altha, 12 Apr 2006, *Anderson 21642.* Second known site for the state of Florida.

Knowledge on the composition and distribution of the state's flora is still incomplete. The large number of reports given here for Calhoun County of relatively common species (plus some rare ones) reinforces the observation (see Moerman & Estabrook 2006) that generally the further a county is from a university in the state, the less well-known is its flora [e.g., Leon County (home of Florida State University) had 1664 species listed by Wunderlin and Hansen (2004) prior to this paper; Alachua County (home of University of Florida) had 1535; Calhoun County had 911 prior to this paper; and Lafayette County (equidistant between FSU and UF) had the fewest with 423 species listed].

Emphasis on Calhoun County has been twofold. Anderson made frequent visits to his dentist in Blountstown and then collected while in the county. Travis and Karen MacClendon live in the county and have begun a "Calhoun County Herbarium" with support from the county officials who donated herbarium supplies. This grassroots effort will provide a valuable plant identification resource for interested local citizenry.

The high number of first reports for Gadsden and Jackson counties is one result of the ongoing extensive survey of the limestone glades (unique within the state) by Wilson Baker and Loran Anderson.

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Bill and Pam Anderson, Wilson Baker, James Burkhalter, the MacClendons, and Harry Neel contributed collections or made localites known to the author. Charles Bryson provided help with identifications with some sedges; Paul Berry and Michael Huft did so with the somewhat atypical spurge from Leon County;

and Guy Nesom and John Semple did so with some asters. NY provided a virtual herbarium loan. Elizabeth A. Jensen and Elaine M. Norman provided valuable reviews of the manuscript.

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BOOK NOTICES

PAMELA A. MATSON, ASHOK GADGIL, and DANIEL M. KAMMEN (eds.). 2006. **Annual Review of Environment and Resources, Vol. 31, 2006.** (ISBN 0-8243-2331-9, hbk.). Annual Reviews, 4139 El Camino Way, PO Box 10139, Palo Alto, CA 94303-0139, U.S.A. (**Orders:** www.annualreviews.org, service@annualreviews.org, 650-493-4400, 650-424-0910 or 650-855-9815 fax, 1-800-523-8635). $85.00, 494 pp., color figures, 6¼" × 9¼".

This volume "will be a useful resource for researches and practitioners working on nature-society interactions who want and ought to know the current state of affairs on the topics reviewed, but who do not have the time to cover the individual articles in each of the dozen or so high-impact journals that would need to be read to keep up to date." The individual reviews are divided into four categories.

I. Earth's Life Support Systems
1) Abrupt change in earth's climate system. **2)** Earth's cryosphere: current state and recent changes. **3)** Integrated regional changes in arctic climate feedbacks: implications for the global climate system. **4)** Global marine biodiversity trends. **5)** Biodiversity conservation planning tools: present status and challenges for the future.

II. Human Use of Environment and Resources
6) Energy efficiency policies: a retrospectiveg examination. **7)** Energy-technology innovation. **8)** Water markets and trading. **9)** Biotechnology in agriculture.

III. Management, Guidance, and Governance of Resources and Environment
10) Environmental governance. **11)** Neoliberalism and the environment in Latin America. **12)** Assessing the vulnerability of social-environmental systems. **13)** Environment and security. **14)** Sustainability values, attitudes, and behaviors: a review of multinational and global trends.

IV. Integrative Themes
15) Linking knowledge and action for sustainable development.
—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

DIANTHA STATES and JACK STATES. 2004. **Wildflowers of Wyoming.** (ISBN 0-87842-496-2, pbk.). Mountain Press Publishing Company, Box 2399, Missoula, MT 59806, U.S.A. $20.00. (**Orders:** www.mountain-press.com, info@mtnpress.com, 406-728-1900, 406-728-1635 fax). $19.00, 254 pp., 5½" × 8½".

Both of the authors of this handy field guide are experienced botanists. They begin the book with a concise description of the varied biomes of Wyoming: alpine, subalpine, montane, foothills, steppe, and plains, noting the dominant plants and common wildflowers in each. Following a key to plant families, there are plates of postage stamp- size photographs of the flowers arranged by color, by corolla form, and other distinguishing features. The page number leads the user to the text. Arrangement is by plant family. Each species is described with blooming period, growth habitat, and general locations noted. A photograph of each species is on the opposite page. For the most part, the photographs are adequate for assured identification.—*Joann Karges, (TCU Library, retired), Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

DONALD ANTHONY SCHIEMANN. 2005. **Wildflowers of Montana.** (ISBN 0-87842-504-7, pbk.). Mountain Press Publishing Company, Box 2399, Missoula, MT 59806, U.S.A. $20.00. (**Orders:** www.mountain-press.com, info@mtnpress.com, 406-728-1900, 406-728-1635 fax). $22.00, 306 pp., 5½" × 8½".

Following the introduction describing the general landscape of the state, its climate, and vegetation zones, the author provides hints for flower identification, floral forms, leaf forms, and terms that are useful in consulting the text. Arranged by plant family, the text clearly describes each species and any with which it might be confused.

Habitat, range, and significance of the plant are noted. The color photographs are excellent. A "thumb-nail" sketch of photographs of the flowers by color and form lead even a beginner to the appropriate textual description. An added feature is the appended guide to flowers of the Bitteroot Region and of Glacier National Park which should be most welcome to visitors of those areas. This is a well-conceived and executed field guide.

Dr. Schiemann earned his doctoral degree in Environmental Science and Microbiology at the University of North Carolina, Chapel Hill.—*Joann Karges, (TCU Library, retired), Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

NEW, CORRECTED, AND INTERESTING RECORDS FOR THE KANSAS VASCULAR FLORA

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ABSTRACT

Field and herbarium studies have produced records for 25 vascular plants previously undocumented in Kansas, or known only from historic records. Three taxa are considered to be native occurrences and 22 are considered the results of recent introductions. Non-native taxa represent 21.7% of the vascular flora of the state.

RESUMEN

Los estudios de campo y de herbario han dado citas de 25 plantas vasculares previamente sin documentar en Kansas, o conocidas únicamente de citas históricas. Tres taxa se consideran nativos y 22 son considerados introducciones recientes. Los taxa no nativos representan 21.7% de la flora vascular del estado.

Continuing field and herbarium studies in the grassland biome of central North American have produced records for 24 vascular plants previously undocumented in Kansas, and one species known only from a single, historic collection. Only three taxa are considered to be native occurrences in the state; the remaining 22 (marked with an asterisk below), including 21 species and two interspecific hybrids, are considered the results of recent introductions. Following the concepts of Richardson et al. (2000), we consider 11 of these introduced taxa to be casual aliens in Kansas, seven to be naturalized, and four to be invasive in the state. In reports of floristic novelties for the state since 1998 (Freeman et al. 1998; Freeman 2000; Freeman et al. 2003; Singhurst & Holmes 2005; Barnard 2006) new non-native taxa (52) have outpaced native taxa (33), which illustrates a trend in our knowledge of the Kansas flora. While the number of vascular taxa known for the state rose from 1,872 taxa in 1940 (Stuckey & Barkley 1993) to 2,366 in 2007 (Freeman, unpublished data), the percentage of introduced taxa has increased from 17.4% to 21.7%. A similar change in the relative abundance of non-native taxa has been documented for the Missouri flora by Yatskievych and Raveill (2001), who found that introduced taxa had increased from 22.8% to 27.7% between 1965 and 2001. We anticipate that the introduced component of the Kansas flora will continue to increase as a percentage of all taxa known for the state. These reports update the distribution data contained in *Atlas of the Flora of the Great Plains* (Great Plains Flora Association 1977) and *Flora of the Great Plains* (Great Plains Flora Association 1991). All voucher specimens are deposited in the R. L. McGregor Herbarium (KANU), University of Kansas.

***Aethusa cynapium** L. (Apiaceae). Though reportedly poisonous, this European native is cultivated in North America for use as a homeopathic remedy. Fool's-parsley has been documented from most of the northeast U.S. and from Alabama (USDA, NRCS 2004). In the Midwest, it is known from Illinois (Mohlenbrock 1986), Minnesota (Ownbey & Morley 1991) and Wisconsin (Harriman 1972). Early reports of fool's-parsely in Kansas (Carruth 1873; Carruth 1877; Smyth 1890; Smyth 1892) were not substantiated with voucher specimens, however, and this species was not treated for the Great Plains by McGregor (1991). Upon reexamination, a specimen from Miami County reported by Freeman et al. (2003) as *Carum carvi* L. has proven to be *A. cynapium*, where it is considered to be a casual alien.

Carex bulbostylis Mack. (Cyperaceae). Thick-style sedge is native to the south-central U.S. and, in the Great Plains, has been reported as far north as Oklahoma (Naczi & Bryson 2003). Recent examination of

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specimens at KANU confirms the presence of *C. bulbostylis* in the Chautauqua Hills, in the southeast part of the state.

Voucher specimen: **KANSAS. Woodson Co.:** 10 mi N Yates Center, wooded area along Turkey Creek, 18 Jun 1975, *Stephens 85266.*

Carex corrugata Fernald (Cyperaceae). Native to the southeast U.S., as far north as Illinois, corrugate sedge was documented from several of the western two tiers of counties in Missouri (Yatskievych 2006) and was mapped for Kansas by Naczi and Bryson (2003), based on a single, historical specimen at NY (R.F.C. Naczi, in litt.). However, no vouchers in Kansas herbaria had been verified as belonging to *C. corrugata* and this species was not treated for the Great Plains by Kolstad (1991). Examination of historic specimens at KANU and several recent collections confirm the presence of corrugate sedge in two counties along the eastern border of the state.

Voucher specimens: **KANSAS. Cherokee Co.:** 1 mi E, 1 mi S Chetopas, 0.5 mi E Neosho River, roadside ditch, 3 Jun 1964, *Harms 2230* [Additional specimen at NY, fide Naczi]; 0.25 mi N, 3 mi E jct of US Hwy 69 & KS Hwy 96 at Crestline, Spring River Wildlife Area, T33S, R25E, sec 10, NE¼, SE¼ & sec 11, W½, SW¼, near 37°10'53", 94°38'59"W, elev 245–265 m, sandstone glade, post-blackjack oak forest on E-facing slope, and floodplain forest along Spring River, 17 Jun 2003, *Morse 9653* [Additional voucher at DOV]. **Linn Co.:** 3.5 mi S, 3.5 mi E Trading Post, Marais des Cygnes National Wildlife Refuge, T21S, R25E, sec 24, S½, SW¼, sec 25, N½, NW¼, & sec 26, NE¼, NE¼, 38.1944—38.1961°N, 94.6131—94.6254°W, elev 780–850 ft, periodically inundated swamp white-pin oak-sycamore bottomland forest and wet sedge-cordgrass prairie along tributary to Mine Creek, 14 May 2004, *Morse 10423 et al.* [Additional voucher at DOV]; 1.75 mi S, 4 mi E Trading Post, Marais des Cygnes National Wildlife Refuge, T21S, R25E, sec 13, NE¼, NE¼, 38.2259°N, 94.6124°W, elev 780 ft, bottomland pin oak-hickory-pecan forest remnant along Marais des Cygnes River, 20 May 2004, *Morse 10471 & Morse* [Additional voucher at DOV].

***Cerastium dubium** (Bast.) Guépin (Caryophyllaceae). First reported in North America from Washington in 1973 and from eastern North America in 1986 (Shildneck & Jones 1986), doubtful chickweed is now known from a handful of states in the Pacific Northwest, Midwest, and southern U.S. (Chester 2000; Belden et al. 2004; USDA, NRCS 2004). Though it has been documented from several of the western tier of counties in Missouri (Yatskievych 2006), a single collection confirms the presence of this European species in Kansas, where it is considered to be naturalized.

Voucher specimen: **KANSAS. Labette Co.:** Parsons, E-central part of town, Marvel Park, T31S, R20E, sec 20, NW ¼. 37.3387°N, 95.2481°W, elev 870–880 ft, mowed, weedy bank of Labette Creek and disturbed ground near parking lot in Marvel Park, 15 Apr 2003, *Freeman 19660.*

***Cymbalaria muralis** Gaertn. et al. (Scrophulariaceae). Native to the Mediterranean, Kenilworth ivy has been introduced as an ornamental throughout the northeast U.S. and in several western states (USDA, NRCS 2004). In the Great Plains, *C. muralis* has been documented in Nebraska and South Dakota. A recent collection confirms the presence of this species in Kansas. It is considered to be a casual alien in the state.

Voucher specimen: **KANSAS. Chase Co.:** Cottonwood Falls, N side of town, N end of Main St, on W side of street, T19S, R8E, sec 29, NE¼, NE¼, 38.3730°N 96.5418°W, elev 1200 ft, cracks in foundations of buildings and in sidewalk, 1 Apr 2006, *Freeman 21456.*

***Cyperus fuscus** L. (Cyperaceae). Introduced to North America from Eurasia, brown galingale is known from scattered localities throughout the U.S. and southeastern Canada (Gillett 1971; Tucker et al. 2003). This species has been reported along the Platte River in Douglas and Lincoln counties, Nebraska (Rolfsmeier 1995), and from several counties along the Missouri River in central Missouri (Yatskievych 1999). A large population was documented in 2003 and 2004 on dry bars along the Kansas side of the Missouri River, where it is considered to be naturalized.

Voucher specimens: **KANSAS. Leavenworth Co.:** Ft. Leavenworth, NE part, N side of Sherman Army Airfield, just S of Weston Bend of the Missouri River, 39°22'48"—23'28"N, 94°54'01"—11"W, elev ca 770 ft, mud flat along Missouri River, 30 Sep 2003, *Morse 9815*; Ft. Leavenworth, NE part, N side of Sherman Army Airfield, just S of Weston Bend of the Missouri River, 39°22'39"—41"N, 94°53'26"—52'50"W, elev 760–770 ft, muddy bar along river, 20 Nov 2003, *Morse 9911 et al.*; Ft. Leavenworth, E-central part, E side of Sherman Army Airfield, just S of Weston Bend of the Missouri River, 39.3645—39.3663°N, 94.8966—94.8902°W, elev ca 770 ft, sandy mudflats and muddy bank of river, 15 Oct 2004, *Morse 10871*; Ft. Leavenworth, NE part, N side of Sherman Army Airfield, just S of Weston Bend of the Missouri River, 39.3835°—39.3837°N, 94.9206—94.9290°W, elev 760 ft, sandy mud flats and muddy bank along river, 12

Oct 2004, *Morse 10858*; Ft. Leavenworth; S-central part, Area ca 0.5 mi NE main entrance to Fort and due N of water treatment plant, 39.3421—39.3348°N, 94.9111—94.9172°W, elev 760 ft, mudflats and muddy bank of Missouri River, 21 Oct 2004, *Morse 10898*.

Dichanthelium laxiflorum (Lam.) Gould (Poaceae). Soft-tufted panicgrass is known from throughout the southeast U.S. (Freckmann & Lelong 2003) and has been collected along the Kansas-Missouri border in Newton County, Missouri (Yatskievych 1999). A large population recently was discovered in extreme southeast Kansas, growing on sandy soil in a post oak-blackjack oak forest.

Voucher specimen: **KANSAS. Cherokee Co.:** 0.25 mi N, 3 mi E jct of US Hwy 69 & KS Hwy 96 at Crestline, Spring River Wildlife Area, T33S, R25E, sec 10, NE ¼, SE ¼ and sec 11, W½, SW¼, near 37°10'53"N, 94°38'59"W, elev 245–265 m, sandstone glade and post-blackjack oak forest on E-facing slope, 17 Jun 2003, *Morse 9665*.

***Euonymus alata** (Thunb.) Siebold (Celastraceae). Winged burningbush is locally established throughout the northeastern U.S. and in Montana (Gleason & Cronquist 1991; USDA, NRCS 2004) and has been reported as "sporadic but becoming more widespread" in Missouri (Yatskievych 2006). In Kansas, this species is known from scattered stations in the eastern two tiers of counties, where it is considered to be invasive. It appears to be especially common in white oak-shagbark hickory upland forests in the northeasternmost part of the state.

Voucher specimens: **KANSAS. Cherokee Co.:** 1.5 mi E, 1.75 mi S Baxter Springs, Woods S of small stream, old home site in area, 2 Jun 1980, *Brooks 14724*. **Douglas Co.:** Lawrence, E side of University of Kansas Main Campus, T12S, R19E, sec 36, SE¼, 38.9576—38.9620°N, 95.2430—95.2424°W, elev 980–1010 ft, weedy woodlots between Battenfeld Scholarship Hall & Lilac Ln, 17 Apr 2006, *Morse 12672*. **Leavenworth Co.:** Ft. Leavenworth, W-central part, area to N of water reservoir and E of Hancock Hill, 39°21'57"—22'03"N, 94°56'06"—55'47"W, elev 850–1060 ft, mesic oak-hickory-basswood forest on NE-facing slope and hackberry-mulberry floodplain forest along tributary to Quarry Creek, 11 Jun 2003, *Morse 9497*; Ft. Leavenworth; W-central part, area to N and W of National Cemetery, 39°20'59"—21'01"N, 94°56'00"—14"W, elev 920–1010 ft, disturbed oak-hickory-basswood forest on SE-facing slope, 23 Jun 2003, *Morse 9695*; Ft. Leavenworth, W-central part, ravine 0.25 mi E of Bell Point, between reservoir and radio tower, 39°21'46"—43"N, 94°55'58"—56'14"W, elev 880–1000 ft, disturbed oak-hickory-basswood forest on moderate E-facing slopes with deep, steep-sided draws along tributary to Quarry Creek, 18 Jul 2003, *Morse 9761*; Ft. Leavenworth, W-central part, area to E of Wagner Point and NW of National Cemetery, 39°21'10"—16"N, 94°56'21"—55'49"W, elev 850–1030 ft, disturbed oak-hickory-basswood forest on steep slopes above tributary to Quarry Creek and floodplain forest along creek, 31 Oct 2003, *Morse 9877*. **Neosho Co.:** 1 mi S of Erie, Centerville Township, in woods just above Neosho River, near old river bridge, 17 Nov 2004, *Holland 10709*. **Wyandotte Co.:** 0.75 mi S, 0.75 mi E northern jct KS Hwy 5 & I-435, NW side of Wyandotte Co Lake, T10S, R24E, sec 19, NW¼, NW¼, 39.1702°N 94.7867°W, 850–900 ft, disturbed oak-hickory forest on moderate E-facing slope, 9 May 2004, *Morse 10384*.

***Eriochloa villosa** (Thunb.) Kunth (Poaceae). Native to eastern Asia, woolly cup grass is known from scattered records throughout the U.S. (Shaw et al. 2003; Belden et al. 2004). In the Great Plains, this species has been documented in Nebraska (Rolfsmeier et al. 1991) and Iowa, where it has reportedly become a serious weed of agricultural crops (Stubbendieck et al. 1994; Darbyshire et al. 2003). Though reported for the state (USDA, NRCS 2004), woolly cup grass was not mapped from Kansas by Shaw et al. (2003) and to our knowledge a single, recent specimen confirms the presence of *E. villosa* in northeast part of the state. Based on its behavior in other states in the Great Plains, it is considered to be invasive.

Voucher specimen: **KANSAS. Douglas Co.:** 0.5 mi S, 2 mi E Big Springs, T12S, R17E, sec 18, S½, 39.0051°N, 95.4553°W, elev 1100 ft, Conservation Reserve Program field with high graminoid cover and low forb cover; terraced site with weedy, low-lying patches, 14 Jul 2005, *Fritts & Castle s.n.*

***Fatoua villosa** (Thunb.) Nakai (Moraceae). Native to China, mulberry-weed was first reported in North America from Louisiana in 1964, where it had already been known for about 15 years (Vincent 2004). The species has subsequently spread through the continental U.S., and is now reported from 30 states and the District of Columbia (Vincent 2004). It often is reported as a weed of greenhouses and cultivated ground. In the Great Plains, *F. villosa* is known from eastern Iowa (Cusick 2002), eastern Missouri (Yatskievych & Raveill 2001), and Oklahoma (Taylor & Taylor 1981; Taylor et al. 1996), where it has reportedly become a nuisance. Mulberry-weed is added to the flora of Kansas based on a small population, introduced as a seed contaminant that has persisted for several years in a flower bed in the eastern part of the state. It is considered to be a casual alien.

Voucher specimen: **KANSAS. Douglas Co.:** Lawrence, SW side of town at 3410 W 24th Place, T13S, R19E, sec 10, NE¼, NE¼, 38°56'23"N 95°16'49"W, elev 870 ft, flower bed in front of house, 2 Sep 2004, *Freeman 20106*.

Ligustrum obtusifolium Sieb. & Zucc. (Oleaceae). Native to Japan, obtuse-leaf privet is naturalized throughout the northeastern U.S. (USDA, NRCS 2004). Recent fieldwork and examination of specimens at KANU misidentified as *L. vulgare* L. have confirmed that this species is naturalized in forested areas of eastern Kansas, where it is considered to be invasive. *Ligustrum vulgare*, for its part, is frequently planted in hedges in eastern Kansas, but has not been verified as an escape.

Voucher specimens: **KANSAS. Cherokee Co.:** E side of Baxter Springs, Kiwanis Park, along N side of US Hwy 166-400, T35S, R24E, sec 1, SE¼, NE¼, 37°01'35"N, 94°43'30"W, elev 790 ft, disturbed floodplain forest edge on W side of Spring River, 13 Apr 2004, *Morse 10343 & Roth*. **Douglas Co.:** University of Kansas Campus West, brushy wooded area SW of Bridwell Lab, area undisturbed for 45 years, 6 Nov 1995, *McGregor 41206*, 11 Jun 1996, *McGregor 41211*; Baldwin Woods, ca 2 mi N Baldwin City, Kansas Ecological Reserves, Ray and Eleanor Wall Woods, T14S, R20E, sec 28, S½, NW¼, elev 990–1100 ft, oak-hickory forest and floodplain forest along Coal Creek, disturbed right of way of abandoned RR tracks, 10 Aug 1991, *Freeman 4028*. **Leavenworth Co.:** 2 mi S, 3 mi W Leavenworth, steep, wooded bank of small creek, 19 Oct 1967, *Stephens 19459*; Ft. Leavenworth, W-central part, T8S, R22E, sec 15, SE¼, elev 900–1050 ft, mesic, upland, oak-hickory-maple-basswood forest on slopes SE of Wagner Point, steep draws with few limestone outcrops, 18 May 1995, *Freeman 7133*; Ft. Leavenworth, E of Wagner Point, T8S, R22E, sec 15, NE¼, SE¼, elev 950–1050 ft, mesic edge of oak-hickory forest clearing, 15 Jun 1995, *Elliott & Morse 634*; Ft. Leavenworth, SE corner along Corral Creek, E and W along Grant Ave, T8S, R22E, sec 23, SE¼, elev 770–800 ft, open banks of creek and wooded riparian area immediately W of Grant Ave, 12 Oct 1995, *Freeman 7863*; Ft. Leavenworth, SE corner, T8S, R22E, sec 23, SE¼. 39.3372°N, 94.9247°W, elev 800 ft, disturbed riparian forest along N side of Corral Creek, 27 May 2003, *Freeman 19863*; Ft. Leavenworth, NW part, Fort de Cavagnial Picnic Area, 39°22'19"N, 94°55'55"W, elev 1020 ft, weedy edge of oak-hickory-basswood forest and mowed parkland, 11 Jun 2003, *Morse 9519*; Ft. Leavenworth, W-central part, area to E of water reservoir, below Hancock Hill, 39°21'57"—22'00"N, 94°56'06"—55'41"W, elev 850–950 ft, mesic oak-hickory-basswood forest on NE-facing slope and hackberry floodplain forest along tributary to Quarry Creek, 8 Aug 2003, *Morse 9792*; Ft. Leavenworth, S-central part, area ca 0.5 mi NE main entrance to Fort and due N of water treatment plant, 39.3421—39.3348°N,94.9111—94.9172°W, elev 760–850 ft, weedy, early successional woodlands and forests on N and E-facing slopes along Corral Creek, dominated by *Carya-Quercus* and *Celtis-Gleditsia-Maclura* assocations and exotic shrubby understory and mid-successional floodplain forest on E side of RR tracks, dominated by *Acer negundo-A. saccharinum-Salix* and *Platanus-Populus* associations with *Carex* abundant in understory, 21 Oct 2004, *Morse 10888*. **Neosho Co.:** 2 mi W Erie, low woods above Neosho River, 24 Nov 1994, *Holland 8228*.

Lonicera ×bella Zabel (*L. morrowii* A. Gray × *L. tatarica* L., Caprifoliaceae). Pretty honeysuckle is a cultivated shrub that has become established in the northeast U.S., New Mexico, and Wyoming (USDA, NRCS 2004). Recent examination of specimens at KANU revealed that plants from extreme northeastern Kansas, previously misidentified as *L. tatarica*, represent the first verified records of this fertile hybrid from the state, where it is considered to be invasive. Interestingly, in examining specimens of the *Lonicera tatarica* complex *sensu* Green (1966) for his treatment in the *Flora of Missouri*, Whittemore (2006) did not find material referable to either parent species occurring outside cultivation in that state. However, *L. ×bella* is known from scattered localities, primarily through the eastern half of Missouri. Our re-examination of Kansas material leaves *L. tatarica* represented by a single collection from Cloud County. *Lonicera morrowii* has not been verified from the state, although, using characters employed by Green (1966) in distinguishing hybrids of this complex, two specimens here referred to *L. ×bella* (*Morse 12673b*, *Morse 12673c*) appear somewhat intermediate between *L. ×bella* and *L. morrowii*.

Voucher specimens: **KANSAS. Douglas Co.:** Lawrence, just N of 19th St at S end of alley between the 1800 blocks of Indiana and Mississippi Sts, T13S, R19E, sec 1, SE¼ , NE¼. 38.9503°N, 95.2437°W, elev 880 ft, weedy, brushy right of way in alley, 11 Apr 2006, *Morse 12671;* Lawrence, E side of University of Kansas Main Campus, T12S, R19E, sec 36, SE¼. 38.9576—38.9620°N, 95.2430—95.2424°W, elev 980–1010 ft, weedy woodlots between Battenfeld Scholarship Hall & Lilac Ln, and on S side of 12th St, just E intersection with Oread Ave, 17 Apr 2006, *Morse 12673a*, *Morse 12673b*, *Morse 12673c*, 25 Apr 2006, *Morse 12673b-A*; Lawrence, E side of University of Kansas Main Campus, T12S, R19E, sec 36, SE¼. 38.9620°N 95.2424°W, elev 980 ft, weedy woodlot on S side of 12th St, just E inters with Oread Ave, 5 Jun 2006, *Morse s.n;* Lawrence, N side of University of Kansas Main Campus, T12S, R19E, sec 36, NE¼, SW¼, near 38.9640°N, 95.2493°W, elev 940–990 ft, weedy woodlot on moderate, N-facing slope along 11th St, just N of Phi Kappa Theta fraternity, 25 Apr 2006, *Morse s.n*, 5 Jun 2006, *Morse s.n*. **Leavenworth Co.:** Ft. Leavenworth, W-central part, Hills ESE of Wagner Point, T8S, R22E, sec 15, SE¼, elev 900–1050 ft, mesic, upland, oak-hickory-basswood-maple forest on hills ESE of Wagner Point, 3 May 1995, *Freeman 7087*; Ft. Leavenworth, S-central part, area ca 0.5 mi NE main entrance to Fort and due N of water treatment plant, 39.3421—39.3348°N, 94.9111—94.9172°W, elev 760 ft, weedy, early successional woodlands and forests on N and E-facing slopes along Corral Creek, dominated by *Carya-Quercus* and *Celtis-Gleditsia-Maclura* assocations and exotic shrubby understory, 21 Oct 2004, *Morse 10879*.

Malus L. (Rosaceae). Three species of Eurasian crab-apple, which are frequently cultivated in the U.S. and reported as occasional escapes throughout the northeastern states (Gleason & Cronquist 1991; Rhoads & Block 2000; USDA, NRCS 2004), have been observed growing spontaneously in eastern Kansas, where they sometimes occurred with congener *M. floribunda* Sieb. ex Van Houtte. This latter species was first reported for the state by Freeman et al. (1998).

***Malus baccata** Borkh. (Rosaceae). Siberian crabapple is consdered to be naturalized in the state.

Voucher specimens: **KANSAS. Douglas Co.:** Lawrence, University of Kansas Campus West, just S of Foley Hall, T13S, R19E, sec 2, S½, NE¼, SE¼. 38.9480°N, 95.2638°W, elev 910 ft, weedy tree line along chain link fence, 11 Apr 2005, *Morse s.n*, 25 May 2005, *Morse s.n;* Lawrence, University of Kansas Campus West, T13S, R19E, sec 2, S½, NE¼, SE¼. 38.9477°N, 95.2632°W, elev 920 ft, weedy lots near Bridwell Lab, 7 Apr 2006, *Morse 12665*, *Morse 12666*; 25 Apr 2006, *Morse 12665-A*, *Morse 12666-A*; 2 Aug 2006, *Morse 12665-B*, *Morse 12666-B*, 11 Oct 2006, *Morse 12665-C*, *Morse 12666-C*; Lawrence, SW side of town, T13S, R19E, sec 20, NE¼. 38.9131°N, 95.3189°W, elev 840 ft, low, wooded, disturbed ground S of the radio-control airfield, 17 Apr 2006, *Freeman 21459 & Morse*.

***Malus prunifolia** (Willd.) Borkh. Plumleaf crabapple is considered to be a casual alien in the state.

Voucher specimens: **KANSAS. Douglas Co.:** Lawrence, near inters of 31st and Louisiana Sts, T13S, R19E, sec 12, SE ¼, SE ¼, near 38.9293°N, 95.2435°W, elev 820 ft, weedy bank of Naismith Creek, 6 Apr 2006, *Morse 12661*, *Morse 12662*; 24 Apr 2006, *Morse 12661-A*, *Morse 12662-A*; 2 Aug 2006, *Morse 12661-B*, *Morse 12662-B*; 11 Sep 2006, *Morse 12662-C*.

***Malus sieboldii** Regel. Toringo crabapple is considered to be a casual alien in the state.

Voucher specimens: **KANSAS. Douglas Co.:** Lawrence, University of Kansas Campus West, brushy woodland SW of greenhouse; area originally an open wooded pasture, undisturbed for 45 yr, 7 Apr 1995, 26 Apr 1996, *McGregor 41119*; Lawrence, just N of intersection of Iowa St and 21st St, T13S, R19E, sec 1, W edge NW¼, SW¼. 38.9480°N, 95.2607°W, elev 920 ft, weedy drainage ditch along E side of Iowa St, 7 April 2006, *Morse 12664*, 24 Apr 2006, *Morse 12664-A*; 2 Aug 2006, *Morse 12664-B*.

***Najas minor** Allioni (Hydrocharitaceae). Native to Europe, brittle waternymph has steadily expanded its range westward in North America since first documented in New York in 1934 (Clausen 1936; Meriläinen 1968; Haynes 1979). The species has been reported from southeast Missouri (USDA, NRCS 2004) and south-central Oklahoma (Nelson & Couch 1981, Haynes 2000). A recent collection confirms the presence of *N. minor* in Kansas, where the collector reports this species has been present for several years. It is considered to be naturalized in the state.

Voucher specimen: **KANSAS. Coffey Co.:** ca 2 mi N, 2.5 mi E Burlington, Wolf Creek Lake: vicinity of Wolf Creek Generating Station, T21S, R15E or R16E, near 38.2280°N, 95.6842°W, elev ca 1070 ft, station intake and elsewhere in lake, growing in mixed population with *Najas guadalupensis* subsp. *guadalupensis*, 09 Aug 2006, *Haines s.n.*

***Oxalis corniculata** L. (Oxalidaceae). Introduced to the U.S. from tropical America, creeping woodsorrel is a common weed of greenhouses (Cusick 2002). It previously has been reported from 43 states and the District of Columbia in the continental U.S. (USDA, NRCS 2004) and from the majority of the states in the Great Plains. In Kansas, this species was first noticed in greenhouses around the University of Kansas in 1982; it has been collected from disturbed sites throughout the eastern part of the state since then. It is considered to be naturalized in the state.

Voucher specimens: **KANSAS. Chautauqua Co.:** 4 mi N, 0.5 mi E Peru, Riley Memorial Cemetery, T33S, R12E, sec 3, SE¼, SE¼, SW¼. 37°08'28"N, 96°04'56"W, elev 260 m, mowed, weedy, upland tallgrass prairie in cemetery, 23 Apr 2001, *Morse 5419 & Michener*; 0.75 mi W Peru, Peru Cemetery, T34S, R12E, sec 20, W¼, NE¼, 37°04'45"N, 96°06'41"W, elev 285 m, mowed, weedy, upland tallgrass prairie in cemetery, scattered oaks and junipers, 23 Apr 2001, *Morse 5435 & Michener*. **Cherokee Co.:** 4.75 mi S, 2.75 mi E jct of US Hwy 69 & KS Hwy 96 at Crestline, S side of SE Lostline Rd, T34S, R25E, sec 3, S½, SE¼. 37.1077°N, 94.6550°W, elev 810–900 ft, open post oak-blackjack oak-Texas hickory woodland on moderate to steep, predominately W- and S-facing slopes above Spring River, 28 Sep 2005, *Morse 11803 et al*. **Douglas Co.:** Lawrence, University of Kansas West Campus, in greenhouse beds and pots, 8 Mar 1982, *McGregor 32859*; Lawrence, 521 Lawrence Ave, in garden and lawn, 14 oct 1997, *McGregor 41335*; Lawrence, yard of private residence at 1733 Mississippi St, T13S, R20E, sec 1, SE¼, NE¼, 38.9518°N, 95.2446°W, elev 890 ft, cultivated garden, 25 Oct 2005, *Morse s.n.*

Philadelphus L. (Hydrangeaceae). Three taxa of mock-orange are reported here for the first time from Kansas. Two occurrences may represent instances in which individuals have merely persisted from prior cultivation. However, both observations were of large plants, several meters in diameter, occurring well away from any recent human habitation. A fourth taxon, *P. pubescens* Loisel (hoary mock orange), is occasionally planted as an ornamental in eastern Kansas, but has not been observed to escape.

***Philadelphus coronarius** L. Native to Eurasia, sweet mock-orange has been reported from the eastern U.S., as far west as Minnesota and Missouri (Mohlenbrock 1986; Rhoads & Block 2000, USDA, NRCS 2004). A single large individual inside the edge of an oak-hickory forest confirms the presence of this species in Kansas, where it is considered to be a casual alien.

Voucher specimens: **KANSAS. Wyandotte Co.:** 0.5 mi N, 1.75 mi E jct of KS Hwy 32 & Loring Rd on E side of Bonner Springs, Theodore Naish Boy Scout Reservation, T11S, R23E, sec 22, S¼, SW¼ and sec 27, NW¼. 39.0689—39.0735°N, 94.8507—94.8481°W, elev 900–980 ft, mesic, upland, white oak-white ash-hickory forest on generally N-facing slopes of ridge above N side of Kansas River, 18 April 2004, *Morse 11053*; 12 May 2005, *Morse 11216 et al.*

***Philadelphus inodorus** L. Scentless mock-orange is native to southeastern North America, but is frequently cultivated and has escaped throughout the northeast U.S. (Mohlenbrock 1986; Rhoads & Block 2000; USDA, NRCS 2004). A single individual found in extreme northeast Kansas confirms the presence of this species in the state, where it is considered to be a casual alien.

Voucher specimen: **KANSAS. Leavenworth Co.:** Ft. Leavenworth, E of Sherman Army Airfield along Missouri River, T8S, R23E, sec 12, S ½, elev 750–800 ft, open disturbed area along Missouri River, 28 Jun 1998, *Elliott & Freeman 834.*

***Philadelphus ×nivalis** Jacques (*P. coronarius* L. × *P. pubescens* Loisel). Though not reported as an escape in North America, this hybrid mock-orange was noted by Hu (1954–1956) as "one of the most commonly cultivated *Philadelphus* in the gardens of Boston." A single large individual growing 30 m inside the edge of an oak-hickory forest confirms the presence of this taxon in Kansas, where it is considered to be a casual alien.

Voucher specimens: **KANSAS. Leavenworth Co.:** Ft. Leavenworth, W-central part, ravine 0.25 mi E of Bell Point, between reservoir (to N) and radio tower (to S), 39°21'46"N 94°55'58"W, elev 880–1000 ft, disturbed oak-hickory-basswood forest on moderate E-facing slopes with deep, steep-sided draws along tributary to Quarry Creek, 18 Jul 2003, *Morse 9759*; 3 Jun 2004, *Morse 10537 & Rossow.*

***Poncirus trifoliata** (L.) Raf. (Rutaceae). Native to Asia, hardy-orange has been naturalized throughout the southeastern U.S. and as far north as Pennsylvania (Rhoads & Block 2000; USDA, NRCS 2004). In the Great Plains, this species has been reported from Oklahoma and eastern Texas (USDA, NRCS 2004). A single collection confirms the presence of hardy-orange in Kansas. It is considered to be a casual alien in the state.

Voucher specimen: **KANSAS. Cowley Co.:** 1.5 mi W Arkansas City, Chaplin Nature Center, T34S, R3E, sec 16, S½. 37°05'32"N, 97°06'17"W, elev 1080–1170 ft, forested uplands and floodplain, and open, sandy floodplain along W side of the Arkansas River, 25 Sep 2004, *Freeman 20199.*

***Pyracantha coccinea** M. Roem. (Rosaceae). Native to Eurasia, scarlet firethorn is reported from scattered states through the southern U.S., a handful of northeastern states, and Oregon (USDA, NRCS 2004). The species is reported by Welsh et al. (2003) as "persisting, and escaping rarely" in Utah. A single occurrence confirms the presence of this species in Kansas, where it is considered to be a casual alien.

Voucher specimen: **KANSAS. Douglas Co.:** Lawrence, ca 2 mi S, Haskell Ave, 0.5 mi S of Wakarusa River, T13S, R20E, sec 20, W ½. 38.9043°N, 95.2225°W, elev 860 ft, grazed, upland pasture E of blacktop, 17 Apr 2006, *Freeman 21461 & Morse.*

***Rhodotypos scandens** (Thunb.) Makino (Rosaceae). A native of Japan, jetbead is widely cultivated in eastern North America as an ornamental shrub and has been reported as an occasional escape, or perhap a more aggressive invader, in the northeast U.S. and from Alabama and Georgia (Rhoads & Block 2000; Lamont & Young 2002; USDA, NRCS 2004). In the Midwest, jetbead is known from Illinois (Mohlenbrock 1986) and Minnesota (Ownbey & Morley 1991), but the species has not been reported in the Great Plains. Two populations were discovered recently in forested areas of northeast Kansas, where it is considered to be naturalized.

Voucher specimens: **KANSAS. Leavenworth Co.:** Ft. Leavenworth, W-central part, area to N of water reservoir and E of Hancock Hill, 39°21'57"—22'03"N, 94°56'06"—55'47"W, elev 850–1060 ft, mesic oak-hickory-basswood forest on NE-facing slope and hackberry-mulberry floodplain forest along tributary to Quarry Creek, 11 Jun 2003, *Morse 9507*; Ft. Leavenworth, NW part, Bluffs W of N end of Sherman Army Airfield and ca 0.75 mi NE Hancock Hill, 39°22'04"—29"N, 94°55'59"—40"W, elev 770–850 ft, maple-basswood-oak forest on steep NE- and W-facing bluffs above Missouri River, and marshy floodplain forest at base of bluffs, 10 Nov 2003, *Morse 9896 & Loring*. **Shawnee Co.:** SE side of Topeka, Dornwood Park, T12S, R16E, sec 9, E½, near 39°01'18"N, 95°38'18"W, elev 900–960 ft, wooded hillside, 9 May 2002, *Hansen s.n.*

***Viola striata** Aiton (Violaceae). Native to the eastern U.S. as far west as Oklahoma (USDA, NRCS 2004), striped cream violet was mapped by Steyermark (1963) from throughout the Ozarks and in Clay Co., Missouri. Though it is occasionally cultivated in shaded gardens and lawns, the species was excluded from the Great Plains by Brooks & McGregor (1991) for lack of specimen evidence. A recent observation of a persistent population confirms the presence of *V. striata* in eastern Kansas. It is considered to be a casual alien in the state

Voucher specimen: **KANSAS. Lyon Co.:** 0.5 mi S Hartford, T20S R13E, sec 22, SE¼, SE¼, elev 350 m, mowed upland cemetery with remnant prairie, surrounded by mesic to dry-mesic tallgrass prairie in Osage Questas, 23 Apr 1997, *Morse et al. 1160.*

***Zoysia japonica** Steud. (Poaceae). Korean lawngrass is naturalized sporadically throughout the eastern U.S. and in California (Catling et al. 1977; Anderson 2003; USDA, NRCS 2004). Though commonly cultivated in lawns in Kansas, the species has only recently been confirmed as naturalized in the state.

Voucher specimen: **KANSAS. Neosho Co.:** 1 mi S Galesburg, New Mount Hope Cemetery, T30S, R19E, sec 5, SW¼, SE¼. 37°27'33"N, 95°21'01"W, elev 970 ft, mowed, grassy, E side of cemetery, scattered moist depressions with abundant *Juncus* and *Cyperus*, 16 Jun 2005, *Freeman 20505.*

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BOOK NOTICES

Douglas J. Futuyma, H. Bradley Shaffer, and Daniel Simberloff (Eds.). 2006. **Annual Review of Ecology, Evolution, and Systematics, Vol. 37, 2006.** (ISBN 0-8243-1437-9, hbk.). Annual Reviews, 4139 El Camino Way, PO Box 10139, Palo Alto, CA 94303-0139, U.S.A. (**Orders:** www.annualreviews.org, service@annualreviews.org, 650-493-4400, 650-424-0910 or 650-855-9815 fax, 1-800-523-8635). $80.00, 682 pp., color figures, 7½" × 9½".

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Winsome Shepherd. 2000. **Wellington's Heritage: Plants, Gardens, and Landscape.** (ISBN 0-909010-73-0, pbk.). Te Papa Press, Museum of New Zealand Te Papa Tongarewa, Cable Street, PO Box 467, Wellington, New Zealand. (**Orders:** www.tepapa.govt.nz/TePapa/English/TePapaPress, +64 (0)4 381-7470, +64 (0)4 381-7280 fax). ~$34.29 ($49.99 NZD), 256 pp., color photos and illustrations, b/w photos, 8¼" × 11¾".

"This book tells the story of the Wellington [New Zealand] landscape and its private and public gardens, from colonial times to the present. It looks in detail at key plantsmen and gardeners in the nineteenth century in Wellington and the Hutt Valley, gives a history of gardens of especial interest, and describes the development of the Botanic Gardens and the Town Belt, as well as other parks. Wellington's distinctive wildflowers are also well illustrated." The author notes that "the book's origins go back to 1979 when [he] was asked by the New Zealand Historic Places Trust to research plant introductions to New Zealand after the Missionary period."

It is an amazing chronicle of the evolution of the botanical landscape of this beautiful city, its "eco-history." Paintings, maps, and hundreds of photos of structures and associated landscape provide documentation of such detail and care that this account surely is a strong academic contribution. But the text is fascinating and non-technical and many interested in similar aspects of their own city, in whatever part of the world, will be interested to have this book.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

James I.L. Morison and Michael D. Morecroft (Eds.). 2006. **Plant Growth and Climate Change.** (ISBN 978-1-4051-3192-6, hbk.). Blackwell Publishing, 2121 State Avenue, Ames, IA 50014-8300, U.S.A. (**Orders:** www.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $199.99, 232 pp., illustrations, 6¼" × 9½".

The book examines the major aspects of how climate change affects plants, focusing on atmospheric CO_2, temperature, water availability and the interactions between these factors. Topics are nicely organized and cover the field with technical but easily readable discussions. Plenty of good illustrations and charts. "It is directed at advanced-level university students, researchers and professionals across the range of plant science disciplines, including plant physiology, plant ecology and crop science."

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—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

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MINUARTIA DRUMMONDII (CARYOPHYLLACEAE) AND *GRATIOLA FLAVA* (PLANTAGINACEAE) REDISCOVERED IN LOUISIANA AND *GRATIOLA FLAVA* HISTORICALLY IN ARKANSAS

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ABSTRACT

Collected in Louisiana in the mid-nineteenth century and not found since, *Minuartia drummondii* and *Gratiola flava* have recently been discovered in saline prairies in Caddo and De Soto parishes. Two herbarium sheets of *M. drummondii* collected in the mid-nineteenth century in Louisiana were located as well as an herbarium specimen of *M. drummondii*, misidentified as *M. muriculata* (*M. muscorum*), collected in a saline prairie in Red River Parish in 1990. Herbarium sheets from the mid-nineteenth century containing *G. flava* specimens from Texas, Louisiana, and possibly Arkansas were also located.

RESUMEN

Minuartia drummondii y *Gratiola flava* colectadas en Louisiana a mediados del siglo diez y nueve, y que no habían vuelto a encontrarse desde entonces, se han descubierto recientemente en paraderas salinas en las parróquias de Caddo y De Soto. Fueron localizados dos pliegos de herbario de *M. drummondii* colectados a mediados del siglo diez y nueve en Louisiana, así como un pliego de *M. drummondii*, mal identificada como *M. muriculata* (*M. muscorum*), colectada en una paradera salina en la parroquia de Red River en 1990. Se localizaron también pliegos de herbario de la mitad de la mitad del siglo diez y nueve que contienen especímenes de *G. flava* de Texas, Louisiana, y posiblemente Arkansas.

Minuartia drummondii (Shinners) McNeill [*Arenaria drummondii* Shinners] was first reported in Louisiana by Riddell (1852) under the name *Stellaria nuttallii* Torr. & A. Gray. Schutz (1979) reported it under the same name for Rapides Parish on the basis of a specimen collected in the mid-nineteenth century by Josiah Hale (*s.n.* NO). Hale's specimen is presumably the source of Riddell's (1852) inclusion since he and Hale collaborated. MacRoberts (1984) included the taxon as *M. drummondii* in his checklist of the Louisiana flora on the basis of the Schutz report. MacRoberts (1989) later reported it for Louisiana citing the Hale (*s.n.* NO) specimen. Thomas and Allen (1996) excluded *M. drummondii* from the Louisiana flora apparently because they were unable to locate an herbarium specimen. It is currently reported from Texas, Oklahoma, and Arkansas by Kartesz and Meacham (1999), Turner et al. (2003), NatureServe (2006), and USDA (2006) and in Texas, Oklahoma, Arkansas, and Louisiana by the *Flora of North America* (2006).

We located two Josiah Hale (*s.n.* NO) specimens of *M. drummondii* collected in Louisiana in the mid-nineteenth century. One label reads: "Stellaria Nuttallii, Prairies on Red River, J. Hale, M.D." and the other, "Stellaria Nuttallii, Moist Prairies, Caddo Par. La., April, Collected by Dr Josiah Hale." Neither of these specimens has a specific date.

Gratiola flava Leavenw. ex Pennell, a West Gulf Coastal Plain endemic (MacRoberts et al. 2002), is currently reported from Texas and Louisiana (Kartesz & Meacham 1999; Turner et al. 2003; NatureServe 2006;

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USDA 2006). In Louisiana, *G. flava* is currently considered to be an historical species (Louisiana Natural Heritage Program 2006) because it has not been observed or collected since Josiah Hale's collections in the mid-nineteenth century (Vincent 1982; Pennell 1935; Thomas & Allen 1998).

Specimens of *G. flava* collected by Hale exist at GH, NO, and NY. The specimen at GH is part of a composite sheet containing additional specimens of *G. flava* and a single individual of *Gratiola neglecta* Torr. The *G. flava* specimens are separated on the sheet into six different groups, each of which is associated with its own typed label, packet, or handwritten inscription. The Hale specimen is located in the lower left corner of the sheet above a label bearing the following information: "Torr. & Gray; Flora, N. Amer. Louisiana. Hale." Three of the other specimens on the sheet were collected from Texas. Two of these are Charles Wright (*s.n.*) collections, one from "Texas" and the other from "Texas. On the Colorado [River] below Lagrange [Fayette County]." The third Texas specimen is a collection by Elihu Hall (*414*) from Hempstead, Waller County. One packet containing three individuals, located in the lower right corner, bears the note "Texas & Arkansas, Leavenworth (Hb. Torr.)." Just above this packet in the right-central portion of the sheet are two individuals and to the lower right of these specimens there is an annotation "Arkansas, Leavenworth."

Whether "Arkansas" here refers to modern Oklahoma or Arkansas is unknown. Between 1819 and 1835 the Arkansas Territory incorporated both and Melines Conkling Leavenworth was collecting in the upper West Gulf Coastal Plain when Oklahoma and Arkansas were divided in 1835. To possibly further confuse matters, in territorial times there was a town of Leavenworth on the Arkansas River in Oklahoma. But from the sheet as a whole, it appears unlikely that the reference is to the town of Leavenworth.

At NO, there is a Hale specimen that is a collection consisting of a single individual of *G. flava* and two stems of *Gratiola brevifolia* Raf. The specimen has no original label data but has been annotated by Francis W. Pennell (in 1921), Karl A. Vincent (in 1980–81), and Dwayne Estes (in 2005). It is unclear from the available data whether this specimen was actually collected in Louisiana.

At NY, there are two Hale specimens. One has a form label that bears the information "*Gratiola flava*. Josiah Hale, M.D. Alexandria, Louisiana." This specimen was deposited at NY in 1983 and was formerly part of the Sartwell Collection at Hamilton College in Clinton, New York. It was annotated by Karl Vincent in 1988 but has not been annotated by anyone else. The second specimen at NY is of a single individual of *G. flava* collected by Hale from "Moist Prairies. April" and was given the collection number "12"; it was identified only as "*Gratiola*." Someone later wrote the specific epithet "*pusilla* Torr." on the specimen following the genus name. This specimen was also annotated by F.W. Pennell in 1920 (as *G. tenella* Pennell ined.) and again in 1930 (as *G. flava* Leavenworth). Vincent verified the specimen in 1980–81 and provided the following annotation: "The specimen of *Gratiola flava* is not a type specimen. This Hale collection is merely cited by Pennell as from Louisiana in his 1935 monograph (pg 83)."

Examination of all available Hale material of *G. flava* revealed that these specimens lack specific locality data. Therefore, it is quite interesting that Thomas and Allen (1998) and the USDA Plants Database (2006) map the species from Rapides Parish, Louisiana. Thomas and Allen (1998, p. 159) cite the Hale specimen at NO as the basis for the Rapides Parish record in spite of the lack of explicit label data on the specimen. Therefore, the attribution of *G. flava* to Rapides Parish is likely based on the fact that Hale primarily collected in the vicinity of Alexandria where he lived for a period of time (Ewan 2005; Anne Bradburn, Tulane University, pers. comm.). It is also possible that the species was attributed to Rapides Parish based on one of the specimens at NY that has a form label with "Alexandria, Louisiana" printed on it. Whether or not the specimen actually came from the Alexandria area cannot be known, and it is possible that this is merely the address of Hale and not the origin of the specimen. However, it is not unreasonable to believe that *G. flava* could have been collected from Rapides Parish for three reasons. First, the species is known from within a few kilometers of the Louisiana state line in northern Newton County, Texas, only about 55 km west of Rapides Parish. Second, the geologic formation with which populations of *G. flava* are associated in Newton County, the Catahoula Formation, extends eastward into northern Rapides Parish. Last, since the Hale specimen at NO was mixed with *G. brevifolia*, a species that within Louisiana is found only in Allen, Beauregard, Calcasieu, Cameron, Jefferson Davis, Rapides, and Vernon parishes (Thomas & Allen 1998; Knapp & Estes 2006) mostly in pineland seeps, it seems quite plausible that *G. flava* could have been collected by Hale from central or southwestern Louisiana, possibly in Rapides Parish.

Alternatively, it is also possible that Hale collected the specimens of *Gratiola flava* from northwestern Louisiana in prairies along the Red River. It is interesting to note that one of the specimens at NY bears the label data "Moist Prairies. April" and that similar data are found on one of the specimens of *Minuartia drummondii* collected by Hale from Caddo Parish in northwestern Louisiana (this paper).

The presence of specimens of *Gratiola flava* labeled as having been collected from "Arkansas" (*Leavenworth s.n.* GH) prompted us to investigate the literature in search of additional notes concerning the distribution of this species. Small (1903) reported *G. flava* (as *Gratiola pusilla* Torr.) from "prairies" in Arkansas and Texas without citing any vouchers, although he most likely attributed the species to Arkansas based on a specimen at NY bearing the label data "Arkansas. Dr. Leavenworth." Later, Pennell (1921) gave the distribution of *G. flava* as "sandy prairies in and near the pinelands of southern Arkansas, western Louisiana, and eastern Texas." Pennell based his citation of the species from Arkansas on the same Leavenworth specimen at NY following Small, and his attribution of the species to Louisiana was based on one of the Hale specimens at NY (Pennell 1921, p. 473). Later, Pennell (1935, p. 83) maintained *G. flava* as a component of the Louisiana flora based again on the Hale specimens (at both GH and NY); however, he did not attribute the species to Arkansas. In the list of synonyms for *G. flava,* Pennell (1935, p. 83) dismisses the occurrence of the species in Arkansas, noting "As no specimen was found marked as from 'Arkansas,' the plant must have originally been attributed to that territory because of Leavenworth's residence there or his form-labels so printed." Smith (1988:424) also excluded *G. flava* from Arkansas and provided the following note: "reported (as *G. pusilla*) for Arkansas by Small (1913) [Smith probably meant 1903], but apparently not in the state."

Extant populations of Minuartia drummondii and Gratiola flava in saline prairies in Louisiana—In March and April 2006, we found thousands of flowering *M. drummondii* and *G. flava* scattered across the 9.7 ha (23.4 acres) Barron Road Saline Prairie in southern Caddo Parish. On 13 April 2006, we found thousands of *M. drummondii* and a small number of *G. flava* on the 10.9 ha (26.8 acres) Dickson Saline Prairie in northern De Soto Parish. Subsequently, these two species have been found at two more saline prairies in De Soto Parish. The discovery of *M. drummondii* in these prairies was initially thought to be the first discovery in Louisiana since Hale's collections. However, subsequently while visiting NLU we found a specimen of *M. drummondii* (*Thomas 115,384*) misidentified as *M. muriculata* (Maguire) McNeill (*M. muscorum* (Fassett) Rabeler), collected in 1990 from a saline prairie in Red River Parish.

Saline prairies have been described by McInnis et al. (1993), Keith et al. (2004), Lester et al. (2005), and Arkansas Natural Heritage Commission (2006) in Louisiana, Texas, and Arkansas. Those in Caddo and De Soto parishes resemble other saline prairies, being open grassy expanses with treed mima mounds scattered over them. They are a mosaic of dense to sparse herbaceous vegetation with interspersed bare soils or "slicks." The soils, which are typically cryptogamic, are poorly drained with slow permeability and high sodium content. The soil series for the saline prairies in Caddo, De Soto, and Red River parishes is Bonn silt loam (Edwards et al. 1980, 1991). Brimstone and Lafe soils are also known to support saline prairies in Louisiana. In addition to *M. drummondii* and *G. flava*, species found in Louisiana saline prairies include *Anagallis minima* (L.) Krause, *Aristida longespica* Poir., *Aristida oligantha* Michx., *Astragalus distortus* Torr. & Gray, *Cooperia drummondii* Herbert, *Coreopsis tinctoria* Nutt., *Crassula aquatica* (L.) Schoenl., *Croton michauxii* G.L. Webster, *Evolvulus sericeus* Sw., *Fimbristylis puberula* (Michx.) Vahl, *Geocarpon minimum* Mackenzie, *Habranthus tubispathus* (L'Her.) Traub, *Houstonia micrantha* (Shinners) Terrell, *Houstonia pusilla* Schoepf, *Houstonia rosea* (Raf.) Terrell, *Isolepis carinata* Hook. & Arn. ex Torr., *Iva angustifolia* Nutt. ex DC., *Krigia occidentalis* Nutt., *Lepuropetalon spathulatum* Ell., *Lotus unifoliolatus* (Hook.) Benth., *Marshallia caespitosa* Nutt. ex DC., *Mimosa strigillosa* Torr. & Gray, *Minuartia muscorum* (Fassett) Rabeler, *Mirabilis albida* (Walt.) Heimerl, *Neptunia lutea* (Leavenworth) Benth., *Nothoscordum bivalve* (L.) Britt., *Opuntia humifusa* (Raf.) Raf., *Phacelia glabra* Nutt., *Phalaris caroliniana* Walt., *Plantago pusilla* Nutt., *Rumex hastatulus* Baldw., *Sabatia campestris* Nutt., *Schedonnardus* *paniculatus* (Nutt.) Trel., *Schoenolirion wrightii* Sherman, *Sporobolus pyramidatus* (Lam.) Hitchc., *Sporobolus vaginiflorus* (Torr. & Gray) Wood., *Talinum parviflorum* Nutt., *Tradescantia hirsutiflora* Bush, *Tradescantia occidentalis* (Britt.) Smyth, and *Valerianella radiata* (L.) Dufr.

Since we collected *M. drummondii* and *G. flava* in saline prairies, it is possible that Hale also did so. If that is the case and if the label information for his *M. drummondii* is correct, it would follow that at least some of the prairies on the Red River floodplain that existed in Caddo Parish in the mid-nineteenth century were saline prairies (MacRoberts et al. 1997; MacRoberts & MacRoberts 2005), and perhaps it was from these that Hale collected *G. flava*. However, it is also possible that *G. flava* was collected by Hale farther to the south in western or west-central Louisiana quite possibly from Rapides Parish. Given the close proximity of the newly discovered Louisiana populations to Arkansas, it is quite possible that Leavenworth collected *G. flava* from southwestern Arkansas in saline prairies or similar habitats.

Voucher for *Gratiola flava*. **LOUISIANA. Caddo Parish:** *B.R. & M.H. MacRoberts 7296* (LSUS), *B.R. & M.H. MacRoberts 7310* (TENN). **De Soto Parish:** *B.R. & M.H. MacRoberts 7584* (LSUS), *Reid 5724* LSU).

Vouchers for *Minuartia drummondii*. **LOUISIANA. Caddo Parish:** *B.R. & M.H. MacRoberts 7314* (LSUS). **De Soto Parish:** *B.R. & M.H. MacRoberts 7586* (LSUS), *Reid 5721* (LSU). **Red River Parish:** *Thomas 115384* (NLU).

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BOOK NOTICES

Jim L. Bowyer, Rubin Shmulsky, and John G. Haygreen. 2007. **Forest Products and Wood Science: An Introduction (5th Ed.).** (ISBN 978-0-8138-2036-1, hbk.). Blackwell Publishing, 2121 State Avenue, Ames, IA 50014-8300, U.S.A. (**Orders:** www.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $89.99, 568 pp., illustrations, 7¼" × 10¼".

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Contents.—Introduction. **1)** Tree Growth and Production of Woody Tissue. **2)** Macroscopic Character of Wood. **3)** Composition and Structure of Wood Cells. **4)** Softwood Structure. **5)** Hardwood Structure. **6)** Juvenile Wood, Reaction Wood, and Wood of Branches and Roots. **7)** Bark. **8)** Wood and Water. **9)** Density and Specific Gravity. **10)** Strength and Mechanics. **11)** Wood Durability and Protection. **12)** Silvicultural Practices and Wood Quality. **13)** Lumber. **14)** Structural Panels. **15)** Nonstructural Panels. **16)** Composite Lumber Products. **17)** Pulp and Paper. **18)** Energy and Chemical Products. **19)** Wood in the Global Raw Materials Picture.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060, U.S.A.*

Anthony R. Yeo and Timothy J. Flowers (eds). 2007. **Plant Solute Transport.** (ISBN 978-1-4051-3995-3, hbk.). Blackwell Publishing, 2121 State Avenue, Ames, IA 50014-8300, U.S.A. (**Orders:** www.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $199.99, 424 pp., illustrations, 6¼" × 9½".

A technical consideration of solute transport, with easy-to-reach information owing to the detailed and highly organized subtopical structure of the discussions. Some of the topics include diversity and roles of solutes, physical bases of ion and water movement, solute movement across membranes, adaptation of solute use to more extreme environments, and internally-controlled dehydration concomitant with seed formation. "The book is directed at postgraduates, researchers, and professionals in plant physiology, biochemistry, and molecular biology."

Contents.—**1)** General Introduction. **2)** Solutes, what are they, where are they and what do they do? **3)** The driving forces for water and solute movement. **4)** Membrane structure and the study of solute transport across plant membranes. **5)** Transport across plant membranes. **6)** Regulation of ion transporters. **7)** Intracellular transport: solute transport in chloroplasts, mitochondria, peroxisomes and vacuoles, and between organelles. **8)** Ion uptake by plant roots. **9)** Transport from root to shoot. **10)** Solute transport in the phloem. **11)** Factors limiting the rate of supply of solutes to the root surface. **12)** Mineral deficiency and toxicity. **13)** Water-limited conditions. **14)** Salinity. **15)** Desiccation tolerance.—*Guy Nesom, Botanical Research Institute of Texas, 509 Pecan Street, Fort Worth, TX 76102-4060,*

Ron Russo. 2007. **Field Guide to Plant Galls of California and Other Western States.** (ISBN 978-0-520-24885-4, pbk.). California Natural History Guide series no. 91. The University of California Press, Berkeley, CA 94704, U.S.A. (**Orders:** California Princeton Fulfillment Services, 1445 Lower Ferry Road, Ewing, NJ 08618, U.S.A., www.ucpress.edu, 609-883-1759, 609-883-7413 fax). $24.95, 400 pp., 338 color illustrations, 89 line illustrations, 15 tables, 4½" × 7¼".

Plant galls are as fascinating as they are complicated to understand. Some may appear to be no more than deformities on the plant; others are quite beautiful in shape, texture, and color. All involve a complex relationship of the gall inducer to the plant, whether it be bacterium, fungus, insect, or mistletoe. In the clear, concise, and comprehensive introduction to cecidology, the author explains the various inducers and the differences between such gall responses and those of abnormal plant growth such as cankers, burls, and root nodules.

As a field guide, the book is arranged by plant types—trees, shrubs and then by family, such as ash galls, oak galls, with indication of the parts affected, which may be stem, leaf, inflorescence, root, etc. Color photographs and line drawings accompany the descriptions of the galls, their distribution, and approximate dates of appearance.

While the book concentrates on galls of the western states, many of the galls or similar ones, especially those of the cynipid wasps that constitute 75% of gall makers, are found across the continent. This book will be useful to horticulturists, particularly perhaps those engaged in conifer culture, but it will also be useful to botanists and others who interpret the natural world.—*Joann Karges, (TCU Library, retired), Botanical Research Institute of Texas, Fort Worth, TX, 76102-4060, U.S.A.*

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NOTEWORTHY COLLECTIONS FROM THE YAZOO-MISSISSIPPI DELTA REGION OF MISSISSIPPI

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ABSTRACT

The flora of the Yazoo-Mississippi Delta Region is the least represented in the checklist of Mississippi plants currently being compiled for the state. This paper reports 20 noteworthy collections from the region and discusses their distributions within the state. *Typha angustifolia* is reported new to Mississippi and *Bowlesia incana*, *Caperonia palustris*, *Carya cordiformis*, *Carya glabra*, *Chenopodium standleyanum*, *Eichhornia crassipes*, *Hottonia inflata*, *Oplismenus setarius*, *Podophyllum peltatum*, *Polystichum acrostichoides*, *Proserpinaca palustris*, *Scirpus atrovirens*, *Senecio vulgaris*, *Sparganium americanum*, and *Spigelia marilandica* are reported new to the Yazoo-Mississippi Delta Region. Range extensions are reported for *Callicarpa americana*, *Carex intumescens*, *Carya laciniosa*, and *Menispermum canadense* within the Yazoo-Mississippi Delta Region. Of the 20 species, *Bowlesia incana*, *Caperonia palustris*, *Eichhornia crassipes*, and *Senecio vulgaris* are weeds of agricultural and humankind disturbed areas. *Carya laciniosa*, *Hottonia inflata*, and *Menispermum canadense* are plants of special concern within the state and are on the state's special plant tracking list.

RESUMEN

La flora de la región del delta del Yazoo-Mississippi es la menos representada en el catálogo de plantas de Mississippi que se está compilando actualmente para el estado. En este artículo se citan 20 colecciones notables de la región y se discute su distribución en el estado. *Typha angustifolia* se cita como nueva para Mississippi y *Bowlesia incana*, *Caperonia palustris*, *Carya cordiformis*, *Carya glabra*, *Chenopodium standleyanum*, *Eichhornia crassipes*, *Hottonia inflata*, *Oplismenus setarius*, *Podophyllum peltatum*, *Polystichum acrostichoides*, *Proserpinaca palustris*, *Scirpus atrovirens*, *Senecio vulgaris*, *Sparganium americanum*, y *Spigelia marilandica* se citan como unevas para la región del delta de Yazoo-Mississippi. Se incrementa el área de extensión de *Callicarpa americana*, *Carex intumescens*, *Carya laciniosa*, and *Menispermum canadense* dentro de la región Yazoo-Mississippi. De las 20 especies, *Bowlesia incana*, *Caperonia palustris*, *Eichhornia crassipes*, y *Senecio vulgaris* son malas hierbas para la agricultura y de áreas alteradas por el hombre. *Carya laciniosa*, *Hottonia inflata*, and *Menispermum canadense* son plantas de especial interés en el estado y están en la lista estatal del plan especial de seguimiento.

INTRODUCTION

The Yazoo-Mississippi Delta Region is not a delta in the geomorphic sense, but rather is the floodplain of the Mississippi and Yazoo rivers. This vast alluvial plain occupies approximately 18,389 km^2 and covers 10 counties entirely including Bolivar, Coahoma, Humphreys, Issaquena, Leflore, Quitman, Sharkey, Sunflower, Tunica, and Washington counties and parts of 8 other counties including Carroll, DeSoto, Grenada, Holmes, Panola, Tate, Warren, and Yazoo in northwest Mississippi. The Yazoo-Mississippi Delta Region is bordered to the west by the Mississippi River and to the east by the Loess Bluff Region (Lowe 1921; Morris 1989). From its northern terminus near Memphis, Tennessee, the Yazoo-Mississippi Delta Region extends southward to the confluence of the Yazoo and Mississippi rivers near Vicksburg, Mississippi. Topography of the region is flat and drainage is slow. Extant ridges (natural levees) rise slightly above adjacent areas of lower elevation along ancient and current stream-channels, and represent the highest elevations in the region. Soils range from poorly drained, fine clays on sites of lower relief to well drained, silt-loams and sandy soils on natural levees. Construction of artificial levee systems during the last century has altered historical flooding regimes and minimized the severity of seasonal flooding events across the region.

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The Yazoo-Mississippi Delta Region remains the least understood floristically and most under-collected region in the state of Mississippi (Carter et al. 1980). Poor geographic distribution data also characterize the region's flora. Significant collections from the region, however, are provided in Carter (1978), Gunn et al. (1980), and Wiseman (1982). The mass conversion of the native bottomland hardwood forests to agriculture production has hindered efforts to accurately define the area's historical floristic composition. Native forest vegetation is now mostly restricted to sites of lower relief not suited to agricultural production due to poor drainage. Species of these sites comprise the majority of taxa presented in the three works referenced earlier. Because of the desirability for row crop production, higher elevation, well-drained sites remaining in native vegetation are rare in the region. These specialized sites have yielded significant additions to the Yazoo-Mississippi Delta Region flora in recent decades (Bryson and Jones 1990; Carter et al. 1990; Rabler and Bryson 1990; Bryson and Elmore 1991; Bryson and Carter 1992; Bryson et al. 1992; Rosen et al. 2006), and provided some historical perspective on the original floristic composition of the area. Additionally, state and nation-wide geographic distribution data often preclude the Yazoo-Mississippi Delta Region in the native range of many plant species. Thus, the area apparently interrupts geographic distributions of species, whose ranges continue in areas of differing physiography adjacent to the Yazoo-Mississippi Delta Region. This is attributed partially to the edaphic characteristics of the region, but anthropogenic activities, particularly widespread conversion of natural ecosystems to agriculture, are also relevant. Collections presented by Carter et al. (1990) and those presented here from the isolated ridge sites remaining in native vegetation have bridged the native ranges of many species otherwise extirpated or omitted from the Yazoo-Mississippi Delta Region flora. Continued exploration of these sites will be required to attain an accurate floral description for the Yazoo-Mississippi Delta Region of Mississippi.

NOTEWORTHY COLLECTIONS

Listed below are noteworthy collections from the Yazoo-Mississippi Delta Region of Mississippi. Many represent significant new discoveries to the region. Others are range extensions of species considered rare or weedy within the Yazoo-Mississippi Delta first reported by Carter et al. (1990), or otherwise documented in the region by McCook and Kartesz's (2000) preliminary checklist of Mississippi plants. Distributional data are taken from Little (1971), McCook and Kartesz's (2000) checklist, and The PLANTS database (USDA, NRCS 2006). Herbarium abbreviations follow Holmgren et al. (1990) and Holmgren and Holmgren (1998), except the Southern Hardwoods Laboratory, Stoneville, MS (shl).

Bowlesia incana Ruiz & Pavon (Apiaceae). Hoary bowlesia (USDA, NRCS 2006), a non-native invasive weed, continues to spread northward in Mississippi in container plants supplied at nurseries and as contaminates of sod, mowing, and lawn maintenance equipment. Previously, this plant was only reported from a single collection in Harrison County in Mississippi (McCook & Kartesz 2000). Our collections are important because they document the northward range extension of *B. incana* in Mississippi and report it as a weed of lawns, landscape beds, woodland edges, nurseries, and no- and reduced-tillage row crop production systems in the Yazoo-Mississippi Delta Region. This weed is often misidentified in the seedling stage because of its similarity to *Ranunculus parviflorus* L., also a common weed of gardens, lawns, landscape beds, and woodland edges. In *B. incana* seedlings, the deeply lobed leaves are not toothed compared to the deeply lobed toothed leaves of *R. parviflorus*. Our vouchers represent significant range extensions northward and the first records of this species in the Yazoo-Mississippi Delta Region.

Voucher specimens: **U.S.A. MISSISSIPPI. Bolivar Co.:** Cleveland, Delta State University campus, 29 Apr 1993, *Stewart 4709* (SWSL); 29 Feb 1996, *Stewart 5379* (SWSL). **Issaquena Co.:** Grace, N of Hwy MS 14 in mowed lawn, 27 Apr 2001, *Bryson 18365 & Goodlett* (SWSL). **Washington Co.:** Leland, along Deer Creek Drive, 14 Apr 1991, *Bryson 10715 & Bryson* (SWSL); Leland NE jct. of Broad and Willeroy streets, 13 Mar 1994, *Bryson 13309 & Bryson* (SWSL); Leland, 2 blocks SE of Broad St. at 306 Garrison St. (private residence), in flower beds and lawn, T18N R7W S14, 20 Mar 2004, *Skojac 785* (shl); Stoneville, 16 Mar 2006, *Bryson 20609* (DOV, MISS, MISSA, MMNS, SWSL, USMS, VSC).

Callicarpa americana L. (Verbenaceae). American beautyberry (USDA, NRCS 2006) is a common woodland shrub of hardwood and mixed pine-hardwood forests throughout the state. It was most likely a common understory shrub on sites with higher elevation than surrounding areas throughout the Delta prior to the conversion of theses sites to row crop production. This species was first reported in the region by Carter et al. (1990) from ridge-bottom sites in two Yazoo-Mississippi Delta counties. Our vouchers more than double the number of documented sites within the Yazoo-Mississippi Delta Region where this otherwise common shrub occurs.

Voucher specimens: **U.S.A. MISSISSIPPI. Humphreys Co.:** SW of Belzoni and Gunn Bayou near Townson Lake, T15N R2W S16, well-drained ridge site supporting bottomland hardwood forest, 2 Sep 2005, *Skojac 1142* (shl). **Leflore Co.:** NW of Sidon, between Sidon cut-off and old Yazoo River run, T18N R1E S19, 1 Jul 1996, *Bryson 15400 & MacDonald* (SWSL); 16 Jun 1999, *Bryson 17254* (SWSL). **Sharkey Co.:** Delta National Forest, approx. 4 mi S of Holly Bluff, F.S. compartment 39, T11N R5W S34, bottomland hardwood forest, ridge-bottom site with notably higher relief than surrounding terrain, 26 May 2005, *Skojac 1108* (shl).

Caperonia palustris (L.) St.-Hil. (Euphorbiaceae). Sacatrapo (USDA, NRCS 2006) or Texasweed (WSSA 1989) is reported in four southern states, including neighboring Arkansas and Louisiana, but is not listed in Mississippi (USDA, NRCS 2006). McCook and Kartesz (2000) do not report vouchers of *C. palustris* from Mississippi either, but do indicate that the species has likely been introduced into the state. Our vouchers from Washington County are the first published accounts of this species from the Yazoo-Mississippi Delta Region, where it is a weed of rice and soybeans, two of the principal agricultural row crops of the region. During the past decade, *C. palustris* has become a major weed of rice production in Washington County, Mississippi.

Voucher specimens: **U.S.A. MISSISSIPPI. Washington Co.:** ca. 4 mi W of Arcola in rice field, 30 Aug 1982, *McDaniel* (SWSL); 5 mi W of Arcola in soybean field, 11 Jul 1983, *Elmore 208* (SWSL); Leland, weed in flowerbed along Cotton Drive, 28 Jul 1997, *Bryson 16076* (SWSL); Leroy Percy State Park, along S side of dirt road near ball field NE of alligator pond, T13W R5W S9, 6 Nov 2005, *Walker MS24* (shl).

Carex intumescens Rudge (Cyperaceae). Greater bladder sedge (USDA, NRCS 2006) was first reported new to the region in Carter et al. (1990). It is locally common in many bottomland hardwood forests throughout the rest of Mississippi. Our voucher represents a range extension and county record of this seemingly rare sedge in the Yazoo-Mississippi Delta Region.

Voucher specimen: **U.S.A. MISSISSIPPI. Bolivar Co.:** appox. 3.7 mi NW of Shelby, MS and ca. 2.0 mi W of US 61 in an isolated tract of bottomland hardwood forest, 33°59'N 90°48'W, T25N R6W S34, 3 Jun 2004, *Skojac 871 & Bryson* (shl, SWSL).

Carya cordiformis (Wangenh.) K. Koch (Juglandaceae). Bitternut hickory (USDA, NRCS 2006) has wide distribution across much of the eastern U.S., but was excluded from the Yazoo-Mississippi Delta Region by Little (1971). In Mississippi, it occurs in the northern half of the state on mesic to dry upland sites with other hardwoods and it is somewhat common on well-drained soils of minor stream-bottom systems as well. Our voucher is the first record of this hickory in the Yazoo-Mississippi Delta Region. Interestingly, this collection was made from a river-bordering county rather than from one bordering the Loess Bluffs, where the species is quite abundant.

Voucher specimen: **U.S.A. MISSISSIPPI. Washington Co.:** Yazoo National Wildlife Refuge, wooded tract S of Alligator Pond along extant ridge bordering slough, 17 Aug 2004, *Skojac 982* (shl).

Carya glabra (Mill.) Sweet (Juglandaceae). According to Little (1971), the native range of pignut hickory (USDA, NRCS 2006) extends across all of Mississippi with the exception of the Yazoo-Mississippi Delta Region. Our collections extend the known native range of this hickory into the Yazoo-Mississippi Delta, where it appears to be restricted to the higher elevation ridge sites in the region. It is possible the material we collected is of the *C. leiodermis* Sarg. form of pignut hickory, which is of special concern in the state.

Voucher specimens: **U.S.A. MISSISSIPPI. Holmes Co.:** Hillside National Wildlife Refuge, ca. 3 mi N of Eden in woods near the Alligator Slough Nature Trail on ridge-bottom site, 29 Jul 2004, *Skojac 937* (shl). **Humphreys Co.:** SW of Belzoni and Gunn Bayou near Townson Lake, T15N R2W S16, well-drained ridge site supporting bottomland hardwood forest, 2 Sep 2005, *Skojac 1143* (shl).

Carya laciniosa (Michx. f.) Loud. (Juglandaceae). Shellbark hickory (USDA, NRCS 2006) is a scattered tree of alluvial sites north of Mississippi. According to Little (1971), its native range extends southward to southwestern Tennessee and northeastern Arkansas along the Mississippi river. A single record of this species from DeSoto County in extreme northwest MS is reported in McCook and Kartesz's (2000) checklist of Mississippi plants. Our vouchers represent a significant range extension southward in the state. Shellbark hickory is listed on the Mississippi special plant tracking list (Mississippi Natural Heritage Program 2002).

Voucher specimens: **U.S.A. MISSISSIPPI. Bolivar Co.:** ca. 3.7 mi NW of Shelby, MS and ca. 2.0 mi W of US 61 in an isolated tract of bottomland hardwood forest, 33°59'N 90°48'W, T25N R6W S34, 3 Jun 2004, *Skojac 865 & Bryson* (SWSL, shl). **Tunica Co.:** ca. 4 mi S of Tunica; 1 mi S jct. Hwy US 61 and MS 4, then 1 mi E of Hwy US 61 on Hurt Rd., S of Hurt Rd., T5S R11W S28, N34°37.574' W 090°22.189', bottomland hardwood forest, 3 May 2006, *Skojac 1257 & Bryson* (shl).

Chenopodium standleyanum Aellen (Chenopodiaceae). Standley's goosefoot (USDA, NRCS 2006) has limited distribution in Mississippi and is known only from the Yazoo-Mississippi Delta counties of Sharkey and Leflore (McCook & Kartesz 2000; USDA, NRCS 2006). Our specimens were taken within and along the edges of bottomland hardwood forests. This habitat differs from that of the more common *C. album* L., which occurs most frequently in open fields and along row crop field margins in the Yazoo-Mississippi Delta Region, and elsewhere in the state. Both McCook and Kartesz (2000) and USDA, NRCS (2006) cite our Leflore County voucher based on duplicate material provided by the authors. Our vouchers document the Leflore County station and provide an additional county record within the Yazoo-Mississippi Delta Region, and represent the only other documented records of this species in the state.

Voucher specimens: **U.S.A. MISSISSIPPI. Bolivar Co.:** Approx. 3.7 mi NW of Shelby, MS and ca. 2.0 mi W of US 61 in an isolated tract of bottomland hardwood forest, along southern edge of forest growing on spoil material from adjacent ditch, 33°59'N 90°48'W, T25N R6W S34, 12 Aug 2004, *Skojac 971* (SWSL, shl). **Leflore Co.:** NW of Sidon, between Sidon cut-off and old Yazoo River run, T18N R1E S19, 31 Aug 1998, *Bryson 16654 et al.* (MISS, SWSL).

Eichhornia crassipes (Mart.) Solms (Pontederiaceae). Common water hyacinth (USDA, NRCS 2006) is an exotic aquatic weed native to S. America. It has invaded most southern states, where it is a problem in waterway canals, ditches, and ponds. McCook and Kartesz (2000) report this invasive aquatic weed in seven counties in southern Mississippi and NRCS (2006) reports it from an additional two counties. Our vouchers are a significant range extension northward in the state, and represent the first records of this species in the Yazoo-Mississippi Delta Region.

Voucher specimen: **U.S.A. MISSISSIPPI. Issaquena Co.:** ca. 5 air mi NE of Mayersville at jct. of Grace Road and Steele Bayou, 30 Oct 2006, *Bryson 21940 & Hoagland* (DOV, SWSL, VSC). **Leflore Co.:** ca. 6 mi SW of Greenwood on S end of Lake Roebuck and just N of Leflore County Road 512, 31 Oct 2006, *Bryson 21943* (DOV, MISS, MISSA, MMNS, SWSL, VSC). **Washington Co.:** SW of Greenville at Warfield Point Park, sandbar along Mississippi river, T18N R9W S13, 10 Oct 2005, *Walker MS11* (shl); ca. 2.2 air mi E of Glen Allan at jct. of Hwy MS 1 and Steele Bayou, 30 Oct 2006, *Bryson 21938 & Hoagland* (DOV, MISS, MISSA, SWSL, VSC); ca. 5.8 mi NE of Glen Allan at jct. of Bear Garden Road and Steele Bayou, 30 Oct 2006, *Bryson 21942 & Hoagland* (MISSA, SWSL).

Hottonia inflata Ell. (Primulaceae). American featherfoil (USDA, NRCS 2006) is a submersed aquatic native to the eastern half of the United States. Where observed, it is known to be sporadic in appearance from year to year. In Mississippi, the species is of special concern and is listed on the state's special plant tracking list (Mississippi Natural Heritage Program 2002). McCook and Kartesz (2000) report this species from neighboring Quitman County in the Delta, and a second voucher is reported from the eastern part of the state in Oktibbeha County by USDA, NRCS (2006). Our voucher represents only the third published account of this species in the state, and doubles the number of sites within the Yazoo-Mississippi Delta Region where this species occurs.

Voucher specimen: **U.S.A. MISSISSIPPI. Tunica Co.:** ca. 5.5 mi S of Tunica; lake parallel to Margie Rd., T5S R11W S33, growing in lake, 3 May 2006, *Bryson 21414 & Skojac* (ALA, DOV, FLAS, FSU, GH, LSU, MICH, MISS, MISSA, MMNS, MO, NY, SWSL, TENN, UARK, US, USCH, USMS, VDB, VPI, VSC, WIN), *Skojac 1266 & Bryson* (shl).

Menispermum canadense L. (Menispermaceae). Common moonseed (USDA, NRCS 2006) is considered rare in Mississippi (Morris et al. 1993) and is listed on the state's special plant tracking list (Mississippi Natural Heritage Program 2002). It was first reported from the Yazoo-Mississippi Delta Region by Carter et al. (1990) from Bolivar, Coahoma, and Sunflower counties. Two other stations in Bolivar County are listed in McCook and Kartesz's (2000) checklist, representing the only other published accounts of this species in the Yazoo-Mississippi Delta Region. Our voucher from Washington County provides an additional county record for this woody vine rare to Mississippi.

Voucher specimen: **U.S.A. MISSISSIPPI. Washington Co.:** Delta Experimental Forest, along eastern side of woods directly N of W entrance onto Forest via Feather Farms Rd., T19W R7W S33, bottomland hardwood forest, 6 Nov 2004, *Skojac 1091 & M. Skojac* (shl).

Oplismenus setarius (Lam.) Roem. & Schult. (Poaceae). Bristle basketgrass (USDA, NRCS 2006) is reported in several southern counties within the state by McCook and Kartesz (2000). It was not, however, reported in Carter's (1978) flora of Delta National Forest, most likely due to the rather isolated population from which the Sharkey County material was collected. Our vouchers represent a significant range extension northward in the state and are the first records of this species in the Yazoo-Mississippi Delta Region, where it appears restricted to well-drained ridge sites.

Voucher specimens: **U.S.A. MISSISSIPPI. Sharkey Co.:** Delta National Forest, Sweetgum Research Natural Area, T12N R5W S9, old-growth bottomland hardwood forest, 19 Sep 2003, *Skojac 775* (shl). **Washington Co.:** Yazoo National Wildlife Refuge, wooded tract S of Alligator Pond along extant ridge bordering slough, 17 Aug 2004, *Skojac 980* (shl).

Podophyllum peltatum L. (Berberidaceae). This is the first published record of mayapple (USDA, NRCS 2006) from the Yazoo-Mississippi Delta Region. Its principle distribution within the state lies east of the Delta in the rich deciduous woods of the Loess Bluffs (McCook & Kartesz 2000; USDA, NRCS 2006). It is common elsewhere in the state as well, except in the extreme lower coastal plain, where it occurs on mesic sites in upland hardwood forests and occasionally on ridge sites within minor stream-bottom forests.

Voucher specimen: **U.S.A. MISSISSIPPI. Tunica Co.:** ca. 6 mi S of Tunica; along Margie Rd., T5S R11W S33, on elevated ridge-bottom parallel to lake, 3 May 2006, *Bryson 21417 & Skojac* (DOV, SWSL, VSC); *Skojac 1272 & Bryson* (shl).

Polystichum acrostichoides (Michx.) Schott (Dryopteridaceae). Specimens of Christmas fern (USDA, NRCS 2006) were collected from a small group of plants growing on an elevated ridge site with notably higher relief than the surrounding terrain. This single isolated station was not reported in Carter's (1978) flora of Delta National Forest. This voucher represents the first record of Christmas fern from the Yazoo-Mississippi Delta Region. It is common elsewhere in the state, except in the extreme lower coastal plain, usually occurring in upland hardwood and mixed pine-hardwood forests.

Voucher specimen: **U.S.A. MISSISSIPPI. Sharkey Co.:** Delta National Forest, approx. 4 mi S of Holly Bluff, F.S. compartment 39, T11N R5W S34, 7 Nov 2005, *Skojac 1198* (shl).

Proserpinaca palustris L. (Haloragaceae). Marsh mermaidweed (USDA, NRCS 2006) is a polymorphic, aquatic to semi-aquatic herb of ponds, sloughs, and seasonally inundated depressions. It has a sporadic distribution within Mississippi, occurring in seven counties ranging from the extreme northern county of Alcorn to the coastal counties of Hancock and Jackson (McCook & Kartesz 2000; USDA, NRCS 2006). Our voucher is the first collection of the species from a county within the Yazoo-Mississippi Delta Region, where it was found in a depression at the edge of a beaver damaged area of bottomland hardwoods.

Voucher specimen: **U.S.A. MISSISSIPPI. Washington Co.:** ca. 5.0 mi W of Hollandale on Hwy MS 12 at Leroy Percy State Park; ca. 0.3 mi W of Park entrance in woods S of Hwy 12 and E of West Park Rd., T15N R7W S17, 12 Jun 2006, *Skojac 1342* (SWSL, shl).

Scirpus atrovirens Willd. (Cyperaceae). Green bulrush (USDA, NRCS 2006) is locally common in the northern third of Mississippi, excluding the Yazoo-Mississippi Delta Region. McCook and Kartesz (2000) and USDA, NRCS (2006) list *S. atrovirens* from six north-central Mississippi counties outside of the Yazoo-Mississippi Delta Region. This voucher represents the first record of this species in the Yazoo-Mississippi Delta, where it is apparently restricted to wet open areas adjacent to a swamp predominated with *Taxodium distichum* (L.) Richard and *Salix nigra* Marshall.

Voucher specimen: **Bolivar Co.:** SE of Rosedale, ca. 1.5 mi SE jct. Hwy MS 1 and MS 8, 17 Jun 1996, *Bryson 15343 & Carter* (DOV, MISS, MISSA, MMNS, MO, SWSL, VSC).

Senecio vulgaris L. (Asteraceae). Common groundsel (WSSA 1989) or old-man-in-the-spring (USDA, NRCS 2006) is a common weed of agricultural and non-agricultural areas throughout most of the United States; however, it was undetected in the Yazoo-Mississippi Delta Region by Gunn et al. (1980) and others. McCook and Kartesz (2000) and USDA, NRCS (2006) report *S. vulgaris* from Mississippi but do not provide data. This voucher represents the first collection of this species in the Yazoo-Mississippi Delta Region, where it was found locally on clay soils in no- and reduced-tillage cotton and soybean fields in association with *Alopecurus carolinianus* Walt., *Bowlesia incana*, *Conyza canadensis* (L.) Cronq., *Coronopus didymus* (L.) Sm., *Lamium amplexicaule* L., *Myosurus minimus* L., *Oenothera laciniata* Hill, and other early season weeds commonly found in reduced-tillage row crop production systems.

Voucher specimen: **U.S.A. MISSISSIPPI. Washington Co.:** 2.5 mi NE of Stoneville, W side of Napanee Rd., T19N R7W sect. 36; locally common weed on edge of no-till soybean field, 6 Apr 2006, *Bryson 20617* (ALA, DOV, MICH, MISS, MISSA, MMNS, MO, SWSL, UARK, USMS, VDB, VSC, shl).

Sparganium americanum Nutt. (Sparganiaceae). Threesquare burreed (WSSA 1989) or American burweed (USDA, NRCS 2006) is reported from 9 Mississippi counties (McCook & Kartesz 2000; USDA, NRCS 2006) excluding the Yazoo-Mississippi Delta Region. This voucher represents the first collection of this species to the Yazoo-Mississippi Delta Region, where it was found locally in a ditch and small oxbow lake in association with *Hottonia inflata* and *Hydrocotyle ranunculoides* L. and surrounded by *Taxodium distichum*, *Salix nigra* and *Styrax americana* Lamarck.

Voucher specimen: **U.S.A. MISSISSIPPI. Tunica Co.:** 5.5 mi S of Tunica; lake parallel to Margie Rd., T5S R11W S33, growing in lake, 3 May 2006, *Bryson 21416 & Skojac* (DOV, SWSL, VSC), *Skojac 1267 & Bryson* (shl); 3 Oct 2006, *Bryson 21928* (MISS, MISSA, SWSL).

Spigelia marilandica L. (Loganiaceae). Indian pink or woodland pinkroot (USDA, NRCS 2006) is a common herb of rich woodland sites. In Mississippi, it occurs on mesic upland sites and on elevated ridges within minor stream-bottom systems. This species has wide distribution throughout the state but is not reported from the Yazoo-Mississippi Delta Region (McCook & Kartesz 2000). Our voucher is the first record of this species from the region, where it appears restricted to well-drained ridge bottom sites.

Voucher specimen: **U.S.A. MISSISSIPPI. Tunica Co.:** ca. 6 mi S of Tunica along Margie Rd., T5S R11W S33, elevated ridge-bottom parallel to lake, 3 May 2006, *Skojac 1274 & Bryson* (shl).

Typha angustifolia L. (Typhaceae). Narrowleaf cattail (USDA, NRCS 2006) has limited distribution in the southeastern U.S. The species is reported from the neighboring states of Arkansas, Louisiana and Tennessee (USDA, NRCS 2006), but is not included in the preliminary checklist of Mississippi plants being compiled by McCook and Kartesz (2000). Our voucher from the Yazoo-Mississippi Delta Region is the first record of the species in the state of Mississippi.

Voucher specimen: **U.S.A. MISSISSIPPI. Washington Co.:** 0.5 mi S of southern entrance onto Delta Experimental Forest, in ditch on E side of Experiment Station Rd., 28 May 2003, *Skojac 724* (shl).

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ANNOUNCEMENTS

THE 2007 DELZIE DEMAREE TRAVEL AWARD

Applications for the 2007 Delzie Demaree Travel Award should include a letter from the applicant telling how symposium attendance will benefit his/her graduate work and letter of recommendation sent by the major professor. Please send letters of application to: Dr. Donna M.E. Ware, P.O. Box 8795, Herbarium, Biology Department, The College of William and Mary, Williamsburg, VA 23185-8795, U.S.A. 1-757-221-2799; Email: ddmware@wm.edu. The period for receiving applications will end three weeks prior to the date of the symposium if a sufficient number of applications are in hand at that time. Anyone wishing to apply after that date should inquire whether applications are still being accepted before applying. The Systematics Symposium dates for 2006 are 12–13 October.

The Delzie Demaree Travel Award was established in 1988 honoring **Delzie Demaree** who attended 35 out of a possible 36 symposia before he died in 1987. Delzie Demaree was a frontier botanist, explorer, discoverer, and teacher. His teaching career as a botanist began in Arkansas at Hendrix College in 1922. He also taught botany at the University of Arkansas, Navajo Indian School, Yale School of Forestry, Arkansas A&M, and Arkansas State University at Jonesboro where he retired as professor emeritus in 1953. One of the things he enjoyed most as a botanist was assisting students with their field botany research.

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The New York Botanical Garden is pleased to announce that Valquiria Ferreira Dutra, of the Universidade Federal de Viçosa is the recipient of the Rupert Barneby Award for the year 2007. She will be studying the genus Mimosa in the "campos rupestres" in Eastern Brazil.

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TALINUM RUGOSPERMUM (PORTULACACEAE) NEW TO OKLAHOMA

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ABSTRACT

Talinum rugospermum Holz. (Portulacaceae) is reported new to Oklahoma. It was discovered at The Nature Conservancy's Boehler Seeps and Sandhills Preserve in Atoka County.

RESUMEN

Se cita cono nuevo para Oklahoma *Talinum rugospermum* Holz. (Portulacaceae). Se ha descubierto en la reserva Nature Conservancy's Boehler Seeps and Sandhills en el condado de Atoka.

Talinum rugospermum Holz. has not been reported from Oklahoma although it occurs in Texas, Arkansas, Kansas, and Louisiana (Cochrane 1993; Tayor & Taylor 1994; Singhurst 1996; MacRoberts & MacRoberts 1997; Kartesz & Meacham 1999; Kiger 2003; USDA, NRCS 2006; NatureServe 2006; Oklahoma Natural Heritage Inventory 2003; Hoagland et al. 2004, Bruce Hoagland pers. comm., Jason Singhurst, pers. comm.). On May 18 and 19, 2006, we found over one hundred *T. rugospermum* plants in flower in xeric sandylands at The Nature Conservancy's Boehler Seeps and Sandhills Preserve, Atoka County, Oklahoma. Also known as a bluejack oak sandhill community or *Quercus incana-Quercus stellata* woodland association, xeric sandylands occur in eastern Texas, southern Oklahoma, southwestern Arkansas, and western Louisiana, and are rare in all but Texas (Jones 1993; Hoagland 2000; MacRoberts et al. 2002a; Diggs et al. 2006). Xeric sandylands are characterized by deep sands, an open understory, sparse vegetation, and a distinct assemblage of plants, many of which are endemic to the West Gulf Coastal Plain (MacRoberts et al. 2002a, 2002b). In Oklahoma, Boehler Seeps and Sandhill Preserve is the best remaining site for this community (Jones & Carpenter 1995; Gatti Clark 1997). The global conservation status rank for *T. rugospermum* assigned by NatureServe (2006) is G3G4, meaning that it is either vulnerable across its range (G3) or apparently secure (G4). Associate species at the site included *Cnidoscolus texanus, Collinsia violacea, Commelina erecta, Eriogonum longifolium, Evax prolifera, Loeflingia squarrosa, Opuntia humifusa, Paronychia drummondii, Phacelia strictiflora, Quercus incana, Selaginella arenicola* ssp. *riddellii,* and *Stylisma pickeringii*.

Voucher specimen: **U.S.A. Oklahoma. Atoka Co.:** Boehler Seeps and Sandhills Preserve, just W of Boehler, SE1/4 SE1/4 S25 and NE1/4 NE1/4 S36, T4S R13E. 18 May 2006, *Reid, Faulkner, MacRoberts, MacRoberts 5754* (LSU, OKL)

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ADDITIONAL NOTEWORTHY COLLECTIONS OF *CYPERUS DRUMMONDII* (CYPERACEAE) FROM TEXAS AND FIRST REPORT FROM MEXICO

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ABSTRACT

Recent noteworthy collections of *Cyperus drummondii* from the Texas Gulf Prairies and Marshes, Piney Woods Natural Regions, and a first record from Mexico are reported.

RESUMEN

Se citan colecciones recientes notables de of *Cyperus drummondii* de las paraderas y charcas del Golfo de Texas, Piney Woods Natural Regions, y una primera cita de México.

Collections of *Cyperus drummondii* Torr. & Hook. from the Gulf Coast Prairies and Marshes as defined by Gould (1975) from Texas counties not previously reported by Rosen (2004) were made during field work in 2004–2007 as follows:

TEXAS. Fort Bend Co.: Buffalo Creek Unit of the San Bernard National Wildlife Refuge, S of FM 442, 7.2 km W of its intersection with Hwy. 36, between the towns of Boling and Needville, 10 May 2007, *Rosen 4114* (BRIT, TAES, TEX, VSC).

At this location, *Cyperus drummondii* occurred frequently in prairie wetlands on clayey-loam soils with *Carex aureolensis* Steud., *C. festucacea* Schkuhr ex Willd., *C. triangularis* Boeck., *Cyperus reflexus* Vahl, *Eleocharis* sp., *Juncus acuminatus* Michx., *J. brachycarpus* Engelm., *J. marginatus* Rostk., *Polygonum* sp., *Sesbania drummondii* (Rydb.) Cory., and *Steinchisma hians* (Elliott) Nash.

Victoria Co.: McFaddin Ranch, about 2.8 mi E of the jct. of U.S. Hwy. 77 and FM 445 in the town of McFaddin, 11 Sep 2004, *Rosen 3056 & Carter* (MICH, TEX); *Carter 15438 & Rosen* (VDB, VSC, others to be distributed).

At this location, *Cyperus drummondii* was locally abundant in a large prairie wetland on clayey-loam soils of the Lissie Formation with *Acacia farnesiana* (L.) Willd., *Andropogon gerardii* Vitman, *Cyperus* spp., *Eleocharis ravenelii* Britton, *Leersia hexandra* Sw., *Paspalum* spp., *Polygonum* sp., *Prosopis glandulosa* Torr., and *Rhynchospora* spp.

Reports of *Cyperus drummondii* from the Piney Woods in the *Illustrated Flora of East Texas, Vol. 1.* (Diggs et al. 2006) are based on two very old collections from the southeast margin of East Texas (Rosen 2004). Recent field work in Hardin County has resulted in collections of *C. drummondii* from a hillside seepage bog and the margins of a flat-woods pond as cited here:

TEXAS. Hardin Co.: Roy E. Larsen Sandyland Sanctuary, N of State Hwy. 327, between the towns of Silsbee and Kountze, 08 Oct 2006, *Rosen 3949 & Brown and Boensch* (BRIT, MICH, TAES, TEX, VSC).

The label data from the historic collections of *Cyperus drummondii* from eastern Texas provide no details on its habitat (Rosen 2004). We expand the habitat description of this species in Texas to include hillside seepage bogs and flat-woods ponds, in addition to the relict Coastal Prairie wetlands noted by Rosen (2004). At the Roy E. Larsen Sandyland Sanctuary, *C. drummondii* was occasional to frequent on sandy soils in shallow water on the fringes of a flatwoods pond and wet sandy soils of a hillside seep with *Dichanthelium* sp., *Eleocharis* spp., *Fuirena* sp., *Morella cerifera* (L.) Small, *Panicum hemitomon* Schult., *Saccharum giganteum* (Walter) Pers., and *Scirpus cyperinus* (L.) Kunth. This is very similar to the habitat of this species in the Gulf Coastal Plain of Georgia and Mississippi (Carter et al. 1999).

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Denton (1978) reported *Cyperus drummondii* [as *C. virens* Michx. var. *drummondii* (Torr. & Hook.) Kük.] as occurring in North America (Texas and Louisiana), Nicaragua, Jamaica, the Galapagos Islands, Surinam, and Brazil. Tucker (1994) and Espejo Serna and López-Ferrari (1997) included *C. drummondii* under *C. virens* in Mexico. During field work near the city of Durango following the Second Botanical Symposium of Northern Mexico, we collected specimens of *C. drummondii*, confirming its occurrence in Mexico. Review of specimens at CIIDIR also resulted in the discovery of other collections of *C. drummondii* from the Mexican state of Durango previously identified as *C. virens*.

Specimens examined. **MÉXICO. Durango:** proximidad a Canelas, terrenos de la UAF Topia, Mpio. Canelas, montemojino, transición entre el bosque tropical caducifolio y el bosque de pino, 1414 m snm, suelo profundo, café muy pedregoso, con pendientes hasta de 45°, 27 Sep 1990, *Benítez 2409* (CIIDIR); Carretera Durango-Nombre de Dios, Km 246.5, Mpio. Nombre de Dios, Aug1997, matorral xerófilo, *González 354* (CIIDIR); 17 km al E de Durango por la carretera a Fresnillo, lugar inundado cerca de la carretera, localmente abundante, 1960 m, 18 Oct 1983, *González & Acevedo 2747* (CIIDIR); Río Tunal, bajo puente en libramiento de carretera Zacatecas–Torreón (cerca del Balneario San Juan), Mpio. Durango, 19 Jan 1999, *Pinedo 24* (CIIDIR); 31 km de La Guajolota, por el camino a Los Charcos, Mpio. El Mezquital, estanque en medio de bosque de pino-encino, escaso, dentro del agua, 2000 m, 8 Oct 1983, *González 2701* con *González y Acevedo* (CIIDIR); Carretera 45 al E de la Ciudad de Durango (Puente Gavilanes), Mpio. Durango, 24°0'51" N, 104°29'25" W, 1850 m, vegetación riparia (*Salix bonplandiana*), común, hierba, 08 Oct 1999, *González 3195* (CIIDIR); Mpio. Durango, 17.7 km al SSE de Durango, por la carretera a El Mezquital, al S de Felipe Ángeles, 23°55'21" N, 104°32'40" W, 1850 m, vegetación subacuática, abundante a orilla de canal, 16 Sep 2005, *González 7091* con *Guaglianone*, *Torres*, *Rosen, Carter y Peterson* (CIIDIR, ANSM, ENCB, IEB, MEXU, SI); *Carter 16149, 16150 & González, Guaglianone, Torres, Rosen, & Peterson* (VDB, VSC, others to be distributed); *Rosen 3493, 3494 & Carter, González, Guaglianone, Torres, & Peterson* (TAES).

The following key modified from Denton (1978) and Carter et al. (1999) will separate *Cyperus drummondii* from other members of the *C. virens* complex in Mexico.

1. Primary peduncles 3–5; floral scales 1.0–1.5(–1.8) mm long; spikelets at least 2.25 mm wide **C. drummondii**
1. Primary peduncles 6–12(–14); floral scales 1.5–2.4 mm long; spikelets (2–)2.2–3.3 mm wide.
    2. Achenes (2.5–)3–5 times longer than wide, (1–)1.2–1.5 mm long; spikelets (5–)7–15 mm long **C. virens** var. **virens**
    2. Achenes 2–2.5 times longer than wide, 1–1.2 mm long; spikelets 5–6.5 mm long **C. virens** var. **minarum**

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We are grateful to Wade Harrell with the Nature Conservancy's Refugio-Goliad Prairie Project and Kirk Feuerbacher with the McFaddin Ranch for arranging access for field work in Victoria County, and to Bob Boensch and Wendy Ledbetter with the Nature Conservancy for access to the Roy E. Larsen Sandyland Sanctuary. We would like to thank Guy Nesom for reviewing this manuscript and Socorro Gonzalez-Elizondo for reviewing this manuscript and the kind hospitality and her indispensable assistance, without which the field work resulting in discovery of this species in México would not have been possible. The Valdosta State University Foundation and Faculty Internationalization Fund are gratefully acknowledged for financial support.

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Fort Worth, Texas 76102-4060, U.S.A.

It is with great sadness to report the loss of a friend and colleague Lawrence K. Magrath, biologist, orchidologist and curator, who died Saturday, 24 February 2007, after a long illness. Magrath, a 35-year member of the University of Science and Arts of Oklahoma (USAO) science faculty, previously served as professor of biology, director of interdisciplinary studies and curator of the OCLA Herbarium (herbarium acronym). Though he officially resigned March 2005, he continued teaching on a limited schedule.

Through the 1990s he led or supported one campus beautification project after another, adding flowers, trees, and shrubbery to create the String of Pearls Garden surrounding Austin Hall, the Water Garden to the north, the Sculpture Garden east of Davis Hall, and more. As a result of his leadership, the college won two Keep Oklahoma Beautiful awards in the 1990s, and the USAO Board of Regents presented a special commendation to him.

As a long-time leader in USAO's unique Interdisciplinary Studies Program, Magrath was recognized for classroom teaching, his dedication to liberal arts education, mentoring young scientists, and encouraging learning both inside and outside the classroom. He advised several student organizations and academic honor societies at USAO.

In 1994, Magrath was presented a plaque by the Oklahoma Junior Academy of Science (OJAS) for "Outstanding Contributions and Long-time Service." Magrath welcomed the OJAS conference to the USAO campus on several occasions. Also during 1994, Magrath published three poems in the "Journal of Evolutionary Psychology." As one of Oklahoma's authorities on Orchids in this region, he attended the American Orchid Society Trustees Meeting in New York City to serve as vice chair for the AOS Conservation Committee. He was a member of more than a dozen national and international societies in science, wildlife preservation, and teaching. For decades, he worked with the Oklahoma Academy of Science, the American Orchid Society, the Oklahoma Native Plant Society, the Flora of Oklahoma Project, and the Flora of North America Project, authored or co-authored some 50 articles, read at least 30 papers at professional conferences.

Larry was born 28 March 1943 in Garnett, Kansas. He was salutatorian at Westphalia Rural High School in Coffey County, Kansas. His bachelor's and master's degrees were from Kansas State Teachers College (now Emporia State University). He received an undergraduate fellowship to Argonne National Laboratory in Illinois. Larry was awarded his Ph.D. in botany in 1973 at the University of Kansas; his dissertation was entitled "*The native orchids of the prairies and plains region of North America.*" Orchids remained the primary focus of Larry's research throughout his career. He developed the OCLA herbarium (ca. 22,000 specimens) with noteworthy collections from southeastern Oklahoma and the Orchidaceae of the central and southeastern United States.

ACKNOWLEDGMENTS

Thanks to the USAO News Bureau (University of Science and Arts of Oklahoma) for permission to extract information from the USAO website (http://www.usao.edu/news/spring-07/LarryMagrath.htm). Randy Talley, Michael Bendure, and Charles Mather (USAO) provided the photograph. The Oklahoma Flora committee, particularly Susan Barber and Wayne Elisens, gave encouragement and support. Judy MacKenzie kindly read and suggested improvements to the manuscript.

J. Bot. Res. Inst. Texas 1(1): 781 – 784. 2007

SCIENTIFIC PUBLICATIONS AND REPORTS

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Magrath, L.K. 1970. *Spiranthes tuberosa*, new for Kansas. Rhodora 72:141.

Magrath, L.K. 1971. Vascular plants new for Oklahoma, Kansas, and Nebraska. Rhodora 73:300–304.

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Magrath, L.K. and K.L. Johnson. 1971. The genus *Rhynchospora* (Cyperaceae) in Kansas. SouthW. Naturalist 15:389.

Magrath, L.K. 1972. The Nelson Tract botanical survey, 1971. In: Barr, B.G., J.R. Eagleman, R.J. Eastmond, and S.A. Morain. Atmospheric pollution and its effect in the Kansas City-Topeka Corridor. The University of Kansas. NSF Grant #GI-29760. The Center for Research, Inc.

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Magrath, L.K. 2001. *Galium parisiense* var. *leiocarpum* Tausch, new for Oklahoma. Oklahoma Native Pl. Rec. 1(1):67.

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MAGRATH, L.K., R.L. DRESSLER, J.T. ATWOOD, and J. BECKNER. 2002. Key to the genera of Orchidaceae. In: Flora of North America Editorial Committee, eds. Fl. North Amer. 26:494–499. Oxford Univ. Press., New York and Oxford.

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MAGRATH, L.K. 1973. Native orchids of Kansas. Paper read before the Kansas Orchid Society.

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MAGRATH, L.K. and J. TAYLOR. 1977. Oklahoma orchids: new species and new distributions. Paper read before the Oklahoma Academy of Science.

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MAGRATH, L.K. 1980. *Spiranthes praecox* (Orchidaceae), new for Oklahoma. Paper read before the Oklahoma Academy of Science.

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MAGRATH, L.K. 1983. A morphological comparison of two taxa of *Calopogon* occurring in Oklahoma. Paper read before the Oklahoma Academy of Science.

MAGRATH, L.K. 1984. Orchids and other spring wildflowers. Presentation at 7th Annual Oklahoma Wildflower Meeting.

MAGRATH, L.K. 1984. *Cypripedium kentuckiense* (Rafinesque's ladyslipper) a previously unrecognized ladyslipper in southeastern Oklahoma. Paper read before the Oklahoma Academy of Science.

MAGRATH, L.K. 1985. Latest Royal Horticultural Society Awards in *Cymbidium* (1978–1984). Presentation made at Great Plains Regional Judging Center of the American Orchid Society Meeting.

MAGRATH, L.K. 1986. Spaceship earth and the geopolitical implications of resource allocation and overpopulation. Banquet Address, 1986 Model United Nations at University of Science & Arts of Oklahoma.

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NEW NAMES

Aster oblongifolius f. *albaligulatus* Magrath—Rhodora 73:303. 1971.

Commelina erecta f. *alba Magrath*—Rhodora 73:300. 1971.

Cypripedium parviflorum f. *albolabium* Magrath & J.L.Norman—Sida 13:372. 1989.

Sida spinosa f. *albiflora* Magrath—Rhodora 74:383. 1972.

BOOK REVIEW

Gerhard Gottsberger and Ilse Silberbauer-Gottsberger. 2006. **Life in the Cerrado: a South American Tropical Seasonal Ecosystem. Vol. I. Origin, Structure, Dynamics and Plant Use.** (ISBN 3-00-017928-3, hbk.). Abteilung Systematische Botanikund Ökologie und Botanischer Garden, Universität, Ulm, GERMANY (**Orders:** http://www.cerrado.eu/avail.html)**.** €49.00 ($64.60), 277 pp., numerous color figures, drawings, and tables, 8⅝" × 9½".

Gerhard Gottsberger and Ilse Silberbauer-Gottsberger. 2006. **Life in the Cerrado: a South American Tropical Seasonal Ecosystem. Vol. II. Pollination and Seed Dispersal.** (ISBN 3-00-017929-1, hbk.). Abteilung Systematische Botanikund Ökologie und Botanischer Garden, Universität, Ulm, Germany**.** (**Orders:** http://www.cerrado.eu/avail.html)**.** €59.00 ($77.78), 385 pp., numerous color figures, drawings, and tables, 8⅝" × 9½".

This authoritative monograph on one of the most remarkable ecosystems of the Neotropics is based on more than 35 years of field work and research by the two authors. It gives not only a survey of the main results of their own multidisciplinary studies, but offers an up-to-date and competent synthesis of the relevant and voluminous literature, often not easily accessible and partly written in Portuguese. The text is well organized and very clearly written, copiously illustrated by many excellent colour photographs and drawings, and supported by numerous schemata and tables.

Volume I covers the more general aspects of the cerrado biome and starts with chapters characterizing the eco-geographical and floristic position of the Central Brazilian cerrado. Relationships are discussed with the Amazonian, Guiana and Central American savannas and the caatinga to the North and Northeast, as well as the Pantanal and Beni savannas, and the chaco and campo rupestre ecosystems towards the West and South. The cerrado and other South American savanna types developed as a consequence of climatic changes from the Miocene (about 25 mya bp) onward. During the Pleistocene they had a much more extensive distribution relative to the tropical rain forests. An important difference with respect to comparable African ecosystems is that large and mostly ungulate herbivore mammals had died out in South America by the early Postglacial. For many flowering plant families and genera (e.g., palms, *Annona*, *Jacaranda*, etc.) an origin of cerrado taxa from tropical rain forest ancestors can be demonstrated. There is impressive fossil evidence for an increase and final dominance in the cerrado grass flora of better adapted C_4 over less specialized C_3 taxa from 10 to 3mya bp. Species diversity is remarkably high in the cerrado flora: For one hectare plots 350–400 vascular plant species are recorded, including 50–90 shrubs and trees. For the whole cerrado area one estimates about 10.000 species. Annual changes of pronounced dry and rainy seasons, and regular fires dominate the cerrado ecosystem. This influences its vegetation rhythm, physiognomy and life form spectrum, and explains the frequent occurrence of excessive bark formations and subterranean xylopodia. Thus, cerrado has an excellent regeneration capacity. Literature reports and personal contacts with Kayapó and Xavante Amerindians reveal the many ways in which cerrado plants are used as fire wood, food, medicine, game attractant, fertilizer and for cultivation by the natives. Remarkable is their management of artificial forest islands in which they concentrate useful plants (also from outside of the cerrado). This contrasts with the destruction of cerrado areas by modern developments which had reached 37% already in 1990 and is sadly accelerating since. Thus, immediate measures are necessary, to preserve at least parts of this unique ecosystem.

Volume II concentrates on the reproductive biology of the flowering plants of the cerrado biome. After an introduction, a first major block of chapters deals with pollination and breeding systems, another with seed dispersal. For not less than 625 cerrado species of flowering plants more or less detailed descriptions and partly illustrations of pollination modes are presented, including references to many hundreds of pollinating animals. Data are arranged according to the following principles: flowers of generalist versus specialist nature; pollinators either collecting pollen, nectar or oil; small to large bees, beetles, butterflies, moths and flies, as well as hummingbirds and bats as pollinators; wind pollination. –Flowering plant spectra of different pollination modes for the single Botucatu plot versus the whole of the cerrado area demonstrate: The majority of species are melittophilous and dependent on small (22/26%) and large bees (16/24%); generalist taxa come second (37/22%), followed by anemophilous (13/4%) and ornithophilous (2/7,5%) taxa, whereas all others remain below 5%. This spectrum differs from other biomes, e.g. from the tropical rain forest where more ornithophilous and less anemophilous species occur. Of particular interest are chapters concerned with families and genera which exhibit evolutionary radiation in response to different pollinators and different flowering periods. A good example is the *Vochysiaceae* which have differentiated from large bee to small bee, hawkmoth and hummingbird pollination. The *Bignoniaceae* are represented by a group of 6 genera with 10 species in the cerrado which produce pollen and nectar and are pollinated in different proportions by 74 bee species. In addition *Jacaranda* has specialized in the production of perfumes from glands at the large staminode, attracting Euglossine bees. Among 19 cerrado species of *Annonaceae* 13 belong to the genus *Annona* and are pollinated by large scarab beetles, whereas 6 species from other genera have smaller beetles and thrips as pollinators. The *Annona* species attract a similar spectrum of scarab species by floral heating and strong odor emission in the evening, but are differentiated with respect to their flowering seasons throughout the year. The 9, mostly short stemmed cerrado palms (*Arecaceae*) studied, are pollinated partly by bees, partly by beetles, but only rarely by wind. Comparative analyses of the breeding system are another important approach, relevant for evolutionary differentiation: 6–15% of the cerrado taxa studied are dioecious, among the hermaphrodite and monoecious taxa 40–50% are reported as self-compatible and 6–8,6% as apomictic A remarkable set of data is presented on different seed dispersal modes among 301 flowering plant species in the cerrado area of Botucatu. Generally, there is more zoochory (64%, mainly endozoochory) and anemochory (34%), but less autochory (2%) in the tree layer as compared with the ground layer. Endozoochory is even more dominant in trees of the tropical rain forest. Epizoochory greatly declines from the more open cerrado sesu stricto (21%) to the quite dense cerradão (1%). Most of the larger animals involved in seed dispersal (birds, mammals and bats) live in the gallery forests adjacent to the cerrado. Further chapters deal with interactions of flowering plants with herbivores and fungi with as well as with ants and termites.

In retrospect: The two volumes on the cerrado ecosystem by Gerhard Gottsberger and Ilse Silberbauer-Gottsberger are a major contribution to our understanding of the biological problems of South America and a must for all interested in this field. Beyond that these volumes are an important step forward in current efforts to better evaluate the links between species diversity, ecological interdependences and evolutionary aspects in the different biomes of our biosphere.—*Prof. Dr. F. Ehrendorfer, Institute of Botany, University of Vienna, A-1030, Rennweg 14, Vienna, Austria, friedrich.ehrendorfer@univie.ac.at.*

BOOKS RECEIVED

BLACKWELL PUBLISHING: ANNUAL PLANT REVIEWS

Jeremy Roberts and Zinnia Gonzalez-Carranza (eds.). 2007. **Annual Plant Reviews, Volume 25: Plant Cell Separation and Adhesion.** (ISBN-13 978-14051-3892-5, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** www.blackwellprofessional.com, orders@ames.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $199.99, 232 pp., 6" × 9".

Contents.—**1)** Cell separation and adhesion processes in plants; **2)** Cell wall structure, biosynthesis and assembly; **3)** Vascular cell differentiation; **4)** Cell adhesion, separation and guidance in compatible plant reproduction; **5)** Cell separation in roots; **6)** Organ abscission; **7)** Dehiscence; **8)** Fruit ripening; **9)** the role of polymer cross-linking in intercellular adhesion. References, Index.

Klaus D. Grasser (ed.). 2006. **Annual Plant Reviews, Volume 29: Regulation of Transcription in Plants.** (ISBN-13 978-14051-4528-2, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** www.blackwellprofessional.com, orders@ames.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $199.99, 350 pp., 6" × 9".

Contents.—**1)** General transcription factors and the core promoter: ancient roots; **2)** Transcription factors of *Arabidopsis* and rice: a genomic perspective; **3)** Chromatin-associated architectural HMGA and HMGB proteins assist transcription factor function; **4)** Histone modifications and transcription in plants; **5)** Chromatin remodeling and histone variants in transcriptional regulation and in maintaining DNA methylation; **6)** Matrix attachment regions and transcriptional gene silencing; **7)** Polymerase I transcription; **8)** Transcription of plastid genes; **9)** Control of flowering time; **10)** Combinatorial control of floral organ identity by MADS-domain transcription factors; **11)** Networks of transcriptional regulation underlying plant defense responses toward phytopathogens; **12)** Temperature-regulated gene expression; **13)** Application of inducible transcription in plant research and biotechnology; **14)** Modulation of transcriptional networks in crop plants.

Garry C. Whitelam and Karen J. Halliday (eds.). 2007. **Annual Plant Reviews, Volume 30: Light and Plant Development.** (ISBN-13 978-14051-4538-1, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** www.blackwellprofessional.com, orders@ames.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $199.99, 325 pp., 6" × 9".

Contents.—**1)** Phytochromes; **2)** Cryptochromes; **3)** Phototropins and other LOV-containing proteins; **4)** Phytochrome-interacting factors; **5)** Phosphorylation/dephosphorylation in photoreceptor signalling; **6)** The role of ubiquitin/proteasome-mediated proteolysis in photoreceptor action; **7)** UV-B perception and signal transduction; **8)** Photocontrol of flowering; **9)** Red:far-red ration perception and shade avoidance; **10)** Photoreceptor interactions with other signals; **11)** Photoreceptor biotechnology; **12)** Light-quality manipulation by horticulture industry. References, Index.

David C. Logan (ed.). 2007. **Annual Plant Reviews, Volume 31: Plant Mitochondria.** (ISBN-13 978-14051-4939-6, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** www.blackwellprofessional.com, orders@ames.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $199.99, 342 pp., 6" × 9".

Contents.—**1)** Mitochondrial dynamics: the control of mitochondrial shape, size, number, motility, and cellular inheritance; **2)** The unique biology of mitochondrial genome instability in plants; **3)** Expression of the plant mitochondrial genome; **4)** Import of nuclear-encoded mitochondrial proteins; **5)** Mitochondrial respiratory complex biogenesis: communication, gene expression and assembly; **6)** Supramolecular structure of the oxidative phosphorylation system in plants; **7)** Mitochondrial electron transport and oxidative stress; **8)** Mitochondrial metabolism; **9)** Cytoplasmic male sterilities and mitochondrial gene mutations in plants; **10)** The mitochondrion and plant programmed cell death. References, Index.

J. Bot. Res. Inst. Texas 1(1): 787. 2007

Paul Martin Brown (Text) and Stan Folsom (Original Artwork). 2007. **Wild Orchids of the Northeast: New England, New York, Pennsylvania.** (ISBN 978-0-8130-3034-0, flexibind). University Press of Florida, 15 Northwest 15th Street, Gainesville, FL 32611-2079, U.S.A. (**Orders:** www.upf.com, 352-392-1351, 352-392-7302 fax, 1-800-226-3822). $29.95, 376 pp., 316 color plates, 94 b/w illustrations, 81 maps, 6" × 9".

Andrus Voitk and Maria Voitk. 2006. **Orchids on the Rock: The Wild Orchids of Newfoundland.** (ISBN 0-9699509-3-4, pbk.). Gros Morne Co-operating Association, Publicity Dept., Rocky Harbour, Newfoundland A0K 4N0 (**Orders:** http://www.grosmornetravel.com/intro_details.asp?Id=15). $12.95, 96 pp., color photographs, 5¼" × 6½".

Luis M. Botana (ed.). 2007. **Phycotoxins: Chemistry and Biochemistry.** (ISBN 13 978-0-8138-2700-1, hbk.). Blackwell Publishing. 2121 State Ave., Ames, IA 50014-8300, U.S.A. and 9600 Garsington Road, Oxford, OX4 2DQ, UK. (**Orders:** www.blackwellprofessional.com, orders@ames.blackwellpublishing.com, 515-292-0140, 515-292-3348 fax, 1-800-862-6657). $199.99, 345 pp., 7" × 10".

Contents.—**1)** Gambierol; **2)** Brevetoxins: Structure, Toxicology, and Origin; **3)** Chemistry of Maitotoxin; **4)** Biochemistry of Maitotoxin; **5)** Chemistry of Palytoxins and Ostreocins; **6)** Biochemistry of Palytoxins and Ostreocins; **7)** Chemistry of Cyanobacterial Neurotoxins—Anatoxini-a: Synthetic Approaches; **8)** Anatoxin-a and Analogues: Discovery, Distribution, and Toxicology; **9)** Pectenotoxins; **10)** Chemistry, Origins, and Distribution of Yessotoxin and It's analogues; **11)** Pharmacology of Yessotoxin; **12)** Chemistry of Diarrhetic Shellfish Poisoning Toxins; **13)** The Molecular and Integrative Basis to DomoicAcid Toxicity; **14)** Hepatotoxic Cyanobacteria; **15)** Polycavernosides; **16)** Structural Assignment and Total Synthesis of Azaspiracid-1; **17)** Biochemistry of Azaspiracid Poisoning Toxins; **18)** Cyclin Imines: An Insight into this Emerging Group of Bioactive Marine Toxins. Index.

Illustrated Flora of East Texas

George Diggs, Barney Lipscomb, Monique Reed, Bob O'Kennon

From Big "D" to the Big Thicket there is a land of beautiful prairies interwoven
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Publication date: **26 May 2006** Botanical Research Institute of Texas (SBM 26)
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ISSN 0833-1475; ISBN 1-889878-12-X

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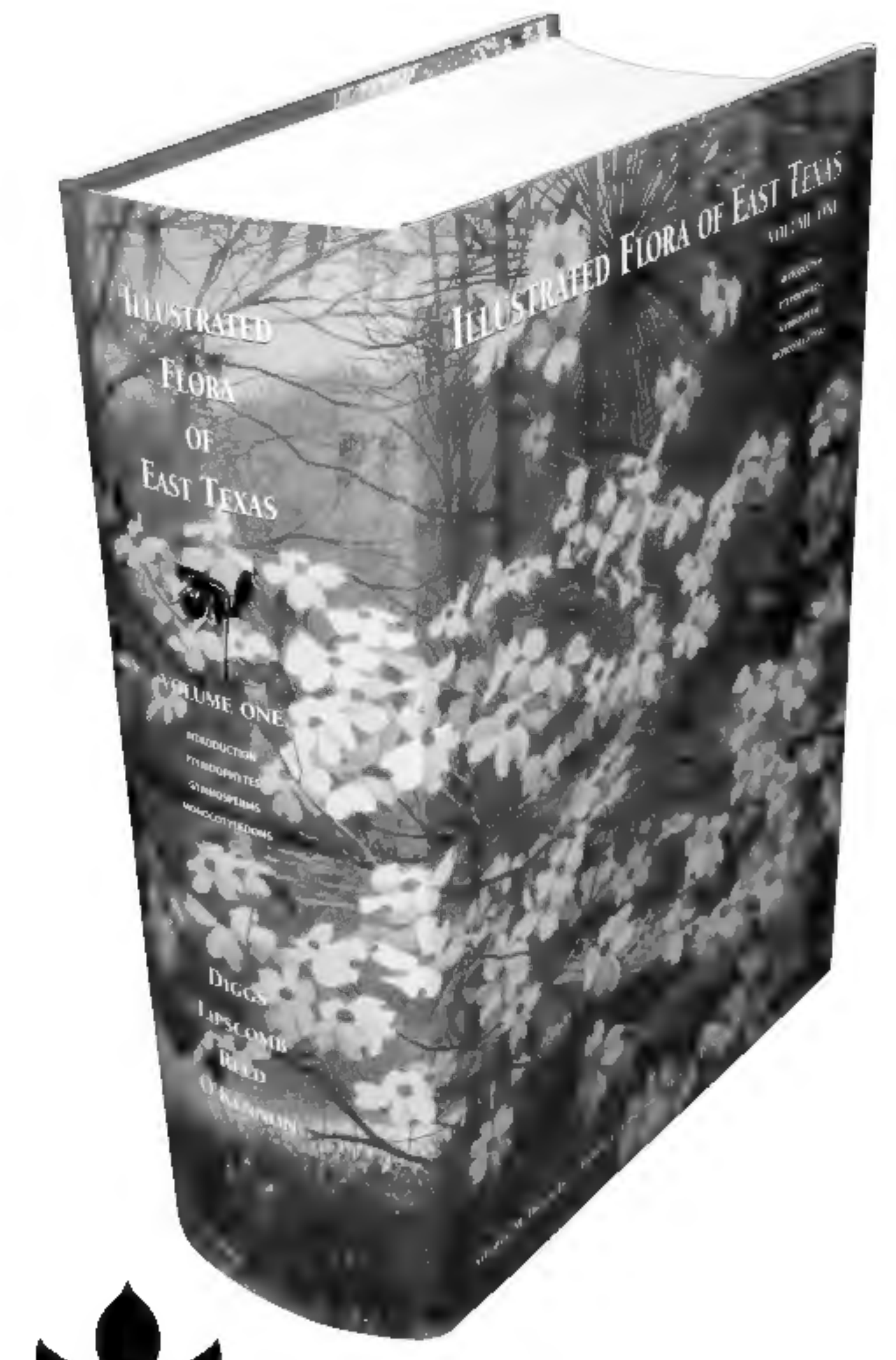

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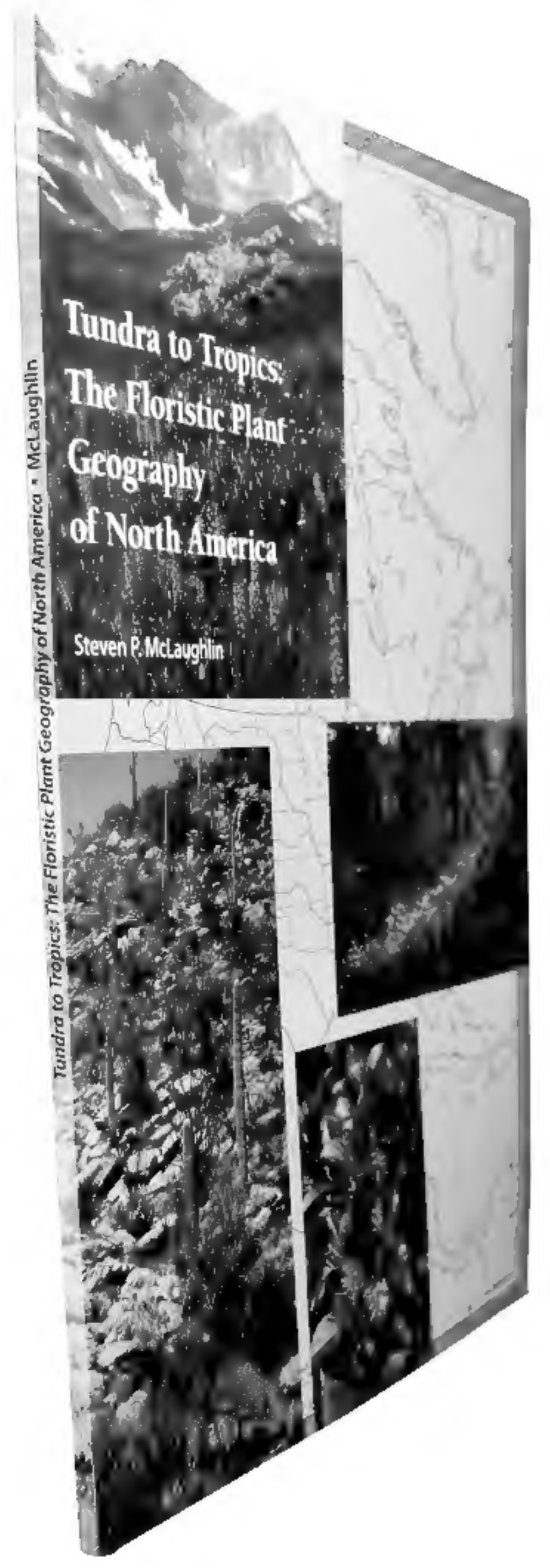

Tundra to Tropics: The Floristic Plant Geography of North America

Steven P. McLaughlin

Floristic elements and floristic areas for North America were circumscribed using principle components analysis (PCA) of a sample of 245 local floras from Canada, the United States, and Mexico. Three analyses were conducted: 1) a PCA on a matrix of Otsuka similarity indices based on shared species, which identified 27 floristic subprovinces; 2) a PCA on a matrix of Pearson correlations on the log number of species per genus in each flora, which identified 12 floristic provinces; and 3) a PCA on a matrix of Pearson correlations on the log number of species per family in each flora, which identified 4 floristic regions. Seventy-eight percent of the 245 floras formed nested hierarchical groups across all three analyses; 98% formed nested groups over two levels of the hierarchy. When compared with earlier biogeographic treatments of North America by Dice, Udvardy, and Cronquist, McLaughlin's results supported different aspects of each one but also showed that none completely captured the major floristic patterns on the continent.

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Trees in the Life of the Maya World

Regina Aguirre de Riojas and Elfriede de Pöll

Trees in the Life of the Maya World brings together the knowledge of the shaman and the scientist, the myths and arts of ancient civilizations and the practices of modern people and treats it all with wisdom and clarity of vision. It is an example of how we should respect and treat not just trees but our entire natural surroundings. Chapters include: 1) Introduction; 2) Trees in the Life of the Maya World; 3) Trees in the Popol Vuh; 4) Trees as Nourishment; 5) Trees Used in Building and Carpentry; 6) Trees as Firewood; 7) Trees as Medicine; 8) Other Uses; 9) The Special Place of Trees; Glossary, Bibliography, and Index.

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JOURNAL OF THE BOTANICAL RESEARCH INSTITUTE OF TEXAS

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The *Journal of the Botanical Research Institute of Texas,* formerly called *Sida, Contributions to Botany,* publishes research in classical and modern systematic botany—including studies of anatomy, biogeography, chemotaxonomy, ecology, evolution, floristics, genetics, paleobotany, palynology, and phylogenetic systematics. Geographic coverage is global. Articles are published in either English or Spanish; an abstract is provided in two languages. All contributions are peer reviewed and frequently illustrated with maps, line drawings, and full color photographs.

The journal is published twice yearly in a multiple topic format and provides information to scientists, professionals, and the general public for research, education, and cultural enhancement. All articles are indexed and abstracted in print and/or electronic form by the following: AGRICOLA Database (National Agricultural Library); Applied Botany Abstracts; Biosciences Information Service of Biological Sciences (BIOSIS); Current Awareness in Biological Sciences (CABS); Excerpta Botanica; The Kew Record of Taxonomic Literature; Natural Products Alert (NAPRALERT); and Referativnyi Zhurnal (Abstracts Journal of the Institute of Scientific Information of the Republic of Russia).

Lloyd H. Shinners, whose herbarium and library were the basis of the Southern Methodist University (SMU) legacy that became BRIT in 1987, founded the journal in 1962. **William F. Mahler** succeeded Shinners as SMU herbarium director in 1971 and inherited both ownership and editorship of the journal. Since 1993, it has been published by the Botanical Research Institute of Texas.

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